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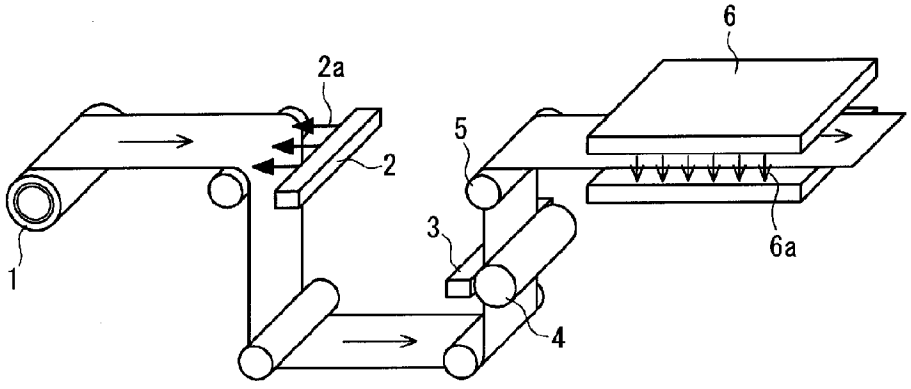
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[続葉有]

(54) **Title:** SLURRY FOR FORMING INSULATING LAYER, SEPARATOR FOR ELECTROCHEMICAL DEVICE, METHOD FOR PRODUCING THE SAME, AND ELECTROCHEMICAL DEVICE

(54) 発明の名称: 絶縁層形成用スラリー、電気化学素子用セパレータおよびその製造方法、並びに電気化学素子

[図1]



(57) **Abstract:** Disclosed is a slurry for forming insulating layers, which contains heat-resistant insulating fine particles, a thickening agent and a dispersion medium. The insulating fine particles are dispersed in the dispersion medium, and the ratio of particles having a particle diameter of not more than 1 μm is not less than 30% by volume and the ratio of particles having a particle diameter of not less than 3 μm is not more than 10% by volume in the particles contained in the insulating fine particles. The slurry for forming insulating layers has a viscosity of 5-500 mPa s. An electrochemical device comprising a separator for electrochemical devices which is produced by using the slurry for forming insulating layers is also disclosed.

(57) 要約: 本発明の絶縁層形成用スラリーは、耐熱性を有する絶縁性微粒子と、増粘剤と、分散媒とを含み、前記絶縁性微粒子は、前記分散媒に分散しており、前記絶縁層形成用

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SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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スラリーの粘度が、５～５００ｍＰａ・ｓであり、前記絶縁性微粒子に含まれる粒子の中で、粒径が１μｍ以下の粒子の割合が３０体積％以上であり、かつ粒径が３μｍ以上の粒子の割合が１０体積％以下であることを特徴とする。また、本発明の電気化学素子は、上記本発明の絶縁層形成用スラリーを用いて作製した本発明の電気化学素子用セパレータを備えている。

明 細 書

絶縁層形成用スラリー、電気化学素子用セパレータおよびその製造方法、並びに電気化学素子

技術分野

[0001] 本発明は、電気化学素子用セパレータを構成するのに好適な絶縁層を形成するためのスラリー、上記スラリーを用いて形成される絶縁層を有する電気化学素子用セパレータおよびその製造方法、並びに上記電気化学素子用セパレータを有する電気化学素子に関するものである。

背景技術

[0002] 電気化学素子の一種であるリチウム二次電池は、エネルギー密度が高いという特徴から、携帯電話やノート型パーソナルコンピューターなどの携帯機器の電源として広く用いられている。携帯機器の高性能化に伴ってリチウム二次電池の高容量化が更に進む傾向にあり、その安全性の確保が重要となっている。

[0003] 現行のリチウム二次電池では、正極と負極の間に介在させるセパレータとして、例えば厚みが20～30μm程度のポリオレフィン系の微多孔性フィルム(微多孔膜)が使用されている。また、セパレータには、電池の安全性を向上させるため、電池の異常発熱温度(熱暴走温度)以下でセパレータの構成樹脂を溶融させて空孔を閉塞させ、電池の内部抵抗を上昇させる機能、所謂シャットダウン機能が必要とされる場合がある。このため、セパレータの素材としては、融点の低いポリエチレンが好ましく用いられる。

[0004] ところで、こうしたセパレータとしては、例えば、多孔化と強度向上のために一軸延伸または二軸延伸したフィルムが用いられている。このようなセパレータは、単独で存在する膜として供給されるため、作業性などの点で一定の強度が要求され、これを上記延伸によって確保している。しかし、このような延伸フィルムでは結晶化度が増大しており、シャットダウンが生じる温度(シャットダウン温度)も、電池の熱暴走温度に近い温度にまで高まっているため、電池の安全性確保のためのマージンが十分とは言い難い。

[0005] また、上記延伸によってフィルムにはひずみが生じており、これが高温に曝されると、残留応力によって収縮が起こるという問題がある。収縮温度は、フィルム樹脂の融点、すなわちシャットダウン温度と非常に近いところに存在する。このため、ポリオレフィン系の微多孔性フィルムをセパレータとして使用するときには、充電異常などにより電池の温度がシャットダウン温度に達すると、電流を直ちに減少させて電池の温度上昇を防止しなければならない。空孔が十分に閉塞せず電流を直ちに減少できなかった場合には、電池の温度は容易にセパレータの収縮温度にまで上昇するため、内部短絡を生じることもある。

[0006] このようなセパレータの熱収縮による短絡を防止し、電池の信頼性を高める技術として、例えば、耐熱性の良好な多孔質基体と、無機微粒子と、シャットダウン機能を確保するための樹脂成分とを有するセパレータにより電気化学素子を構成することが提案されている(特許文献1および2)。

[0007] 特許文献1:国際公開第2006／062153号公報
特許文献2:国際公開第2007／066768号公報

[0008] 特許文献1および2に開示の技術によれば、異常発熱した際にも熱暴走が生じ難い安全性に優れた電気化学素子を提供することができる。

[0009] ところで、特許文献1および2には、無機微粒子を使用し、上記無機微粒子を分散させたスラリーを基材などに塗布する工程を経てセパレータを製造する方法も記載されている。

[0010] ところが、無機微粒子は、水や有機溶媒といった媒体に比べて比重が大きいためにスラリー中で沈降しやすく、また、特に粒径が1μm以下の微粒子の場合には、微粒子同士が凝集しやすいことから、スラリー中での微粒子の分散状態を安定に保つことが困難な場合がある。

[0011] スラリー中での微粒子の分散状態を安定に保つことができない場合には、スラリーの保管時に微粒子の凝集や沈降が生じてしまう。微粒子が凝集したり沈降したりしたスラリーを基材などに塗布すると、塗布ムラが生じやすい。また、スラリー中での微粒子の分散状態が特に不安定なものでは、基材などへの塗布後、乾燥するまでの間に微粒子が凝集したり沈降したりして、塗布面にムラが生じる場合もある。

[0012] スラリーの塗布ムラが生じると、形成されるセパレータの均一性が低くなり、リチウム二次電池内において、セパレータ中のイオン伝導性にムラが生じ、特に高電流密度での充電時において、リチウムの析出などの不具合が生じる虞があり、また、析出したリチウムがデンドライト状の結晶となった場合には、かかるデンドライトによって短絡が発生する虞もある。

[0013] このようなことから、セパレータ製造用のスラリーにおいては、製造されるセパレータの品質をより安定化するために、微粒子などの分散状態の安定性を高めることが好ましく、特許文献1および2に記載の技術は、このような点において未だ改善の余地を残している。

発明の開示

[0014] 本発明は、上記事情に鑑みてなされたものであり、電気化学素子用セパレータに適用可能な、イオン透過性および耐熱性を有する絶縁層を形成するためのスラリーであって、微粒子が均一に分散し、分散状態を安定して維持することのできるスラリー、このスラリーを用いて製造される電気化学素子用セパレータおよびその製造方法、並びに上記電気化学素子用セパレータを有する電気化学素子を提供するものである。

[0015] 本発明の絶縁層形成用スラリーは、電気化学素子用セパレータの絶縁層の形成に用いることができる絶縁層形成用スラリーであって、前記絶縁層形成用スラリーは、耐熱性を有する絶縁性微粒子と、増粘剤と、分散媒とを含み、前記絶縁性微粒子は、前記分散媒に分散しており、前記絶縁層形成用スラリーの粘度が、5～500mPa・sであり、前記絶縁性微粒子に含まれる粒子の中で、粒径が1μm以下の粒子の割合が30体積%以上であり、かつ粒径が3μm以上の粒子の割合が10体積%以下であることを特徴とする。

[0016] また、本発明の電気化学素子用セパレータ(以下、単に「セパレータ」という場合がある。)は、多孔質の絶縁層を含む電気化学素子用セパレータであって、前記絶縁層は、耐熱性を有する絶縁性微粒子とバインダとを含み、前記絶縁性微粒子に含まれる粒子の中で、粒径が1μm以下の粒子の割合が30体積%以上であり、かつ粒径が3μm以上の粒子の割合が10体積%以下であることを特徴とする。

[0017] 更に、本発明の電気化学素子用セパレータの製造方法は、多孔質の絶縁層を含む電気化学素子用セパレータの製造方法であって、上記本発明の絶縁層形成用スラリーを、正極、負極および多孔質基材よりなる群から選択される少なくとも1種の基材に塗布する工程と、前記絶縁層形成用スラリーが塗布された前記基材を乾燥する工程とを含むことを特徴とする。

[0018] また、本発明の電気化学素子は、正極、負極および上記本発明の電気化学素子用セパレータを含むことを特徴とする。

[0019] 本発明によれば、絶縁性微粒子が均一に分散し、その分散状態を安定して維持できる絶縁層形成用スラリーが提供できる。また、本発明の絶縁層形成用スラリーを用いて製造される本発明の電気化学素子用セパレータは、優れた耐熱性を有するものであり、上記電気化学素子用セパレータを有する本発明の電気化学素子は、優れた信頼性を有するものである。更に、本発明の電気化学素子用セパレータの製造方法によれば、セパレータを安定かつ連続的に製造できる。

図面の簡単な説明

[0020] [図1]図1は、本発明のセパレータの製造に適用できる塗工装置の一例を示す概略図である。

発明を実施するための最良の形態

[0021] (実施形態1)

先ず、本発明の絶縁層形成用スラリーの実施形態を説明する。本発明の絶縁層形成用スラリーは、電気化学素子用セパレータを構成可能な多孔質の絶縁層を形成するためのものであり、少なくとも、耐熱性を有する絶縁性微粒子(以下、単に「絶縁性微粒子」という場合がある。)および増粘剤を分散媒に分散させたものである。増粘剤は分散媒に溶解していてもよい。

[0022] 上記絶縁性微粒子は、本発明の絶縁層形成用スラリーにより製造される電気化学素子用セパレータにおいて、その耐熱性を高め、電気化学素子用セパレータの高温での寸法安定性を向上させたり、リチウムデンドライトに起因する微小短絡の発生を抑制する作用を有するものである。

[0023] 上記絶縁性微粒子は、電気絶縁性を有しており、電気化学的に安定で、電気化学

素子の有する有機電解液（以下、「電解液」という場合がある。詳しくは後述する。）や、絶縁層形成用スラリーに用いる分散媒に対して安定であり、高温状態で電解液に溶解しないものであれば、特に制限はない。

[0024] 本明細書でいう「有機電解液に対して安定な絶縁性微粒子」とは、有機電解液（電気化学素子の電解液として使用される有機電解液）中で変形および化学的組成変化の起こらない絶縁性微粒子を意味している。また、本明細書でいう「高温状態」とは、具体的には150℃以上の温度であり、絶縁性微粒子は、このような温度の電解液中で変形および化学的組成変化の起こらない安定な粒子であればよい。すなわち、「耐熱性を有する絶縁性微粒子」における「耐熱性」とは、少なくとも150℃において、電解液中で変形および化学的組成変化が生じないことを意味している。更に、本明細書でいう「電気化学的に安定な」とは、電気化学素子の充放電の際に化学変化が生じないことを意味している。

[0025] 上記絶縁性微粒子の具体例としては、例えば、酸化鉄、Al_2O_3（アルミナ）、SiO_2（シリカ）、TiO_2、$BaTiO_3$、ZrO_2などの酸化物微粒子；窒化アルミニウム、窒化ケイ素などの窒化物微粒子；フッ化カルシウム、フッ化バリウム、硫酸バリウムなどの難溶性のイオン結晶微粒子；シリコン、ダイヤモンドなどの共有結合性結晶微粒子；タルク、モンモリロナイトなどの粘土微粒子；ベーマイト、ゼオライト、アパタイト、カオリン、ムライト、スピネル、オリビン、セリサイト、ベントナイトなどの鉱物資源由来物質またはそれらの人造物；などが挙げられる。また、金属微粒子；SnO_2、スズ－インジウム酸化物（ITO）などの酸化物微粒子；カーボンブラック、グラファイトなどの炭素質微粒子；などの導電性微粒子の表面を、電気絶縁性を有する材料（例えば、上記絶縁性微粒子を構成する材料など）で表面被覆することで、電気絶縁性を持たせた微粒子であってもよい。これらの中でも、アルミナ、シリカおよびベーマイトよりなる群から選択される少なくとも1種の微粒子であることが好ましい。絶縁性微粒子には、これらを1種単独で用いてもよく、2種以上を併用してもよい。

[0026] 上記絶縁性微粒子の形態としては、球状、多面体形状、板状などいずれの形態であってもよいが、絶縁性微粒子には板状粒子が含まれていることが好ましく、絶縁性微粒子の全てが板状粒子であってもよい。板状粒子としては、各種市販品が挙げら

れ、例えば、旭硝子エスアイテック社製のSiO_2「サンラブリー(商品名)」、石原産業社製のTiO_2「NST－B1(商品名)」の粉砕品、堺化学工業社製の板状硫酸バリウム「Hシリーズ(商品名)」、「HLシリーズ(商品名)」、林化成社製のタルク「ミクロンホワイト(商品名)」、林化成社製のベントナイト「ベンゲル(商品名)」、河合石灰社製のベーマイト「BMM(商品名)」、「BMT(商品名)」、河合石灰社製のアルミナ「セラシュールBMT－B(商品名)」、キンセイマテック社製のアルミナ「セラフ(商品名)」、斐川鉱業社製のセリサイト「斐川マイカ Z－20(商品名)」などが入手可能である。この他、SiO_2、Al_2O_3、ZrO_2、CeO_2については、特開2003－206475号公報に開示の方法により作製することができる。

[0027] 上記絶縁性微粒子が板状である場合には、セパレータ中において、絶縁性微粒子を、その平板面がセパレータの面にほぼ平行となるように配向させることで、短絡の発生をより良好に抑制できる。これは、絶縁性微粒子を前記のように配向させることで、絶縁性微粒子同士が平板面の一部で重なるように配置されるため、セパレータの片面から他面に向かう空孔(貫通孔)が、直線ではなく曲折した形で形成される(すなわち、曲路率が大きくなる)と考えられ、これにより、リチウムデンドライトがセパレータを貫通することを防止できることから、短絡の発生がより良好に抑制されるものと推測される。

[0028] 上記絶縁性微粒子が板状粒子である場合の形態としては、例えば、アスペクト比(板状粒子の最大長さ／板状粒子の厚み)が、好ましくは5以上、より好ましくは10以上であって、好ましくは100以下、より好ましくは50以下である。また、板状粒子の平板面の長軸方向長さと短軸方向長さの比(短軸方向長さ／長軸方向長さ)の平均値は、好ましくは0．3以上、より好ましくは0．5以上であり、その平均値が1、すなわち、長軸方向長さと短軸方向長さとがほぼ同じであってもよい。板状の絶縁性微粒子が、前記のようなアスペクト比や平板面の長軸方向長さと短軸方向長さの比の平均値を有する場合には、前記の短絡防止作用がより有効に発揮される。

[0029] 上記絶縁性微粒子が板状である場合における前記の平板面の長軸方向長さと短軸方向長さの比の平均値は、例えば、走査型電子顕微鏡(SEM)により撮影した画像を画像解析することにより求めることができる。更に、絶縁性微粒子が板状である

場合における前記のアスペクト比も、SEMにより撮影した画像を、画像解析することにより求めることができる。

[0030] また、上記絶縁性微粒子には、一次粒子が凝集した二次粒子が含まれていることが好ましく、絶縁性微粒子の全てが二次粒子構造の微粒子であってもよい。上記二次粒子には、通常の分散工程では一次粒子に分離し難い凝集体、例えば、一次粒子が互いに連晶を形成して繋がり合って二次粒子を形成したものなどを好ましく用いることができる。このような微粒子の例としては、大明化学社製のベーマイト「ベーマイト C06(商品名)」、「ベーマイト C20(商品名)」、米庄石灰工業社製の$CaCO_3$「ED－1(商品名)」、J. M. Huber社製のクレイ「Zeolex 94HP(商品名)」などが挙げられる。

[0031] 上記絶縁性微粒子として一次粒子が凝集した二次粒子構造を有している微粒子を用いた場合には、凝集した二次粒子が粒子同士の最密充填を阻止するので、絶縁層の空孔をより大きくすることが可能であり、かかる絶縁層を有する電気化学素子用セパレータにより構成されるリチウム二次電池などの電気化学素子は、電気自動車、ハイブリッド式自動車、電動バイク、電動アシスト自転車、電動工具、シェーバーなどの、より高出力が要求される用途に好適なものとなる。

[0032] 上記絶縁性微粒子の平均分散粒径は、好ましくは0．01μm以上、より好ましくは0．1μm以上であって、好ましくは1．5μm以下、より好ましくは1μm以下である。

[0033] 本発明の絶縁層形成用スラリーに係る絶縁性微粒子は、分散媒に分散している状態で、全分散粒子中、粒径が1μm以下の粒子の割合が30体積%以上でかつ粒径が3μm以上の粒子の割合が10体積%以下である。このように絶縁性微粒子が微細な粒子を多く含む場合には、より耐熱性に優れた絶縁層を形成しやすくなるが、微粒子同士が凝集しやすく、スラリー中での微粒子の分散状態を安定に保つことが困難になりやすい。しかし、本発明のスラリーでは、前記のような微細な粒子を多く含んでいても、均一な分散状態を長時間保つことができる。また、粗大な粒子の割合が少ないほど、優れた耐熱性を維持しながら絶縁層の厚みを薄くすることができるので、分散媒に分散している状態の、絶縁性微粒子に含まれる粒径が3μm以上の粒子の割合を10体積%以下とし、粒径が2μm以上の粒子の割合を10体積%以下とすること

が好ましい。

[0034] 本明細書でいう絶縁性微粒子の粒径は、例えば、レーザー散乱粒度分布計(例えば、日機装社製「MT－3000(商品名)」)を用い、絶縁性微粒子を溶解したり、絶縁性微粒子が膨潤したりしない媒体(例えば、スラリーに使用する分散媒)に、絶縁性微粒子を分散させて測定した体積基準での粒度分布から求めることができる。すなわち、体積基準で粒度分布を測定し、その累積頻度から、平均粒径、粒径が1μm以下の粒子の割合、および、粒径が3μm以上の粒子の割合をそれぞれ求めることができる。

[0035] 本発明の絶縁層形成用スラリーには増粘剤を使用する。増粘剤を使用することにより、絶縁層形成用スラリーの粘度を好適な範囲に調整し、絶縁性微粒子の分散を均一化し、優れた分散状態を安定して維持できるようになる。

[0036] 上記増粘剤としては、絶縁層形成用スラリー中において、絶縁性微粒子を凝集させるなどの副作用がなく、必要な粘度にスラリーを調整できる増粘剤であればよいが、少量の添加で高い増粘作用を有するものが好ましい。また、増粘剤は、スラリーに使用する分散媒に対して良好に溶解または分散し得るものであることが好ましい。増粘剤の未溶解分や凝集物がスラリー中に多数存在すると、絶縁性微粒子の分散が不均一になり、スラリーを基材などに塗布し、乾燥することにより形成される絶縁層において、絶縁性微粒子の分布が不均一となる。そのため、絶縁層の耐熱性が低下し、ひいては、電気化学素子の信頼性や耐熱性を低下させる虞が生じる。

[0037] 絶縁層形成用スラリー中に残存する増粘剤の未溶解分や凝集物の含有量の目安としては、スラリーを目開き30μmのメッシュフィルターに通したときに、フィルター上に残る残渣が、スラリー1L当たり1個以下であることが好ましく、スラリー5L当たり1個以下であることがより好ましい。

[0038] 上記増粘剤の具体例としては、ポリエチレングリコール、ポリアクリル酸、ポリビニルアルコール、ビニルメチルエーテル－無水マレイン酸共重合体などの合成高分子;カルボキシメチルセルロース、ヒドロキシエチルセルロース、ヒドロキシプロピルセルロースなどのセルロース誘導体;キサンタンガム、ウェランガム、ジェランガム、グアーガム、カラギーナンなどの天然多糖類;デキストリン、アルファー化でんぷんなどのでん

ぷん類;モンモリロナイト、ヘクトライトなどの粘土鉱物;ヒュームドシリカ、ヒュームドアルミナ、ヒュームドチタニアなどの無機酸化物類;などが挙げられる。これらは1種単独で用いてもよく、2種以上を併用してもよい。前記の粘土鉱物や無機酸化物類の場合には、絶縁性微粒子よりも一次粒子の粒径が小さいもの(例えば、数nm～数十nm程度)を使用することが好ましく、また、一次粒子が多数繋がったストラクチャ構造を有するもの(ヒュームドシリカなど)が好ましい。

[0039] 上記例示の増粘剤のなかでも、絶縁層形成用スラリーに好適な分散媒である水に対する溶解性が高く、少量で増粘効果の高い、天然多糖類がより好ましく、キサンタンガム、ウェランガム、ジェランガムが更に好ましく、キサンタンガムが特に好ましい。また、絶縁層形成用スラリーにチクソ性を付与する場合には、ヒュームドシリカ、ヒュームドアルミナ、ヒュームドチタニアなどの無機酸化物類を添加することが好ましい。

[0040] 上記絶縁層形成用スラリーにおける増粘剤の含有量は、設定する絶縁層形成用スラリーの粘度に応じて変動するが、例えば、増粘剤としてスラリー塗布後の乾燥工程で揮発しないものを用いる場合には、絶縁層中に残留することになるため、多量に用いるのは好ましくなく、具体的には、スラリー中の固形分(分散媒を除く構成成分。以下、同じ。)の全体積中、10体積%以下であることが好ましく、5体積%以下であることがより好ましく、1体積%以下であることが更に好ましい。また、絶縁層形成用スラリーにおける増粘剤の含有量は、スラリー中の固形分の全体積中、0.1体積%以上であることが好ましい。

[0041] また、本発明の絶縁層形成用スラリーには、分散剤を使用することが好ましい。分散剤の使用によって、例えば、分散剤が絶縁性微粒子の表面に付着することで、絶縁層形成用スラリー中での絶縁性微粒子の分散性がより向上し、これら絶縁性微粒子同士の凝集が防止されて、絶縁性微粒子の分散状態をより安定して維持できるようになる。

[0042] 更に、例えば、絶縁性微粒子が板状粒子の場合、その製造方法によっては、各粒子の板面が重なった状態で得られることがある(例えば、板状ベーマイトなど)。このように各粒子が積層状態で存在する絶縁層形成用スラリーを用いて絶縁層を形成すると、板状粒子の使用による前記の短絡防止効果が十分に得られないことがあるが、こ

のような凝集した粒子と共に分散剤を用いて絶縁層形成用スラリーを調製すれば、個々の粒子を分離させ、スラリー中に均一に分散させることができる。そのため、分散剤を用いた絶縁層形成用スラリーによれば、板状粒子を用いた場合にも、その作用がより良好に発揮される絶縁層を形成することができる。

[0043] 上記分散剤の具体例としては、アニオン系、カチオン系、ノニオン系の各種界面活性剤;ポリカルボン酸、ポリアクリル酸、ポリメタクリル酸、ポリカルボン酸塩、ポリアクリル酸塩、ポリメタクリル酸塩などの高分子系分散剤;などを用いることができる。より具体的には、ADEKA社製の「アデカトール(商品名)シリーズ」、「アデカノール(商品名)シリーズ」、サンノプコ社製の「SNディスパーサント(商品名)シリーズ」、ライオン社製の「ポリティ(商品名)シリーズ」、「アーミン(商品名)シリーズ」、「デュオミン(商品名)シリーズ」、花王社製の「ホモゲノール(商品名)シリーズ」、「レオドール(商品名)シリーズ」、「アミート(商品名)シリーズ」、日油社製の「ファルバック(商品名)シリーズ」、「セラミゾール(商品名)シリーズ」、「ポリスター(商品名)シリーズ」、味の素ファインテクノ社製の「アジスパー(商品名)シリーズ」、東亞合成社製の「アロン分散剤(商品名)シリーズ」などが挙げられる。分散剤には、上記例示のものを1種単独で用いてもよく、2種以上を併用してもよい。

[0044] これらの分散剤の中でも、微粒子を分散させる作用が強いことから、イオン解離性の酸基(カルボキシル基、スルホン酸基、アミノ酸基、マレイン酸基など)またはイオン解離性の酸塩基(カルボン酸塩基、スルホン酸塩基、マレイン酸塩基など)を複数含有するものが好ましく、ポリカルボン酸塩、ポリアクリル酸塩、ポリメタクリル酸塩がより好ましい。また、前記の高分子系分散剤が塩の場合(酸塩基を有する場合)、アンモニウム塩であることが好ましい。

[0045] 上記絶縁層形成用スラリーにおける分散剤の含有量は、その作用をより有効に発揮させる観点から、絶縁性微粒子100質量部に対して、0.1質量部以上であることが好ましく、0.3質量部以上であることがより好ましい。絶縁層形成用スラリーにおける分散剤の量を多くしすぎると、その効果が飽和するのみならず、絶縁層における他の成分の比率が低下して、それらによる効果が小さくなる虞がある。よって、絶縁層形成用スラリーにおける分散剤の含有量は、絶縁性微粒子100質量部に対して、5質

量部以下であることが好ましく、1質量部以下であることがより好ましい。

[0046] また、本発明の絶縁層形成用スラリーには、形成される絶縁層において、絶縁性微粒子同士や、絶縁性微粒子と後述するその他の成分とを接着したり、絶縁層と基材とを接着したりする目的で、バインダを含有させることができる。バインダの種類は、電気化学素子内部で電気化学的に安定であり、電気化学素子の電解液に対して安定であるものであれば、特に制限はない。また、前記の増粘剤のうち、バインダとしての機能も有するものについては、増粘剤とバインダとを兼用させることもできる。

[0047] 上記バインダの具体例としては、例えば、エチレン－酢酸ビニル共重合体(EVA、酢酸ビニル由来の構造単位が20～35モル%のもの);エチレン－エチルアクリレート共重合体、エチレン－エチルメタクリレート共重合体などの(メタ)アクリル酸共重合体;フッ素系ゴム;スチレン－ブタジエンゴム(SBR);ポリビニルアルコール(PVA);ポリビニルブチラール(PVB);ポリビニルピロリドン(PVP);ポリN－ビニルアセトアミド;架橋アクリル樹脂;ポリウレタン;エポキシ樹脂;などが用いられる。これらのバインダは、1種単独で使用してもよく、2種以上を併用してもよい。

[0048] 上記例示のバインダの中でも、150℃以上の耐熱性を有する耐熱樹脂が好ましく、特に、エチレン－アクリル酸共重合体、フッ素系ゴム、SBRなどの柔軟性の高い材料がより好ましい。これらの具体例としては、三井デュポンポリケミカル社製のEVA「エバフレックスシリーズ(商品名)」、日本ユニカー社製のEVA、三井デュポンポリケミカル社製のエチレン－アクリル酸共重合体「エバフレックス－EEAシリーズ(商品名)」、日本ユニカー社製のEEA、ダイキン工業社製のフッ素ゴム「ダイエルラテックスシリーズ(商品名)」、JSR社製のSBR「TRD－2001(商品名)」、日本ゼオン社製のSBR「EM－400B(商品名)」などが挙げられる。また、(メタ)アクリル酸類をモノマーの主成分とし、これを重合した構造を有する(メタ)アクリル酸共重合体も好ましい。本明細書において、「(メタ)アクリル酸」とは、アクリル酸とメタクリル酸の両者を意味している。

[0049] これらの中でも、自己架橋性を有する(メタ)アクリル酸共重合体がより好ましく、自己架橋性を有し、かつガラス転移温度(Tg)が－20℃以下の(メタ)アクリル酸共重合体が更に好ましい。上記Tgを有するものの具体例としては、側鎖エステル基の末端

が、炭素数2以上10以下のアルキル基であるものが好ましく、より具体的には、側鎖エステル基の末端の主体が、ｎ－プロピル基、iso－プロピル基、ｎ－ブチル基、sec－ブチル基、ｎ－ヘキシル基である上記共重合体がより好ましい。側鎖エステル基の末端アルキル基の炭素数が少なすぎると、バインダのTgがより高くなって柔軟性が低下してしまう。また、側鎖エステル基の末端アルキル基の炭素数が多すぎると、側鎖同士が結晶化して、バインダの柔軟性が却って低下してしまう。

[0050] 詳しくは後述するが、本発明の絶縁層形成用スラリーにより得られる絶縁層は、絶縁層形成用スラリーを基材などに塗布し、乾燥により溶媒を除去する工程を経て得られるが、自己架橋性の（メタ）アクリル酸共重合体を上記スラリーに含有させて絶縁層を形成すれば、乾燥の段階で上記共重合体が自己架橋して架橋構造を形成する。そのため、バインダによる絶縁性微粒子同士や絶縁性微粒子と他の構成成分（微多孔膜など）との密着性を高めつつ、良好な耐電解液性を確保し、更に絶縁層形成用スラリーの安定性を高めることができる。

[0051] すなわち、自己架橋性の（メタ）アクリル酸共重合体をバインダとして用いることにより、絶縁性微粒子が自己架橋性の（メタ）アクリル酸共重合体の架橋体により一体化し、自己架橋性を有しないバインダを用いた場合に比べ、形成される絶縁層の耐電解液性を向上させることができる。また、初めから架橋構造を有するバインダの場合は、バインダ粒子の形状が保持された状態でスラリーが乾燥し、絶縁性微粒子や基材とバインダとの接触面積が減少する場合があるが、自己架橋性の（メタ）アクリル酸共重合体では、乾燥の段階で上記共重合体が自己架橋して架橋構造を形成するため、初めから架橋構造を有するバインダに比べて絶縁層の結着性を向上させることができる。更に、主材である樹脂に架橋剤を添加して架橋構造を形成する所謂二液性のものを使用した場合には、耐電解液性や被接着物との密着性は良好となるものの、架橋剤により絶縁層形成用スラリーの安定性が低下する虞が生じるが、自己架橋性の（メタ）アクリル酸共重合体を用いれば、スラリーの安定性を維持することができる。

[0052] 上記自己架橋性の（メタ）アクリル酸共重合体を得るには、従来から知られている方法、例えば、自己架橋性を付与し得る単量体を用いて、常法に従って（メタ）アクリル

酸共重合体を合成すればよい。自己架橋性を付与し得る単量体としては、例えば、自己架橋性の官能基を有する不飽和単量体;水酸基やカルボキシル基などの官能基を有する単量体(アクリレート、メタクリレート類を含む)と、水酸基やカルボキシル基などと反応する官能基を有する官能性単量体との組み合わせ;などが挙げられる。

[0053] 上記自己架橋性の官能基を有する不飽和単量体としては、例えば、N－メチロールメタクリルアミド、N－メチロールアクリルアミド、N－ブチロールメタクリルアミド、N－ブチロールアクリルアミドなどのメチロール基含有単量体;アリルグリシジルエーテル、グリシジル(メタ)アクリレートなどのエポキシ基含有単量体;メトキシメチル(メタ)アクリレート、エトキシメチル(メタ)アクリレート、メトキシエチル(メタ)アクリレート、ブトキシエチル(メタ)アクリレートなどのアルコキシアルキル基含有単量体;2－アセトアセトキシエチル(メタ)アクリレート、3－アセトアセトキシプロピル(メタ)アクリレート、4－アセトアセトキシブチル(メタ)アクリレートなどのアセトアセトキシアルキル(メタ)アクリレート誘導体;ビニルトリメトキシシラン、ビニルメトキシジメチルシラン、ビニルトリクロロシラン、アリルトリクロロシランなどの加水分解シリル基を有するビニル単量体;2－(1－アジリジニル)エチル(メタ)アクリレートなどのアジリジニル基含有単量体;などが挙げられる。本明細書において「(メタ)アクリレート」とは、アクリレートとメタクリレートの両者を意味している。

[0054] 上記水酸基やカルボキシル基などの官能基を有する単量体としては、例えば、(メタ)アクリル酸、クロトン酸、イタコン酸、マレイン酸、無水マレイン酸、フマル酸、β－ヒドロキシエチル(メタ)アクリレート、β－ヒドロキシプロピル(メタ)アクリレート、β－ヒドロキシエチルビニルエーテルなどが挙げられる。また、上記水酸基やカルボキシル基などと反応する官能基を有する官能性単量体としては、例えば、N－メチロールアクリルアミド、N－ブトキシメチルアクリルアミドなどのN－メチロール基含有単量体;ジメチルアミノエチル(メタ)アクリレート、ジメチルアミノプロピルアクリルアミドなどのアミノ基含有単量体;グリシジル(メタ)アクリレートなどのエポキシ基含有単量体;などが挙げられる。

[0055] 上記自己架橋性の(メタ)アクリル酸共重合体の中でも、ブチルアクリレートをモノマーの主成分として得られた低Tgのアクリル酸共重合体が、特に好ましい。

[0056] また、上記バインダの具体例以外にも、公知の樹脂にアミン化合物やポリアクリル酸樹脂などを混合して柔軟性を高めたり、Tgを下げたり、柔軟性付与添加剤として公知の可塑剤(フタル酸エステル類など)を配合したりするなどして、破断強度を向上させたものをバインダに用いることができる。また、カルボキシル基を導入することで、バインダの接着性を高めることもできる。樹脂のTgを高めるには、架橋構造を導入してその架橋密度を高めたり、剛直な分子構造(アリール基など)を導入したりするなどの公知の方法が採用でき、樹脂のTgを下げるには、架橋密度の低い架橋構造を導入したり、長鎖の側鎖を導入したりするなどの公知の方法が採用できる。

[0057] 上記絶縁層形成用スラリーにおけるバインダの含有量は、バインダの使用による作用をより有効に発揮させる観点から、絶縁性微粒子の体積を100とした場合の体積比で、1以上であることが好ましく、5以上であることがより好ましく、10以上であることが更に好ましい。また、絶縁層形成用スラリー中のバインダ量が多すぎると、形成される絶縁層において、その空孔が埋められてイオンの透過性が低下し、電気化学素子の特性に悪影響が出る虞があることから、その含有量は、絶縁性微粒子の体積を100とした場合の体積比で、30以下であることが好ましく、20以下であることがより好ましい。

[0058] 上記絶縁層形成用スラリーの分散媒としては、水を主成分とするものや有機溶媒(トルエンなどの芳香族炭化水素;テトラヒドロフランなどのフラン類;メチルエチルケトン、メチルイソブチルケトンなどのケトン類;など)が挙げられるが、水を主成分とするものが好ましい。本発明でいう「分散媒」とは、絶縁層形成用スラリー中において、絶縁層形成時の乾燥の際に残る固形分を除いた残りの部分を指す。また、「水を主成分とする」とは、分散媒の構成成分のうち、水を70質量%以上含有していることを指し、90質量%以上含有していることが好ましい。水を主成分とする場合のその他の分散媒としては、例えば、絶縁層形成用スラリーの界面張力制御のために添加される後述するアルコール類などが挙げられる。環境保護の観点からは、水のみを分散媒とすることが特に好ましい。

[0059] 上記絶縁層形成用スラリーの粘度は、絶縁性微粒子の沈降を抑制し、その分散の安定性を高める観点から、5mPa・s以上であり、10mPa・s以上であることが好ましく

、20mPa・s以上であることがより好ましい。また、絶縁層形成用スラリーの粘度が高すぎると、必要な厚みに均一に塗布することが困難になることから、その粘度は、500mPa・s以下であり、300mPa・s以下であることが好ましく、200mPa・s以下であることがより好ましい。本発明の絶縁層形成用スラリーにおける粘度は、日本工業規格(JIS)R 1653に準じた方法でE型粘度計により測定された粘度であり、温度が23℃、せん断速度が1000／sの条件で測定されたものを指す。

[0060] 上記絶縁層形成用スラリーにおいて、例えば、増粘剤として天然多糖類などを用いた場合には、大気中のバクテリアなどによって増粘剤が分解される場合があることから、スラリーに適宜防腐剤や殺菌剤を添加して増粘剤の分解を抑制してもよく、これにより天然多糖類を含有するスラリーの貯蔵性を高めることができる。防腐剤や殺菌剤の具体例としては、安息香酸、パラヒドロキシ安息香酸エステル、アルコール類(エタノール、メタノールなど)、塩素類(次亜塩素酸ナトリウムなど)、過酸化水素、酸類(ホウ酸、酢酸など)、アルカリ類(水酸化ナトリウム、水酸化カリウムなど)などが挙げられる。

[0061] また、上記絶縁層形成用スラリーが発泡しやすく、塗布性に影響する場合には、消泡剤を用いることができる。消泡剤としては、ミネラルオイル系、シリコン系、アクリル系、ポリエーテル系の各種消泡剤を用いることができる。消泡剤の具体例としては、日華化学社製の「フォームレックス(商品名)」、日信化学社製の「サーフィノール(商品名)シリーズ」、荏原エンジニアリング社製の「アワゼロン(商品名)シリーズ」、サンノプコ社製の「SNデフォーマー(商品名)シリーズ」などが挙げられる。

[0062] 更に、上記絶縁層形成用スラリーには、界面張力を制御する目的で、添加剤を加えることができる。添加剤としては、分散媒が有機溶媒である場合には、エチレングリコール、プロピレングリコールなど、または、モノメチルアセテートなどの各種プロピレンオキサイド系グリコールエーテルなど用いることができ、分散媒が水の場合には、アルコール類(メチルアルコール、エチルアルコール、イソプロピルアルコール、エチレングリコールなど)を用いて界面張力を制御することもできる。

[0063] 本発明の絶縁層形成用スラリーでは、絶縁性微粒子、増粘剤、分散剤、バインダや、後述する熱溶融性微粒子などを含む固形分含量を、例えば10～80質量%とする

ことが好ましい。

[0064] 絶縁層形成用スラリーの調製には従来から知られている方法を用いることが可能である。例えば、上記各種材料(絶縁性微粒子、増粘剤、分散剤、バインダ、防腐剤、殺菌剤、消泡剤、更には後述の熱溶融性微粒子など)を、市販の各種分散装置を用いて分散媒中に分散させることで、絶縁層形成用スラリーを調製することが可能である。また、一部の材料は分散媒中に溶解していてもよい。分散装置が強いシェアを発生する場合には、増粘剤やバインダなどの高分子物質の分子鎖が切断されるのを防ぐため、絶縁性微粒子および分散媒、更には必要に応じて分散剤などを添加し、ハイシェアの分散装置でまず絶縁性微粒子を分散媒中に分散させ、その後、増粘剤やバインダなどを添加し、シェアの弱い装置(プロペラ式攪拌装置など)を用いてスラリーを調製することが望ましい。

[0065] 上記分散装置の具体例としては、ビーズミル、ボールミル、遊星式ボールミル、サンドミルなどのメディア方式の分散機;ジェットミル、ロッドミル、ナノマイザー、ホモジナイザーなどのメディアレスの分散機;などが挙げられる。

[0066] (実施形態2)

次に、本発明の電気化学素子用セパレータの実施形態について説明する。本発明の電気化学素子用セパレータは、多孔質の絶縁層を含み、上記絶縁層は、耐熱性を有する絶縁性微粒子とバインダとを含み、上記絶縁性微粒子に含まれ粒子の中で、粒径が1μm以下の粒子の割合が30体積%以上であり、かつ粒径が3μm以上の粒子の割合が10体積%以下であることを特徴とする。

[0067] より具体的には、本発明の電気化学素子用セパレータは、実施形態1で説明した本発明の絶縁層形成用スラリーを、電気化学素子用正極、電気化学素子用負極および多孔質基材よりなる群から選択される少なくとも1種の基材に塗布し、乾燥する工程を経て形成されたイオン透過性および耐熱性を有する絶縁層を有するものである。

[0068] 本明細書でいう「耐熱性を有する絶縁層」とは、絶縁層の耐熱温度が150℃以上であること、すなわち、絶縁層が少なくとも150℃において実質的に変形しないことを意味しており、具体的には、150℃に加熱された絶縁層を目視観察した際に熱収縮が

確認されないことをいう。

[0069] 上記絶縁層形成用スラリーを塗布する基材として多孔質基材を用いた場合には、絶縁層と多孔質基材とが別個の層を構成しつつ、これらが一体化した構造のセパレータや、絶縁層形成用スラリーの成分と多孔質基材とが一体となって絶縁層を構成した構造のセパレータを得ることができる。また、セパレータは、絶縁層と多孔質基材とが一体化した層と、別の多孔質層とでセパレータを構成していてもよい。この場合には、絶縁層と多孔質基材とが一体化した層と、多孔質層とが一体化していてもよく、多孔質層が、絶縁層と多孔質基材とが一体化した層とは別個の独立膜で、これらが電気化学素子内で重ねられてセパレータを構成していてもよい。

[0070] 他方、絶縁層形成用スラリーを塗布する基材として、電気化学素子用正極や電気化学素子用負極を用いた場合には、絶縁層と、電気化学素子用正極および電気化学素子用負極から選ばれる少なくとも一方とが一体化する。この場合、絶縁層のみでセパレータを構成していてもよく、かかる絶縁層と、別の多孔質層とでセパレータを構成してもよい。絶縁層と、別の多孔質層とでセパレータを構成する場合には、絶縁層と多孔質層とが一体化していてもよく、多孔質層が絶縁層とは別個の独立膜で、電気化学素子内で絶縁層と重ねられてセパレータを構成していてもよい。

[0071] 上記電気化学素子用正極および上記電気化学素子用負極としては、後述するリチウム二次電池などの本発明の電気化学素子を構成するための正極および負極が挙げられる。

[0072] 上記多孔質基材としては、材質が、電気絶縁性で、電気化学素子内部の電気化学反応に対し安定で、電解液に対し安定なものであればいずれでもよいが、織布、不織布または微多孔膜であることが好ましい。微多孔膜としては、通常のリチウム二次電池などのセパレータで使用されている微多孔膜(微多孔性フィルム)と同様の構造を有するものが挙げられる。

[0073] 上記多孔質基材の具体的な構成材料としては、例えば、セルロース、セルロース変成体(カルボキシメチルセルロースなど)、ポリオレフィン[ポリプロピレン(PP)、ポリエチレン(PE)、エチレン由来の構造単位が85モル%以上の共重合ポリオレフィンなど]、ポリエステル[ポリエチレンテレフタレート(PET)、ポリエチレンナフタレート(PEN)

、ポリブチレンテレフタレート(PBT)など]、ポリアクリロニトリル(PAN)、アラミド、ポリアミドイミド、ポリイミドなどの樹脂;ガラス、アルミナ、シリカなどの無機材料(無機酸化物);などが挙げられる。上記共重合ポリオレフィンとしては、エチレン－ビニルモノマー共重合体、より具体的には、エチレン－酢酸ビニル共重合体(EVA)、エチレン－メチルアクリレート共重合体、またはエチレン－エチルアクリレート共重合体が例示できる。多孔質基材は、これらの構成材料の1種を含有していてもよく、2種以上を含有していても構わない。また、多孔質基材は、構成成分として、上記構成材料の他に、必要に応じて、公知の各種添加剤(例えば、樹脂である場合には酸化防止剤など)を含有していても構わない。

[0074] 上記多孔質基材を用いてセパレータを構成するに当たり、セパレータの耐熱性をより重視する場合には、多孔質基材の構成材料として、上記例示の各種材料の中でも、耐熱性の高いもの(ポリエステル、アラミド、ポリアミドイミド、ポリイミドなどの耐熱性樹脂や、無機材料)を用いるのが好ましい。

[0075] 他方、電気化学素子が高温になった場合に、多孔質基材の溶融によりセパレータの空孔を閉塞させ、イオンの伝導を阻害して電気化学素子の安全性を確保する所謂シャットダウン機能を付与する場合には、所定の温度で溶融、軟化する材料によって構成した多孔質基材を用いることが好ましい。多孔質基材の構成樹脂の溶融、軟化する温度としては、好ましくは80℃以上、より好ましくは100℃以上であって、好ましくは150℃以下、より好ましくは140℃以下である。多孔質基材の構成樹脂の溶融、軟化する温度は、JIS K 7121の規定に準じて、示差走査熱量計(DSC)を用いて測定される融解温度で判断できる(後述する熱溶融性微粒子についても、同じである。)。このような構成材料としては、ポリオレフィンが好ましく、PEがより好ましい。そして、より良好なシャットダウン機能を得るためには、PE製の微多孔膜や、PEとPPとを2～5層積層した積層微多孔膜などを用いてセパレータを構成することが特に好ましい。

[0076] PEのように融点が80℃以上150℃以下の熱可塑性樹脂と、PPなどのように融点が150℃を超える熱可塑性樹脂とを併用して構成された多孔質基材を用いる場合(例えば、PEと、PPなどのPEよりも高融点の樹脂とを混合して構成された微多孔膜を

多孔質基材として用いたり、PE層と、PP層などのPEよりも高融点の樹脂で構成された層とを積層して構成された積層微多孔膜を多孔質基材として用いたりする場合）には、多孔質基材を構成する熱可塑性樹脂中、融点が80℃以上150℃以下の樹脂（例えばPE）が、30質量％以上であることが好ましく、50質量％以上であることがより好ましい。

[0077] また、上記多孔質基材には、絶縁性微粒子との接着性を高めるために、紫外線照射処理、コロナ放電処理、プラズマ処理、界面活性剤処理などの表面処理を施してもよい。本発明の絶縁層形成用スラリーと多孔質基材の表面との濡れ性を高めることにより、上記スラリーのより均一な塗布が可能になり、より均質で耐熱性に優れた絶縁層を形成しやすくなる。また、上記表面処理は、多孔質基材の表面部分にのみ行うのが望ましい。すなわち、上記スラリーと多孔質基材の細孔内部との濡れ性は低い方がよい。多孔質基材の細孔内部に上記処理が施されなければ、多孔質基材の細孔内には上記スラリーが侵入しにくくなり、上記スラリーや上記スラリーに用いられている分散媒が、多孔質基材の細孔を通過して塗布面とは反対側の面に抜けるのを防ぐことができる。

[0078] 例えば、表面処理後の多孔質基材の室温における臨界表面張力（B）は、絶縁層形成用スラリーの表面張力（A）と同じか、またはそれより大きくするのが望ましく、その差〔（A）－（B）〕が0mN／m以下であるのが望ましく、－10mN／m以下であることがより望ましい。

[0079] 上記表面張力および上記臨界表面張力の測定には、従来から知られている測定方法を適用することが可能である。すなわち、絶縁層形成用スラリーについては、プレート法、ペンダントドロップ法、最大泡圧法などの従来公知の方法で表面張力を測定することができる。また、多孔質基材については、表面張力が既知の液体を数種類用いて、多孔質基材と液体との接触角（θ）を測定し、表面張力に対して$\cos\theta$をプロットし、$\cos\theta = 1$となる点から臨界表面張力を求めることができる。

[0080] 上記多孔質基材としては、表面処理前の臨界表面張力（B'）が18．5mN／m以上のものが一般に用いられ、一方、50mN／m以下のものを用いることが好ましい。例えば、ポリオレフィンを主成分とする微多孔膜では、室温における臨界表面張力（B'

)が、ポリエチレンの場合およそ31mN／m、ポリプロピレンの場合およそ29mN／mである。これらの多孔質基材に上記表面処理を施すことにより、所望の臨界表面張力(B)になるよう調整すればよい。

[0081] 上記多孔質基材の表面処理の条件は、使用する装置、多孔質基材の表面処理前の臨界表面張力(B')および絶縁層形成用スラリーの表面張力(A)などに応じて変動するが、例えば、春日電機社製のコロナ処理装置により、金属電極を用いて表面処理を行う場合、放電量を25～100W／min・m^2とすることが好ましい。

[0082] 上記多孔質基材として織布または不織布を用いる場合には、その構成材料は繊維であるが、その繊維の直径は、セパレータの厚み以下であればよい。具体的には、上記繊維の直径は、例えば、0．01～5μmであることが好ましい。上記繊維の直径が大きすぎると、繊維同士の絡み合いが不足して、これらで構成される多孔質基材の強度、ひいてはセパレータの強度が小さくなって取扱いが困難となることがある。また、上記繊維の直径が小さすぎると、セパレータの空孔が小さくなりすぎてイオン透過性が低下する傾向にあり、電気化学素子の負荷特性を低下させてしまうことがある。

[0083] また、上記多孔質基材としての織布または不織布は、繊維同士を結着するために適宜バインダを用いてもよい。バインダとしては、例えば、絶縁層に含有させるバインダ(絶縁層形成用スラリーに含有させるバインダ)として先に例示した各種バインダが挙げられる。

[0084] また、上記多孔質基材が、織布または不織布のように、繊維で構成されるものであって、特にその空孔の開口径が比較的大きい場合(例えば、空孔の開口径が5μm以上の場合)には、これが電気化学素子の短絡の要因となりやすい。よって、この場合には、絶縁性微粒子の一部または全部が多孔質基材の空孔内に存在する構造とすることが好ましい。また、絶縁性微粒子以外の微粒子(後述する熱溶融性微粒子など)の一部または全部が、多孔質基材の空孔内に存在する構造とすることがより好ましい。このような構造とすることで、絶縁性微粒子以外の微粒子を用いることによる作用(熱溶融性微粒子であればシャットダウン機能)がより有効に発揮されるようになる。多孔質基材の空孔内に絶縁性微粒子や熱溶融性微粒子などを存在させるには、例えば、絶縁層形成用スラリーを多孔質基材に含浸させた後、一定のギャップを通して

余分なスラリーを除去し、その後乾燥するなどの工程を経ればよい。

[0085] 本発明のセパレータに用いる多孔質基材としては、厚みを薄くできるという点で、不織布や微多孔膜がより好ましい。不織布や微多孔膜は従来公知の方法によって製造したものを用いることができる。より具体的には、不織布については、スパンボンド法、メルトブロー法、湿式法、乾式法、エレクトロスピニング法などの方法によって製造したものを使用することができる。また、微多孔膜については、発泡法、溶剤抽出法、乾式延伸法、湿式延伸法などの各種公知の方法によって製造したものを使用することができる。

[0086] 上記絶縁層中にシャットダウン機能を付与するための材料を含有させたり、セパレータにシャットダウン機能を付与するための層を設けたりして、セパレータにシャットダウン機能を付与することもできる。特に、耐熱性の高い樹脂を用いて構成した多孔質基材を使用したり、多孔質基材を用いずにセパレータを構成したりする場合に、セパレータのシャットダウン機能を確保するには、上記のような方法が推奨される。

[0087] セパレータにシャットダウン機能を付与するための層は、前述の、絶縁層と多孔質基材とが一体化した層と、別の多孔質層とで構成されるセパレータや、絶縁層と別の多孔質層とで構成されるセパレータにおける「別の多孔質層」に該当する。このような「別の多孔質層」としては、例えば、前述の、所定の温度で溶融、軟化する材料によって構成した多孔質基材(より好ましくは微多孔膜)が挙げられる。

[0088] シャットダウン機能を付与するための層(特に微多孔膜)は、高温下で熱収縮を起こしやすいが、本発明のセパレータでは、絶縁性微粒子を含有する絶縁層の作用によって、セパレータ全体の熱収縮が抑制され、高温時のセパレータの寸法安定性を高めることができる。また、シャットダウン機能を付与するための層を別途設けない構成のセパレータであっても、絶縁層に係る絶縁性微粒子の作用によって、セパレータの熱収縮が抑制される。そのため、本発明のセパレータを用いた電気化学素子では、高温時におけるセパレータの収縮による内部短絡の発生を抑制して、その信頼性、安全性を高めることができる。

[0089] 上記絶縁層中にシャットダウン機能を付与するために添加する材料としては、電気化学素子内が高温になった際に溶融、軟化する熱溶融性微粒子が挙げられる。

[0090] 上記熱溶融性微粒子の溶融、軟化する温度としては、好ましくは80℃以上、より好ましくは100℃以上であって、好ましくは150℃以下、より好ましくは140℃以下である。このような熱溶融性微粒子の構成材料の具体例としては、PE、エチレン由来の構造単位が85モル%以上の共重合ポリオレフィン、PP、またはポリオレフィン誘導体(塩素化ポリエチレン、塩素化ポリプロピレンなど)、ポリオレフィンワックス、石油ワックス、カルナバワックスなどが挙げられる。上記共重合ポリオレフィンとしては、エチレン－ビニルモノマー共重合体、より具体的には、EVA、エチレン－メチルアクリレート共重合体、またはエチレン－エチルアクリレート共重合体が例示できる。また、ポリシクロオレフィンなどを用いることもできる。上記熱溶融性微粒子は、これらの構成材料の1種のみから形成されていてもよく、2種以上から形成されていても構わない。これらの中でも、PE、ポリオレフィンワックス、またはエチレン由来の構造単位が85モル%以上のEVAが好適である。また、上記熱溶融性微粒子は、構成成分として、上記構成材料の他に、必要に応じて、樹脂に添加される公知の各種添加剤(例えば、酸化防止剤など)を含有していても構わない。

[0091] 上記熱溶融性微粒子の粒径としては、絶縁性微粒子と同じ測定法で測定される数平均粒子径で、例えば、好ましくは0．01μm以上、より好ましくは0．1μm以上であって、好ましくは15μm以下、より好ましくは1μm以下である。

[0092] セパレータに係る前記のシャットダウン機能は、例えば、モデルセルの温度による抵抗上昇により評価することが可能である。すなわち、正極、負極、セパレータ、および電解液を備えたモデルセルを作製し、このモデルセルを高温槽中に保持し、5℃／分の速度で昇温しながらモデルセルの内部抵抗値を測定し、測定された内部抵抗値が、加熱前(室温で測定した抵抗値)の5倍以上となる温度を測定することで、この温度をセパレータの有するシャットダウン温度として評価することができる。

[0093] セパレータは、絶縁層や多孔質基材からなる層を複数有していてもよい。例えば、絶縁層の両面に微多孔膜を配置してセパレータを構成したり、微多孔膜の両面に絶縁層を配置してセパレータを構成したりしてもよい。ただし、セパレータの有する層数が多くなりすぎると、セパレータの厚みが増えて電気化学素子の内部抵抗の増加やエネルギー密度の低下を招く虞があるので好ましくなく、セパレータ中の層数は5層

以下であることが好ましい。

[0094] 本発明のセパレータにおける絶縁性微粒子の含有量は、絶縁性微粒子を使用することによる作用をより有効に発揮させる観点から、セパレータの構成成分の全体積中、10体積%以上であることが好ましく、30体積%以上であることがより好ましく、40体積%以上であることが更に好ましい。

[0095] また、例えば上記多孔質基材を用いずに、電極表面に絶縁層を形成する場合、上記熱溶融性微粒子を含有させてシャットダウン機能も持たせるときには、セパレータ中の絶縁性微粒子の体積比率は、例えば80体積%以下であることが好ましい。他方、多孔質基材を用いず、かつシャットダウン機能を有しないセパレータとする場合には、セパレータ中の絶縁性微粒子の体積比率は、更に高い比率でもよく、例えば95体積%以下であれば問題ない。

[0096] また、上記多孔質基材を用いてセパレータを構成する場合であって、絶縁層中に上記熱溶融性微粒子を含有させて、シャットダウン機能も持たせたセパレータとしたり、熱溶融性の樹脂で構成された多孔質基材(例えば微多孔膜)と絶縁層とでセパレータを構成したりするときには、セパレータ中の絶縁性微粒子の体積比率は、例えば60体積%以下であることが好ましい。他方、上記多孔質基材を用い、かつシャットダウン機能を必要としない場合には、セパレータ中の絶縁性微粒子の体積比率は、更に高い比率でもよく、例えば80体積%以下であることが好ましい。

[0097] また、セパレータにおいて、良好なシャットダウン機能を確保する観点からは、セパレータ中における熱溶融性樹脂(熱溶融性樹脂で構成される多孔質基材または熱溶融性微粒子)の含有量は、セパレータの構成成分の全体積中、5～70体積%であることが好ましい。セパレータ中における熱溶融性樹脂の含有量が少なすぎると、これらを含有させることによるシャットダウン効果が小さくなることがあり、多すぎると、セパレータ中における絶縁性微粒子などの含有量が減ることになるため、これらによって確保される効果が小さくなることがある。

[0098] 従って、本発明の絶縁層形成用スラリーにおいては、形成後の絶縁層における各構成成分の含有量が上記好適値を満足できるような量で、これら構成成分を配合することが好ましい。

[0099] 電気化学素子の短絡防止効果をより高め、セパレータの強度を確保して、その取り扱い性を良好とする観点から、セパレータの厚みは、例えば、3μm以上とすることが好ましく、5μm以上とすることがより好ましい。他方、電気化学素子のエネルギー密度をより高める観点からは、セパレータの厚みは、50μm以下とすることが好ましく、30μm以下とすることがより好ましい。例えば、絶縁層のみでセパレータを構成する場合には、絶縁層の厚みが、上記セパレータの好適厚みを満足するようにすればよい。

[0100] また、例えば、絶縁層と多孔質基材とを有し、これらが別個の層を形成しているセパレータの場合(特に多孔質基材が微多孔膜の場合)には、絶縁層の厚みをX(μm)、多孔質基材の厚みをY(μm)としたとき、XとYとの比率Y/Xを1～10としつつ、セパレータ全体の厚みが上記好適値を満足するようにすることが好ましい。Y/Xが大きすぎると、絶縁層が薄くなりすぎて、例えば、多孔質基材の高温時での寸法安定性が劣る場合に、その熱収縮を抑制する効果が小さくなる虞がある。また、Y/Xが小さすぎると、絶縁層が厚くなりすぎて、セパレータ全体の厚みを増大させ、負荷特性などの電気化学素子の特性の低下を引き起こす虞がある。セパレータが、絶縁層を複数有する場合には、厚みXはその総厚みであり、多孔質基材を複数有する場合には、厚みYはその総厚みである。

[0101] 具体的な値で表現すると、多孔質基材の厚み(セパレータが多孔質基材を複数有する場合には、その総厚み)は、5μm以上であることが好ましく、また、30μm以下であることが好ましい。そして、絶縁層の厚み(セパレータが絶縁層を複数有する場合には、その総厚み)は、1μm以上であることが好ましく、2μm以上であることがより好ましく、4μm以上であることが更に好ましく、また、20μm以下であることが好ましく、10μm以下であることがより好ましく、6μm以下であることがより好ましい。

[0102] また、セパレータの空孔率は、電解液の保液量を確保してイオン透過性を良好にするために、乾燥した状態で、20%以上であることが好ましく、30%以上であることがより好ましい。一方、セパレータ強度の確保と内部短絡の防止の観点から、セパレータの空孔率は、乾燥した状態で、70%以下であることが好ましく、60%以下であることがより好ましい。セパレータの空孔率:P(%)は、セパレータの厚み、面積あたりの

質量、構成成分の密度から、次式を用いて各成分iについての総和を求めることにより計算できる。

[0103] $P = \Sigma a_i \rho_i / (m/t)$

[0104] ここで、上記式中、a_i:質量%で表した成分iの比率、ρ_i:成分iの密度(g/cm^3)、m:セパレータの単位面積あたりの質量(g/cm^2)、t:セパレータの厚み(cm)である。

[0105] また、本発明のセパレータは、JIS P 8117に準拠した方法で測定され、0.879g/mm^{2}の圧力下で100mlの空気が膜を透過する秒数で示されるガーレー値により表される透気度が、10～300secであることが望ましい。透気度が大きすぎると、イオン透過性が小さくなり、小さすぎるとセパレータの強度が小さくなることがある。上記透気度は、これまでに説明した構成のセパレータとすることで確保できる。

[0106] 次に、本発明の電気化学素子用セパレータの製造方法について説明する。本発明の電気化学素子用セパレータの製造方法は、実施形態1で説明した本発明の絶縁層形成用スラリーを、正極、負極および多孔質基材よりなる群から選択される少なくとも1種の基材に塗布する工程と、上記絶縁層形成用スラリーが塗布された上記基材を乾燥する工程とを含んでいる。

[0107] 上記絶縁層形成用スラリーを基材表面に塗布する際には、従来から知られている塗工機、例えば、ダイコーター、グラビアコーター、リバースロールコーター、スクイズロールコーター、カーテンコーター、ブレードコーター、ナイフコーターなどの塗工機を用いることができる。

[0108] 図1に、本発明のセパレータの製造に適用できる塗工装置の一例の概略図を示す。図1に示す塗工装置は、絶縁層形成用スラリーを塗布する前の多孔質基材1に表面処理を施す装置として、コロナ放電装置2を備えている。

[0109] 図1に示す塗工装置を用いて本発明のセパレータを製造する場合、まず、ロール状に巻き取られた樹脂製の多孔質基材1を引き出し、その表面にコロナ放電装置2によってコロナ放電2aによる表面処理を施し、引き続いて、表面処理後の多孔質基材1の表面に、ダイヘッド3により絶縁層形成用スラリーを塗布する。上記表面処理を多孔質基材1の表面部分にとどめることにより、絶縁層形成用スラリーやその分散媒が多孔質基材1の細孔内に侵入するのを防ぎ、塗布面とは反対側にあるバックロー

ル4の表面や、塗布を終えた多孔質基材1を搬送するターンロール5の表面が汚染されるのを防止することができる。これにより、上記スラリーのより均一な塗布が可能になり、絶縁層の均質性を高めることができる。

[0110] 多孔質基材1の表面に形成された塗膜は、乾燥ゾーン6において乾燥エア6aなどにより乾燥され、樹脂多孔質膜と耐熱多孔質層とを有するセパレータが得られる。図1では、樹脂製の多孔質基材1の片面に耐熱性を有する多孔質の絶縁層が形成されたセパレータの製造例を示したが、本発明のセパレータは、上記絶縁層を多孔質基材の片面にのみ有する構成でもよく、両面に有する構成でもよい。また、多孔質基材を複数有する構成としてもよい。

[0111] また、図1では、多孔質基材に表面処理を施す工程と、表面処理後の上記多孔質基材の表面に、絶縁層形成用スラリーを塗布して絶縁層を形成する工程とが連続して実施される態様を示したが、これらの工程はそれぞれ独立に実施されても構わない。

[0112] また、セパレータ中において、絶縁性微粒子として板状粒子を用いた場合、その配向性を高めるには、絶縁層形成用スラリーを基材に塗布する際に、絶縁層形成用スラリーにシェアをかければよい。絶縁層形成用スラリーにシェアをかけるには、例えば、多孔質基材を用いてセパレータを製造する場合では、絶縁層形成用スラリーを多孔質基材に含浸させた後、一定のギャップを通して余分なスラリーを除去し、その後乾燥するなどの工程を経ればよい。

[0113] また、セパレータ中において、板状の絶縁性微粒子の配向性をより高めるには、前記のシェアをかける方法以外にも、高固形分濃度(例えば50～80質量%)の絶縁層形成用スラリーを使用する方法;絶縁性微粒子を溶媒に、ディスパー、アジター、ホモジナイザー、ボールミル、アトライター、ジェットミルなどの各種混合・攪拌装置、分散装置などを用いて分散させ、得られた分散体にバインダ(更に、必要に応じて熱溶融性微粒子など)を添加・混合して調製した絶縁層形成用スラリーを使用する方法;表面に油脂類、界面活性剤、シランカップリング剤などの分散性剤を作用させて、表面を改質した絶縁性微粒子を用いて調製した絶縁層形成用スラリーを使用する方法;形状、直径またはアスペクト比の異なる絶縁性微粒子を併用して調製した絶縁層形

成用スラリーを使用する方法;絶縁層形成用スラリーを多孔質基材に塗布した後の乾燥条件を制御する方法;セパレータを加圧や加熱加圧によりプレスする方法;絶縁層形成用スラリーを基材に塗布した後、乾燥前に磁場をかける方法;などが採用でき、これらの方法をそれぞれ単独で実施してもよく、2種以上の方法を組み合わせて実施してもよい。

[0114] 本発明の製造方法では、セパレータを構成する絶縁層の形成に、絶縁性微粒子の分散の安定性が良好な本発明の絶縁層形成用スラリーを用いている。そのため、本発明の製造方法によれば、例えば、長期間貯蔵した絶縁層形成用スラリーを使用しても、均一性の高い絶縁層を有するセパレータを製造できる。また、本発明の製造方法によれば、長尺のセパレータを連続的に製造しても、製造初期と製造終期とで均一性が高い絶縁層を有し、品質が安定したセパレータとすることができる。

[0115] (実施形態3)

続いて、本発明の電気化学素子について説明する。本発明の電気化学素子は、実施形態2で説明した耐熱性の良好な本発明のセパレータを有しており、電気化学素子内が高温になっても、セパレータの熱収縮に起因する内部短絡の発生が抑制でき、また、上記セパレータによってリチウムデンドライトの析出に起因する微小短絡の発生も抑制できることから、安全性および信頼性が優れている。

[0116] 本発明の電気化学素子の用途は特に限定されるものではなく、有機電解液を用いるリチウム電池(一次電池および二次電池)の他、スーパーキャパシタなど、高温での安全性が要求される用途であれば好ましく適用できる。すなわち、本発明の電気化学素子は、本発明の電気化学素子用セパレータを用いていれば、その他の構成、構造については特に制限はなく、従来から知られている有機電解液を有する各種電気化学素子(リチウム二次電池、リチウム一次電池、スーパーキャパシタなど)が備えている各種構成、構造を採用することができる。

[0117] 以下、本発明の電気化学素子の一例として、正極と、負極と、正極と負極との間に配置されたセパレータと、電解液とを備えたリチウム二次電池への適用について詳述する。リチウム二次電池の形態としては、スチール缶やアルミニウム缶などを外装缶として使用した筒形(角筒形や円筒形など)などが挙げられる。また、金属を蒸着したラ

ミネートフィルムを外装体としたソフトパッケージ電池とすることもできる。

[0118] 上記正極としては、従来から知られているリチウム二次電池に用いられている正極、すなわち、Liイオンを吸蔵放出可能な活物質を含有する正極であれば特に制限はない。例えば、正極活物質として、$Li_{1+x}MO_2$（−0．1＜x＜0．1、M:Co、Ni、Mn、Mg、Al、Zr、Tiなど）で表されるリチウム含有遷移金属酸化物;$LiMn_2O_4$などのリチウムマンガン酸化物;$LiMn_2O_4$のMnの一部を他元素で置換した$LiMn_xM_{(1-x)}O_2$;オリビン型$LiMPO_4$（M:Co、Ni、Mn、Fe）;$LiMn_{0.5}Ni_{0.5}O_2$;$Li_{(1+a)}Mn_xCo_yNi_{(1-x-y)}O_2$（−0．1＜a＜0．1、0＜x＜0．5、0＜y＜0．5）;などを適用することが可能である。また、正極としては、これらの正極活物質に公知の導電助剤（カーボンブラックなどの炭素材料など）やポリフッ化ビニリデン（PVDF）などのバインダなどを適宜添加した正極合剤を、集電体を芯材として成形体（正極合剤層）に仕上げたものなどを用いることができる。

[0119] 上記正極の集電体としては、アルミニウムなどの金属の、箔、パンチングメタル、網、エキスパンドメタルなどを用い得るが、通常、厚みが10～30μmのアルミニウム箔が好適に用いられる。

[0120] 正極側のリード部は、通常、正極作製時に、集電体の一部に正極合剤層を形成せずに集電体の露出部を残し、そこをリード部とすることによって設けられる。ただし、リード部は必ずしも当初から集電体と一体化されたものであることは要求されず、集電体にアルミニウム製の箔などを後から接続することによって設けてもよい。

[0121] 上記負極としては、従来から知られているリチウム二次電池に用いられている負極、すなわち、Liイオンを吸蔵放出可能な活物質を含有する負極であれば特に制限はない。例えば、負極活物質として、黒鉛、熱分解炭素類、コークス類、ガラス状炭素類、有機高分子化合物の焼成体、メソカーボンマイクロビーズ（MCMB）、炭素繊維などの、リチウムを吸蔵、放出可能な炭素系材料の1種または2種以上の混合物が用いられる。また、Si、Sn、Ge、Bi、Sb、Inなどの元素およびその合金、リチウム含有窒化物などのリチウム金属に近い低電圧で充放電できる化合物、もしくはリチウム金属やリチウム／アルミニウム合金も負極活物質として用いることができる。また、負極としては、これらの負極活物質に導電助剤（カーボンブラックなどの炭素材料など）やP

VDFなどのバインダなどを適宜添加した負極合剤を、集電体を芯材として成形体(負極合剤層)に仕上げたものや、上記各種合金やリチウム金属の箔を単独で用いたり、上記合金やリチウム金属の層を集電体に積層して形成した負極剤層を有するものなどが用いられる。

[0122] 上記負極に集電体を用いる場合には、集電体としては、銅製やニッケル製の、箔、パンチングメタル、網、エキスパンドメタルなどを用い得るが、通常、銅箔が用いられる。この負極集電体は、高エネルギー密度の電池を得るために負極全体の厚みを薄くする場合、厚みの上限は30μmであることが好ましく、また、下限は5μmであることが望ましい。

[0123] 負極側のリード部も、正極側のリード部と同様に、通常、負極作製時に、集電体の一部に負極剤層(負極活物質を有する層、負極合剤層を含む)を形成せずに集電体の露出部を残し、そこをリード部とすることによって設けられる。ただし、この負極側のリード部は必ずしも当初から集電体と一体化されたものであることは要求されず、集電体に銅製の箔などを後から接続することによって設けてもよい。

[0124] 上前正極と上記負極とは、本発明のセパレータを介して積層した積層構造の電極群や、更にこれを巻回した巻回構造の電極群の形態で用いることができる。

[0125] 上記電解液(有機電解液)としては、リチウム塩を有機溶媒に溶解した溶液が用いられる。リチウム塩としては、溶媒中で解離してLi^+イオンを形成し、電池として使用される電圧範囲で分解などの副反応を起こさないものであれば特に制限はない。例えば、$LiClO_4$、$LiPF_6$、$LiBF_4$、$LiAsF_6$、$LiSbF_6$などの無機リチウム塩;$LiCF_3SO_3$、$LiCF_3CO_2$、$Li_2C_2F_4(SO_3)_2$、$LiN(CF_3SO_2)_2$、$LiC(CF_3SO_2)_3$、$LiC_nF_{2n+1}SO_3$($2 \leqq n \leqq 5$)、$LiN(RfOSO_2)_2$〔ここでRfはフルオロアルキル基〕などの有機リチウム塩;などを用いることができる。

[0126] 上記電解液に用いる有機溶媒としては、上記リチウム塩を溶解し、電池として使用される電圧範囲で分解などの副反応を起こさないものであれば特に限定されない。例えば、エチレンカーボネート、プロピレンカーボネート、ブチレンカーボネート、ビニレンカーボネートなどの環状カーボネート;ジメチルカーボネート、ジエチルカーボネート、メチルエチルカーボネートなどの鎖状カーボネート;プロピオン酸メチルなどの

鎖状エステル；γ－ブチロラクトンといった環状エステル；ジメトキシエタン、ジエチルエーテル、1，3－ジオキソラン、ジグライム、トリグライム、テトラグライムなどの鎖状エーテル；ジオキサン、テトラヒドロフラン、2－メチルテトラヒドロフランなどの環状エーテル；アセトニトリル、プロピオニトリル、メトキシプロピオニトリルといったニトリル類；エチレングリコールサルファイトなどの亜硫酸エステル類；などが挙げられ、これらを1種単独で用いてもよいし、2種以上を併用しても構わない。より良好な特性の電池とするためには、エチレンカーボネートと鎖状カーボネートとの混合溶媒など、高い誘電率を得ることができる組み合わせで用いることが望ましい。また、これらの電解液に安全性や充放電サイクル性、高温貯蔵性といった特性を向上させる目的で、ビニレンカーボネート類、1，3－プロパンサルトン、ジフェニルジスルフィド、シクロヘキシルベンゼン、ビフェニル、フルオロベンゼン、t－ブチルベンゼンなどの添加剤を適宜加えることもできる。

[0127] 上記このリチウム塩の電解液中の濃度としては、0．5～1．5mol／lとすることが好ましく、0．9～1．25mol／lとすることがより好ましい。

[0128] また、上記有機溶媒の代わりに、エチル－メチルイミダゾリウムトリフルオロメチルスルホニウムイミド、ヘプチル－トリメチルアンモニウムトリフルオロメチルスルホニウムイミド、ピリジニウムトリフルオロメチルスルホニウムイミド、グアジニウムトリフルオロメチルスルホニウムイミドといった常温溶融塩を用いることもできる。

[0129] 更に、上記電解液を含有してゲル化するような高分子材料を添加して、電解液をゲル状にして電池に用いてもよい。電解液をゲル状とするための高分子材料としては、PVDF、フッ化ビニリデン－ヘキサフルオロプロピレン共重合体（PVDF－HFP）、PAN、ポリエチレンオキシド、ポリプロピレンオキシド、エチレンオキシド－プロピレンオキシド共重合体、主鎖または側鎖にエチレンオキシド鎖を有する架橋ポリマー、架橋したポリ（メタ）アクリル酸エステルなど、公知のゲル状電解質形成可能なホストポリマーが挙げられる。

[0130] 本発明の電気化学素子は、携帯電話、ノート型パーソナルコンピューターなどの携帯機器、電気自動車、ハイブリッド式自動車、電動バイク、電動アシスト自転車、電動工具、シェーバーなどの各種機器の電源用途などを始めとして、従来から知られてい

る電気化学素子が用いられている各種用途と同じ用途に適用することができる。

[0131] 以下、実施例に基づいて本発明を詳細に述べる。ただし、下記実施例は、本発明を制限するものではない。

[0132] 以下の実施例では、絶縁性微粒子の体積基準の粒度分布におけるメジアン径(d50)、累積分布10%の値(d10)、累積分布30%の値(d30)、累積分布90%の値(d90)をそれぞれ求め、メジアン径を絶縁性微粒子の平均粒径とした。また、d30から、粒径が1μm以下の粒子の割合が30体積%以上であることを、d90から、粒径が3μm以上の粒子の割合が10体積%以下であることを、それぞれ確認した。

[0133] <絶縁層形成用スラリーの調製>

(実施例1)

アスペクト比が10の板状ベーマイト(絶縁性微粒子)1000gに、水(分散媒)1000gと、ベーマイト100質量部に対して1質量部のポリアクリル酸アンモニウム(分散剤)とを添加し、これを卓上ボールミルにて6日間混合して、板状ベーマイトを水に分散させた。得られた分散液中のベーマイトのd10、d30、d50およびd90は、それぞれ、0.40μm、0.68μm、0.98μmおよび1.86μmであり、平均粒径が0.98μmで、粒径が1μm以下の粒子の割合が50体積%以上であり、粒径が3μm以上の粒子の割合が10体積%以下であることが確認された。

[0134] 次に、上記分散液に、バインダとしてブチルアクリレートをモノマーの主成分として得られた自己架橋性のアクリル酸共重合体のエマルジョンを、ベーマイト100質量部に対して3質量部添加し、更に、増粘剤としてキサンタンガムを2g添加し、スリーワンモーターで1時間攪拌して分散させて、均一な絶縁層形成用スラリーを得た。

[0135] 得られた絶縁層形成用スラリーの粘度を、E型粘度計を用いて20℃で測定したところ、200mPa・sであった。

[0136] また、上記絶縁層形成用スラリーの安定性を、タービスキャン(英弘精機社製の「MA-2000(商品名)」)を用いて、サンプル管中での沈降高さを測定することで評価した。すなわち、サンプル管に上記絶縁層形成用スラリーを高さ60mmに注入して後方散乱光強度を測定し、散乱光強度が1以上になる点までの高さを測定し、沈降高さとした。本実施例1での測定開始後1週間での沈降高さは54mmであった。

[0137] （実施例2）

板状ベーマイトに代えて多面体形状のアルミナを用いた以外は、実施例1と同様にして絶縁層形成用スラリーを調製した。水に分散後のアルミナのd10、d30、d50およびd90は、それぞれ、0．40μm、0．47μm、0．54μmおよび1．15μmであり、平均粒径が0．54μmで、粒径が1μm以下の粒子の割合が50体積%以上であり、粒径が3μm以上の粒子の割合が10体積%以下であることが確認された。得られた絶縁層形成用スラリーについて実施例1と同様にして測定した結果、粘度が180mPa・s、1週間後の沈降高さが53mmであった。

[0138] （実施例3）

板状ベーマイトに代えてアスペクト比が25の板状アルミナを用いた以外は、実施例1と同様にして絶縁層形成用スラリーを調製した。水に分散後のアルミナのd10、d30、d50およびd90は、それぞれ、0．43μm、0．78μm、1．05μmおよび1．20μmであり、平均粒径が1．05μmで、粒径が1μm以下の粒子の割合が30体積%以上であり、粒径が3μm以上の粒子の割合が10体積%以下であることが確認された。得られた絶縁層形成用スラリーについて実施例1と同様にして測定した結果、粘度が190mPa・s、1週間後の沈降高さが55mmであった。

[0139] （実施例4）

板状ベーマイトに代えて二次粒子構造のベーマイトを用いた以外は、実施例1と同様にして絶縁層形成用スラリーを調製した。水に分散後のベーマイトのd10、d30、d50およびd90は、それぞれ、0．34μm、0．48μm、0．71μmおよび1．24μmであり、平均粒径が0．71μmで、粒径が1μm以下の粒子の割合が50体積%以上であり、粒径が3μm以上の粒子の割合が10体積%以下であることが確認された。得られた絶縁層形成用スラリーについて実施例1と同様にして測定した結果、粘度が220mPa・s、1週間後の沈降高さが56mmであった。

[0140] （実施例5）

板状ベーマイトに代えて多面体形状のシリカを用い、増粘剤の添加量を10gに変更した以外は、実施例1と同様にして絶縁層形成用スラリーを調製した。水に分散後のシリカのd10、d30、d50およびd90は、それぞれ、0．11μm、0．16μm、0．20

μmおよび0．39μmであり、平均粒径が0．20μmで、粒径が1μm以下の粒子の割合が90体積%以上であり、粒径が3μm以上の粒子の割合が10体積%以下であることが確認された。得られた絶縁層形成用スラリーについて実施例1と同様にして測定した結果、粘度が200mPa・s、1週間後の沈降高さが50mmであった。

[0141] （実施例6）

実施例1の絶縁層形成用スラリーに、更に防腐剤であるパラオキシ安息香酸エステルを1g添加して絶縁層形成用スラリーを調製した。得られた絶縁層形成用スラリーについて実施例1と同様にして測定した結果、粘度および1週間後の沈降高さは、実施例1の絶縁層形成用スラリーと同じであった。

[0142] （実施例7）

実施例1の絶縁層形成用スラリーに、更に消泡剤であるポリエーテル系の消泡剤（ポリエーテル変性オルガノポリシロキサン）を0．1g添加して絶縁層形成用スラリーを調製した。得られた絶縁層形成用スラリーについて実施例1と同様にして測定した結果、粘度および1週間後の沈降高さは、実施例1の絶縁層形成用スラリーと同じであった。

[0143] （比較例1）

増粘剤を添加しなかった以外は、実施例1と同様にして絶縁層形成用スラリーを調製した。得られた絶縁層形成用スラリーについて実施例1と同様にして測定した結果、粘度が3mPa・s、1週間後の沈降高さが34mmであった。

[0144] ＜セパレータの製造1＞

（実施例8～14）

実施例1～7の絶縁層形成用スラリーをそれぞれ均一に攪拌し、脱泡した後、上記スラリー中に厚みが15μmのPET製不織布（多孔質基材）を通し、引き上げ塗布により上記スラリーを塗布した後、所定の間隔を有するギャップの間を通し、乾燥して、厚みが20μmのセパレータを得た。但し、消泡剤を含有する実施例7の絶縁層形成用スラリーについては、脱泡処理を行う必要がなかった。

[0145] 実施例1～7の絶縁層形成用スラリーは、いずれも安定性が高く、長時間連続して基材に均一に塗布することができた。そのため、実施例1～7のスラリーを用いること

により、均一性の高い絶縁層を有するセパレータ(実施例8～14)を長時間にわたり得ることができた。

[0146] これに対し、増粘剤を含有しておらず、粘度が低い比較例1の絶縁層形成用スラリーを用い、前記と同様にしてセパレータを作製したところ、塗布開始直後には、比較的均一性の高い絶縁層を有するセパレータが得られた。しかし、時間の経過と共に、絶縁層形成用スラリーにおいて絶縁性微粒子の沈降が発生し、均一な絶縁層が形成されなくなった。このため、比較例1の絶縁層形成用スラリーでは、長時間の連続塗工ができなかった。

[0147] ＜セパレータの製造2＞

(実施例15～21)

実施例1～7および比較例1の絶縁層形成用スラリーをそれぞれ均一に攪拌し、脱泡した後、ダイコーターを用いて、厚さ16μmのPE製微多孔膜(多孔質基材)の片面に上記スラリーを塗布し、乾燥して、厚みが20μmのセパレータを得た。但し最、消泡剤を含有する実施例7の絶縁層形成用スラリーについては、脱泡処理を行う必要がなかった。

[0148] 実施例1～7の絶縁層形成用スラリーは、いずれも安定性が高く、長時間連続して基材に均一に塗布することができた。そのため、実施例1～7のスラリーを用いることにより、均一性の高い絶縁層を有するセパレータ(実施例15～21)を長時間にわたり得ることができた。

[0149] これに対し、増粘剤を含有しておらず、粘度が低い比較例1の絶縁層形成用スラリーを用い、前記と同様にしてセパレータを作製したところ、塗布開始直後には、比較的均一性の高い絶縁層を有するセパレータが得られた。しかし、時間の経過と共に、ダイヘッド中で、絶縁層形成用スラリーにおいて絶縁性微粒子の沈降が発生し、スラリーの塗布膜にスジが生じるようになった。このため、比較例1の絶縁層形成用スラリーでは、長時間の連続塗工ができなかった。

[0150] ＜セパレータの耐熱性の評価＞

実施例1～7のそれぞれの絶縁層形成用スラリーを、アプリケーターを用いて銅箔の表面に塗布して乾燥し、厚みが20μmの多孔質の絶縁層を形成した。更に、上記

絶縁層を形成した銅箔を、150℃に加熱して熱収縮の有無を目視観察で調べたが、上記絶縁層に熱収縮は認められなかった。

[0151] 次に、以下の方法により、実施例8～21のセパレータの耐熱性を評価した。先ず、厚み1mmの厚紙を9×9cmに切り出し、中央に3cm四方の穴を開けたものを2枚用意した。次に、1枚の厚紙の、中央の穴の周囲4辺に両面テープを貼り、試験に用いるセパレータを中央に置いて貼り付け、もう1枚の厚紙で挟み、固定した。続いて、厚紙で固定したセパレータを150℃の高温槽中に吊り下げて3時間放置し、その後取り出してセパレータの破膜の有無を観察した。比較として、リチウム二次電池用のPE微多孔膜(厚み20μm)についても、同様の評価を行った。

[0152] 実施例8～21のセパレータは、上記試験後においても破膜が見られず、良好な耐熱性を示した。これに対し、PEのみで構成されている微多孔膜は、試験後に破膜が見られ、耐熱性に劣ることが判明した。

[0153] ＜リチウム二次電池の製造＞

(実施例22)

正極活物質である$LiCoO_2$:85質量部、導電助剤であるアセチレンブラック:10質量部、およびバインダであるPVDF:5質量部を、N－メチル－2－ピロリドン(NMP)を溶剤として均一になるように混合して、正極合剤含有ペーストを調製した。このペーストを、集電体となる厚さ15μmのアルミニウム箔の両面に、塗布長が表面320mm、裏面250mになるように間欠塗布し、乾燥した後、カレンダー処理を行って、全厚が150μmになるように正極合剤層の厚みを調整し、幅43mmになるように切断して、長さ340mm、幅43mmの正極を作製した。更に、この正極のアルミニウム箔の露出部にリード部を接続した。

[0154] また、負極活物質である黒鉛:90質量部と、バインダであるPVDF:5質量部とを、NMPを溶剤として均一になるように混合して、負極合剤含有ペーストを調製した。このペーストを、集電体となる厚さ10μmの銅箔の両面に、塗布長が表面320mm、裏面260mmになるように間欠塗布し、乾燥した後、カレンダー処理を行って全厚が142μmになるように負極合剤層の厚みを調整し、幅45mmになるように切断して、長さ330mm、幅45mmの負極を作製した。更に、この負極の銅箔の露出部にリード部を

接続した。

[0155] 上記のようにして得られた正極と負極とを、実施例8のセパレータを介して重ね合わせ、渦巻状に巻回して巻回構造の電極群とした。この電極群を直径14mm、高さ50mmの円筒状の電池ケース内に挿入した。その後、電解液として、エチレンカーボネートとエチルメチルカーボネートを1:2の体積比で混合した溶媒に、$LiPF_6$を1.2mol/lの濃度で溶解させた溶液を、上記電池ケース内に注入し、電池ケースの開口部を定法に従って封止し、リチウム二次電池を製造した。

[0156] (実施例23～28)

実施例9～14のセパレータをそれぞれ用いた以外は、実施例22と同様にして、実施例23～28のリチウム二次電池を製造した。

[0157] (実施例29～35)

実施例15～21のセパレータをそれぞれ用い、PE製微多孔膜が負極側に配置されるように、セパレータを正極と負極の間に介在させた以外は、実施例22と同様にして、実施例29～35のリチウム二次電池を製造した。

[0158] 各実施例のリチウム二次電池に用いたセパレータおよび絶縁層形成用スラリーについて、表1にまとめて示す。

[0159] [表1]

リチウム二次電池	絶縁層形成用スラリー	セパレータ
実施例22	実施例1	実施例8
実施例23	実施例2	実施例9
実施例24	実施例3	実施例10
実施例25	実施例4	実施例11
実施例26	実施例5	実施例12
実施例27	実施例6	実施例13
実施例28	実施例7	実施例14
実施例29	実施例1	実施例15
実施例30	実施例2	実施例16
実施例31	実施例3	実施例17
実施例32	実施例4	実施例18
実施例33	実施例5	実施例19
実施例34	実施例6	実施例20
実施例35	実施例7	実施例21

[0160] <充放電特性の評価>

実施例22～35で作製したリチウム二次電池について、予備充電(化成時充電)とし

て、電池の定格容量750mAhに対して20%にあたる電気量となるように、150mAで4．2Vまで充電する定電流充電を行い、次いで、4．2Vでの定電圧充電を、上記定電流充電との合計で6時間行った。更に、充電後の電池に対して、電圧が3Vに低下するまで150mAで定電流放電を行い、電池の化成処理とした。

[0161] 次に、化成処理を行った実施例22～35のリチウム二次電池について、電流150mAで4．2Vまでの定電流充電と4．2Vでの定電圧充電を、合わせて15時間行った後、150mAで3．0Vまでの放電を行ったところ、いずれの電池もほぼ定格容量となる放電容量が得られた。このときの充電電気量に対する放電容量の割合は、いずれの電池もほぼ100%となっており、良好な充放電特性および信頼性を有していることが確認された。

[0162] 絶縁層形成用スラリーに添加するバインダに、自己架橋性のアクリル樹脂を用いたことで、これらにより形成された絶縁層（セパレータ）の柔軟性が向上して、巻回構造の電極群の最内周部におけるセパレータのひび割れや絶縁性微粒子の剥離が抑制され、リチウムデンドライトの析出による微小な短絡の発生を充分に抑制できたため、より信頼性の高いセパレータを構成することができたと考えられる。

[0163] ＜絶縁性微粒子の分散性の評価＞

（比較例2）

分散剤であるポリアクリル酸アンモニウムを使用しなかった以外は、実施例1と同様にして絶縁層形成用スラリーを調製した。水に分散後の板状ベーマイトのd10、d30、d50およびd90は、それぞれ、1．05μm、1．83μm、2．72μmおよび4．82μmであり、平均粒径が2．72μmで、粒径が1μm以下の粒子の割合が10体積%未満であり、粒径が3μm以上の粒子の割合が50体積%以上であった。

[0164] （実施例36）

分散剤であるポリアクリル酸アンモニウムを使用しなかった以外は、実施例2と同様にして絶縁層形成用スラリーを調製した。水に分散後のアルミナのd10、d30、d50およびd90は、それぞれ、0．53μm、0．70μm、0．85μmおよび1．32μmであり、平均粒径が0．85μmで、粒径が1μm以下の粒子の割合が50体積%以上であり、粒径が3μm以上の粒子の割合が10体積%以下であることが確認された。

[0165] （実施例37）

分散剤であるポリアクリル酸アンモニウムを使用しなかった以外は、実施例3と同様にして絶縁層形成用スラリーを調製した。水に分散後の板状アルミナのd10、d30、d50およびd90は、それぞれ、0．55μm、0．88μm、1．22μmおよび1．43μmであり、平均粒径が1．22μmで、粒径が1μm以下の粒子の割合が30体積%以上であり、粒径が3μm以上の粒子の割合が10体積%以下であることが確認された。

[0166] 実施例1～3、36、37および比較例2の絶縁層形成用スラリー中での絶縁性微粒子の分散性を評価するために、これらの各スラリーを、アプリケーターを用いて銅箔表面に塗布して乾燥し、イオン透過性および耐熱性を有する多孔質の絶縁層（厚み20μm）を形成した。

[0167] 上記絶縁層を形成した銅箔の絶縁層側に金属リチウムを対向させ、これらを電解液中に含浸させて評価用セルを作製した。電解液には、エチレンカーボネートとジメチルカーボネートとを1：2の体積比で混合した溶媒に、$LiPF_6$を1mol／lの濃度で溶解させた溶液を用いた。

[0168] 上記各評価用セルに、1mA／cm^2の電流密度で電流を1分間流し、その後電流値を0．1mA／cm^2ずつ順次増大させ、短絡が発生した時点での電流値を、上記絶縁層の短絡電流とした。これらの結果を表2に示す。

[0169] [表2]

	絶縁層形成用スラリーの構成		短絡電流（mA／cm^2）
	絶縁性微粒子	分散剤	
実施例1	板状ベーマイト	ポリアクリル酸アンモニウム	24．7
実施例2	多面体形状アルミナ	ポリアクリル酸アンモニウム	7．8
実施例3	板状アルミナ	ポリアクリル酸アンモニウム	21．4
比較例2	板状ベーマイト	なし	3．3
実施例36	多面体形状アルミナ	なし	4．5
実施例37	板状アルミナ	なし	6．5

[0170] 表2に示すように、分散剤を用いた実施例1～3の絶縁層形成用スラリーにより形成された絶縁層は、分散剤を用いなかった実施例36、37および比較例2のスラリーにより形成された絶縁層と比べて、短絡電流が大きく、短絡の発生が抑制されていることが分かる。これは、実施例1～3の絶縁層形成用スラリーでは、実施例36、37および比較例2のスラリーに比べて、絶縁性微粒子がより均一に分散していることから、よ

り均一性の高い絶縁層が形成でき、これにより絶縁層内でのリチウムイオンの移動がより均一になり、電流集中によるデンドライト成長が抑制されたためと推測される。特に、板状の絶縁性微粒子を用いた場合に、分散剤の添加により短絡電流が大きく上昇し、分散剤による粒子の分散性向上の効果が大きいことが分かる。

[0171] ＜電極とセパレータの一体化＞

（実施例38～44）

実施例1～7の絶縁層形成用スラリーをそれぞれ均一に攪拌した後、脱泡し、ダイコーターを用いて、実施例22で作製したものと同じ負極の両面に塗布し、乾燥して、片面当たりの厚みが20μmの絶縁層からなるセパレータを負極の表面に形成した。但し、消泡剤を含有する実施例7の絶縁層形成用スラリーについては、脱泡処理を行う必要がなかった。

[0172] 更に、実施例22で使用したものと同じ正極と、上記セパレータと一体化した負極とを重ね、渦巻状に巻回して巻回構造の電極群とした。この電極群を用いた以外は、実施例22と同様にして、実施例38～44のリチウム二次電池を製造した。実施例38～44のリチウム二次電池の作製に用いた絶縁層形成用スラリーについて、表3にまとめて示す。

[0173] [表3]

リチウム二次電池	絶縁層形成用スラリー
実施例３８	実施例１
実施例３９	実施例２
実施例４０	実施例３
実施例４１	実施例４
実施例４２	実施例５
実施例４３	実施例６
実施例４４	実施例７

[0174] 実施例1～7の絶縁層形成用スラリーから形成された絶縁層（セパレータ）と一体化された負極をそれぞれ有する実施例38～44のリチウム二次電池についても、実施例22～35のリチウム二次電池と同様にして充放電特性の評価を行った。いずれの電池もほぼ定格容量となる放電容量が得られ、良好な充放電特性および信頼性を有していることを確認した。

[0175] 本発明は、その趣旨を逸脱しない範囲で、上記以外の形態としても実施が可能で

ある。本出願に開示された実施形態は一例であって、これらに限定はされない。本発明の範囲は、上述の明細書の記載よりも、添付されている請求の範囲の記載を優先して解釈され、請求の範囲と均等の範囲内での全ての変更は、請求の範囲に含まれるものである。

産業上の利用可能性

[0176] 本発明によれば、絶縁性微粒子が均一に分散し、その分散状態を安定して維持できる絶縁層形成用スラリーが提供でき、この絶縁層形成用スラリーを用いて製造される電気化学素子用セパレータは、優れた耐熱性を有するものであり、上記電気化学素子用セパレータを用いることにより、優れた信頼性を有する電気化学素子を提供できる。

請求の範囲

[1] 電気化学素子用セパレータの絶縁層の形成に用いることができる絶縁層形成用スラリーであって、

前記絶縁層形成用スラリーは、耐熱性を有する絶縁性微粒子と、増粘剤と、分散媒とを含み、

前記絶縁性微粒子は、前記分散媒に分散しており、

前記絶縁層形成用スラリーの粘度が、5～500mPa・sであり、

前記絶縁性微粒子に含まれる粒子の中で、粒径が1μm以下の粒子の割合が30体積%以上であり、かつ粒径が3μm以上の粒子の割合が10体積%以下であることを特徴とする絶縁層形成用スラリー。

[2] 前記絶縁性微粒子に含まれる粒子の中で、粒径が2μm以上の粒子の割合が10体積%以下である請求項1に記載の絶縁層形成用スラリー。

[3] 前記絶縁性微粒子が、アルミナ、シリカおよびベーマイトよりなる群から選択される少なくとも1種の微粒子である請求項1に記載の絶縁層形成用スラリー。

[4] 前記絶縁性微粒子が、板状粒子を含む請求項1に記載の絶縁層形成用スラリー。

[5] 前記絶縁性微粒子が、一次粒子が凝集した二次粒子を含む請求項1に記載の絶縁層形成用スラリー。

[6] 前記増粘剤が、天然多糖類である請求項1に記載の絶縁層形成用スラリー。

[7] 分散剤を更に含む請求項1に記載の絶縁層形成用スラリー。

[8] 前記分散剤は、分子内にイオン解離性の酸基または酸塩基を複数含む請求項1に記載の絶縁層形成用スラリー。

[9] 前記分散剤が、ポリカルボン酸塩、ポリアクリル酸塩およびポリメタクリル酸塩よりなる群から選択される少なくとも1種である請求項8に記載の絶縁層形成用スラリー。

[10] バインダを更に含む請求項1に記載の絶縁層形成用スラリー。

[11] 前記バインダが、自己架橋性の(メタ)アクリル酸共重合体からなる請求項10に記載の絶縁層形成用スラリー。

[12] 防腐剤および殺菌剤から選ばれる少なくとも一方を更に含む請求項1に記載の絶縁層形成用スラリー。

[13] 消泡剤を更に含む請求項1に記載の絶縁層形成用スラリー。

[14] 多孔質の絶縁層を含む電気化学素子用セパレータであって、

前記絶縁層は、耐熱性を有する絶縁性微粒子とバインダとを含み、

前記絶縁性微粒子に含まれる粒子の中で、粒径が1μm以下の粒子の割合が30体積%以上であり、かつ粒径が3μm以上の粒子の割合が10体積%以下であることを特徴とする電気化学素子用セパレータ。

[15] 多孔質基体を更に含む請求項14に記載の電気化学素子用セパレータ。

[16] 前記多孔質基体が、織布、不織布および微多孔膜よりなる群から選択される少なくとも1種である請求項15に記載の電気化学素子用セパレータ。

[17] 前記微多孔膜が、融点が80℃以上150℃以下の熱可塑性樹脂からなる請求項16に記載の電気化学素子用セパレータ。

[18] 前記絶縁性微粒子が、自己架橋性の(メタ)アクリル酸共重合体の架橋体により一体化している請求項14に記載の電気化学素子用セパレータ。

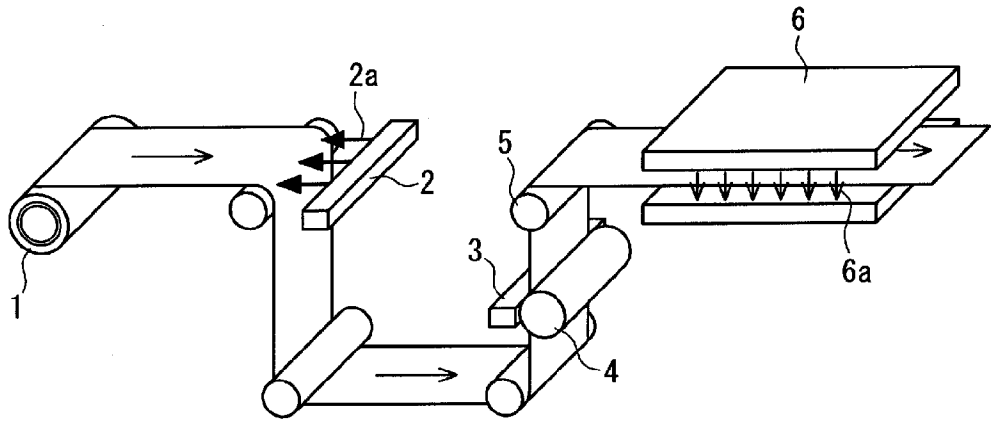
[19] 多孔質の絶縁層を含む電気化学素子用セパレータの製造方法であって、

請求項1～13のいずれかに記載の絶縁層形成用スラリーを、正極、負極および多孔質基材よりなる群から選択される少なくとも1種の基材に塗布する工程と、

前記絶縁層形成用スラリーが塗布された前記基材を乾燥する工程とを含むことを特徴とする電気化学素子用セパレータの製造方法。

[20] 正極、負極および請求項14～18のいずれかに記載の電気化学素子用セパレータを含むことを特徴とする電気化学素子。

[図1]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/051429

A. CLASSIFICATION OF SUBJECT MATTER
H01M2/16(2006.01)i, *H01G9/02*(2006.01)i, *H01M4/02*(2006.01)i, *H01M4/04*(2006.01)i, *H01M10/40*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01M2/16, H01G9/02, H01M4/02, H01M4/04, H01M10/40

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2009
Kokai Jitsuyo Shinan Koho 1971-2009 Toroku Jitsuyo Shinan Koho 1994-2009

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2008-16313 A (Matsushita Electric Industrial Co., Ltd.), 24 January, 2008 (24.01.08), Claim 3; Par. Nos. [0051], [0065], [0078] to [0079]; examples 1 to 7 & WO 2008/004430 A1 & KR 10-2008-0017015 A	1-6,10, 14-17,19,20 7-9,11-13,18

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 April, 2009 (13.04.09)	28 April, 2009 (28.04.09)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (April 2007)

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2007/066768 A1 (Hitachi Maxell, Ltd.), 14 June, 2007 (14.06.07), Par. Nos. [0056] to [0070], [0123] to [0179]; Claims & JP 2006-164761 A & JP 2007-157723 A & JP 2008-177595 A & JP 2008-243825 A & JP 2008-123988 A & JP 2008-123996 A & JP 4151852 B & US 2007/0264577 A1 & EP 1965454 A1 & EP 1826842 A1 & WO 2006/062153 A1 & CA 2586062 A & KR 10-2008-0073371 A & CN 101218695	14-16,18,20 1-13,19
X Y	WO 2006/093049 A1 (Matsushita Electric Industrial Co., Ltd.), 08 September, 2006 (08.09.06), Claim 2; Par. Nos. [0032] to [0043], [0049] & US 2006/0199294 A1 & EP 1780820 A1 & KR 10-2007-0062458 A & CN 101006595 A	14-17,20 18
Y	JP 2007-273443 A (Asahi Kasei Chemicals Corp.), 18 October, 2007 (18.10.07), Par. No. [0013] (Family: none)	7-9,13
Y	JP 2005-63846 A (Nippon Zeon Co., Ltd.), 10 March, 2005 (10.03.05), Par. No. [0028] (Family: none)	7-9
Y	JP 7-308563 A (Sanyo Chemical Industries, Ltd.), 28 November, 1995 (28.11.95), Claims (Family: none)	7-9
Y	JP 2002-334721 A (Atofina), 22 November, 2002 (22.11.02), Par. No. [0032] & JP 2004-265874 A & US 2002/0168569 A1 & EP 1244161 A1 & FR 2822296 A & CA 2378622 A & KR 10-2002-0074424 A & CN 1378298 A & CA 2378622 A1	12
Y	JP 2006-169503 A (Du Pont-Mitsui Fluorochemicals Co., Ltd.), 29 June, 2006 (29.06.06), Par. No. [0043] (Family: none)	12

国際調査報告

国際出願番号　ＰＣＴ／ＪＰ２００９／０５１４２９

Ａ．　発明の属する分野の分類（国際特許分類（ＩＰＣ））

Int.Cl.　H01M2/16(2006.01)i, H01G9/02(2006.01)i, H01M4/02(2006.01)i, H01M4/04(2006.01)i, H01M10/40(2006.01)i

Ｂ．　調査を行った分野

調査を行った最小限資料（国際特許分類（ＩＰＣ））

Int.Cl.　H01M2/16, H01G9/02, H01M4/02, H01M4/04, H01M10/40

最小限資料以外の資料で調査を行った分野に含まれるもの

日本国実用新案公報	１９２２－１９９６年
日本国公開実用新案公報	１９７１－２００９年
日本国実用新案登録公報	１９９６－２００９年
日本国登録実用新案公報	１９９４－２００９年

国際調査で使用した電子データベース（データベースの名称、調査に使用した用語）

Ｃ．　関連すると認められる文献

引用文献のカテゴリー＊	引用文献名　及び一部の箇所が関連するときは、その関連する箇所の表示	関連する請求項の番号
X Y	JP 2008-16313 A (松下電器産業株式会社) 2008.01.24, 請求項3, [0051], [0065], [0078]-[0079], 実施例1-7 & WO 2008/004430 A1 & KR 10-2008-0017015 A	1-6,10,14-17,19,20 7-9,11-13,18

☑　Ｃ欄の続きにも文献が列挙されている。　　☐　パテントファミリーに関する別紙を参照。

＊　引用文献のカテゴリー
「Ａ」特に関連のある文献ではなく、一般的技術水準を示すもの
「Ｅ」国際出願日前の出願または特許であるが、国際出願日以後に公表されたもの
「Ｌ」優先権主張に疑義を提起する文献又は他の文献の発行日若しくは他の特別な理由を確立するために引用する文献（理由を付す）
「Ｏ」口頭による開示、使用、展示等に言及する文献
「Ｐ」国際出願日前で、かつ優先権の主張の基礎となる出願の日の後に公表された文献
「Ｔ」国際出願日又は優先日後に公表された文献であって出願と矛盾するものではなく、発明の原理又は理論の理解のために引用するもの
「Ｘ」特に関連のある文献であって、当該文献のみで発明の新規性又は進歩性がないと考えられるもの
「Ｙ」特に関連のある文献であって、当該文献と他の１以上の文献との、当業者にとって自明である組合せによって進歩性がないと考えられるもの
「＆」同一パテントファミリー文献

国際調査を完了した日 １３．０４．２００９	国際調査報告の発送日 ２８．０４．２００９
国際調査機関の名称及びあて先 日本国特許庁（ＩＳＡ／ＪＰ） 郵便番号１００－８９１５ 東京都千代田区霞が関三丁目４番３号	特許庁審査官（権限のある職員）　４Ｘ　３８３９ 近野　光知 電話番号　０３－３５８１－１１０１　内線　３４７７

様式ＰＣＴ／ＩＳＡ／２１０（第２ページ）（２００７年４月）

Ｃ（続き）．　関連すると認められる文献

引用文献のカテゴリー＊	引用文献名　及び一部の箇所が関連するときは、その関連する箇所の表示	関連する請求項の番号
X Y	WO 2007/066768 A1（日立マクセル株式会社）2007.06.14, [0056]-[0070], [0123]-[0179], 請求の範囲 & JP 2006-164761 A & JP 2007-157723 A & JP 2008-177595 A & JP 2008-243825 A & JP 2008-123988 A & JP 2008-123996 A & JP 4151852 B & US 2007/0264577 A1 & EP 1965454 A1 & EP 1826842 A1 & WO 2006/062153 A1 & CA 2586062 A & KR 10-2008-0073371 A & CN 101218695	14-16,18,20 1-13,19
X Y	WO 2006/093049 A1（松下電器産業株式会社）2006.09.08, 請求項2, [0032]-[0043], [0049] & US 2006/0199294 A1 & EP 1780820 A1 & KR 10-2007-0062458 A & CN 101006595 A	14-17,20 18
Y	JP 2007-273443 A（旭化成ケミカルズ）2007.10.18, [0013]（ファミリーなし）	7-9,13
Y	JP 2005-63846 A（日本ゼオン株式会社）2005.03.10, [0028]（ファミリーなし）	7-9
Y	JP 7-308563 A（三洋化成工業株式会社）1995.11.28, 特許請求の範囲（ファミリーなし）	7-9
Y	JP 2002-334721 A（アトフィナ）2002.11.22, [0032] & JP 2004-265874 A & US 2002/0168569 A1 & EP 1244161 A1 & FR 2822296 A & CA 2378622 A & KR 10-2002-0074424 A & CN 1378298 A & CA 2378622 A1	12
Y	JP 2006-169503 A（三井・デュポンフロロケミカル株式会社）2006.06.29, [0043]（ファミリーなし）	12

Electronic Patent Application Fee Transmittal

Application Number:	12673961
Filing Date:	17-Feb-2010
Title of Invention:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY
First Named Inventor/Applicant Name:	Hideaki Katayama
Filer:	John Wayne Bailey/Yerin Cho
Attorney Docket Number:	5271-0195PUS1

Filed as Large Entity

U.S. National Stage under 35 USC 371 Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Claims in excess of 20	1615	14	60	840
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**840**

Electronic Acknowledgement Receipt

EFS ID:	13129354
Application Number:	12673961
International Application Number:	
Confirmation Number:	2754
Title of Invention:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY
First Named Inventor/Applicant Name:	Hideaki Katayama
Customer Number:	2292
Filer:	John Wayne Bailey/Yerin Cho
Filer Authorized By:	John Wayne Bailey
Attorney Docket Number:	5271-0195PUS1
Receipt Date:	28-JUN-2012
Filing Date:	17-FEB-2010
Time Stamp:	13:16:42
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$840
RAM confirmation Number	14056
Deposit Account	022448
Authorized User	BAILEY,JOHN

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. 1.492 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)					
File Listing:					
Document Number	**Document Description**	**File Name**	**File Size(Bytes)/ Message Digest**	**Multi Part /.zip**	**Pages (if appl.)**
1	Miscellaneous Incoming Letter	5271-0195PUS1_FeeTransm.pdf	841683 bee3c3555d6a2073b4f336021510df8bb2d7c5c0	no	1
Warnings:					
Information:					
2		5271-0195PUS1_Restriction.pdf	5538834 403dbb8a6fba605b1b407959389e302183d6b10	yes	13
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Response to Election / Restriction Filed		1	1	
	Claims		2	9	
	Applicant Arguments/Remarks Made in an Amendment		10	13	
Warnings:					
Information:					
3		5271-0195PUS1_IDS.pdf	3237782 44fcea99b422e8a00ae2dd608691fb2d115d3d02	yes	7
	Multipart Description/PDF files in .zip description				
	Document Description		**Start**	**End**	
	Transmittal Letter		1	6	
	Information Disclosure Statement (IDS) Form (SB08)		7	7	
Warnings:					
Information:					
4	Foreign Reference	5271-0195PUS1_WO-2009-096451.pdf	2648991 288627489d1eb46e1e3d2ef4895f6c9c4e8b8eff	no	49
Warnings:					
Information:					
5	Fee Worksheet (SB06)	fee-info.pdf	30683 caa624d1257a6d1e4cc0e69efceab6c979cf1468	no	2
Warnings:					
Information:					

Total Files Size (in bytes):	12297973

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New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/17 (09-11)
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FEE TRANSMITTAL

Complete if Known		
Application Number	12/673,961	Conf. No.: 2754
Filing Date	February 17, 2010	
First Named Inventor	Hideaki KATAYAMA	
Examiner Name	J. S. MAPLES	
Art Unit	1728	
Attorney Docket No.	5271-0195PUS1	

☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT ($) 840.00

METHOD OF PAYMENT (check all that apply)

☐ Check ☑ Credit Card ☐ Money Order ☐ None ☐ Other (please identify): _____

☑ Deposit Account Deposit Account Number: 02-2448 Deposit Account Name: Birch, Stewart, Kolasch & Birch, LLP

For the above-identified deposit account, the Director is hereby authorized to: (check all that apply)

☐ Charge fee(s) indicated below ☐ Charge fee(s) indicated below, **except for the filing fee**

☑ Charge any additional fee(s) or underpayments of fee(s) under 37 CFR 1.16 and 1.17 ☑ Credit any overpayments

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES

	FILING FEES		SEARCH FEES		EXAMINATION FEES		
		Small Entity		Small Entity		Small Entity	
Application Type	Fee ($)	Fee ($)	Fee ($)	Fee ($)	Fee ($)	Fee ($)	Fees Paid ($)
Utility	380	190	620	310	250	125	0.00
Design	250	125	120	60	160	80	0.00
Plant	250	125	380	190	200	100	0.00
Reissue	380	190	620	310	750	375	0.00
Provisional	250	125	0	0	0	0	0.00

2. EXCESS CLAIM FEES

Fee Description	Fee ($)	Small Entity Fee ($)
Each claim over 20 (including Reissues)	60	30
Each independent claim over 3 (including Reissues)	250	125
Multiple dependent claims	450	225

Total Claims		Extra Claims		Fee ($)		Fee Paid ($)
34	- 20 or HP =	14	x	60.00	=	840.00

HP = highest number of total claims paid for, if greater than 20.

Indep. Claims		Extra Claims		Fee ($)		Fee Paid ($)
1	- 3 or HP =	0	x	250.00	=	0.00

HP = highest number of independent claims paid for, if greater than 3.

Multiple Dependent Claims	
Fee ($)	Fee Paid ($)
0.00	0.00

3. APPLICATION SIZE FEE

If the specification and drawings exceed 100 sheets of paper (excluding electronically filed sequence or computer listings under 37 CFR 1.52(e)), the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

Total Sheets		Extra Sheets		Number of each additional 50 or fraction thereof		Fee ($)		Fee Paid ($)
	- 100 =	0	/ 50 =	0 (round up to a whole number)	x		=	0.00

4. OTHER FEE(S)

	Fees Paid ($)
Non-English Specification, $130 fee (no small entity discount)	0.00
Other (e.g., late filing surcharge):	

SUBMITTED BY

Signature		Registration No. (Attorney/Agent) 32881	Telephone 703-205-8000
Name (Print/Type)	John W. Bailey		Date June 28, 2012

This collection of information is required by 37 CFR 1.136. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number	Filing Date	☐ To be Mailed
12/673,961	02/17/2010	

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY ☐ RATE ($)	SMALL ENTITY FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT	06/28/2012	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	* 34	Minus	** 20	= 14	X $ =		OR	X $60=	840
	Independent (37 CFR 1.16(h))	* 2	Minus	***2	= 0	X $ =		OR	X $250=	0
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	**840**

AMENDMENT		(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
	Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
						TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/JAMILAH Z. HARRIS/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

AMENDMENTS TO THE CLAIMS

1. (**Currently Amended**) A battery separator comprising:

heat-resistant fine particles; and

a thermoplastic resin,

wherein the heat-resistant fine particles along with a binder constitute a heat-resistant layer,

the thermoplastic resin constitutes a shutdown layer formed of a microporous film,

the heat-resistant layer and the shutdown layer are integrated into a multilayer structure,

a proportion of particles with a particle size of 0.2 μm or less in the heat-resistant fine particles is 10 vol% or less and a proportion of particles with a particle size of 2 μm or more in the heat-resistant fine particles is 10 vol% or less, and

a shutdown is effected in a range of ~~100~~ 135°C to 150°C.

2. (Original) The battery separator according to claim 1, wherein a thermal shrinkage ratio in a width direction is 10% or less at 200°C.

3. (**Currently Amended**) The battery separator according to claim 1, wherein ~~the heat-resistant fine particles along with a binder constitute a heat-resistant layer~~ a content of the heat-resistant fine particles in the heat-resistant layer is 20 vol% or more of a total volume of components in the heat-resistant layer.

4. (Original) The battery separator according to claim 1, wherein the heat-resistant fine particles are inorganic fine particles.

5. **(Currently Amended)** The battery separator according to claim 4, wherein the inorganic fine particles **[[**are**]]** include fine particles of at least one selected from the group consisting of alumina, silica, **[[**and**]]** $BaTiO_3$, boehmite, zeolite, and kaoline.

6. **(Currently Amended)** The battery separator according to claim 1, wherein the heat-resistant fine particles **[[**are**]]** include plate-like particles.

7. **(Currently Amended)** The battery separator according to claim 1, wherein ~~the thermoplastic resin constitutes a shutdown layer~~ the heat-resistant layer has a thickness of 1 μm to 10 μm.

8. (Original) The battery separator according to claim 1, wherein the thermoplastic resin includes polyolefin.

9. **(Currently Amended)** The battery separator according to claim 1, wherein the heat-resistant fine particles have an average particle size of **[[**1**]]** 1.5 μm or less.

10. **(Currently Amended)** A nonaqueous electrolyte battery comprising:

a positive electrode having a positive active material capable of intercalating and deintercalating a lithium ion;

a negative electrode having a negative active material capable of intercalating and deintercalating a lithium ion;

a separator interposed between the positive electrode and the negative electrode; and

a nonaqueous electrolyte,

wherein a heat generation starting temperature of the positive electrode is 180°C or higher, and

wherein the separator ~~comprises heat-resistant fine particles and a thermoplastic resin,~~

~~a proportion of particles with a particle size of 0.2 μm or less in the heat-resistant fine particles is 10 vol% or less and a proportion of particles with a particle size of 2 μm or more in the heat-resistant fine particles is 10 vol% or less, and~~

~~the separator effects a shutdown in a range of 100°C to 150°C~~ is the battery separator according to claim 1.

11. (Original) The nonaqueous electrolyte battery according to claim 10, wherein a thermal shrinkage ratio of the separator is 10% or less at a temperature T (°C) that is 10°C lower than the heat generation starting temperature of the positive electrode (where an upper limit of T is 200°C).

12. (Original) The nonaqueous electrolyte battery according to claim 10, wherein a width of the separator is larger than that of the negative electrode at a temperature T (°C) that is 10°C lower than the heat generation starting temperature of the positive electrode (where an upper limit of T is 200°C).

13. (Original) The nonaqueous electrolyte battery according to claim 10, wherein the positive active material is at least one selected from the group consisting of the following: a spinel-type lithium-containing complex oxide expressed as a general formula $Li_{1+t}Mn_{(2-x)}M^1{}_xO_4$ (where M^1 is at least one element selected from the group consisting of Fe, Ni, Mg, Zn, Co, Cr, Al, B, V, Si, Sn, Nb, Ta, Cu, Mo, Ti, and W, $-0.1 \leq t \leq 0.1$, and $0 \leq x \leq 0.6$); an olivine-type lithium-containing complex oxide expressed as a general formula LiM^2PO_4 (where M^2 is Co, Ni, Mn, or Fe); a lithium-containing complex oxide having a layered crystal structure expressed as a general formula $Li_{(1+a)}M^3{}_{2b}Mn_{(0.5-b)}Ni_{(0.5-b)}O_2$ (where M^3 is at least one element selected from the group consisting of Fe, Mg, Zn, Co, Cr, Al, B, V, Si, Sn, Nb, Ta, Cu, Mo, Ti, and W, $-0.1 < a < 0.1$, and $0 \leq b \leq 0.05$); and a lithium-containing complex oxide expressed as a general formula $Li_{(1+y+\alpha)}Ni_{(1-y-z+\delta)/2}Mn_{(1-y-z-\delta)/2}M^4{}_zO_2$ (where M^4 is at least one element selected from the group consisting of Ti, Cr, Fe, Co, Cu, Zn, Al, Ge, Sn, Mg, and Zr, $-0.1 \leq y \leq 0.1$, $-0.05 \leq \alpha \leq 0.05$, $0 \leq z < 0.45$, and $-0.24 \leq \delta \leq 0.6$).

14. (**Currently Amended**) The nonaqueous electrolyte battery according to claim 10, wherein ~~the heat-resistant fine particles along with a binder constitute a heat-resistant layer~~ a content of the heat-resistant fine particles in the heat-resistant layer of the separator is 20 vol% or more of a total volume of components in the heat-resistant layer.

15. (**Currently Amended**) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator are inorganic fine particles.

16. (**Currently Amended**) The nonaqueous electrolyte battery according to claim 15, wherein the inorganic fine particles **[[**are**]]** include fine particles of at least one selected from the group consisting of alumina, silica, **[[**and**]]** $BaTiO_3$, boehmite, zeolite, and kaoline.

17. (**Currently Amended**) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles **[[**are**]]** of the separator include plate-like particles.

18. (**Currently Amended**) The nonaqueous electrolyte battery according to claim 10, wherein ~~the thermoplastic resin constitutes a shutdown layer~~ the heat-resistant layer of the separator has a thickness of 1 μm to 10 μm.

19. (**Currently Amended**) The nonaqueous electrolyte battery according to claim 10, wherein the thermoplastic resin of the separator includes polyolefin.

20. (**Currently Amended**) The nonaqueous electrolyte battery according to claim **[[**18**]]** 10, wherein the shutdown layer of the separator is located on a negative electrode side.

21. (**New**) The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator is not in contact with the positive active material.

22. (**New**) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator have an average particle size of 1.5 μm or less.

23. (**New**) The battery separator according to claim 1, wherein the shutdown layer has a thickness of 5 μm to 30 μm.

24. (**New**) The battery separator according to claim 1, wherein a ratio A/B is 1/2 to 5, where A (μm) represents a thickness of the shutdown layer, and B (μm) represents a thickness of the heat-resistant layer.

25. (**New**) The battery separator according to claim 1, wherein a content of the binder in the heat-resistant layer is 1 to 20 vol% of a total volume of components in the heat-resistant layer.

26. (**New**) The battery separator according to claim 1, wherein a content of the heat-resistant fine particles in the heat-resistant layer is 50 vol% or more of a total volume of components in the heat-resistant layer.

27. (**New**) The battery separator according to claim 1, wherein the binder includes at least one selected from the group consisting of an ethylene-vinyl acetate copolymer (having 20 to 35 mol% of a structural unit derived from vinyl acetate); an ethylene-acrylic acid copolymer; fluoro-rubber; styrene-butadiene rubber; carboxymethyl cellulose; hydroxyethyl cellulose; polyvinyl alcohol; polyvinyl butyral; polyvinyl pyrrolidone; poly-N-vinylacetamide; a cross-linked acrylic resin; polyurethane; and an epoxy resin.

28. (**New**) The battery separator according to claim 1, wherein the heat-resistant fine particles have an average particle size of 0.3 μm or more.

29. (**New**) The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator has a thickness of 5 μm to 30 μm.

30. (**New**) The nonaqueous electrolyte battery according to claim 10, wherein a ratio A/B is 1/2 to 5, wherein A (μm) represents a thickness of the shutdown layer of the separator, and B (μm) represents a thickness of the heat-resistant layer of the separator.

31. (**New**) The nonaqueous electrolyte battery according to claim 10, wherein a content of the binder in the heat-resistant layer of the separator is 1 to 20 vol% of a total volume of components in the heat-resistant layer.

32. (**New**) The nonaqueous electrolyte battery according to claim 10, wherein a content of the heat-resistant fine particles in the heat-resistant layer of the separator is 50 vol% or more of a total volume of components in the heat-resistant layer.

33. (**New**) The nonaqueous electrolyte battery according to claim 10, wherein the binder of the separator includes at least one selected from the group consisting of an ethylene-vinyl acetate copolymer (having 20 to 35 mol% of a structural unit derived from vinyl acetate); an ethylene-acrylic acid copolymer; fluoro-rubber; styrene-butadiene rubber; carboxymethyl

cellulose; hydroxyethyl cellulose; polyvinyl alcohol; polyvinyl butyral; polyvinyl pyrrolidone; poly-N-vinylacetamide; a cross-linked acrylic resin; polyurethane; and an epoxy resin.

34. (**New**) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator have an average particle size of 0.3 μm or more.

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/673,961	02/17/2010	Hideaki Katayama	5271-0195PUS1	2754

2292 7590 08/30/2012

BIRCH STEWART KOLASCH & BIRCH
PO BOX 747
FALLS CHURCH, VA 22040-0747

EXAMINER	
MAPLES, JOHN S	

ART UNIT	PAPER NUMBER
1728	

NOTIFICATION DATE	DELIVERY MODE
08/30/2012	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

mailroom@bskb.com

Office Action Summary	Application No.	Applicant(s)	
	12/673,961	KATAYAMA ET AL.	
	Examiner	Art Unit	
	John S. Maples	1728	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *28 June 2012*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

5)☒ Claim(s) *1-34* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-34* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

10)☒ The specification is objected to by the Examiner.

11)☒ The drawing(s) filed on *17 February 2010* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

12)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

13)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☒ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☒ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *2/17/2010;4/27/2012;6/28/2012*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

1. In view of applicant's amendments to the claims and the arguments set forth, the lack of unity requirement has been dropped.

2. The beginning of the specification should be amended to include the details of both the PCT application and the two Japanese applications on which priority is based.

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

5. Claims 1-34 are rejected under 35 U.S.C. 103(a) as being unpatentable over Nakura et al.-US 2008/0038631 (Nakura) in view of Katayama et al.-US 2007/0264577. (Katayama)

For claim 1, Nakura teaches a battery separator comprising a shutdown layer formed of a microporous film and a heat-resistant layer comprising fine particles and a binder-see the Abstract in Nakura along with paragraphs 22-49. As paragraphs 19 and 30 in Nakura recite, the shutdown is effected in the claimed range of 135-150 degrees C. The only claimed features not shown by Nakura are the proportion of particle sizes. Katayama discloses a separator for a lithium secondary battery that includes a heat-resistant layer comprising fine particles, where the sizes thereof fall within that range claimed by applicant-see Example 1 in Katayama where the particles are in a size distribution of 0.3-0.7 micron size. To include the sized particles of Katayama in the separator of Nakura would have been obvious to one of ordinary skill in this art at the time the invention was made because the same would allow for greater transport across the separator.

For claim 2, paragraph 28 in Nakura teaches the claimed temperature for the shrinkage ratio which would inherently fall within the claimed range.

For claims 3, 14, 25, 26, 31 and 32, paragraph 44 in Nakura recite the content of the fine particles and the binder.

Paragraph 42 in Nakura disclose alumina fine particles thus meeting claims 4, 5, 15 and 16.

For claims 6 and 17, Katayama recites plate shaped particles in paragraph 77 and to include the same in Nakura would have been obvious so that short-circuiting would be hindered.

For claims 7, 18, 23, 24, 29, 30, paragraphs 30 and 36 in Nakura teach the claimed thicknesses of both the shut-down layer and the heat-resistant layers.

With regard to claims 8 and 19, paragraph 38 in Nakura teaches the claimed thermoplastic resin.

For claims 9, 22, 28 and 34, the claimed particle size is taught in Example 1 of Katayama and to include the same in Nakura would have been obvious to allow greater compacting in the separator.

Claims 10-13 are met by the specific first compound recited in the next to the last line of paragraph 100 in Katayama. It is noted that this compound is the same compound set forth in applicant's Example 1 so the properties set forth in claims 11 and 12 would inherently be met and to utilize this compound of Katayama in Nakura would have been obvious because, as set forth in paragraph 46 of Nakura, provision of made for the lithium manganese nickel cobalt oxide.

For claims 20 and 21, reference is made to the Abstract and paragraph 37 for the shutdown layer located on the negative electrode side.

For claims 27 and 33, paragraph 49 in Nakura disclose the claimed binder.

6. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure.

Kato et al. disclose a separator for a lithium secondary battery of interest.

7. Any inquiry concerning this communication or earlier communications from the examiner should be directed to John S. Maples whose telephone number is (571)272-1287. The examiner can normally be reached on Monday-Friday, 8:30-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Jennifer Michener can be reached on 571-272-1424. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/John S. Maples/
Primary Examiner
Art Unit 1728

JSM/8-24-2012

Notice of References Cited	Application/Control No. 12/673,961	Applicant(s)/Patent Under Reexamination KATAYAMA ET AL.	
	Examiner John S. Maples	Art Unit 1728	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	Classification
*	A	US-2006/0141352	06-2006	Kato et al.	429/144
	B	US-			
	C	US-			
	D	US-			
	E	US-			
	F	US-			
	G	US-			
	H	US-			
	I	US-			
	J	US-			
	K	US-			
	L	US-			
	M	US-			

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

PTO/SB/08a (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
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Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 1

Complete if Known	
Application Number	12/673,961
Filing Date	02-17-10
First Named Inventor	Hideaki Katayama
Art Unit	1728
Examiner Name	J. S. MAPLES
Attorney Docket Number	5271-0195PUS1

U.S. PATENT DOCUMENTS

Examiner initial *	Cite No	Document Number: Number - Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	US-2010/0221965 - A1	09-02-2010	KATAYAMA et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Cite No. 1	Foreign Patent Document: Country[3] Code Number[4] Kind Code (if known)[5]	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear	T
	2	WO 2009/096451 - A1	08-06-2009			✓

Examiner Signature	/John Maples/	Date Considered	08/24/2012

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not Considered. Include copy of this form with next communication to applicant. 1. Applicant's unique citation design number (optional). 2 See Kinds Codes of USPTO patent Documents, at www.uspto.gov or MPEP 901.04. 3. Enter Office that issued the document, by the two-letter code (WIPO Standard ST 3). 4. For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5. Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. 6. Applicant is to place a check mark here if English language Translation is attached.

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450 Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS.

SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 (1-800-786.9199) and select option 2.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.M./

PTO/SB/08a (07-09)
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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	12/673,961
Filing Date	02-17-10
First Named Inventor	Hideaki Katayama
Art Unit	1728
Examiner Name	J. S. Maples
Attorney Docket Number	5271-0195PUS1

U.S. PATENT DOCUMENTS

Examiner initial *	Cite No.	Document Number Number - Kind Code[2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	US-2007/0264577 - A1	11-15-2007	Katayama et al.	
	2	US-2008/0038631 - A1	02-14-2008	Nakura et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Cite No. 1	Foreign Patent Document Country Code[3] Number[4] Kind Code (if known)[5]	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear	T
	3	EP 1 115 166 - A1	07-11-2001			☐
	4	CN 101019266 - A	08-15-2007			☑
	5	WO 2006/062153 - A1	06-15-2006			☑
						☐
						☐
						☐

Examiner Signature	/John Maples/	Date Considered	08/24/2012

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not Considered. Include copy of this form with next communication to applicant. 1. Applicant's unique citation design number (optional). 2 See Kinds Codes of USPTO patent Documents. at www.uspto.gov or MPEP 901.04. 3. Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4. For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5. Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. 6. Applicant is to place a check mark here if English language Translation is attached.

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.M./

PTO/SB/08b (07-09)
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Substitute for form 1449B/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet	2	of	2

Complete if Known	
Application Number	12/673,961
Filing Date	02-17-10
First Named Inventor	Hideaki Katayama
Art Unit	1728
Examiner Name	J. S. Maples
Attorney Docket Number	5271-0195PUS1

NON PATENT LITERATURE DOCUMENTS

Examiner initial *	Cite No. [1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T [2]
	6	~~Chinese Office Action, dated March 1, 2012, for Chinese Application No. 200880105805.8~~	

Examiner Signature	/John Maples/	Date Considered	08/24/2012

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

1. Applicants unique citation designation number. (optional) 2. Applicant is to place a check mark here if English language Translation is attached.

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ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.M./

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	302	(429/144 or 429/145).ccls. and (shutdown or (shut adj down))	US-PGPUB; USPAT; USOCR	OR	ON	2012/08/24 13:46
L2	137	1 and (inorganic near2 (filler or particle))	US-PGPUB; USPAT; USOCR	OR	ON	2012/08/24 13:47
L3	98	2 and ((microporous or porous) near2 film)	US-PGPUB; USPAT; USOCR	OR	ON	2012/08/24 13:47
S1	1	("20110052987").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/07/18 10:18
S2	1	("6632561").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/07/18 13:14
S3	1	("20070157723").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/08/17 14:18
S4	1	("20070264577").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/08/17 14:19
S5	1	("20040191611").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/08/17 15:18
S6	1	("20070231700").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/08/17 15:20
S7	1	("20010005560").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/08/17 15:22
S8	0	("20010221965").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/08/17 15:26
S9	0	("20010221985").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/08/17 15:26
S10	1	("20080038631").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/08/17 15:27
S11	1	("20100221965").PN.	US-PGPUB; USPAT; USOCR	OR	OFF	2012/08/23 14:31

8/ 24/ 2012 1:52:20 PM
C:\ Users\ jmaples\ Documents\ EAST\ Workspaces\ 12673961.wsp

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 1

Complete if Known	
Application Number	NEW
Filing Date	February 17, 2010
First Named Inventor	Hideaki KATAYAMA
Art Unit	N/A
Examiner Name	Not Yet Assigned
Attorney Docket Number	5271-0195PUS1

U.S. PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Document Number Number-Kind Code[2] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages or Relevant Figures Appear
	AA*	US-2004/0191611-A1	09-30-2004	Imachi et al.	
	AB*	US-2007/0264577-A1	11-15-2007	Katayama et al.	
	AC*	US-2007/0231700-A1	10-04-2007	Watanabe	
	AD*	US-2001/0005560-A1	06-28-2001	Yoshida et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initials*	Cite No.[1]	Foreign Patent Document Country Code[3]-Number[4]-Kind Code[5] (*if known*)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, Columns, Lines, Where Relevant Passages Or Relevant Figures Appear	T[6]
	BA	JP-2004-296325-A	10-21-2004			ABS
	BB	JP-2004-303474-A	10-28-2004			ABS
	BC	JP-2006-351386-A	12-28-2006			ABS
	BD	WO-2007/066768-A1	06-14-2007			ABS
	BE	JP-2007-273123-A	10-18-2007			ABS
	BF	JP-2007-273443-A	10-18-2007			ABS
	BG	JP-2007-280911-A	10-25-2007			ABS
	BH	JP-2007-157723-A	06-21-2007			ABS
	BI	JP-2006-139978-A	06-01-2006			√
	BJ	JP-2008-210541-A	09-11-2008			√
	BK	JP-2008-27634-A	02-07-2008			ABS
	BL	JP-2008-123996-A	05-29-2008			ABS
	BM	JP-2007-335294-A	12-27-2007			ABS
	BN	JP-2006-269359-A	10-05-2006			ABS
	BO	WO-00/79618-A1	12-28-2000			ABS

Examiner Signature	/John Maples/	Date Considered	08/24/2012

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JWB/sym

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Search Notes	Application/Control No.	Applicant(s)/Patent under Reexamination	
	12/673,961	KATAYAMA ET AL.	
	Examiner	Art Unit	
	John S. Maples	1728	

SEARCHED			
Class	Subclass	Date	Examiner

INTERFERENCE SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES (INCLUDING SEARCH STRATEGY)		
	DATE	EXMR
Inventor Sch	8/17/2012	JSM
EAST-USOCR,USPAT,USPGPUB see search history printout	8/17/2012	JSM

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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Sheet 1 of 2

Complete if Known	
Application Number	12/673,961
Filing Date	02-17-10
First Named Inventor	Hideaki Katayama
Art Unit	1728
Examiner Name	J. S. MAPLES
Attorney Docket Number	5271-0195PUS1

U.S. PATENT DOCUMENTS

Examiner Initial *	Cite No.	Document Number: Number - Kind Code [2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	US-6,447,958 - B1	09-10-2002	SHINOHARA et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Cite No. 1	Foreign Patent Document: Country Code [3] Number [4] Kind Code (if known) [5]	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear	T
	2	KR 10-2007-0083975 - A	08-24-2007			☑
	3	JP 2000-30686 - A	01-28-2000			☑

Examiner Signature		Date Considered	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT

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Sheet	2	of	2

Complete if Known	
Application Number	12/673,961
Filing Date	02-17-10
First Named Inventor	Hideaki Katayama
Art Unit	1728
Examiner Name	J. S. MAPLES
Attorney Docket Number	5271-0196PUS1

NON PATENT LITERATURE DOCUMENTS

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	4	Office Action for corresponding Korean Patent Application No. 10-2010-7004859, mailed October 4, 2012.	

Examiner Signature		Date Considered	

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Espacenet

Bibliographic data: KR20070083975 (A) — 2007-08-24

SEPARATOR FOR ELECTROCHEMICAL DEVICE AND ELECTROCHEMICAL DEVICE

Inventor(s): KATAYAMA HIDEAKI [JP]; ABE TOSHIHIRO [JP]; MATSUMOTO NOBUAKI [JP]; KITA FUSAJI [JP]; AOYAMA SHIGEO [JP] ± (KATAYAMA HIDEAKI, ; ABE TOSHIHIRO, ; MATSUMOTO NOBUAKI, ; KITA FUSAJI, ; AOYAMA SHIGEO)

Applicant(s): HITACHI MAXELL [JP] ± (HITACHI MAXELL, LTD)

Classification: **- international:** ***H01M2/16***
- European: H01M10/052; H01M10/42M; H01M2/16C3; H01M2/16C5; Y02E60/12

Application number: KR20077010172 20070504

Priority number(s): JP20040354850 20041208

Also published as: KR100911742 (B1) EP1826842 (A1) KR20090075741 (A) JP2006164761 (A) CN101048892 (A) CN100511769 (C) less

Abstract of KR20070083975 (A)

Disclosed is a separator for electrochemical devices which is composed of a porous film containing a porous base (5) having a heat resistance of not less than 1500C and containing filler particles (3), at least one shutdown resin (6) selected from resins A having a melting point of 80-1300C and resins B which absorb the electrolyte solution and swell when heated and the swelling degree of which becomes higher as the temperature is increased, and a binder (4). By using such a separator, there can be obtained an electrochemical device having excellent safety at high temperatures.

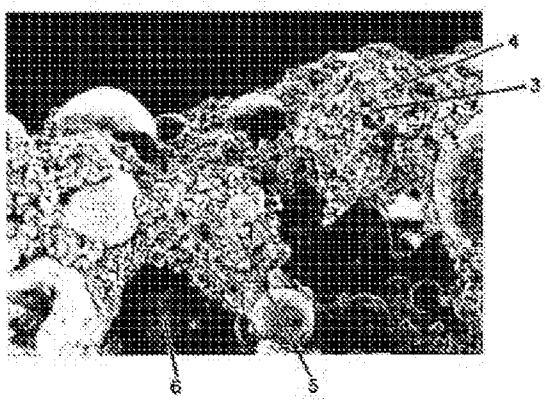


FIG. 2

Last updated: 04.12.2012 Worldwide Database 5.7.44.6; 93p

(19)대한민국특허청(KR)
(12) 공개특허공보(A)

(51) 。Int. Cl.
H01M 2/16 (2006.01)

(11) 공개번호 10-2007-0083975
(43) 공개일자 2007년08월24일

(21) 출원번호 10-2007-7010172
(22) 출원일자 2007년05월04일
심사청구일자 2007년05월04일
번역문 제출일자 2007년05월04일
(86) 국제출원번호 PCT/JP2005/022540
국제출원일자 2005년12월08일
(87) 국제공개번호 WO 2006/062153
국제공개일자 2006년06월15일

(30) 우선권주장 JP-P-2004-00354850 2004년12월08일 일본(JP)

(71) 출원인 히다치 막셀 가부시키가이샤
일본국 오사카후 이바라키시 우시토라 1쵸메 1-88

(72) 발명자 가타야마 히데아키
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아베 도시히로
일본국 오사카후 이바라키시 우시토라 1-1-88,히다치 막셀가부시키가이샤 내
마츠모토 노부아키
일본국 오사카후 이바라키시 우시토라 1쵸메 1-88, 히다치 막셀가부시키가이샤 내
기타 후사지
일본국 오사카후 이바라키시 우시토라 1-1-88,히다치 막셀가부시키가이샤 내
아오야마 시게오
일본국 오사카후 이바라키시 우시토라 1쵸메 1-88, 히다치 막셀가부시키가이샤 내

(74) 대리인 특허법인화우

전체 청구항 수 : 총 20 항

(54) 전기화학 소자용 세퍼레이터 및 전기화학 소자

(57) 요약

본 발명은 150℃ 이상의 내열온도를 가지고 또한 필러입자(3)를 포함하는 다공질 매체(5)와, 융점이 80 ~ 130℃의 범위에 있는 수지 A 및 가열에 의하여 전해액을 흡수하여 팽윤하고 또한 온도상승과 함께 팽윤도가 증대하는 수지 B에서 선택되는 적어도 1종의 섯다운 수지(6)와, 바인더(4)를 포함하는 다공질막으로 이루어지는 전기화학소자용 세퍼레이터를 이용함으로써, 고온에서의 안전성이 우수한 전기화학소자를 제공할 수 있다.

대표도

도 2

특허청구의 범위

청구항 1.

다공질 기체와, 수지를 포함하는 다공질막으로 이루어지는 전기화학 소자용 세퍼레이터에 있어서,

상기 다공질 기체는, 150℃ 이상의 내열온도를 가지고, 또한 필러입자를 포함하며,

상기 수지는, 융점이 80~130℃의 범위에 있는 수지 A, 및 가열에 의하여 전해액을 흡수하여 팽윤하고, 또한 온도상승과 함께 팽윤도가 증대하는 수지 B에서 선택되는 적어도 1종의 셧다운 수지인 것을 특징으로 하는 전기화학 소자용 세퍼레이터.

청구항 2.

제 1항에 있어서,

상기 다공질 기체의 적어도 일부가, 상기 필러입자로 구성되어 있는 것을 특징으로 하는 전기화학 소자용 세퍼레이터.

청구항 3.

제 1항에 있어서,

상기 필러입자는, 상기 다공질 기체의 빈 구멍 내에 함유되어 있는 것을 특징으로 하는 전기화학 소자용 세퍼레이터.

청구항 4.

제 1항에 있어서,

적어도 전해액으로 젖은 상태에서 130℃로 가열되었을 때에, 상기 수지 A의 용융 또는 상기 수지 B의 팽윤에 의하여 셧다운을 일으키는 것을 특징으로 하는 전기화학 소자용 세퍼레이터.

청구항 5.

제 1항에 있어서,

상기 다공질 기체는, 150℃ 이상의 내열온도를 가지는 섬유형상물로 구성되어 있는 것을 특징으로 하는 전기화학 소자용 세퍼레이터.

청구항 6.

제 5항에 있어서,

상기 섬유형상물은, 셀룰로스 및 그 변성체, 폴리올레핀, 폴리에스테르, 폴리아크릴로니트릴, 폴리아라미드, 폴리아미드이미드, 폴리이미드 및 무기산화물로 이루어지는 군으로부터 선택되는 적어도 1종으로 구성되어 있는 것을 특징으로 하는 전기화학 소자용 세퍼레이터.

청구항 7.

제 5항에 있어서,

상기 섬유형상물은, 직포 또는 부직포인 것을 특징으로 하는 전기화학 소자용 세퍼레이터.

청구항 8.

제 1항에 있어서,

상기 셰다운 수지는, 미립자로 구성되어 있는 것을 특징으로 하는 전기화학 소자용 세퍼레이터.

청구항 9.

제 1항에 있어서,

상기 셰다운 수지는, 미립자로 구성되고, 상기 폴리입자와 함께 상기 다공질 기체의 빈 구멍 내에 배치되어 있는 것을 특징으로 하는 전기화학 소자용 세퍼레이터.

청구항 10.

제 1항에 있어서,

상기 수지 A는, 폴리에틸렌, 에틸렌 비닐 모노머 공중합체 및 폴리올레핀 왁스에서 선택되는 적어도 1종인 것을 특징으로 하는 전기화학 소자용 세퍼레이터.

청구항 11.

제 1항에 있어서,

상기 수지 B는, 75 ~ 125℃의 온도범위로 유리 전이온도를 가지는 수지 가교체인 것을 특징으로 하는 전기화학 소자용 세퍼레이터.

청구항 12.

제 11항에 있어서,

상기 수지 가교체는, 스티렌수지, 스티렌부타디엔 공중합체, 아크릴수지, 폴리알킬렌옥시드, 불소수지 및 이것들의 유도체로 이루어지는 군에서 선택되는 적어도 1종의 수지의 가교체인 것을 특징으로 하는 전기화학 소자용 세퍼레이터.

청구항 13.

제 1항에 있어서,

이하의 식으로 나타내는 상기 수지 B의 25℃에서의 팽윤도(B_R)가, 2.5 이하인 것을 특징으로 하는 전기화학 소자용 세퍼레이터.

$$B_R = (V_0 / V_i) - 1$$

단, 상기 식에서 V_0는 전해액 중에 25℃에서 24시간 침지후의 수지 B의 체적(㎤), V_i는, 전해액에 침지하기 전의 수지 B의 체적(㎤)을 각각 나타낸다.

청구항 14.

제 1항에 있어서,

이하의 식으로 나타내는 상기 수지 B의 120℃에서의 팽윤도(B_T)가, 1 이상 인 것을 특징으로 하는 전기화학 소자용 세퍼레이터.

$$B_T = (V_1 / V_0) - 1$$

단, 상기 식에서 V_0는 전해액 중에 25℃에서 24시간 침지후의 수지 B의 체적(㎤), V_1은 전해액 중에 25℃에서 24시간 침지후, 전해액을 120℃로 승온시켜 120℃에서 1시간 유지한 후에 있어서의 수지 B의 체적(㎤)을 각각 나타낸다.

청구항 15.

제 1항에 있어서,

상기 폴리입자는, 무기산화물로 구성되어 있는 것을 특징으로 하는 전기화학 소자용 세퍼레이터.

청구항 16.

제 15항에 있어서,

상기 무기산화물은, Al_2O_3, SiO_2 및 베마이트에서 선택되는 어느 1종인 것을 특징으로 하는 전기화학 소자용 세퍼레이터.

청구항 17.

제 1항에 있어서,

상기 폴리입자는, 판형상의 입자인 것을 특징으로 하는 전기화학 소자용 세퍼레이터.

청구항 18.

제 1항에 있어서,

걸리값으로 표시되는 투기도가, 10~300(sec/100 mL)인 것을 특징으로 하는 전기화학 소자용 세퍼레이터.

청구항 19.

양극, 음극, 비수전해액 및 세퍼레이터를 포함하는 전기화학 소자에 있어서,

상기 세퍼레이터는, 제 1항 내지 제 18항 중 어느 한 항에 기재된 전기화학 소자용 세퍼레이터인 것을 특징으로 하는 전기화학 소자.

청구항 20.

제 19항에 있어서,

상기 세퍼레이터는, 양극 및 음극에서 선택되는 적어도 한쪽과 일체화되어 있는 것을 특징으로 하는 전기화학 소자.

명세서

기술분야

본 발명은 저렴하고 고온시의 치수 안정성이 우수한 전기화학 소자용 세퍼레이터, 및 이것을 이용하여 이루어져 고온환경하에서도 안전한 전기화학 소자에 관한 것이다.

배경기술

리튬 2차 전지나 슈퍼 커패시터로 대표되는 비수전해액을 이용한 전기화학 소자는, 에너지 밀도가 높다는 특징으로부터 휴대전화나 노트형 퍼스널 컴퓨터 등의 휴대기기의 전원으로서 널리 이용되고 있다. 휴대기기의 고성능화에 따라 전기화학 소자의 고용량화가 더욱 진행되는 경향에 있어, 안전성의 확보가 중요하게 되고 있다.

현행의 리튬 2차 전지에서는 양극과 음극의 사이에 개재시키는 세퍼레이터로서, 예를 들면 두께가 20~30 ㎛ 정도의 폴리올레핀계의 다공성 필름이 사용되고 있다. 또 세퍼레이터의 소재로서는 전지의 열폭주(이상발열) 온도 이하에서 세퍼레이터의 구성수지를 용융시켜 빈 구멍을 폐쇄시키고, 이것에 의하여 전지의 내부저항을 상승시켜 단락시 등에 전지의 안전성을 향상시키는 소위 셧다운효과를 확보하기 위하여 융점이 낮은 폴리에틸렌(PE)이 적용되는 경우가 있다.

그런데 이와 같은 세퍼레이터로서는 예를 들면 다공화와 강도향상을 위하여 일축 연신(延伸) 또는 2축 연신한 필름이 사용되고 있다. 이와 같은 세퍼레이터는 단독으로 존재하는 막으로서 공급되기 때문에, 작업성 등의 점에서 일정한 강도가 요구되어 이것을 상기 연신에 의하여 확보하고 있다. 그러나 이와 같은 연신 필름에서는 결정화도가 증대하고 있고, 셧다운 온도도 전지의 열폭주 온도에 가까운 온도로 까지 높아져 있기 때문에 전지의 안전성 확보를 위한 마진이 충분하다고는 하기 어렵다.

또, 상기 연신에 의하여 필름에는 변형이 생기고 있고, 이것이 고온에 노출되면 잔류응력에 의하여 수축이 일어난다는 문제가 있다. 수축온도는 융점, 즉 셧다운 온도와 매우 가까운 곳에 존재한다. 이 때문에 폴리올레핀계의 다공성 필름 세퍼레이터를 사용할 때에는, 충전 이상시 등에 의하여 전지의 온도가 셧다운 온도에 도달하면 전류를 즉시 감소시켜 전지의 온도 상승을 방지하지 않으면 안된다. 빈 구멍이 충분히 폐쇄되지 않아 전류를 즉시 감소할 수 없었던 경우에는 전지의 온도는 용이하게 세퍼레이터의 수축 온도로까지 상승하기 때문에, 내부 단락에 의한 열폭주의 위험성이 있기 때문이다.

이와 같은 열수축에 의한 단락을 방지하기 위하여 내열성의 수지를 사용한 미세 다공막이나 부직포를 세퍼레이터로서 사용하는 방법이 제안되어 있다. 예를 들면 특허문헌 1에는 전방향족 폴리아미드의 미세 다공막을 사용한 세퍼레이터가, 특허문헌 2에는 폴리이미드 다공막을 사용한 세퍼레이터가 개시되어 있다. 또 특허문헌 3에는 폴리아미드 부직포를 사용한 세퍼레이터, 특허문헌 4에는 아라미드섬유를 사용한 부직포를 기재로 한 세퍼레이터, 특허문헌 5에는 폴리프로필렌(PP) 부직포를 사용한 세퍼레이터, 특허문헌 6에는 폴리에스테르 부직포를 사용한 세퍼레이터에 관한 기술이 개시되어 있다.

그러나 상기 내열성의 수지 또는 내열성의 섬유를 사용한 세퍼레이터는, 고온에서의 치수 안정성이 우수하여 박형화가 가능하나, 고온시에 빈 구멍이 폐쇄되는 이른바 셧다운 특성을 가지지 않기 때문에, 외부 단락이나 내부 단락이라는 전지의 온도가 급격하게 상승하는 이상시의 안전성을 충분하게 확보할 수 없다.

이와 같은 문제를 해결하는 기술로서, 예를 들면 특허문헌 7에는 고온시에 전해액의 함유율이 높아지는 폴리머로 이루어지는 세퍼레이터가 나타나 있다. 또특허문헌 8에는 마이크로캡슐 등의 열팽창성의 입자를 함유하는 세퍼레이터가 제안되어 있다.

그러나 특허문헌 7에 기재된 기술에서는 세퍼레이터의 기체로서, 전해액을 함유하는 폴리머의 필름을 사용하고 있기 때문에, 강도의 저하를 초래하기 쉽고, 예를 들면 세퍼레이터를 얇게 하여 전지를 고용량화하는 것이 곤란하다. 원래부터 특허문헌 7에는 세퍼레이터의 재료 및 그 기능에 대한 기재는 있으나, 어떻게 하면 상기 세퍼레이터를 제작할 수 있는지에 대하여 일체 개시가 없고, 어떠한 형태를 가지는 것인지 조차도 불분명하다. 또 특허문헌 8에 기재된 기술에서는 세퍼레이터 중의 입자의 열팽창이 불가역으로 일어나기 때문에, 세퍼레이터나 전지의 제조공정에서 열팽창이 생기는 온도 이상에서의 처리를 할 수 없고, 특히 충분한 건조를 행할 필요가 있는 리튬 2차 전지에서는 건조공정에서의 온도관리를 엄밀하게 행하지 않으면 안된다는 문제가 있다.

[특허문헌 1]

일본국 특개평5-335005호 공보

[특허문헌 2]

일본국 특개2000-306568호 공보

[특허문헌 3]

일본국 특개평9-259856호 공보

[특허문헌 4]

일본국 특개평11-40130호 공보

[특허문헌 5]

일본국 특개2001-291503호 공보

[특허문헌 6]

일본국 특개2003-123728호 공보

[특허문헌 7]

일본국 특개2000-348704호 공보

[특허문헌 8]

일본국 특개2004-111157호 공보

또, 미세 다공막을 사용하지 않고 예를 들면 특허문헌 9에 기재되어 있는 바와 같은 겔형상의 전해질을 사용하는 방법도 검토되고 있다. 그러나, 겔형상 전해질은 열수축성은 없으나 기계적 강도가 약하고, 특히 고온시의 기계적 강도 저하에 의하여 단락 등이 발생할 가능성이 있다. 또한 셧다운 기능이 부여되어 있지 않기 때문에 특히 원통형이나 각형이라는 캔에

봉입된 형태의 전지 등에서는 안전성을 충분히 확보할 수 없다는 문제가 있다. 또 겔형상 전해질을 사용하는 기술에서는 가령 특허문헌 10이나 특허문헌 11에 기재되어 있는 바와 같이 그 기계적 강도의 확보를 위하여 입자나 섬유형상물로 보강한 경우이어도 셧다운 기능이 부여되는 것은 아니기 때문에, 역시 안전성에 관한 문제는 생기게 된다.

[특허문헌 9]

일본국 특개평8-287949호 공보

[특허문헌 10]

일본국 특개평11-185773호 공보

[특허문헌 11]

일본국 특개2002-237332호 공보

한편, 특허문헌 12에는 기체가 되는 폴리불화비닐리덴 등의 수지를 포함하는 용액에, 가교된 폴리메틸메타크릴레이트(PMMA) 등의 미립자를 분산시키고, 이것을 도포·건조시킴으로써, 다공질 수지막의 공극 내에 가교 미립자를 유지시킨 보액성이 우수한 세퍼레이터를 형성하는 기술이 나타나 있다.

그러나 특허문헌 12에 개시된 상기 다공질 수지막은 실질적으로는 고분자 겔 전해질막과 동일하고, 세퍼레이터 내의 전해액은 가교 미립자 및 다공질 수지막에 흡수되어 유지되기 때문에, 고온에서 전지의 반응이 억제되는 것은 아니고, 상기 겔형상 전해질과 마찬가지로 안전성에서 문제를 일으키게 된다.

[특허문헌 12]

일본국 특개2004-241135호 공보

본 발명은 상기 사정을 감안하여 이루어진 것으로, 그 목적은 이상발열하였을 때의 안전성이 우수한 전기화학 소자를 구성할 수 있는 세퍼레이터 및 그 세퍼레이터를 구비한 전기화학 소자를 제공하는 것에 있다.

발명의 상세한 설명

본 발명의 전기화학 소자용 세퍼레이터는, 다공질 기체와, 수지를 포함하는 다공질막으로 이루어지는 전기화학 소자용 세퍼레이터로서, 상기 다공질 기체는 150℃ 이상의 내열온도를 가지고, 또한 필러입자를 포함하며, 상기 수지는 융점이 80~130℃의 범위에 있는 수지 A, 및 가열에 의하여 전해액을 흡수하여 팽윤하고 또한 온도 상승과 함께 팽윤도가 증대하는 수지 B에서 선택되는 적어도 1종의 셧다운 수지인 것을 특징으로 한다.

또, 본 발명의 전기화학 소자는, 양극, 음극, 비수전해액 및 세퍼레이터를 포함하는 전기화학 소자로서, 상기 세퍼레이터는 상기 본 발명의 전기화학 소자용 세퍼레이터인 것을 특징으로 한다.

본 발명에 의하면 단락이나 과충전 등에 의하여 전지의 온도가 이상으로 상승하였을 때의 안전성이 우수한 전기화학 소자를 제공할 수 있다.

실시예

본 발명의 세퍼레이터는 150℃ 이상의 내열온도를 가지고 또한 필러입자를 포함하는 다공질 기체와, 융점이 80~130℃의 범위에 있는 수지 A, 및 가열에 의하여 전해액을 흡수하여 팽윤하고, 또한 온도 상승과 함께 팽윤도가 증대하는 수지 B에서 선택되는 적어도 1종의 셧다운 수지를 구비하는 다공질막이다.

본 발명의 세퍼레이터가 상기 수지 A를 함유하고 있는 경우는, 본 발명의 세퍼레이터가 조립된 리튬 2차 전지의 온도가, 수지 A의 융점 이상에 도달하였을 때에 수지 A가 용융하여 세퍼레이터의 빈 구멍을 막아 전기화학반응의 진행을 억제하

는 셧다운을 일으킨다. 또 본 발명의 세퍼레이터가 상기 수지 B를 함유하고 있는 경우는 전지의 온도상승에 의하여 수지 B가 전지 내의 전해액을 흡수하여 팽윤하고, 팽윤한 입자가 세퍼레이터의 빈 구멍을 막음과 동시에 빈 구멍 내부에 존재하는 유동 가능한 전해액이 감소함으로써 셧다운을 일으킨다.

또, 본 발명의 세퍼레이터는, 150℃ 이상의 내열온도를 가지는 다공질 기체를 구비함으로써, 셧다운 온도를 넘는 고온상태에서도 세퍼레이터의 형상을 안정되게 유지하는 것이 가능해져, 열수축에 기인하는 단락의 발생을 방지할 수 있다. 이 때문에 셧다운이 생긴 후의 전지의 안전성을 향상시킬 수 있다. 또한 본 명세서에서 말하는 「내열온도」란, 대상물의 길이의 변화, 즉 상기 다공질 기체에서는 실온에서의 길이에 대한 수축의 비율(수축률)이 5% 이하를 유지할 수 있는 상한온도를 말한다. 또 본 명세서에서 말하는 「내열성」이란, 연화 등에 의한 실질적인 치수변화가 생기지 않는 것을 말하며, 내열온도가 셧다운 온도보다 충분히 높은 지의 여부에 의하여 내열성을 평가한다. 셧다운후의 안전성을 높이기 위하여 다공질 기체는 셧다운 온도보다 20℃ 이상 높은 내열온도를 가지는 것이 바람직하고, 더욱 구체적으로는 다공질 기체의 내열온도를 150℃ 이상으로 하는 것이 바람직하며, 180℃ 이상으로 하는 것이 더욱 바람직하다.

또한 본 발명의 세퍼레이터에서는 내부 단락의 방지나 세퍼레이터의 형상안정성(특히 고온시에 있어서의 형상 안정성)의 확보 등을 위하여 상기 다공질 기체는 필러입자를 포함하고 있다. 즉, 상기 다공질 기체의 적어도 일부를 필러입자로 구성하거나, 또는 다공질 기체의 빈 구멍 내에 필러입자를 함유시킨다. 필러입자로서는 내열성 및 전기절연성을 가지고 있고, 전해액이나 세퍼레이터의 제조시에 사용하는 용매에 대하여 안정되고, 또한 전지의 작동 전압 범위에서 산화환원되기 어려운 전기화학적으로 안정된 미립자가 사용된다.

본 발명의 세퍼레이터의 더욱 구체적인 형태로서는 예를 들면 하기 (I) 및(II)의 형태를 들 수 있다.

(I) 형태의 세퍼레이터는, 필러입자가 다수 집합하여 다공질 기체를 형성하고 있는 것으로, 다수의 필러입자가 단독으로 또는 섬유형상물 등과 함께, 내열수지 등에 의하여 일체화되어 다공질 기체가 되고, 셧다운 수지와 함께 다공질막을 형성하고 있는 것이다.

또, (II) 형태의 세퍼레이터는, 섬유형상물로 다공질 기체, 예를 들면 직포, 부직포(종이를 포함한다) 등을 구성하고, 그 빈 구멍 내에 필러입자를 함유시켜 셧다운 수지와 함께 다공질막을 형성하고 있는 것이다.

셧다운 수지의 형태는 특별히 한정은 되지 않으나, 다공질막 내에 균일 분산시키기 위하여 미립자의 형상의 것을 사용하는 것이 바람직하고, 그 크기는 건조시에서의 입자지름이 세퍼레이터의 두께보다 작으면 좋고, 세퍼레이터 두께의 1/100~1/3의 평균 입자지름을 가지는 것이 바람직하며, 구체적으로는 평균 입자지름이 0.1~20 ㎛ 인 것이 바람직하다. 입자지름이 너무 작은 경우는 입자끼리의 간극이 작아지고, 이온의 전도 패스가 길어져 전지특성이 저하하는 경우가 있다. 또 입자지름이 너무 크면, 간극이 커져 리튬 덴드라이트 등에 기인하는 단락이 생기는 경우가 있다. 또한 셧다운 수지의 평균 입자지름은, 예를 들면 레이저 산란입도 분포계, 예를 들면 HORIBA 사제 "LA-920"을 사용하고, 셧다운 수지를 팽윤시키지 않는 매체, 예를 들면 물에 해당 미립자를 분산시켜 측정한 수평균 입자지름으로서 규정할 수 있다.

또, 셧다운 수지는 상기 이외의 형태에서 사용하여도 좋고, 다른 구성요소, 예를 들면 다공질 기체나 필러입자의 표면에 적층되어 일체화된 상태에서 사용하여도 좋다. 다공질 기체가 섬유형상물로 구성되어 있는 경우는, 코어재료의 표면에 셧다운 수지를 가지는 복층구조의 섬유로서 사용하여도 좋고, 또 필러입자를 코어로 하고, 셧다운 수지를 셸로 하는 코어셸구조의 입자로서 사용하여도 좋다. 또 수지 A와 수지 B를 함께 사용하는 경우는, 수지 B의 표면에 수지 A를 적층시켜 일체화한 것을 사용할 수도 있다. 또한 셧다운 수지는, 미립자로 구성되고, 필러입자와 함께 다공질 기체의 빈 구멍 내에 배치되어 있어도 좋다.

본 발명의 셧다운 수지는, 융점이 80~130℃의 범위에 있는 수지 A, 또는 가열에 의하여 전해액을 흡수하여 팽윤하고 또한 온도 상승과 함께 팽윤도가 증대하는 수지 B이며, 그 양자를 함께 사용할 수도 있다. 또한 상기 융점은 예를 들면 일본국 공업규격(JIS)K 7121의 규정에 준하여, 시차 주사 열량계(DSC)를 사용하여 측정되는 융해온도에 의하여 규정할 수 있다.

상기 수지 A의 구성재료로서는 전기절연성을 가지고 있고, 전해액에 대하여 안정되며, 또한 전지의 작동 전압 범위에서 산화 환원되기 어려운 전기화학적으로 안정된 재료가 바람직하고, 폴리에틸렌(PE), 공중합 폴리올레핀, 또는 폴리올레핀 유도체(염소화 폴리에틸렌 등), 폴리올레핀 왁스, 석유 왁스, 칼나바 왁스 등을 들 수 있다. 상기 공중합 폴리올레핀으로서는 에틸렌 비닐 모노머 공중합체, 더욱 구체적으로는 에틸렌-아세트산 비닐 공중합체(EVA), 또는 에틸렌-메틸아크릴레이트

공중합체나 에틸렌-에틸아크릴레이트 공중합체 등의, 에틸렌-아크릴산공중합체를 예시할 수 있다. 상기 공중합 폴리올레핀에서의 에틸렌 유래의 구조단위는, 85 mol% 이상인 것이 바람직하다. 또 폴리시클로올레핀 등을 사용할 수도 있고, 상기 구성재료의 2종 이상을 가지고 있어도 상관없다.

상기 재료 중에서도 PE, 폴리올레핀 왁스, 또는 에틸렌 유래의 구조단위가 85 mol% 이상인 EVA가 적합하게 사용된다. 또 수지 A는 구성성분으로서 상기한 구성재료 외에, 필요에 따라 수지에 첨가되는 각종 첨가제, 예를 들면 산화방지제 등을 함유하고 있어도 상관없다.

한편, 상기 수지 B의 구성재료로서는 통상 전지가 사용되는 온도영역(대략 70℃ 이하)에서는, 전해액을 흡수하지 않거나 또는 흡수량이 한정되어 있고, 따라서 팽윤도가 일정 이하이나, 셧다운이 필요하게 되는 온도까지 가열되었을 때에는 전해액을 흡수하여 크게 팽윤하고 또한 온도 상승과 함께 팽윤도가 증대하는 성질을 가지는 수지가 사용된다. 셧다운 온도보다 저온측에서는, 수지 B에 흡수되지않는 유동 가능한 전해액이 세퍼레이터의 빈 구멍 내에 존재하기 때문에, 세퍼레이터 내부의 Li 이온의 전도성이 높아져, 양호한 부하특성을 가지는 전지가 된다. 또한, 본 명세서에서 말하는 「부하특성」이란, 고율 방전특성을 말한다. 한편, 온도 상승에 따라 팽윤도가 증대하는 성질(이하, 「열팽윤성」이라는 경우가 있다.)이 나타나는 온도 이상으로 가열된 경우는, 수지 B는 전지 내의 전해액을 흡수하여 크게 팽윤하고, 팽윤한 입자가 세퍼레이터의 빈 구멍을 막음과 동시에 상기 유동 가능한 전해액이 감소하여 전지가 액마름 상태가 됨으로써 셧다운이 생겨 전지의 안전성이 확보된다. 또한 셧다운 온도를 넘는 고온이 된 경우, 열팽윤성에 의하여 상기 액마름이 더욱 진행되고, 전지의 반응이 더욱 억제되게 되기 때문에, 셧다운 후의 고온 안전성을 더욱 높일 수 있다.

수지 B가 열팽윤성을 나타내기 시작하는 온도는, 적어도 75℃ 이상인 것이 바람직하다. 상기 온도를 75℃ 이상으로 함으로써 Li 이온의 전도성이 현저하게 감소하여 전지의 내부 저항이 상승하는 온도(이른바 셧다운 온도)를 약 80℃ 이상으로 설정할 수 있기 때문이다. 한편, 열팽윤성을 나타내는 온도의 하한이 높아질수록 세퍼레이터의 셧다운 온도가 높아지기 때문에, 셧다운 온도를 대략 130℃ 이하로 설정하기 위하여 열팽윤성을 나타내는 온도의 하한은, 125℃ 이하로 하는 것이 바람직하고, 115℃ 이하로 하는 것이 더욱 바람직하다. 열팽윤성을 나타내는 온도가 너무 높으면, 전지 내의 활물질의 열폭주 반응을 충분히 억제할 수 없어 전지의 안전성 향상 효과를 충분히 확보할 수 없는 경우가 있고, 또 열팽윤성을 나타내는 온도가 너무 낮으면 통상의 전지의 사용 온도역(약 70℃ 이하)에서의 리튬이온의 전도성이 너무 낮아지는 경우가 있다.

또, 열팽윤성을 나타내는 온도보다 낮은 온도에서는 수지 B는 전해액을 가능한 한 흡수하지 않고, 팽윤이 적은 쪽이 바람직하다. 이것은 전지의 사용온도영역, 예를 들면 실온에서는 전해액은 수지 B에 도입되기 보다 세퍼레이터의 빈 구멍 내에 유동 가능한 상태에서 유지되는 쪽이, 부하특성 등의 전지특성이 양호하게 되기 때문이다.

상온(25℃)에서 수지 B가 흡수하는 전해액량은, 수지 B의 체적변화를 나타내는 하기 수학식 (1)에서 정의되는 팽윤도에 의하여 평가할 수 있다.

$$B_R = (V_0 / V_i) - 1$$

단, 상기 식에서 V_0는 전해액 중에 25℃에서 24시간 침지후의 수지 B의 체적(㎤), V_i는 전해액에 침지하기 전의 수지 B의 체적(㎤)을 각각 나타낸다.

본 발명의 세퍼레이터에서는 상온(25℃)에서의 수지의 팽윤도(B_R)는, 2.5 이하인 것이 바람직하고, 1 이하가 더욱 바람직하다. 즉, 전해액의 흡수에 의한 팽윤이 작은 것이 바람직하고, B_R은 가능한 한 0에 가까운 작은 값이 되는 것이 바람직하다. 또 열팽윤성을 나타내는 온도보다 저온측에서는, 팽윤도의 온도변화가 가능한 한 작아지는 것이 바람직하다.

한편, 수지 B로서는 열팽윤성을 나타내는 온도의 하한 이상으로 가열되었을 때는, 전해액의 흡수량이 커지고, 열팽윤성을 나타내는 온도범위에서 온도와 함께 팽윤도가 증대하는 것이 사용된다. 예를 들면 120℃에서 측정되는 하기 수학식 (2)에서 정의되는 팽윤도(B_T)가, 1 이상인 것이 바람직하게 사용되고, 2 이상의 것이 더욱 바람직하다.

$$B_T = (V_1 / V_0) - 1$$

단, 상기 식에서 V_0은, 전해액 중에 25℃에서 24시간 침지후의 수지 B의 체적(㎤), V_1은 전해액 중에 25℃에서 24시간 침지후, 전해액을 120℃로 승온시키고, 120℃에서 1시간 유지한 후에 있어서의 수지 B의 체적(㎤)을 각각 나타낸다.

한편, 상기 수학식 (2)에서 정의되는 수지 B의 팽윤도는, 너무 커지면 전지의 변형을 발생시킬 수도 있기 때문에, 10 이하인 것이 바람직하고, 5 이하가 더욱 바람직하다.

상기 수학식 (2)에서 정의되는 팽윤도는, 수지 B의 크기의 변화를, 광산란법이나 CCD 카메라 등에 의하여 촬영된 화상의 화상해석이라던 방법을 사용하여, 직접 측정함으로써 예측할 수 있으나, 예를 들면 이하의 방법을 사용하여 더욱 정확하게 측정할 수 있다.

상기 수학식 (1) 및 수학식 (2)와 동일하게 정의되는 25℃ 및 120℃ 에서의 팽윤도를 알고 있는 바인더수지를 이용하고, 그 용액 또는 에멀전에 수지 B를 혼합하여 슬러리를 조제하고, 이것을 폴리에틸렌테레프탈레이트(PET)시트나 유리판 등의 기재 위에 도포하여 필름을 제작하고, 그 질량을 측정한다. 다음에 이 필름을 25℃의 전해액 중에 24시간 침지하여 질량을 측정하고, 또한 전해액을 120℃로 가열 승온시켜, 120℃에서 1시간 유지한 후에 있어서의 질량을 측정하고, 하기 수학식 (3)~수학식 (9)에 의하여 팽윤도(B_T)를 산출한다. 또한 하기 수학식 (3)~수학식 (9)에서는 25℃에서 120℃까지 승온하였을 때의, 전해액 이외의 성분의 체적증가는 무시할 수 있는 것으로 한다.

$$V_i = M_i \times W / P_A$$

$$V_B = (M_0 - M_i) / P_B$$

$$V_C = M_1 / P_C - M_0 / P_B$$

$$V_V = M_i \times (1 - W) / P_V$$

$$V_0 = V_i + V_B - V_V \times (B_B + 1)$$

$$V_D = V_V \times (B_B + 1)$$

$$B_T = \{V_0 + V_C - V_D \times (B_C + 1)\} / V_0 - 1$$

여기서, 상기 수학식 (3)~(9)에 있어서,

V_i : 전해액에 침지하기 전의 수지 B의 체적(㎤),

V_o : 전해액 중에 25℃에서 24시간 침지 후의 수지 B의 체적(㎤),

V_B : 전해액 중에 상온에서 24시간 침지 후에, 필름에 흡수된 전해액의 체적(㎤),

V_C : 전해액 중에 상온에서 24시간 침지한 시점에서, 전해액을 120℃까지 승온시키고, 다시 120℃에서 1시간 경과하기까지의 사이에, 필름에 흡수된 전해액의 체적(㎤),

V_V : 전해액에 침지하기 전의 바인더 수지의 체적(㎤),

V_D : 전해액 중에 상온에서 24시간 침지 후의 바인더 수지의 체적(㎤),

M_i : 전해액에 침지하기 전의 필름의 질량(g),

M_0 :전해액 중에 상온에서 24시간 침지 후의 필름의 질량(g),

M_1 : 전해액 중에 상온에서 24시간 침지한 후, 전해액을 120℃까지 승온시키고, 또한 120℃에서 1시간 유지한 후에 있어서의 필름의 질량(g),

W : 전해액에 침지하기 전의 필름 중의 수지 B의 질량비율,

P_A : 전해액에 침지하기 전의 수지 B의 비중(g/㎤),

P_B : 상온에서의 전해액의 비중(g/㎤),

P_C : 소정 온도에서의 전해액의 비중(g/㎤),

P_V : 전해액에 침지하기 전의 바인더 수지의 비중(g/㎤),

B_B : 전해액 중에 상온에서 24시간 침지 후의 바인더 수지의 팽윤도,

B_C : 상기 수학식 (1)에서 정의되는 승온시의 바인더 수지의 팽윤도이다.

수지 B로서는 내열성 및 전기절연성을 가지고 있고, 전해액에 대하여 안정 이며, 또한 전지의 작동 전압 범위에서 산화 환원되기 어려운 전기화학적으로 안정된 재료가 바람직하고, 그와 같은 재료로서는 예를 들면 수지 가교체를 들 수 있다. 더욱 구체적으로는 스티렌수지[폴리스티렌(PS) 등], 스티렌부타디엔 공중합체, 아크릴 수지[폴리메틸메타크릴레이트(PMMA) 등], 폴리알킬렌옥시드[폴리에틸렌 옥시드(PEO) 등], 불소수지[폴리불화비닐리덴(PVDF) 등] 및 이들 유도체로 이루어지는 군에서 선택되는 적어도 1종의 수지의 가교체, 요소수지, 폴리우레탄 등을 예시할 수 있고, 이들을 2종 이상 사용할 수도 있다. 또 수지 B는 구성성분으로서 상기와 같은 주요 구성재료 외에 필요에 따라 수지에 첨가되는 각종첨가제, 예를 들면 산화방지제 등을 함유하고 있어도 상관없다.

상기한 구성재료 중에서는 스티렌 수지 가교체, 아크릴 수지 가교체 및 불소수지 가교체가 바람직하고, 가교 PMMA가 특히 바람직하게 사용된다.

이들 수지 가교체가, 온도 상승에 의하여 전해액을 흡수하여 팽윤하는 메카니즘에 대해서는 분명하지 않으나, 유리 전이온도와의 상관을 생각할 수 있다. 즉, 수지는 일반적으로 그 유리 전이온도(Tg)까지 가열되었을 때에 유연해지기 때문에, 상기와 같은 수지는, 유리 전이온도 이상의 온도에서 많은 전해액의 흡수가 가능하게 되어 팽윤되는 것은 아닌가라고 추정된다. 따라서 수지 B로서는 실제로 셧다운작용이 생기는 온도가, 수지 B가 열팽윤성을 나타내기 시작하는 온도보다 다소 높아지는 것을 고려하여, 대략 75~125℃의 범위에 유리 전이온도를 가지는 재료를 사용하는 것이 바람직하다고 생각된다. 동일한 수지 가교체이어도 시판품에는 여러가지 유리 전이온도의 것이 존재하나, 예를 들면 재료의 가교도를 제어함으로써 유리 전이온도를 변화시킬 수 있기 때문에, 원하는 유리 전이온도가 되도록 조제된 재료를 사용하면 좋다.

상기 수지 가교체에서는 전해액을 포함하기 전의 이른바 건조상태에서는 온도 상승에 의하여 팽창하여도 온도를 내림으로써 다시 수축한다는 바와 같이 온도변화에 따르는 체적변화에 어느 정도 가역성이 있고, 또 열팽윤성을 나타내는 온도보다 상당히 높은 내열온도를 가지기 때문에, 열팽윤성을 나타내는 온도의 하한이 100℃ 정도이어도 200℃ 또는 그것 이상까지 가열하는 것이 가능한 재료를 선택할 수 있다. 그 때문에 세퍼레이터의 제작공정 등에서 가열을 행하여도 수지가 용해되거나 수지의 열팽윤성이 손상되거나 하지 않고 일반의 가열 프로세스를 포함하는 제조공정에서의 취급이 용이해진다. 또 본 발명의 세퍼레이터에서는 종래의 폴리에틸렌제 다공질 필름으로 구성되는 세퍼레이터와는 달리, 강한 응력을 인가하지 않고 제조하는 것이 가능하기 때문에, 제조후의 잔류 응력이 거의 또는 전혀 없고, 다공질 기체에는 근본적으로 열수축이 거의 생기지 않기 때문에 제조방법의 면에서도 고온에서의 안전성 향상을 도모할 수 있다.

상기 수지 A 및 수지 B는, 각각 단독으로 사용할 수도 있고, 또 양자를 공존시킬 수도 있다. 이들 셧다운 수지의 함유량(체적비율)은, 셧다운의 효과를 더욱 얻기 쉽게 하기 위하여 세퍼레이터의 전구성 성분 중, 10 체적% 이상으로 하는 것이 바람직하고, 20 체적% 이상으로 하는 것이 더욱 바람직하며, 한편 세퍼레이터의 고온시에서의 형상 안정성 확보의 점에서, 80 체적% 이하인 것이 바람직하고, 40 체적% 이하인 것이 더욱 바람직하다.

또, 본 발명에서 사용되는 필러입자는, 상기 (I)의 형태와 같이 세퍼레이터를 구성하는 다공질 기체의 적어도 일부로서 존재하거나 또는 상기 (II)의 형태와 같이 다공질 기체의 빈 구멍 내에 존재하는 것이다.

필러입자는 유기입자이어도 무기입자이어도 좋으나, 분산성 등의 점에서 미립자인 것이 바람직하고, 안정성 등의 점에서 무기미립자가 바람직하게 사용된다. 무기입자의 구성재료의 구체예로서는 예를 들면 산화철, SiO_2, Al_2O_3, TiO_2, $BaTiO_2$, ZrO_2 등의 무기산화물, 질화알루미늄, 질화규소 등의 무기질화물, 불화 칼슘, 불화 바륨, 황산 바륨 등의 난용성의 이온 결정, 실리콘, 다이아몬드 등의 공유 결합성 결정, 몬모릴로나이트 등의 점토를 들 수 있다. 여기서 상기 무기산화물은 베마이트, 제올라이트, 아파타이트, 카올린, 뮬라이트, 스피넬, 올리빈 등의 광물자원 유래물질 또는 이것들의 인조물 등이어도 좋다. 또 금속 또는 SnO_2, 주석-인듐산화물(ITO) 등의 도전성 산화물, 또는 카본블랙, 그라파이트 등의 탄소질재료 등에 예시되는 도전성재료의 표면을 전기절연성을 가지는 재료, 예를 들면 상기 무기산화물 등으로 피복함으로써 전기절연성을 가지게 한 입자이어도 좋다. 상기 무기산화물 중에서도 Al_2O_3, SiO_2 및 베마이트가 특히 바람직하게 사용된다.

필러입자의 형상으로서는, 예를 들면 구형상에 가까운 형상이어도 좋고, 판형상이어도 좋으나, 단락방지의 점에서는 판형상의 입자인 것이 바람직하다. 판형상 입자의 대표적인 것으로서는 판형상의 Al_2O_3나 판형상 베마이트 등을 들 수 있다. 또 필러입자의 입자지름은 상기 측정법으로 측정되는 수평균 입자지름으로서, 예를 들면 0.01 ㎛ 이상이 바람직하고, 더욱 바람직하게는 0.1 ㎛ 이상이며, 15 ㎛ 이하가 바람직하고, 5 ㎛ 이하인 것이 더욱 바람직하다.

판형상의 미립자를 세퍼레이터에 함유시키는 경우에는, 뒤에서 설명하는 방법 등에 의하여 미립자의 판면을 세퍼레이터의 막면과 가능한 한 평행하게 되 도록 배향시킬 수 있다. 이에 의하여 전극 표면에 석출하는 리튬 덴드라이트나 전극 표면의 활물질의 돌기에 의하여 내부 단락이 생기는 것을 더욱 효과적으로 방지할 수 있다. 판형상 입자의 경우에는 그 종횡비(판형상 입자 중의 최대 길이와 판형상 입자의 두께의 비)는, 예를 들면 2~100인 것이 바람직하다. 또 평균입자지름은 세퍼레이터의 두께보다 작으면 좋고, 한편, 세퍼레이터 두께의 1/100 이상으로 하는 것이 바람직하다. 또한 판형상의 미립자로서는 상기 무기미립자 이외에, 내열온도가 150℃ 이상의 수지재료 등을 사용할 수 있다. 상기 예시한 재료는, 2종 이상을 병용할 수도 있다.

상기 (I) 형태의 세퍼레이터의 다공질 기체는, 다수의 필러입자를 바인더 등에 의하여 일체화시켜 형성되나, 상기 바인더로서는 EVA(아세트산 비닐 유래의 구조단위가 20~35 mol%인 것), 에틸렌-에틸아크릴레이트 공중합체 등의 에틸렌-아크릴산 공중합체, 불소계 고무, 스티렌부타디엔고무(SBR), 카르복시메틸셀룰로스(CMC), 하이드록시에틸셀룰로스(HEC), 폴리비닐알콜(PVA), 폴리비닐부티랄(PVB), 폴리비닐피롤리돈(PVP), 폴리우레탄, 에폭시수지 등이 사용된다. 특히 150℃ 이상의 내열온도를 가지는 내열수지가 바람직하게 사용되고, 상기 바인더는 2종 이상을 병용하여도 상관없다. 또한 이들 바인더를 사용하는 경우에는 뒤에서 설명하는 세퍼레이터 형성용 액형상 조성물의 용매에 용해시키거나 또는 분산시킨 에멀션의 형태에서 사용하면 좋다.

또, 세퍼레이터의 형상 안정성이나 유연성을 확보하기 위하여 섬유형상물 등을 필러입자와 함께 혼재시켜도 좋고, 섬유형상물로서는, 내열온도가 150℃ 이상이고, 전기절연성을 가지고 있으며, 전기화학적으로 안정되고, 또한 하기에 상세하게 설명하는 전해액이나, 세퍼레이터의 제조시에 사용하는 용매에 안정되면 특별히 재질에 제한은 없다. 또한 본 명세서에서 말하는 「섬유형상물」이란, 종횡비〔긴 방향의 길이/긴 방향으로 직교하는 방향의 폭(직경)〕이 4 이상인 것을 의미하고 있고, 종횡비는 10 이상인 것이 바람직하다.

섬유형상물의 구체적인 구성재료로서는, 예를 들면 셀룰로스 및 그 변성체[카르복시메틸셀룰로스(CMC), 하이드록시프로필셀룰로스(HPC) 등], 폴리올레핀[폴리프로필렌(PP), 프로필렌의 공중합체 등], 폴리에스테르[폴리에틸렌테레프탈레이트(PET), 폴리에틸렌나프타레이트(PEN), 폴리부틸렌테레프탈레이트(PBT) 등], 폴리아크릴로니트릴(PAN), 폴리아라미드, 폴리아미드이미드, 폴리이미드 등의 수지, 유리, 알루미나, 지르코니아, 실리카 등의 무기산화물 등을 들 수 있고, 이들 구성재료는 2종 이상을 함유하고 있어도 상관없다. 또 섬유형상물은 필요에 따라 각종 첨가제, 예를 들면 수지인 경우에는 산화방지제 등을 함유하고 있어도 상관없다.

한편, 상기 (II) 형태의 세퍼레이터의 다공질 기체는, 상기 섬유형상물이 직포, 부직포(종이를 포함한다) 등의 시트 형상물을 형성하여 이루어지는 것이고, 시판의 부직포 등을 기체로서 사용할 수 있다. 이 형태의 세퍼레이터에서는 다공질 기체의 빈 구멍 내에 필러입자를 함유시키나, 다공질 기체와 필러입자를 결착시키기 위하여, 또는 셧다운 수지와 다공질 기체를 결착시키기 위하여 상기 바인더를 사용할 수도 있다.

또, 섬유형상물의 직경은 세퍼레이터의 두께 이하이면 좋으나, 예를 들면 0.01~5 ㎛ 인 것이 바람직하다. 직경이 너무 크면 섬유형상물끼리의 얽힘이 부족하고, 시트형상물을 형성하여 다공질막의 기체를 구성하는 경우에 그 강도가 작아져 취급이 곤란하게 되는 경우가 있다. 또 직경이 너무 작으면 세퍼레이터의 공극이 너무 작아져 이온 투과성이 저하하는 경향에 있고, 전지의 부하특성을 저하시키는 경우가 있다.

(II) 형태의 세퍼레이터에서의 섬유형상물의 함유량은, 세퍼레이터의 전구성 성분 중, 예를 들면 10 체적% 이상이 바람직하고, 더욱 바람직하게는 20 체적% 이상이며, 90 체적% 이하가 바람직하고, 80 체적% 이하가 더욱 바람직하다. 세퍼레이터 중에서의 섬유형상물의 존재상태는, 예를 들면 장축(긴 방향의 축)의 세퍼레이터면에 대한 각도가 평균으로 30°이하인 것이 바람직하고, 20°이하인 것이 더욱 바람직하다.

또, 필러입자의 함유량은 내부 단락방지의 효과를 향상시키기 위해서는, 세퍼레이터의 전구성 성분 중, 20 체적% 이상으로 하는 것이 바람직하고, 50 체적% 이상으로 하는 것이 더욱 바람직하며, 셧다운 수지의 함유량을 확보하여 셧다운특성을 유지하기 위해서는 80 체적% 이하로 함유량을 억제하는 것이 바람직하다.

한편, (I) 형태의 세퍼레이터에서는 다공질 기체가 차지하는 비율이, 세퍼레이터의 전구성 성분 중, 10 체적% 이상 90 체적% 이하가 되도록 필러입자나 바인더의 함유량을 조정하는 것이 바람직하다.

전지의 단락방지 효과를 더욱 높이고, 세퍼레이터의 강도를 확보하여 취급 성을 양호하게 하면서, 전지의 에너지 밀도를 더욱 높이는 관점에서 세퍼레이터의 두께는 예를 들면 3 ㎛ 이상이 바람직하고, 더욱 바람직하게는 5 ㎛ 이상이며, 한편, 30 ㎛ 이하가 바람직하고, 20 ㎛ 이하인 것이 더욱 바람직하다.

또, 세퍼레이터의 공극율로서는 전해액의 보액량을 확보하여 이온 투과성을 양호하게 하기 위하여 건조한 상태에서 20% 이상으로 하는 것이 좋고, 더욱 바람직하게는 30% 이상이다. 한편, 세퍼레이터 강도의 확보와 내부 단락의 방지의 관점에서 세퍼레이터의 공극율은 70% 이하로 하는 것이 바람직하고, 60% 이하인 것이 더욱 바람직하다. 또한 세퍼레이터의 공극율 : P(%)은, 세퍼레이터의 두께, 면적당 질량, 구성성분의 밀도로부터 다음식을 이용하여 각 성분(i)에 대한 총합을 구함으로써 계산할 수 있다.

$$P=100-(\Sigma a_i / \rho_i) \times (m/t)$$

여기서, 상기 식에서 a_i : 질량%로 표시한 성분(i)의 비율, ρ_i : 성분(i)의 밀도(g/㎤), m : 세퍼레이터의 단위 면적당 질량(g/㎠), t : 세퍼레이터의 두께(cm)이다.

또한 수지 B를 포함하는 세퍼레이터에서는 전지의 조립후에 있어서, 수지 B가 전해액을 흡수하여 팽윤하고, 세퍼레이터의 공극율이 다소 저하하여도 문제는 없고, 세퍼레이터의 공극율이 10% 이상이면 적합하다.

또, 본 발명의 세퍼레이터의 걸리값으로 표시되는 투기도는, 10~300 sec 인 것이 바람직하다. 여기서 걸리값이란, JIS P 8117에 준거한 방법으로 측정되는 0.879 g/㎟의 압력하에서 100 mL의 공기가 막을 투과하는 초수의 값을 말한다. 걸리값이 너무 크면 이온 투과성이 작아지고, 한편 너무 작으면 세퍼레이터의 강도가 작아지는 경우가 있다. 또한 세퍼레이터의 강도로서는 직경 1 mm의 바늘을 이용한 돌자강도로 50 g 이상인 것이 바람직하다. 이와 같은 돌자강도가 너무 작으면 리튬의 덴드라이트 결정이 발생한 경우에, 세퍼레이터의 돌파에 의한 단락이 발생하는 경우가 있다.

본 발명의 세퍼레이터의 제조방법으로서는, 예를 들면 하기의 (a) 및 (b)의 방법을 채용할 수 있다. (a)의 제조방법은, 세퍼레이터의 기체에 셧다운 수지 및 필러입자를 포함하는 액형상 조성물(슬러리 등)을 도포 또는 함침시킨 후, 소정의 온도에서 건조하는 방법이다. 이에 의하여 상기 (II) 형태의 세퍼레이터를 제조할 수 있다. 이 경우의 다공질 매체로서는 구체적으로는 상기 예시의 각 재료를 구성성분에 포함하는 섬유형상물의 적어도 1종으로 구성되는 직포나, 이들 섬유형상물끼리가 얽힌 구조를 가지는 부직포 등의 다공질 시트 등이 사용된다. 더욱 구체적으로는 종이, PP부직포, 폴리에스테르 부직포(PET부직포, PEN부직포, PBT 부직포 등), PAN 부직포 등의 부직포를 예시할 수 있다.

상기 액형상 조성물은 셧다운 수지 및 필러입자 외에, 필요에 따라 바인더 등을 함유하고, 이들을 용매(분산매를 포함하는, 이하 동일)에 분산시킨 것이고, 바인더에 대해서는 용매에 용해시킬 수도 있다. 액형상 조성물에 사용되는 용매는 셧다운 수지나 필러입자를 균일하게 분산할 수 있고, 또 바인더를 균일하게 용해 또는 분산할 수 있는 것이면 좋으나, 예를 들면 톨루엔 등의 방향족 탄화수소, 테트라하이드로푸란 등의 푸란류, 메틸에틸케톤, 메틸이소부틸케톤 등의 케톤류등, 일반적으로 유기용매가 적합하게 사용된다. 또한 이들 용매에 계면장력을 제어할 목적으로, 알콜(에틸렌글리콜, 프로필렌글리콜 등), 또는 모노메틸아세테이트 등의 각종 프로필렌옥사이드계 글리콜에테르 등을 적절하게 첨가하여도 좋다. 또 바인더가 수용성인 경우, 에멀전으로서 사용하는 경우 등에서는 물을 용매로 하여도 좋고, 이 때에도 알콜류(메틸알콜, 에틸알콜, 이소프로필알콜, 에틸렌글리콜 등)를 적절하게 가하여 계면장력을 제어할 수도 있다.

상기 액형상 조성물에서는 셧다운 수지, 필러입자 및 바인더를 포함하는 고형분량을, 예를 들면 10~40 질량 %로 하는 것이 바람직하다.

상기 다공질 기체의 빈 구멍의 개구경이 비교적 큰 경우, 예를 들면 5 ㎛ 이상의 경우에는 이것이 선지 난락의 요인이 되기 쉽다. 따라서 이 경우에는 필러입자의 적어도 일부가 기체의 빈 구멍 내에 존재하는 구조로 하는 것이 바람직하다. 또 셧다운 수지 등, 필러입자 이외의 구성물의 적어도 일부도 필러입자와 함께 기체의 빈 구멍 내에 존재하는 구조로 하는 것이 더욱 바람직하다.

또한 세퍼레이터 중에 판형상 입자를 함유시키는 경우에, 배향성을 높이고 그 기능을 유효하게 작용시키기 위해서는 상기 액형상 조성물을 함침시킨 기체에서 이 액형상 조성물에 셰어나 자장을 인가한다는 방법을 사용하면 좋다.

또, 상기 구성물의 각각이 가지는 효과를 더욱 유효하게 발휘시키기 위하여 구성물을 편재시켜 세퍼레이터의 막면과 평행하게 층형상으로 모인 형태로 하여도 좋다. 이와 같은 형태로 하기 위해서는 예를 들면 다이코터나 리버스롤코터의 헤드나 롤을 2개 사용하여 기체의 표리 양 방향에서 각각의 도료, 예를 들면 셧다운 수지를 주체로 한 액형상 조성물과, 필러입자를 주체로 한 액형상 조성물을 따로따로 도포하여 건조하는 방법을 채용할 수 있다.

본 발명의 세퍼레이터의 (b)의 제조방법은, 상기 액형상 조성물에 또한 필요에 따라 섬유형상물을 함유시키고, 이것을 필름이나 금속박 등의 기판상에 도포하여 소정의 온도에서 건조한 후에, 이 기판으로부터 박리하는 방법이다. (b)의 방법에 의하여 상기 (I)의 형태의 세퍼레이터를 제조할 수 있다. (b)의 방법에서 사용하는 액형상 조성물은, 섬유형상물 등을 포함한 고형분량이, 예를 들면 10~40 질량% 인 것이 바람직하다. 또 (b)의 방법에 의하여 전지를 구성하는 양극 및 음극에서 선택되는 적어도 한쪽의 표면에 세퍼레이터를 형성하여 세퍼레이터와 전극을 일체화한 구조로 하여도 좋다.

또한 본 발명의 세퍼레이터는, 상기에 나타낸 각 구조에 한정되는 것이 아니다. 예를 들면 셧다운 수지는, 입자형상으로 하나하나 독립하여 존재하고 있어도 좋고, 서로 또는 섬유형상물 등에 일부가 융착되어 있어도 상관없다. 또 본 발명의 세퍼레이터를 적용할 수 있는 전기화학 소자는, 비수전해액을 사용하는 것이면 특별히 한정되는 것은 아니고, 리튬 2차 전지 외에, 리튬 1차 전지나 슈퍼 커패시터 등, 고온에서의 안전성이 요구되는 용도이면 마찬가지로 적용 가능한 것이다.

이하, 본 발명의 일례로서 리튬 2차 전지에 대한 적용에 대하여 상세하게 설명한다. 리튬 2차 전지의 형태로서는, 스틸캔이나 알루미늄캔 등을 외장 캔으로서 사용한 통형(각통형이나 원통형 등) 등을 들 수 있다. 또 금속을 증착한 라미네이트 필름을 외장체로 한 소프트 패키지 전지로 할 수도 있다.

양극으로서는 종래의 리튬 2차 전지에 사용하고 있는 양극, 즉, Li를 흡장방출 가능한 활물질을 함유하는 양극이면 특별히 제한은 없다. 예를 들면 양극 활물질로서 $Li_{1+x}MO_2$(-0.1 < x < 0.1, M : Co, Ni, Mn, Al, Mg 등)로 나타내는 층형상 구조의 리튬함유 천이금속 산화물, $LiMn_2O_4$나 그 원소의 일부를 다른 원소로 치환한 스피넬 구조의 리튬 망간 산화물, $LiMPO_4$(M : Co, Ni, Mn, Fe 등)로 나타내는 올리빈형 화합물 등을 사용하는 것이 가능하다. 상기 층형상 구조의 리튬함유 천이금속 산화물로서는, $LiCoO_2$나 $LiNi_{1-x}Co_{x-y}Al_yO_2$($0.1 \leq x \leq 0.3$, $0.01 \leq y \leq 0.2$) 등 외에, 적어도 Co, Ni 및 Mn을 포함하는 산화물($LiMn_{1/3}Ni_{1/3}Co_{1/3}O_2$, $LiMn_{5/12}Ni_{5/12}Co_{1/6}O_2$, $LiMn_{3/5}Ni_{1/5}Co_{1/5}O_2$ 등)을 구체적으로 예시할 수 있다.

상기 양극 활물질에는 도전조제로서 카본블랙 등의 탄소재료 및 바인더로서 폴리불화비닐리덴(PVDF) 등의 불소수지가 첨가되어 양극 합제가 조제된다. 이 양극 합제를 사용하여 집전체의 표면에 성형체(양극 합제층)가 형성된다.

또, 양극의 집전체로서는 알루미늄 등의 금속의 박, 펀칭메탈, 금속망, 익스팬드메탈 등을 사용하여 얻어지나, 통상 두께가 10~30 ㎛의 알루미늄박이 적합하게 사용된다.

양극측의 리드부는 통상 양극 제작시에 집전체의 일부에 양극 합제층을 형성하지 않고 집전체의 노출부를 남기고, 그곳을 리드부로 함으로써 설치된다. 단, 리드부는 반드시 당초부터 집전체와 일체화된 것은 요구되지 않고, 집전체에 알루미늄제의 박 등을 뒤에서 접속함으로써 설치하여도 좋다.

음극으로서는, 종래의 리튬 2차 전지에 사용되고 있는 음극, 즉, Li를 흡장 방출 가능한 활물질을 함유하는 음극이면 특별히 제한은 없다. 예를 들면 음극 활물질로서 흑연, 열분해 탄소류, 코크스류, 유리형상 탄소류, 유기고분자 화합물의 소성체, 메소카본 마이크로 비즈(MCMB), 탄소섬유 등의 리튬을 흡장, 방출가능한 탄소계 재료의 1종 또는 2종 이상의 혼합물이 사용된다. 또 Si, Sn, Ce, Bi, Sb, In 등의 원소 및 그 합금, 리튬함유 질화물 또는 리튬함유 산화물 등의 리튬 금속에 가까운 저전압으로 충방전할 수 있는 화합물, 또는 리튬 금속이나 리튬/알루미늄합금도 음극 활물질로서 사용할 수 있다.

상기 음극 활물질에는 도전조제로서 카본블랙 등의 탄소재료나, 바인더로서 PVDF 등이 적절하게 첨가되어 음극 합제가 조제되고, 이 음극 합제를 사용하여 집전체의 표면에 성형체(음극 합제층)가 형성된다. 또 음극 활물질로서 상기 각종 합금이나 리튬 금속을 사용하는 경우에는, 각종 합금이나 리튬 금속의 박을 단독으로 음극으로서 사용할 수 있고, 또한 이들을 집전체 위에 적층하여 사용할 수도 있다.

음극에 집전체를 사용하는 경우에는, 집전체로서는 구리제나 니켈제의 박, 펀칭메탈, 금속망, 익스팬드메탈 등을 사용할 수 있으나, 통상 구리박이 사용된다. 이 음극 집전체는 고에너지 밀도의 전지를 얻기 위하여 음극 전체의 두께를 얇게 하는 경우, 두께의 상한은 30 ㎛인 것이 바람직하고, 하한은 5 ㎛인 것이 바람직하다. 또 음극측의 리드부는 양극측의 리드부와 동일하게 하여 형성하면 좋다.

전극은 상기 양극과 상기 음극을 본 발명의 세퍼레이터를 거쳐 적층한 적층체나 또한 이것을 권회한 전극 권회체의 형태로 사용할 수 있다.

비수전해액으로서는 리튬염을 유기용매에 용해한 용액이 사용된다. 리튬 염으로서는 용매 중에서 해리하여 Li^+ 이온을 형성하고, 전지로서 사용되는 전압범위에서 분해 등의 부반응을 일으키기 어려운 것이면 특별히 제한은 없다. 예를 들면 $LiClO_4$, $LiPF_6$, $LiBF_4$, $LAsF_6$, $LiSbF_6$ 등의 무기리튬염, $LiCF_3SO_3$, $LiCF_3CO_2$, $Li_2C_2F_4(SO_3)_2$, $LiN(CF_3SO_2)_2$, $LiC(CF_3SO_2)_3$, $LiC_nF_{2n+1}SO_3(n\geq 2)$, $LiN(RfOSO_2)_2$[여기서, Rf는 플루오로알킬기] 등의 유기리튬염 등을 사용할 수 있다.

비수전해액에 사용하는 유기용매로서는, 상기 리튬염을 용해하고, 전지로서 사용되는 전압범위에서 분해 등의 부반응을 일으키지 않는 것이면 특별히 한정되지 않는다. 예를 들면 에틸렌카보네이트, 프로필렌카보네이트, 부틸렌카보네이트, 비닐렌카보네이트 등의 고리형상 카보네이트, 디메틸카보네이트, 디에틸카보네이트, 메틸에틸카보네이트 등의 사슬형상 카보네이트, 프로피온산 메틸 등의 사슬형상 에스테르, γ-부티로락톤 등의 고리형상 에스테르, 디메톡시에탄, 디에틸 에테르, 1,3-디옥소란, 디그라임, 트리그라임, 테트라그라임 등의 사슬형상 에테르, 디옥산, 테트라하이드로푸란, 2-메틸테트라하이드로푸란 등의 고리형상 에테르, 아세토니트릴, 프로피오니트릴, 메톡시프로피오니트릴 등의 니트릴류, 에틸렌글리콜술파이트 등의 아황산에스테르류 등을 들 수 있고, 이들은 2종 이상 혼합하여 사용할 수도 있다. 또한 더욱 양호한 특성의 전지로 하기 위해서는 에틸렌카보네이트와 사슬형상 카보네이트와의 혼합용매 등, 높은 도전율을 얻을 수 있는 조합으로 사용하는 것이 바람직하다. 또 이들 비수전해액에 안전성이나 충방전 사이클성, 고온 저장성이라는 특성을 향상시킬 목적으로, 비닐렌카보네이트류, 1,3-프로판술톤, 디페닐디술피드, 시클로헥실벤젠, 비페닐, 플루오로벤젠, t-부틸벤젠 등의 첨가제를 적절하게 가할 수도 있다.

상기 리튬염의 비수전해액 중의 농도로서는 0.5~1.5 mol/L로 하는 것이 바람직하고, 0.9~1.25 mol/L로 하는 것이 더욱 바람직하다.

이하, 실시예에 의거하여 본 발명을 상세하게 설명한다. 단, 본 발명은 하기의 실시예에 한정되는 것이 아니다. 또한 본 실시예에서의 수지 B의 팽윤도 (B_R 및 B_T)는 각각 상기 수학식 (1) 및 (2)에 의거하여 구해진 팽윤도이다.

<음극의 제작>

음극 활물질인 흑연 : 95 질량부와, 바인더인 PVDF : 5 질량부를, N-메틸-2-피롤리돈(NMP)을 용제로 하여 균일해지도록 혼합하여 음극 합제 함유 페이스트를 조제하였다. 이 음극 합제 함유 페이스트를 구리박으로 이루어지는 두께 10 ㎛의 집전체의 양면에 활물질 도포길이가 표면 320 mm, 이면 260 mm이 되도록 간헐 도포하여 건조하였다. 그후 캘린더처리를 행하여 전체 두께가 142 ㎛가 되도록 음극 합제층의 두께를 조정하고, 폭 45 mm가 되도록 절단하여, 길이 330 mm, 폭 45 mm의 음극을 제작하였다. 또한 이 음극의 구리박의 노출부에 태브를 용접하여 리드부를 형성하였다.

<양극의 제작>

양극 활물질인 $LiCoO_2$: 85 질량부, 도전조제인 아세틸렌 블랙 : 10 질량부, 및 바인더인 PVDF : 5 질량부를, NMP를 용제로 하여 균일해지도록 혼합하여 양극 합제 함유 페이스트를 조제하였다. 이 페이스트를 알루미늄박으로 이루어지는 두께 15 ㎛의 집전체의 양면에 활물질 도포길이가 표면 319~320 mm, 이면 258~260 mm이 되도록 간헐 도포하여 건조하였다. 그후 캘린더처리를 행하여, 전두께가 150 ㎛가 되도록 양극 합제층의 두께를 조정하고, 폭 43 mm가 되도록 절단하여 길이 330 mm, 폭 43 mm의 양극을 제작하였다. 또한 이 양극의 알루미늄박의 노출부에 태브를 용접하여 리드부를 형성하였다.

또한 상기 음극 및 상기 양극은, 뒤에서 설명하는 전지의 제작에 사용한다.

<세퍼레이터의 제작과 평가>

(실시예 1)

폴리에틸렌 분말(수지 A)의 물분산액[미츠이화학사제 "케미펄W-700"(상품명)]:2kg과 에탄올 800g을 용기에 넣어, 디스퍼로 2800 rpm의 조건으로 1시간 교반하여 분산시켰다. 이것에 필러입자로서 알루미나(Al_2O_3)미립자[스미토모화학사제 "스미코랜덤AA04"(상품명), 내열온도 : 180℃ 이상, 평균 입자지름 : 0.4 ㎛, 입도 분포 : 0.3~0.7 ㎛] 300g을 가하고, 3시간 교반하여 균일한 슬러리로 하였다. 이 슬러리 중에 다공질 기체가 되는 두께 28 ㎛의 PBT제 부직포(타피루스사제)를 통하여 인상도포에 의하여 슬러리를 도포한 후, 건조함으로써 부직포의 공극 내에 수지 A와 필러입자를 가지는 두께 35 ㎛의 세퍼레이터를 얻었다.

(실시예 2)

바인더로서, 에틸렌-아세트산비닐 공중합체(EVA)[아세트산비닐 유래의 구조단위가 34 mol%, 니혼유니카사제] : 100g을 용매인 톨루엔 : 6 kg과 함께 용기에 넣어 균일하게 용해될 때까지 실온에서 교반하여 바인더용액을 얻었다. 이 바인더용액에 수지 A로서 폴리에틸렌 분말[스미토모세이카화학사제:플로비즈 LE1080"(상품명), 융점 : 107℃, 평균 입자지름 : 6 ㎛, 입도 분포 : 2~15 ㎛] 1kg을 가하고, 디스퍼로 2800 rpm의 조건으로 1시간 교반하여 분산시켰다. 이것에 필러입자로서 폴리프로필렌 분말[세이신기업사제"PPW-5"(상품명)] : 1kg를 가하고, 디스퍼로 2800 rpm의 조건으로 3시간 교반하여 균일한 슬러리로 하였다. 이 슬러리를 갭을 50 ㎛로 하고, 두께 25 ㎛의 종이(니폰고도지사제) 위에 문질러 도포하여 용매를 제거하고, 두께 35 ㎛의 세퍼레이터를 얻었다.

(실시예 3)

실시예 1과 동일한 폴리에틸렌분말의 물분산액 : 750 g, 이소프로필알콜(IPA) : 200 g 및 바인더로서 폴리비닐부티랄(PVB)[세키스이화학사제"에스렉KX-5"상품명)] : 375 g을 용기에 넣고 디스퍼로 2800 rpm의 조건으로 1시간 교반하여 분산시켰다. 이것에 필러입자로서 판형상 베마이드 미립자[카와이석회사제"BMM"(상품명)] : 300g을 가하고, 3시간 교반하여 균일한 슬리리로 하였다.

이 슬러리 중에 두께 15 ㎛의 PP제 부직포(니폰고도지사제)를 통하여 인상도포에 의하여 슬러리를 도포한 후, 건조하여 두께 20 ㎛의 세퍼레이터를 얻었다.

(실시예 4)

수지 B로서 가교 PMMA 미립자[간츠화성사제"간츠펄0104"(상품명), 평균 입자지름 1 ㎛, Tg = 약 120℃, B_R = 0.5, B_T = 2.3] : 1kg, 물 : 800 g, 이소프로필알콜(IPA) : 200 g, 및 바인더로서 실시예 3과 동일한 PVB : 375 g을 용기에 넣고 디

스퍼로 2800 rpm의 조건으로 1시간 교반하여 분산시켰다. 이것에 필러입자로서 실시예 1과 동일한 알루미나 미립자 : 3 kg, 상기 바인더(PVB) : 750 g를 가하고, 3시간 교반하여 균일한 슬러리로 하였다. 이 슬러리 중에 두께 28 ㎛의 PBT제 부직포(타피루스사제)를 통하여 인상도포에 의하여 슬러리를 도포한 후, 건조하여 두께 35 ㎛의 세퍼레이터를 얻었다.

(실시예 5)

바인더로서 SBR 라텍스[JSR사제"TRD-2001"(상품명)] : 300 g 및 CMC[다이셀화학사제"2200"]: 30 g과, 물 : 4 kg을 용기에 넣고, 균일하게 용해될 때까지 실온에서 교반하였다. 또한 가교 PMMA 미립자(수지 B)의 물분산체[간츠화성사제"스타피로이드"상품명), 평균 입자지름 0.3 ㎛, B_R = 1.2, B_T = 1.2] : 2.5 kg을 가하고, 디스퍼로 2800 rpm의 조건으로 1시간 교반하여 분산시켰다. 이것에 실시예3과 동일한 필러입자(판형상 베마이트 미립자) : 3 kg을 가하고, 디스퍼로 2800 rpm의 조건으로 3시간 교반하여 균일한 슬러리로 하였다. 이 슬러리를 어플리케이션을 이용하여 두께 23 ㎛의 PP제 부직포(니혼바이린사제) 위에 갭을 50 ㎛로 하여 문질러 도포하고 건조하여 두께 30 ㎛의 세퍼레이터를 얻었다.

(실시예 6)

실시예 5와 동일한 슬러리에, 또한 수지 A로 하여 실시예 1과 동일한 폴리에틸렌분말의 물분산액 : 1 kg을 가하고, 디스퍼로 2800 rpm의 조건으로 1시간 교반하여 분산시켰다. 이하, 실시예 5와 동일하게 하여 두께 30 ㎛의 세퍼레이터를 얻었다.

(실시예 7)

실시예 4의 알루미나 미립자 대신에 판형상 알루미나 미립자[긴세이마테크사제"세라프"(상품명)] : 3 kg을 가하여 슬러리를 제작하고, 이것을, 갭을 50 ㎛로 하여 두께 15 ㎛의 PET제 부직포(플로이덤벨그사제)에 문질러 도포한 이외는 실시예 4와 동일하게 하여 두께 20 ㎛의 세퍼레이터를 얻었다.

(실시예 8)

폴리에틸렌분말(수지 A)의 물분산액[기후세라믹사제"AB-50"(상품명)] : 3 kg에, 바인더로서 에틸렌-아세트산비닐 공중합체(EVA)의 에멀전[아세트산비닐 유래의 구조단위가 20 mol%, 스미카켐텍스사제"스미카플렉스 S850HQ"(상품명)] : 100g을 가하고, 디스퍼로 2800 rpm의 조건으로 1시간 교반하여 분산시켰다. 이것에 필러입자로서 알루미나섬유[덴키화학공업사제"덴카알센B100"(상품명)] : 1.5 kg을 가하여 균일하게 될 때까지 실온에서 교반하였다. 이 슬러리를 다이코터를 이용하여 도포 두께 50 ㎛로 PET 기재 위에 도포하고, 건조한 후, PET 기재로부터 박리함으로써 알루미나섬유에 의하여 형성된 다공질 기체와 폴리에틸렌분말을 가지는 두께 15 ㎛의 세퍼레이터를 얻었다.

제작한 세퍼레이터의 단면을 주사형 전자현미경으로 관찰한 바, 알루미나섬유의 종횡비는 10 이상이고, 또 세퍼레이터면에 대한 평균 각도는 10°이하였다.

(실시예 9)

실시예 8의 폴리에틸렌분말의 물분산액 대신에 실시예 5와 동일한 가교 PMMA 미립자(수지 B)의 물분산체 : 1 kg을 사용하고, 용매로서 물을 2 kg 가한 이외는 실시예 8과 동일하게 하여 두께 15 ㎛의 세퍼레이터를 얻었다.

(실시예 10)

바인더로서 EVA[아세트산비닐 유래의 구조단위가 34 mol%, 니혼유니카사제] : 100 g을 용매인 톨루엔 : 6 kg과 함께 용기에 넣어 균일하게 용해될 때까지 실온에서 교반하여 바인더용액을 얻었다. 이어서 수지 A로서 폴리에틸렌분말[스미토모세이카사제:플로우비즈 LE 1080"(상품명)] : 500 g을 상기 바인더용액에 가하고 디스퍼로 2800 rpm의 조건으로 1시간 교반하여 분산시켰다. 이것에 필러입자로서 실시예 1과 동일한 알루미나 미립자 : 2 kg를 가하고 디스퍼로 2800 rpm의 조건으로 3시간 교반하여 분산시켜 세퍼레이터형성용의 균일한 액형상 조성물을 얻었다. 이 슬러리를, 50 ㎛의 갭을 통하여 상기한 음극의 양면의 활물질층 위에 문질러 도포한 후, 건조시켜 음극 표면에 음극과 일체화된 두께 15 ㎛의 세퍼레이터를 형성하였다.

이 음극의 단면의 주사형 전자현미경 사진을 도 1에, 또 그 세퍼레이터부분을 확대한 주사형 전자현미경 사진을 도 2에 나타낸다. 도 1에서 1은 세퍼레이터이고, 2는 음극이다. 또 도 2에서 3은 필러입자, 4는 바인더, 5는 다공질 기체, 6은 셧다운 수지이다. 도 1 및 도 2의 사진에서 필러입자(3) 및 바인더(4)로 구성된 다공질 기체(5)와, 셧다운 수지(6)로 이루어지는 세퍼레이터(1)가 음극(2) 위에 형성되어 있는 모양을 알 수 있다.

(실시예 11)

폴리에틸렌분말의 양을 2 kg으로 변경한 이외는 실시예 10과 동일하게 하여 음극 표면에 세퍼레이터를 형성하였다.

(실시예 12)

폴리에틸렌분말의 양을 1 kg으로 변경한 이외는 실시예 10과 동일하게 하여 음극 표면에 세퍼레이터를 형성하였다.

(실시예 13)

알루미나 미립자의 양을 400 g으로 변경하고, 또한 폴리에틸렌분말의 양을 1 kg으로 변경한 이외는 실시예 10과 동일하게 하여 음극 표면에 세퍼레이터를 형성하였다.

(실시예 14)

필러입자를 가교 PMMA 미립자[간츠화성사제"간츠펄0407"(상품명), 내열온도 : 180℃ 이상]: 1 kg으로 변경하고, 또한 폴리에틸렌분말의 양을 1 kg으로 변경한 이외는 실시예 10과 동일하게 하여 음극 표면에 세퍼레이터를 형성하였다. 또한 본 실시예에서 사용한 가교 PMMA는, 입자가 전해액을 흡수하여 팽윤하지 않도록 수지의 가교도를 높임으로써 전해액에 대한 안정성을 높인 것이다.

(실시예 15)

바인더로서 에틸렌-에틸아크릴레이트 공중합체[니혼유니카사제"NUC6570"(상품명)]: 200 g을 용매인 톨루엔 : 6 kg과 함께 용기에 넣어 균일하게 용해될 때까지 실온에서 교반하여 바인더용액을 얻었다. 이어서 수지 A로서 EVA 분말[아세트산비닐 유래의 구조단위가 10 mol%, 스미토모세이카사제"플로우백D5020"(상품 명), 융점 : 89℃, 평균 입자지름 : 10 ㎛, 입도 분포 : 5~20 ㎛] : 1 kg을 상기 바인더용액에 가하고 디스퍼로 2800 rpm의 조건으로 1시간 교반하여 분산시켰다. 이것에 필러입자로서 실시예 1과 동일한 알루미나 미립자 : 400 g을 가하고, 이하, 실시예 10과 동일하게 하여 음극 표면에 음극과 일체화된 두께 20 ㎛의 세퍼레이터를 형성하였다.

(비교예 1)

시판의 두께 20 ㎛의 폴리에틸렌제 미세 다공막을 비교예 1의 세퍼레이터로 하였다.

(비교예 2)

필러입자로서 실시예 1과 동일한 알루미나 미립자 : 3 kg, 물 : 800 g, 이소프로필알콜(IPA) : 200 g, 및 바인더로서 실시예 3과 동일한 PVB : 375 g을 용기에 넣고 디스퍼로 2800 rpm의 조건으로 1시간 교반하여 분산시켜 균일한 슬러리로 하였다. 이 슬러리 중에, 두께 15 ㎛의 PP제 부직포(니혼고도지사제)를 통하여 인상도포에 의하여 슬러리를 도포한 후, 건조하여 두께 20 ㎛의 세퍼레이터를 얻었다.

(비교예 3)

알루미나 미립자 대신에 실시예 1과 동일한 폴리에틸렌분말(수지 A)의 물분산액을 사용한 이외는 비교예 2와 동일하게 하여 두께 20 ㎛의 세퍼레이터를 얻었다.

상기 실시예 1 ~ 실시예 15 및 비교예 1 ~ 비교예 3의 세퍼레이터의 구성을 표 1에 나타낸다.

[표 1]

세퍼레이터	셧다운 수지		필러입자	다공질 기체
	수지 A	수지 B		
실시예 1	폴리에틸렌	-	알루미나	PBT 부직포
실시예 2	폴리에틸렌	-	폴리프로필렌	종이
실시예 3	폴리에틸렌	-	관현상 베마이트	PP 부직포
실시예 4	-	가교 PMMA	알루미나	PBT 부직포
실시예 5	-	가교 PMMA	관현상 베마이트	PP 부직포
실시예 6	폴리에틸렌	가교 PMMA	관현상 베마이트	PP 부직포
실시예 7	-	가교 PMMA	관현상 알루미나	PET 부직포
실시예 8	폴리에틸렌	-	알루미나 섬유	알루미나 섬유
실시예 9	-	가교 PMMA	알루미나 섬유	알루미나 섬유
실시예 10	폴리에틸렌	-	알루미나	알루미나 미립자
실시예 11	폴리에틸렌	-	알루미나	알루미나 미립자
실시예 12	폴리에틸렌	-	알루미나	알루미나 미립자
실시예 13	폴리에틸렌	-	알루미나	알루미나 미립자
실시예 14	폴리에틸렌	-	가교 PMMA	가교 PMMA 미립자
실시예 15	EVA	-	알루미나	알루미나 미립자
비교예 1	-	-	-	PE 미세다공막
비교예 2	-	-	알루미나	PP 부직포
비교예 3	폴리에틸렌	-	-	PP 부직포

제작된 각 세퍼레이터에 대하여, 이하의 방법에 의하여 수축률과 셧다운 온도를 측정하였다.

상기 실시예 1 ~ 실시예 9 및 비교예 1 ~ 비교예 3의 세퍼레이터를 각각 4 cm × 4 cm의 크기로 절단하고, 클립으로 고정한 2매의 스테인레스판으로 끼워 넣고 150℃의 항온조 내에 30분 방치한 후에 꺼내어 각 세퍼레이터편의 길이를 측정하고, 시험전의 길이와 비교하여 그 감소율을 세퍼레이터의 수축률로서 구하였다.

또, 실시예 10 ~ 실시예 15의 전극과 일체화된 세퍼레이터에 대해서는 전극과 함께 150℃의 항온조 내에 60분 방치한 후에 꺼내어 세퍼레이터의 긴 변의 길이를 가열전과 비교하여 수축률을 구하였다. 각 세퍼레이터의 수축률을 표 2에 나타낸다.

[표 2]

세퍼레이터	수축율(%)
실시예 1	0. 1
실시예 2	0
실시예 3	2
실시예 4	1
실시예 5	2
실시예 6	1
실시예 7	2
실시예 8	0. 5
실시예 9	2
실시예 10	0
실시예 11	0
실시예 12	0
실시예 13	0
실시예 14	0
실시예 15	0
비교예 1	35
비교예 2	1
비교예 3	1

또, 실시예 1 ~ 실시예 9 및 비교예 1 ~ 비교예 3의 세퍼레이터의 실온에서의 투기도의 측정을, JIS P 8117에 준거한 방법으로 행하여, 걸리값 즉, 0.879 g/㎟(8620 Pa)의 압력하에서 100 mL의 공기가 막을 투과하는 초수를 구하였다. 또한 실시예 1 ~ 실시예 3, 실시예 8 및 비교예 1 ~ 비교예 3의 세퍼레이터에 대하여, 이하의 방법에 의하여 80℃~150℃의 범위에서 걸리값의 변화를 측정하였다. 각 세퍼레이터를 80℃의 항온조 속에서 10분간 유지한 후, 꺼내어 실온까지 서냉하고, 상기 방법에 의하여 80℃까지 승온 후의 걸리값을 측정하였다. 이후, 5℃ 피치로 150℃ 까지 온도를 상승시켜 각각의 온도에서 세퍼레이터를 10분간 유지한 후, 상기와 동일하게 하여 걸리값을 측정하였다. 구해진 걸리값의 온도에 의한 변화로부터, 걸리값이 1×10^4 sec/100 mL를 넘었을 때의 온도를 세퍼레이터의 셧다운 온도로 하였다. 또한 비교예 2의 세퍼레이터에서는 셧다운이 생기지 않았기 때문에 셧다운 온도는 측정할 수 없었다.

한편, 실시예 4 ~ 실시예 7 및 실시예 9의 세퍼레이터는, 이하의 방법에 의하여 셧다운 온도를 구하였다. 4 cm × 4 cm의 크기로 절단된 각 세퍼레이터편을 단자부착 2매의 스테인레스판으로 끼워 넣고, 알루미늄 라미네이트 필름의 자루에 삽입하여 비수전해액을 주입한 후, 단자의 끝을 자루 밖으로 내민 상태에서 자루를 봉지하여 시험용 시료로 하였다. 여기서 비수전해액으로서는 에틸렌카보네이트와 에틸메틸카보네이트를 체적비 1 : 2로 혼합한 용매에 $LiPF_6$을 1.2 mol/L의 농도로 용해시킨 용액을 사용하였다. 또한 이 비수전해액은 뒤에서 설명하는 전지의 제작에서도 사용한다.

상기 시료를 항온조에 넣고 HIOKI사제 접점 저항계"3560 AC 밀리옴하이테스터"(상품명)에 의하여 상기 단자에 1 kHz의 교류를 인가하였을 때의 저항값을 측정하면서 실온으로부터 매분 1℃의 비율로 온도 상승시켜 가열하여 내부저항의 온도에 의한 변화를 구하였다. 그리고 저항값이 실온에서의 값의 10배 이상이 되었을 때의 온도를, 그 세퍼레이터의 셧다운 온도로 하였다.

상기 실시예 1 ~ 실시예 9 및 비교예 1 ~ 비교예 3의 세퍼레이터의 걸리값 및 셧다운 온도를 표 3에 나타낸다.

[표 3]

세퍼레이터	걸리값 (sec/100mL)	셧다운 온도 (℃)
실시예 1	120	125
실시예 2	250	105
실시예 3	110	125
실시예 4	80	120
실시예 5	60	105
실시예 6	80	105
실시예 7	70	105
실시예 8	90	125
실시예 9	100	105
비교예 1	150	140
비교예 2	90	측정되지 않음
비교예 3	110	125

또한 실시예 10 ~ 실시예 15의 전극과 일체화된 세퍼레이터에 대해서는 뒤에서 설명하는 바와 같이 전지의 조립후에 전지의 내부저항의 온도에 의한 변화를 측정함으로써 세퍼레이터의 셧다운 온도를 구하였다.

<전지의 제작과 평가>

실시예 1 ~ 실시예 9 및 비교예 1 ~ 비교예 3의 세퍼레이터를, 각각 상기한 양극 및 음극과 함께 소용돌이형상으로 권회하여 권회 전극체를 제작하였다. 이 권회 전극체를 찌그러뜨려 편평형상으로 하고, 전지용기 내에 장전하여 상기한 비수전해액을 주입한 후, 밀봉을 행하여 실시예 1A ~ 실시예 9A 및 비교예 1A ~ 비교예 3A의 리튬 2차 전지를 제작하였다.

또, 음극과 일체화된 실시예 10 ~ 실시예 15의 세퍼레이터는, 각각 상기 세퍼레이터를 거쳐 음극과 상기 양극을 겹친 이외는 상기 실시예 1A ~ 실시예 9A 및 비교예 1A ~ 비교예 3A와 동일하게 하여 실시예 10A ~ 실시예 15A의 리튬 2차 전지를 제작하였다.

먼저, 상기 실시예 10A ~ 실시예 15A의 리튬 2차 전지에 대하여, 이하의 방법에 의하여 각각의 전지에 사용한 세퍼레이터의 셧다운 온도를 구하였다. 전지를 항온조에 넣고 상기 세퍼레이터 단독으로 내부저항의 측정과 동일하게 하여 30℃에서 150℃까지 매분 1℃의 비율로 온도 상승시켜 가열하여 전지의 내부저항의 온도에 의한 변화를 구하였다. 그리고 저항값이 30℃에서의 값의 5배 이상으로 상승하였을 때의 온도를, 그 세퍼레이터의 셧다운 온도로 하였다. 또 상기 걸리값의 변화에 의하여 셧다운 온도를 구하는 방법과 비교하기 위하여 비교예 1A의 전지의 내부저항의 온도에 의한 변화도 상기와 동일하게 하여 구하고, 비교예 1의 세퍼레이터의 셧다운 온도를 구하였으나, 어느 방법으로도 대략 동일한 결과가 얻어졌다. 또한 비교예 3A의 전지에 대해서도 마찬가지로 내부저항의 온도에 의한 변화를 측정하고자 하였으나, 전지 제작시에 내부 단락이 생겨있는 것이 밝혀져 전지로서의 평가를 행할 수 없었다. 즉, 비교예 3의 세퍼레이터는 필러입자가 다공질 기체를 구성하고 있는 것이 아니라, 또 다공질 기체의 빈 구멍 내에 필러입자를 가지는 것도 아니기 때문에 세퍼레이터의 강도가 약하여 전지 제작시에 내부 단락을 일으킨 것으로 생각된다.

상기 측정결과를 표 4에 나타낸다. 또 실시예 12A 및 비교예 1A의 내부저항의 온도에 의한 변화를 각각 도 3 및 도 4에 나타낸다.

[표 4]

전지	세퍼레이터	셧다운 온도 (℃)
실시예 10A	실시예 10	106
실시예 11A	실시예 11	103
실시예 12A	실시예 12	103
실시예 13A	실시예 13	106
실시예 14A	실시예 14	106
실시예 15A	실시예 15	90
비교예 1A	비교예 1	136

표 3 및 표 4에 나타내는 바와 같이 본 발명의 실시예 1 ~ 실시예 15의 세퍼레이터에서는 셧다운 온도가 90~125℃의 범위가 되고, 전지의 고온에서의 안전성을 확보하는 데 적절한 온도범위에서 셧다운을 일으키는 것이 분명하게 되었다. 한편, 비교예 1의 세퍼레이터는 셧다운 온도가 130℃를 넘어 있고, 전지의 열폭주 온도에 의하여 가까운 온도에서 셧다운을 일으키고 있었다. 또 비교예 2의 세퍼레이터는 셧다운 수지를 가지지 않기 때문에, 셧다운이 생기지 않았다.

또 표 2에 나타내는 바와 같이 본 발명의 실시예 1 ~ 실시예 15의 세퍼레이터는 셧다운 온도를 넘어 가열한 후의 세퍼레이터의 수축이 아주 약간인 것에 대하여, 비교예 1의 세퍼레이터는 셧다운 온도를 넘은 후에 세퍼레이터가 크게 수축되어 있었다. 이 때문에 도 3에 나타내는 바와 같이 실시예 12A의 전지에서는 150℃에 도달할 때까지 내부저항이 저하하지 않고 셧다운의 상태가 유지되어, 셧다운후의 안전성이 유지되었다. 한편, 비교예 1A의 전지에서는 세퍼레이터의 수축에 의하여 내부저항이 급격하게 저하하여 내부 단락을 일으키기 쉬운 상태가 되었다.

다음에, 실시예 1A ~ 실시예 4A, 실시예 8A, 실시예 10A ~ 실시예 15A 및 비교예 1A의 전지에 대하여 이하의 조건으로 충방전을 행하여 부하특성의 측정을 행하였다. 충전은 0.2 C의 전류값으로 전지 전압이 4.2 V가 될 때까지 정전류충전을 행하고, 이어서 4.2 V에서의 정전압 충전을 행하는 정전류 일정전압 충전으로 하였다. 충전 종료까지의 총충전시간은 실시예 1A ~ 실시예 4A 및 실시예 8A의 전지에서는 15시간으로 하고, 실시예 10A ~ 실시예 15A 및 비교예 1A의 전지에서는 7.5시간으로 하였다. 충전후의 전지는 0.2 C 및 2 C의 방전전류로 각각 전지전압이 3.0 V가 될 때까지 방전을 행하고, 0.2 C 및 2 C의 방전에서의 방전용량을 각각 구하여 0.2 C의 방전용량에 대한 2 C의 방전용량의 비율을 부하특성으로서 평가하였다. 그 결과를 표 5에 나타낸다.

[표 5]

전지	부하특성(용량비) (%)
실시예 1A	60
실시예 2A	85
실시예 3A	72
실시예 4A	80
실시예 8A	75
실시예 10A	90
실시예 11A	80
실시예 12A	85
실시예 13A	63
실시예 14A	82
실시예 15A	68
비교예 1A	60

상기 실시예 1A ~ 실시예 4A, 실시예 8A, 실시예 10A ~ 실시예 15A의 전지는, 부하특성이 종래의 세퍼레이터를 사용한 비교예 1A의 전지와 동등 이상으로, 전지로서 문제없이 기능하고 있었다.

또한 실시예 4A ~ 실시예 7A, 실시예 9A, 비교예 1A 및 비교예 2A의 전지에 대하여 상기 조건으로 충전(총충전시간 : 15시간)을 행하여 충전용량 및 방전용량을 각각 구하고, 충전용량에 대한 방전용량의 비율을 충전효율로서 평가하였다. 그 결과를 표 6에 나타낸다.

[표 6]

전지	충전효율 [용량비] (%)
실시예 4A	99.5
실시예 5A	99.9
실시예 6A	99.6
실시예 7A	99.3
실시예 9A	99.5
비교예 1A	99.5
비교예 2A	56

실시예 4A ~ 실시예 7A, 실시예 9A의 전지는, 비교예 1A와 마찬가지로 충전효율이 대략 100%가 되고, 충전시의 리튬 덴드라이트의 생성이 억지되어 있었다. 한편, 다공질 기체의 빈 구멍 내에 필러입자만을 포함하는 비교예 2A의 전지에서는 충전효율이 나쁘고, 충전시의 리튬 덴드라이트의 생성에 의한 내부 단락이 확인되었다. 상기 필러입자로서 사용한 알루미나 미립자의 형상은, 리튬 덴드라이트의 생성의 억제효과가 우수한 판형상의 형상과는 다른 형상이기 때문에 셧다운 수지입자 등이 공존하지 않는 경우는, 리튬 덴드라이트의 생성을 억제할 수 없는 경우도 있다고 생각된다.

본 발명은 그 취지를 일탈하지 않는 범위에서 상기 이외의 형태로 하여도 실시가 가능하다. 본 출원에 개시된 실시형태는 일례이고, 이들에 한정은 되지 않는다. 본 발명의 범위는 상기한 명세서의 기재에서도 첨부되어 있는 청구범위의 기재를 우선하여 해석되고, 청구의 범위와 균등의 범위 내에서의 모든 변경은 청구의 범위에 포함되는 것이다.

산업상 이용 가능성

이상 설명한 바와 같이, 150℃ 이상의 내열온도를 가지고, 또한 필러입자를 포함하는 다공질 기체와, 융점이 80~130℃의 범위에 있는 수지 A 및 가열에 의하여 비수전해액을 흡수하여 팽윤하고, 또한 온도상승과 함께 팽윤도가 증대하는 수지 B에서 선택되는 적어도 1종의 셧다운 수지를 구비하는 다공질막에 의하여 세퍼레이터를 구성함으로써 종래의 세퍼레이터와 동등 이상의 특성을 가지고, 고온에서의 안전성이 뛰어난 전기화학 소자용 세퍼레이터 및 그것을 이용한 전기화학 소자용 세퍼레이터 및 그것을 이용한 전기화학 소자를 제공할 수 있다.

도면의 간단한 설명

도 1은 실시예 10의 음극의 단면의 주사형 전자현미경 사진,

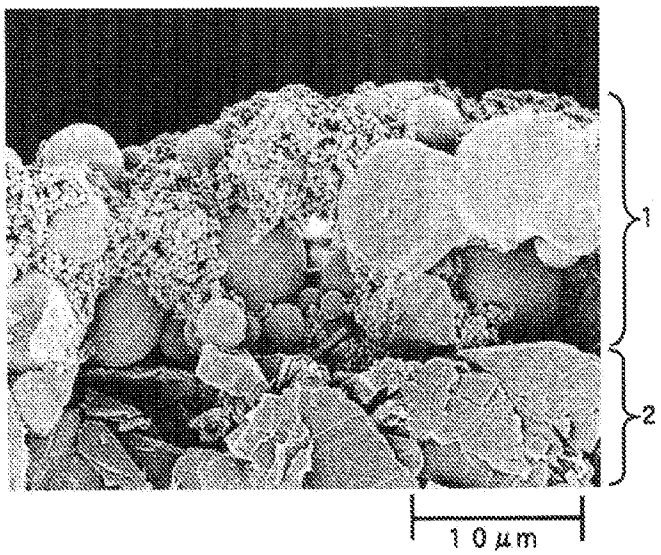
도 2는 도 1의 세퍼레이터부분을 확대한 주사형 전자현미경 사진,

도 3은 실시예 12A의 내부 저항의 온도에 의한 변화를 나타내는 도,

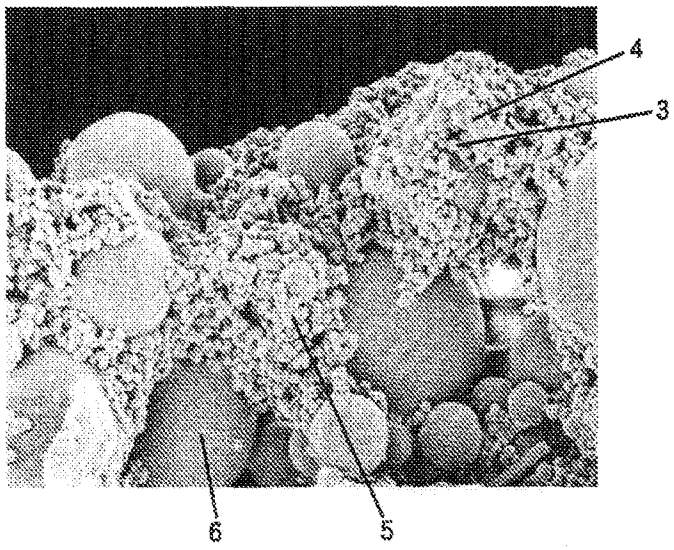
도 4는 비교예 1A의 내부 저항의 온도에 의한 변화를 나타내는 도면이다.

도면

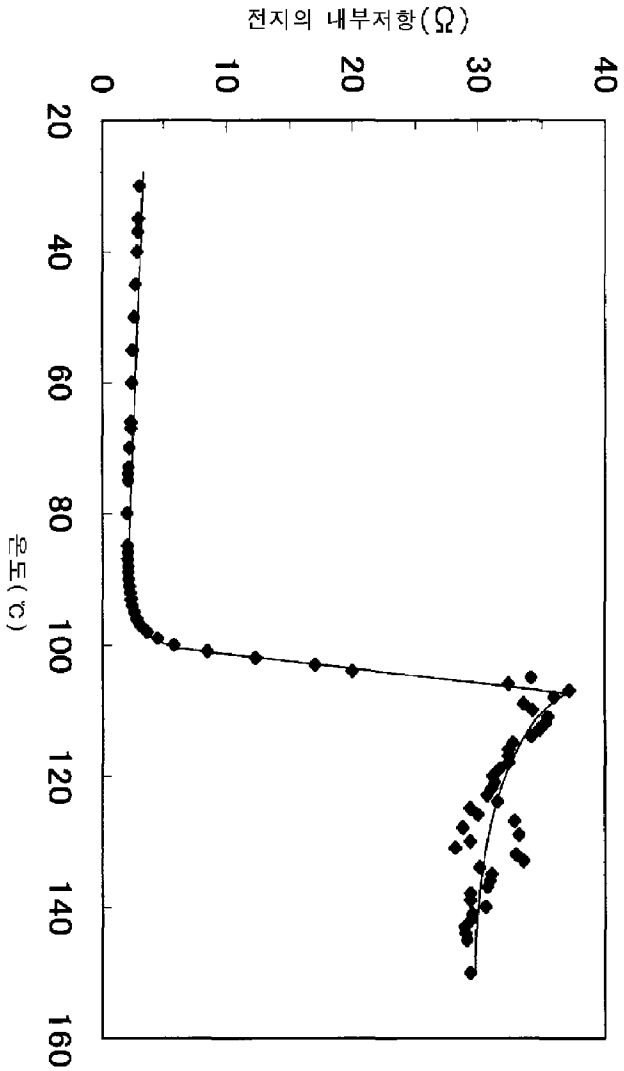
도면1



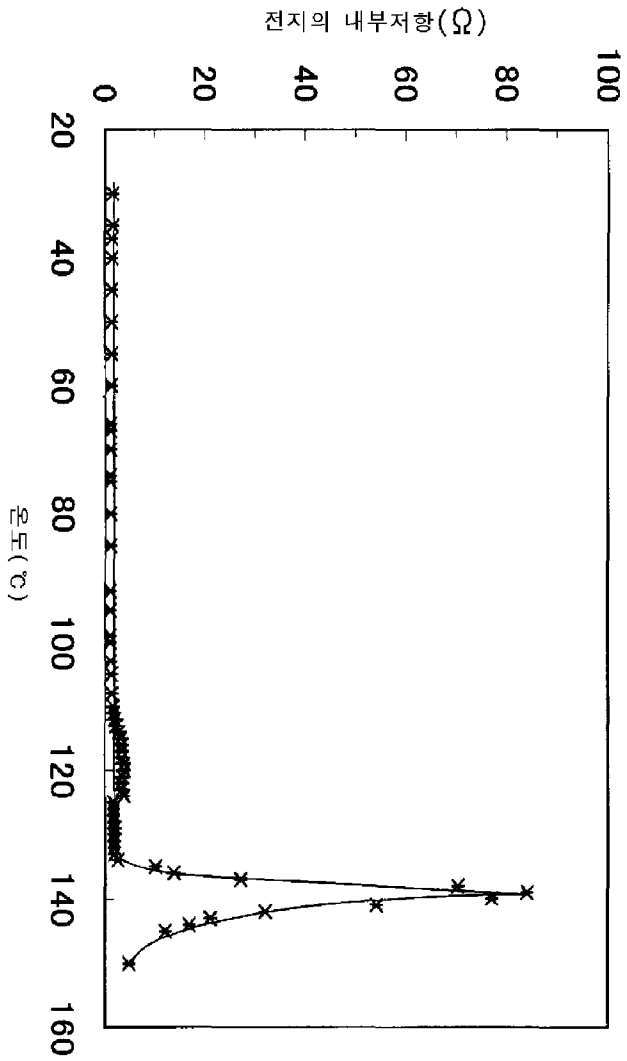
도면2



도면3



도면4



Bibliographic data: JP2000030686 (A) — 2000-01-28

NON-AQUEOUS ELECTROLYTE BATTERY SEPARATOR AND LITHIUM SECONDARY BATTERY

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Abstract of JP2000030686 (A)

PROBLEM TO BE SOLVED: To provide a safe battery with a high shorting temperature by using a separator containing a base material made of fabric, nonwoven fabric, paper or porous film, heat resistant nitrogen-containing aromatic polymer, and ceramic powder. SOLUTION: A base material contains organic fiber and/or inorganic fiber and is 40 g/m2 or less in weight per a unit area and 70 &mu m or less in thickness. Organic fiber is formed of thermoplastic polymer, while inorganic fiber is made of glass fiber. A separator contains 10 weight % or more of thermoplastic polymer melting at 260 deg.C or less, and the thermoplastic polymer is melted according to the increase of temperature so as to close cavities in the separator.; Heat resistant nitrogen-containing aromatic polymer is aromatic polyimide or aromatic polyamide, while ceramic powder is metal oxide metal nitride, or metal carbide with a primary mean grain size of 1.0 &mu m or less. A slurry solution, in which ceramic powder is dispersed in a polar organic solvent solution containing heat resistant nitrogen-containing aromatic polymer, is prepared so as to be applied to the base material and dried then.

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(54)【発明の名称】　非水電解質電池セパレーターとリチウム二次電池

(57)【要約】　（修正有）
【課題】高耐熱性でショート温度が高いという耐熱性含窒素芳香族重合体の特長を生かしつつ、さらにイオン透過性が良好で電池特性が良い非水電解質電池用セパレーターを提供する。また、過熱時にシャットダウンする安全性を備え、さらに加熱されても溶融しない、ショート温度の高い、さらに安全性に優れた非水電解質電池用セパレーターを提供する。さらに、該セパレーターを使用することにより、ショート温度の高い、さらに安全性に優れたリチウム二次電池を提供する。
【解決手段】（１）耐熱性含窒素芳香族重合体およびセラミック粉末を含む非水電解質電池用セパレーター。
（２）織物、不織布、紙または多孔質のフィルムからなる基材、耐熱性含窒素芳香族重合体およびセラミック粉末を含む非水電解質電池用セパレーター。

【特許請求の範囲】
【請求項１】耐熱性含窒素芳香族重合体およびセラミック粉末を含むことを特徴とする非水電解質電池セパレーター。
【請求項２】織物、不織布、紙または多孔質のフィルムからなる基材、耐熱性含窒素芳香族重合体およびセラミック粉末を含むことを特徴とする非水電解質電池セパレーター。
【請求項３】基材が、単位面積当たりの重量が４０ｇ／m^2以下であり、かつその厚みが７０μｍ以下の基材であることを特徴とする請求項２に記載の非水電解質電池セパレーター。
【請求項４】基材が、有機繊維および／または無機繊維を含む基材であることを特徴とする請求項２または３に記載の非水電解質電池セパレーター。
【請求項５】有機繊維が、熱可塑性ポリマーからなることを特徴とする請求項４に記載の非水電解質電池セパレーター。
【請求項６】無機繊維が、ガラス繊維であることを特徴とする請求項４に記載の非水電解質電池セパレーター。
【請求項７】非水電解質電池セパレーターが、２６０℃以下で溶融する熱可塑性ポリマーをセパレーター全体に対して１０重量％以上含み、該熱可塑性ポリマーは、温度上昇時に溶融し、該セパレーターの空隙を閉塞するポリマーであることを特徴とする請求項１～６のいずれかに記載の非水電解質電池セパレーター。
【請求項８】下記（ａ）～（ｅ）の工程を含む方法により製造された塗工膜からなる非水電解質電池セパレーター。
（ａ）耐熱性含窒素芳香族重合体を含む極性有機溶媒溶液に、該耐熱性含窒素芳香族重合体１００重量部に対しセラミック粉末を１～１５００重量部分散した、２６０℃以下で溶融する熱可塑性樹脂を含んでいてもよいスラリー溶液を調製する。
（ｂ）該スラリー溶液を塗工して塗工膜を作成する。
（ｃ）該塗工膜上に該耐熱性含窒素芳香族重合体を析出する。
（ｄ）該塗工膜から極性有機溶媒を除去する。
（ｅ）該塗工膜を乾燥する。
【請求項９】下記（ａ）～（ｅ）の工程を含む方法により製造された塗工膜からなる非水電解質電池セパレーター。
（ａ）耐熱性含窒素芳香族重合体を含む極性有機溶媒溶液に、該耐熱性含窒素芳香族重合体１００重量部に対しセラミック粉末を１～１５００重量部分散した、２６０℃以下で溶融する熱可塑性樹脂を含んでいてもよいスラリー溶液を調製する。
（ｂ）該スラリー溶液を織物、不織布、紙または多孔質のフィルムからなる基材に塗工して塗工膜を作成する。
（ｃ）該塗工膜上に該耐熱性含窒素芳香族重合体を析出させる。
（ｄ）該塗工膜から極性有機溶媒を除去する。
（ｅ）該塗工膜を乾燥する。
【請求項１０】請求項８または９に記載の非水電解質電池セパレーターにさらに熱可塑性ポリマーの微粒状サスペンジョンを塗工、乾燥し、熱可塑性樹脂の微粒子層を付設してなることを特徴とする非水電解質電池セパレーター。
【請求項１１】耐熱性含窒素芳香族重合体が芳香族ポリイミドまたは芳香族ポリアミドであることを特徴とする請求項１～１０のいずれかに記載の非水電解質電池セパレーター。
【請求項１２】芳香族ポリアミドが固有粘度１．０～２．８ｄｌ／ｇのパラ配向芳香族ポリアミドである請求項１１に記載の非水電解質電池セパレーター。
【請求項１３】芳香族ポリイミドが溶媒に可溶な芳香族ポリイミドである請求項１１に記載の非水電解質電池セパレーター。
【請求項１４】セラミック粉末が、一次粒子の平均粒径が１．０μｍ以下であり、該セラミック粉末の含有量が、セパレーター全体の重量の１重量％以上９５重量％以下であるセラミック粉末であることを特徴とする請求項１～１３のいずれかに記載の非水電解質電池セパレーター。
【請求項１５】セラミック粉末が、金属酸化物、金属窒化物および金属炭化物からなる群から選ばれる少なくとも１種のセラミック粉末である請求項１～１４のいずれかに記載の非水電解質電池セパレーター。
【請求項１６】金属酸化物がアルミナ、シリカ、二酸化チタンまたは酸化ジルコニウムであることを特徴とする請求項１５に記載の非水電解質電池セパレーター。
【請求項１７】請求項１～１６に記載の非水電解質電池セパレーターを含むことを特徴とするリチウム二次電池。
【発明の詳細な説明】
【０００１】
【発明の属する技術分野】本発明は、耐熱性含窒素芳香族重合体およびセラミック粉末を含む非水電解質電池セパレーターおよびリチウム二次電池に関する。
【０００２】
【従来の技術】非水系の電解液を用いるリチウム一次電池またはリチウム二次電池は、その高容量および高エネルギー密度が得られるといった特性から大いに期待されている。これらの電池は、正・負極の電極間に電気絶縁性の多孔質のフィルムからなるセパレーターを介在させ、フィルムの空隙内にリチウム塩を溶解した電解液を含浸し、それらの正・負極とセパレーターを積層したり、または渦巻式に巻付けた構造が主である。リチウム二次電池は、その高容量、高エネルギー密度に起因する問題点、例えば電池内外での短絡により電池温度の上昇

が大きいことに対して、種々の安全策を講じる必要がある。このような問題点を解決するために、セパレーターに種々の工夫を加える試みがなされている。

【０００３】特に、セパレーターが寄与できる安全対策としては、シャットダウン特性とショート特性が注目されている。ここに、過充電、外部または内部短絡などのトラブルにより電池温度が上がり、セパレーターの一部が溶融して空隙が閉塞され、電流が遮断されることをシャットダウン（ヒューズともいう）といい、そのときの温度をシャットダウン温度という。さらに温度が上がり、セパレーターが溶融して大きく穴があき、再び短絡することをショートといい、そのときの温度をショート温度という。シャットダウン温度を低くし、ショート温度を高くすることが非水電解質電池用セパレーターに求められている。

【０００４】従来、リチウム二次電池のセパレーターとしては、厚みの薄い多孔質フィルムが使用されており、例えば、ヘキスト社製のＣｅｌｇａｒｄ（登録商標）がリチウム二次電池のセパレーターとして好適に用いられている。しかし、さらに耐熱性が良好でショート温度が高い非水電解質電池用セパレーターが望まれていた。

【０００５】このような非水電解質電池用セパレーターの素材として、耐熱性に優れた全芳香族ポリアミド系重合体を使用することが検討されている。例えば、特公昭５９－３６９３９号公報には、芳香族重合体である、芳香族ポリアミドおよび芳香族ポリイミドの多孔質フィルムの製造方法が記載され、特公昭５９－１４４９４号公報には、芳香族ポリアミドの多孔質フィルムの製造方法が記載されており、電池用セパレーターとして使用できることが記載されている。また、特開平５－３３５００５号公報には、ｄｕ　Ｐｏｎｔ社製のノーメックス（登録商標）紙（メタアラミド紙）をリチウム二次電池のセパレーターとして使用することが記載されている。同じく、特開平７－７８６０８号公報と特開平７－３７５７１号公報にも、メタアラミドからなる不織布または紙状シートを電池用セパレーターに使用することが記載されている。また、ポリイミドについては、特開昭６２－３７８７１号公報と特開平２－４６６４９号公報に、非水電解液電池のセパレーターに使用することが記載されている。これらについては、耐熱性を維持しつつ、さらにイオン透過性が良好で電池特性が良いものが望まれていた。

【０００６】一方、シャットダウン特性とショート特性の観点では、電池内外で短絡した場合に、電池の安全性を確保する点では、特開平３－２９１８４８号公報、特公平４－１６９２号公報には、熱可塑性樹脂の多孔フィルムに、加熱溶融可能な閉塞材を付設し、この閉塞材が加熱溶融されることにより微多孔膜表面を覆うことにより、電流を遮断するシャットダウン機能を電池用セパレーターに持たせることが提案されている。また、特開昭６０－５２号公報、特開昭６０－１３６１６１号公報には、ポリプロピレン不織布にポリエチレン系樹脂粉末を付着させ、該粉末を加熱溶融させて不織布の穴を塞いで、電池用セパレーターにシャットダウン機能を持たせることが提案されている。しかし、これらはいずれも熱可塑性樹脂を用いており、耐熱性が十分でなく、ショート温度が低く安全性の面で用途が限定される。本発明者らは、上記したような問題点がないセパレーターについて鋭意検討を重ねた結果、耐熱性含窒素芳香族重合体にセラミック粉末を含有してなるセパレーターが、高耐熱性でショート温度が高く、さらにイオン透過性も良好であることを見い出した。

【０００７】

【発明が解決しようとする課題】本発明の目的は、高耐熱性でショート温度が高いという耐熱性含窒素芳香族重合体の特長を生かしつつ、さらにイオン透過性が良好で電池特性が良い非水電解質電池用セパレーターを提供することにある。

【０００８】また、本発明の他の目的は、過熱時にシャットダウンする安全性を備え、さらに加熱されても溶融しない、ショート温度の高い、さらに安全性に優れた非水電解質電池用セパレーターを提供することにある。さらに本発明の目的は、該セパレーターを使用することにより、ショート温度の高い、さらに安全性に優れたリチウム二次電池を提供することにある。

【０００９】

【課題を解決するための手段】即ち、本発明は、（１）耐熱性含窒素芳香族重合体およびセラミック粉末を含む非水電解質電池セパレーターに関するものである。

【００１０】また、本発明は、（２）織物、不織布、紙または多孔質のフィルムからなる基材、耐熱性含窒素芳香族重合体およびセラミック粉末を含む非水電解質電池セパレーターに関するものである。

【００１１】次に、本発明は、（３）非水電解質電池用セパレーターが、２６０℃以下で溶融する熱可塑性ポリマーをセパレーター全体に対して１０重量％以上含み、該熱可塑性ポリマーは、温度上昇時に溶融し、該セパレーターの空隙を閉塞するポリマーである（１）または（２）に記載の非水電解質電池セパレーターに関するものである。

【００１２】さらに、本発明は、（４）下記（ａ）～（ｅ）の工程を含む方法により製造された塗工膜からなる非水電解質電池セパレーターに関するものである。

（ａ）耐熱性含窒素芳香族重合体を含む極性有機溶媒溶液に、該耐熱性含窒素芳香族重合体１００重量部に対しセラミック粉末を１～１５００重量部分散した、２６０℃以下で溶融する熱可塑性樹脂を含んでいてもよいスラリー溶液を調製する。

（ｂ）該スラリー溶液を塗工して塗工膜を作成する。

（ｃ）該塗工膜上に該耐熱性含窒素芳香族重合体を析出

させる。
（ｄ）該塗工膜から極性有機溶媒を除去する。
（ｅ）該塗工膜を乾燥する。
【００１３】次いで、本発明は、（５）下記（ａ）～（ｅ）の工程を含む方法により製造された塗工膜からなる非水電解質電池セパレーターに関するものである。
（ａ）耐熱性含窒素芳香族重合体を含む極性有機溶媒溶液に、該耐熱性含窒素芳香族重合体１００重量部に対しセラミック粉末を１～１５００重量部分散した、２６０℃以下で溶融する熱可塑性樹脂を含んでいてもよいスラリー溶液を調製する。
（ｂ）該スラリー溶液を織物、不織布、紙または多孔質のフィルムからなる基材に塗工して塗工膜を作成する。
（ｃ）該塗工膜上に該耐熱性含窒素芳香族重合体を析出させる。
（ｄ）該塗工膜から極性有機溶媒を除去する。
（ｅ）該塗工膜を乾燥する。
【００１４】また、本発明は、（６）本発明（１）～（５）に記載の非水電解質電池セパレーターを含むリチウム二次電池に関するものである。
【００１５】
【発明の実施の形態】以下、本発明について詳しく説明する。本発明の非水電解質電池セパレーターは、耐熱性含窒素芳香族重合体およびセラミック粉末を含むことを特徴とする。
【００１６】本発明における耐熱性含窒素芳香族重合体とは、主鎖に窒素原子と芳香族環を含む重合体であり、例えば、芳香族ポリアミド（以下、「アラミド」ということがある）、芳香族ポリイミド（以下、「ポリイミド」ということがある）、芳香族ポリアミドイミドなどがあげられる。
【００１７】アラミドとしては、例えばメタ配向芳香族ポリアミド（以下、「メタアラミド」ということがある。）とパラ配向芳香族ポリアミド（以下、「パラアラミド」ということがある）があげられ、多孔質になりやすい点でパラアラミドが好ましい。
【００１８】ここに、パラアラミドとは、パラ配向芳香族ジアミンとパラ配向芳香族ジカルボン酸ハライドの縮合重合により得られるものであり、アミド結合が芳香族環のパラ位またはそれに準じた配向位（例えば、４、４’－ビフェニレン、１、５－ナフタレン、２、６－ナフタレン等のような反対方向に同軸または平行に延びる配向位）で結合される繰り返し単位から実質的になるものである。
【００１９】具体的には、ポリ（パラフェニレンテレフタルアミド）、ポリ（パラベンズアミド、ポリ（４、４’－ベンズアニリドテレフタルアミド）、ポリ（パラフェニレン－４、４’－ビフェニレンジカルボン酸アミド）、ポリ（パラフェニレン－２、６－ナフタレンジカルボン酸アミド）、ポリ（２－クロロ－パラフェニレンテレフタルアミド）、パラフェニレンテレフタルアミド／２、６－ジクロロパラフェニレンテレフタルアミド共重合体等のパラ配向型またはパラ配向型に準じた構造を有するパラアラミドが例示される。
【００２０】本発明におけるパラアラミドは、極性有機溶媒に溶けて低粘度の溶液とすることができ、塗工性が優れるので固有粘度１．０ｄｌ／ｇ～２．８ｄｌ／ｇのパラアラミドであることが好ましく、さらには固有粘度１．７ｄｌ／ｇ～２．５ｄｌ／ｇであることが好ましい。また、固有粘度が１．０ｄｌ／ｇ未満では十分なフィルム強度が得られない場合がある。固有粘度が２．８ｄｌ／ｇを越えると安定なパラアラミド溶液となりにくく、パラアラミドが析出しフィルム化が困難となる場合がある。
【００２１】ここに、極性有機溶媒としては、例えば極性アミド系溶媒または極性尿素系溶媒であり、具体的には、Ｎ，Ｎ－ジメチルホルムアミド、Ｎ，Ｎ－ジメチルアセトアミド、Ｎ－メチル－２－ピロリドン、テトラメチルウレア等があげられるが、これらに限定されるものではない。
【００２２】本発明におけるパラアラミドは、多孔質であり、フィブリル状ポリマーであることが好ましい。該フィブリル状ポリマーは、微視的には、不織布状であり、層状で多孔状の空隙を有するものであり、いわゆるパラアラミド多孔質樹脂を形成している。
【００２３】本発明に用いられるポリイミドとしては、芳香族の二酸無水物とジアミンの縮重合で製造される全芳香族ポリイミドが好ましい。該二酸無水物の具体例としては、ピロメリット酸二無水物、３、３’、４、４’－ジフェニルスルホンテトラカルボン酸二無水物、３、３’、４、４’－ベンゾフェノンテトラカルボン酸二無水物、２、２’－ビス（３、４－ジカルボキシフェニル）ヘキサフルオロプロパン、３、３’、４、４’－ビフェニルテトラカルボン酸二無水物などがあげられる。該ジアミンの具体例としては、オキシジアニリン、パラフェニレンジアミン、ベンゾフェノンジアミン、３、３’－メチレンヂアニリン、３、３’－ジアミノベンゾフェノン、３、３’－ジアミノジフェニルスルフォン、１、５’－ナフタレンジアミンなどがあげられるが、本発明は、これらに限定されるものではない。本発明においては、ポリイミド溶液から直接的に多孔質フィルムを作成する場合には、溶媒に可溶なポリイミドが好適に使用できる。このポリイミドとしては、例えば、３、３’、４、４’－ジフェニルスルホンテトラカルボン酸二無水物と、芳香族ジアミンとの重縮合物のポリイミドがあげられる。
【００２４】ポリイミドに用いる極性有機溶媒としては、アラミドのところで例示したもののほか、ジメチルスルホキサイド、クレゾール、およびｏ－クロロフェノール等が好適に使用できる。

【００２５】また、本発明において、ポリイミドとしては、多孔質のものが好ましい。例えば中実フィルムを機械加工、またはレーザー加工等により穴あけして多孔質にすることができる。また、溶液流延法でポリイミドフィルムを作成する際、塗工時のポリマー濃度等のポリイミドの成形条件の制御により、多孔質のものを作成できる。また、セラミック粉末を複合化することにより、任意のポリマー濃度の溶液で、均一で、かつ微細な多孔質を形成することができる。またセラミック粉末の添加量により、透気度を制御することができる。

【００２６】本発明の非水電解質電池用セパレーターは、セラミック粉末を含むことが必要である。該セラミック粉末は、耐熱性含窒素芳香族重合体と絡まって、捕捉され、非水電解質電池用セパレーター中の全体、または部分的に分散して配置している。

【００２７】本発明におけるセラミック粉末は、非水電解質電池用セパレーター強度に与える影響、塗工面の平滑性の点より、一次粒子の平均粒径が１．０μｍ以下であることが好ましく、０．５μｍ以下の粉末であることがより好ましく、０．１μｍ以下であることがさらに好ましい。該一次粒子の平均粒径は、電子顕微鏡により得た写真を、粒子径計測器で解析する方法により測定する。セラミック粉末の一次粒子の平均粒径が１．０μｍを超えるとき、該セパレーターは、脆くなり、塗工面も粗くなる場合がある。また、セラミック粉末の含有量は、好ましくは非水電解質電池用セパレーター重量の１重量％以上９５重量％以下であり、さらに好ましくは５重量％以上５０重量％以下である。セラミック粉末の含有量が、非水電解質電池用セパレーター重量の１重量％未満のとき、イオン透過性および電池特性の促進効果が十分でない場合があり、９５重量％を超えるときは、該セパレーターは、脆くなり、取り扱いが難しくなる場合がある。該セラミック粉末の形状は、特に限定はなく、球状でもランダムな形状でも使用できる。

【００２８】本発明におけるセラミック粉末としては、電気絶縁性の金属酸化物、金属窒化物、金属炭化物等からなるセラミック粉末があげられ、例えばアルミナ、シリカ、二酸化チタンまたは酸化ジルコニウム等の粉末が好ましく用いられる。上記セラミック粉末は、単独で用いてもよいし、２種以上を混合して用いることもできる。

【００２９】本発明における基材とは、電気絶縁性の有機、無機繊維またはパルプからなる多孔質の織物、不織布、紙または多孔質のフィルムがあげられるが、これらの中で、価格、薄さの面から、不織布、紙または多孔質のフィルムが好ましい。

【００３０】該基材の材質としては、電気絶縁性であれば有機物でも無機物でもよく、合成物でも天然物でもよく、該基材は、有機繊維および／または無機繊維および／または有機繊維のパルプおよび／または無機繊維のパルプを含むものがあげられる。具体的には、有機繊維として、熱可塑性ポリマーからなる繊維やマニラ麻などの天然繊維があげられる。該熱可塑性ポリマーからなる繊維として、ポリエチレン、ポリプロピレン等のポリオレフィン、レーヨン、ビニロン、ポリエステル、アクリル、ポリスチレン、ナイロン等の繊維があげられる。無機繊維としては、ガラス繊維、アルミナ繊維等があげられる。

【００３１】本発明（２）の非水電解質電池用セパレーターは、織物、不織布、紙または多孔質のフィルムからなる基材、耐熱性含窒素芳香族重合体およびセラミック粉末を含むことを特徴とする。

【００３２】本発明（２）の非水電解質電池用セパレーターは、該基材を、前記のセラミック粉末を含む耐熱性含窒素芳香族重合体が被覆してなる、または該基材の空隙を該耐熱性含窒素芳香族重合体が充填してなる、または該基材を該耐熱性含窒素芳香族重合体が被覆してなり、かつ該基材の空隙を耐熱性含窒素芳香族重合体が充填してなるものが好ましい。

【００３３】本発明（２）の非水電解質電池用セパレーターに用いる場合に、基材の単位面積当たりの重量は、４０ｇ／ｍ^{2}以下が好ましく、さらに好ましくは１５ｇ／ｍ^{2}以下である。また、該基材の空隙率は、４０％以上が好ましく、さらに好ましくは５０％以上である。また、該基材の厚みは、好ましくは７０μｍ以下であり、さらに好ましくは２５μｍ以下である。

【００３４】また、本発明（３）の非水電解質電池用セパレーターは、該セパレーター全体に対して、２６０℃以下で溶融する熱可塑性ポリマーを１０重量％以上、好ましくは３０重量％以上、さらに好ましくは４０重量％以上含み、該熱可塑性ポリマーが、温度上昇時に溶融し、該セパレーターの空隙を閉塞することを特徴とする。該熱可塑性ポリマーは、本発明の用途である電池用のセパレーターに用いる場合、昇温時に溶融するものであればよい。該熱可塑性ポリマーは、リチウム二次電池のセパレーターとして使用する場合、シャットダウン機能の点から２６０℃以下で溶融するポリマーであることが好ましく、２００℃以下であることがさらに好ましい。また、溶融温度は、シャットダウン温度として適当なので、１００℃程度以上であることが好ましい。

【００３５】該熱可塑性ポリマーとしては、ポリオレフィン樹脂、アクリル樹脂、スチレン樹脂、ポリエステル樹脂またはナイロン樹脂などが例示される。特に、低密度ポリエチレン、高密度ポリエチレン、線状ポリエチレン等のポリエチレン、もしくはそれらの低分子量ワックス分、またはポリプロピレン等のポリオレフィン樹脂が溶融温度が適当で、入手が容易なので好適に用いられる。これらは、１種または２種以上を混合して使用することができる。

【００３６】本発明に用いる熱可塑性ポリマーは、溶媒

への分散性、塗工面の平滑性の点より、平均粒径が好ましくは１０μm以下、さらに好ましくは６μm以下の粉末であることが好ましい。該粉末粒子の形状は、特に限定はなく、球状でもランダムな形状でも使用することができる。

【００３７】本発明（３）の非水電解質電池用セパレーターにおいて、熱可塑性ポリマーは、非水電解質電池用セパレーター中の全体、または部分的に粒子状に分散して配置しており、その態様は、該熱可塑性ポリマーが温度上昇時に溶融し、該セパレーターの空隙を閉塞するような態様であれば特に制限はない。

【００３８】また、本発明（４）の非水電解質電池用セパレーターは、下記（ａ）～(ｅ)の工程を含む方法により製造された塗工膜を用いてなるものである。

（ａ）耐熱性含窒素芳香族重合体を含む極性有機溶媒溶液に、耐熱性含窒素芳香族重合体１００重量部に対しセラミック粉末を１～１５００重量部分散した、２６０℃以下で溶融する熱可塑性樹脂を含んでいてもよいスラリー溶液を調製する。

（ｂ）該スラリー溶液を塗工して塗工膜を作成する。

（ｃ）該塗工膜上に該耐熱性含窒素芳香族重合体を析出する。

（ｄ）該塗工膜から極性有機溶媒を除去する。

（ｅ）該塗工膜を乾燥する。

【００３９】以下、本発明（４）の非水電解質電池用セパレーターの製造方法について具体的に説明する。

工程（ａ）スラリー溶液の調製

耐熱性含窒素芳香族重合体としてパラアラミドおよびポリイミドを用いる場合について例示する。

【００４０】パラアラミドを用いる場合には、例えば、アルカリ金属またはアルカリ土類金属の塩化物を２～１０重量%溶解した極性有機溶媒中で、パラ配向芳香族ジアミン１．００モルに対してパラ配向芳香族ジカルボン酸ジハライド０．９４～０．９９モルを添加して、温度－２０℃～５０℃で縮合重合して製造されるパラ配向芳香族ポリアミド濃度が１～１０%で、固有粘度が１．０～２．８ｄｌ／ｇであるアラミドの極性有機溶媒溶液を作成する。

【００４１】パラアラミドの縮合重合に用いられるパラ配向芳香族ジアミンとして、パラフェニレンジアミン、４、４’－ジアミノビフェニル、２－メチル－パラフェニレンジアミン、２－クロロ－パラフェニレンジアミン、２、６－ジクロロ－パラフェニレンジアミン、２、６－ナフタレンジアミン、１、５－ナフタレンジアミン、４、４’－ジアミノベンズアニリド、３、４’－ジアミノジフェニルエーテル等をあげることができる。パラ配向芳香族ジアミンは、１種または２種以上を混合して縮合重合に供することができる。

【００４２】パラアラミドの縮合重合に用いられるパラ配向芳香族ジカルボン酸ジハライドとして、テレフタル酸ジクロライド、ビフェニル－４、４’－ジカルボン酸ジクロライド、２－クロロテレフタル酸ジクロライド、２、５－ジクロロテレフタル酸ジクロライド、２－メチルテレフタル酸ジクロライド、２、６－ナフタレンジカルボン酸ジクロライド、１、５－ナフタレンジカルボン酸ジクロライド等をあげることができる。パラ配向芳香族ジアミンは、１種または２種以上を混合して縮合重合に供することができる。

【００４３】パラアラミドの溶媒への溶解性を改善する目的で、アルカリ金属またはアルカリ土類金属の塩化物が好適に使用される。具体例としては、塩化リチウムまたは塩化カルシウムがあげられるが、これらに限定されるものではない。

【００４４】上記塩化物の重合系への添加量は、縮合重合で生成するアミド基１．０モル当たり０．５～６．０モルの範囲が好ましく、１．０～４．０モルの範囲がさらに好ましい。塩化物が０．５モル未満では、生成するパラアラミドの溶解性が不十分となる場合があり、６．０モルを越えると実質的に塩化物の溶媒への溶解量を越えるので好ましくない場合がある。

【００４５】一般には、アルカリ金属またはアルカリ土類金属の塩化物が２重量%未満では、パラアラミドの溶解性が不十分となる場合があり、１０重量%を越えてはアルカリ金属またはアルカリ土類金属の塩化物は極性アミド系溶媒または極性尿素系溶媒等の極性有機溶媒に溶解しない場合がある。

【００４６】パラアラミド濃度が０．５重量%未満では、生産性が著しく低下し工業的に不利となる場合がある。パラアラミドが１０重量%を越えるとパラアラミドが析出し、安定なパラアラミド溶液となりにくい場合がある。

【００４７】また、ポリイミドの極性有機溶媒溶液としては、例えば、３、３’、４、４’－ジフェニルスルホンテトラカルボン酸二無水物と、４、４’－ビス（ｐ－アミノフェキシ）ジフェニルスルホン等の芳香族ジアミンとの重縮合反応で得られる、イミド化が完結したポリイミドのＮ－メチル－２－ピロリドン溶液があげられる。この極性有機溶媒としては、ポリイミドを用いる場合には、上記例示の物のほかに、クレゾール、またはｏ－クロロフェノール等があげられる。

【００４８】上記極性有機溶媒溶液中に、セラミック粉末を耐熱性含窒素芳香族重合体１００重量部に対し１～１５００重量部、好ましくは5～１００重量部を十分に分散させてスラリー溶液を調製する。セラミック粉末の量が１重量部未満ならイオン透過性および電池特性の向上が十分でなく好ましくなく、１５００重量部を超えると、該セパレーターは、脆くなり、取り扱いが難しくなるので好ましくない。また、必要に応じ、該スラリー溶液に熱可塑性ポリマーを添加しても良い。

【００４９】工程（ｂ）塗工膜の作成

このスラリー溶液をベースフィルム、スチールベルト、ロール、ドラム上等に塗工し、湿潤な塗工膜を形成する。ベースフィルムとしては、例えば、ポリエチレンテレフタレート、離型処理した紙等があげられる。また、鏡面仕上げした耐蝕性のあるスチールベルト上に塗工することも工業的には良く用いられる。小規模的には、鏡面仕上げした耐蝕性のあるロール、またはドラム上に塗工することもできる。

【００５０】塗工の方法としては、例えばナイフ、ブレード、バー、グラビア、ダイ等の塗工方法があげられる。小規模的には、バー、ナイフ等の塗工が簡便であるが、工業的には、溶液が外気と接触しない構造のダイ塗工が好ましい。

【００５１】工程（ｃ）耐熱性含窒素芳香族重合体の析出

得られた塗工膜を好ましくは２０℃以上の温度、一定湿度に制御した雰囲気中において、耐熱性含窒素芳香族重合体を析出させ、その後凝固液中に浸漬させる。または、凝固液中に浸漬し、ポリマーの析出・凝固を同時に行ない、湿潤塗工膜を得る。析出を均一に、早く行うため、あらかじめスラリー溶液中に貧溶媒、例えば水等を加えて、析液状態にしておくこともできる。

【００５２】パラアラミドの場合は、溶媒の一部または全部を蒸発させると同時にポリマーを析出させ、つまり次の溶媒除去工程と析出工程を同時に行い、半乾燥または乾燥した塗工膜を得ることもできる。

【００５３】ここにいう凝固液としては、水系溶液またはアルコール系溶液などを用いればよく、特に限定されないが、極性有機溶媒溶媒を含む水系溶液またはアルコール系溶液を使用するのが、工業的には溶媒回収工程が簡素化されるので好ましい。具体的には、極性有機溶媒の水溶液があげられる。

【００５４】工程（ｄ）極性有機溶媒の除去

次に、この耐熱性含窒素芳香族重合体が析出した塗工膜から、極性有機溶媒を除去する。除去の方法は、一部または全部を蒸発させても良いし、水、水系溶液、またはアルコール系溶液など極性有機溶媒を溶解できる溶媒で除去しても良い。水を用いて除去する場合には、イオン交換水を用いることが好ましい。また極性有機溶媒を一定濃度含む水溶液中で洗浄した後に、更に水洗することも、工業的に好ましい。乾燥は、加熱により洗浄用の溶媒を蒸発させて除去する。この時の乾燥温度は、溶融する熱可塑性ポリマーを含有する場合には、溶融する温度以下であることが好ましい。

【００５５】また、アルカリ金属またはアルカリ土類金属の塩化物を用いてパラアラミドを調製した場合には、パラアラミドが析出した湿潤塗工膜から、溶媒とともにアルカリ金属またはアルカリ土類金属の塩化物を洗浄、除去する。または乾燥塗工膜から、アルカリ金属またはアルカリ土類金属の塩化物を洗浄、除去する。この除去方法には、塗工膜を溶液に浸漬して溶媒と塩化物を溶出させる方法が採用される。溶媒または塩化物を溶出させるときの溶液としては、水、水系溶液、またはアルコール系溶液が溶媒と塩化物を共に溶解できるので好ましい。

【００５６】（ｅ）乾燥

極性有機溶媒が除去された塗工膜は、好ましくは加熱溶融するポリマーの溶融温度以下で乾燥し、目的とする乾燥塗工膜が製造できる。

【００５７】この乾燥塗工膜をそのまま非水電解質電池用セパレーターとして使用することができる。シャットダウン性能を付与する観点からは、熱可塑性ポリマーを含むことが好ましいが、どの工程で含ませても良い。また、乾燥塗工膜に、さらに熱可塑性ポリマーの微粒状サスペンジョンを塗工、乾燥し、熱可塑性樹脂の微粒子層を付設することが好ましい。

【００５８】塗工の方法としては例えばナイフ、ブレード、バー、グラビア、ダイ等の塗工方法があげられる。小規模的には、バー、ナイフ等の塗工が簡便である。

【００５９】また、本発明（５）の非水電解質電池用セパレーターは、下記（ａ）～（ｅ）の工程を含む方法により製造された塗工膜を用いてなるものである。

（ａ）耐熱性含窒素芳香族重合体を含む極性有機溶媒溶液に耐熱性含窒素芳香族重合体１００重量部に対しセラミック粉末を１～１５００重量部分散した、２６０℃以下で溶融する熱可塑性樹脂を含んでいてもよいスラリー溶液を調製する。

（ｂ）該スラリー溶液を織物、不織布、紙または多孔質のフィルムからなる基材に塗工して塗工膜を作成する。

（ｃ）該塗工膜上に該耐熱性含窒素芳香族重合体を析出させる。

（ｄ）該塗工膜から極性有機溶媒を除去する。

（ｅ）該塗工膜を乾燥する。

【００６０】以下、本発明（５）の非水電解質電池用セパレーターの製造方法について具体的に説明する。

【００６１】本発明（５）の非水電解質電池用セパレーターは、織物、不織布、紙または多孔質のフィルムからなる基材を用いる点を除き、本発明（４）と同じ方法で製造できる。工程（ａ）は、本発明（４）の工程（ａ）と同じである。工程（ｂ）は、織物、不織布、紙または多孔質のフィルムからなる基材に塗工する点を除き、本発明（４）の工程(b)と同じである。また、スラリー溶液をロールまたはドラム上に塗工し、その後に該基材を乗せて含浸させてもよい

【００６２】工程(ｃ)、（ｄ）および（ｅ）は本発明（４）の工程(ｃ)、（ｄ）および（ｅ）と同じ方法で実施できる。

【００６３】この乾燥塗工膜をそのまま非水電解質電池用セパレーターとして、使用することができる。シャットダウン性能を付与または補強する観点からは、熱可塑

性ポリマーを含むことが好ましいが、どの工程で含ませても良い。また、乾燥塗工膜に、さらに熱可塑性ポリマーの微粒状サスペンジョンを塗工、乾燥し、熱可塑性樹脂の微粒子層を付設することが好ましい。塗工の方法は、本発明（４）の方法と同じである。

【００６４】本発明の非水電解質電池用セパレーターの厚みは、５～１００μｍが好ましい。該厚みが５μｍ未満では、非水電解質電池用セパレーターとして強度が不足し取り扱いが難しい場合がある。非水電解質電池用セパレーターとしては、厚いほど取り扱いが容易であるが、ニッケル・カドニウム電池ではあまり制約はないものの、リチウム二次電池では内部抵抗をできるだけ小さくするために、短絡しない範囲で厚みが小さいセパレーターが望ましい。即ち、リチウム二次電池用セパレーターでは、厚みとして好ましくは５～１００μｍ、さらに好ましくは５～５０μｍ、特に好ましくは５～３０μｍである。

【００６５】本発明で用いる耐熱性含窒素芳香族重合体は、常用温度２００℃程度まで強度劣化がほとんど無く、耐熱性に優れていることが知られている。また、自己消火性で、約３００℃程度まで熱分解せずに形態を保ち、それ以上の温度で熱分解する。また、セラミック粉末は、１０００℃程度まで強度劣化がほとんど無く、耐熱性に優れていることが知られている。従って、本発明のセパレーターを用いた非水電解質電池は、電池内外の短絡等により電池温度が上昇してもシャットダウン機能が作動し、しかも、更に温度が上昇しても、高温まで形態を保ち、即ち正負極間の絶縁性を保ち、安全性に特に優れている。

【００６６】本発明の非水電解質電池用セパレーターの空隙の大きさ、または該空隙が球形に近似できるときはその球の直径（以下、孔径ということがある）は、１μｍ程度以下が好ましい。該空隙の平均の大きさまたは孔径が１μｍを越える場合には、正極や負極の主成分である炭素粉やその小片が脱落したときに、短絡しやすいなどの問題が生じる可能性がある。

【００６７】本発明の非水電解質電池用セパレーターは、リチウム二次電池に好適に使用することができる。本発明の非水電解質電池用セパレーターは、耐熱性含窒素芳香族重合体とセラミック粉末を含むので温度が上昇しても非水電解質電池用セパレーターは、フィルム形状を保つ。さらに、熱可塑性樹脂を含む本発明の非水電解質電池用セパレーターを用いると、電池が局部的にまたは全体的に温度上昇した時に、該熱可塑性ポリマーが溶融し、該セパレーターの微細孔の中に入り込んで微細孔を封じ、電流が流れないようにする。さらに温度が上昇した時にも、表面ではなく微細孔の中に入り込んでいるので流れ出ることがない。このようにして、電池のシャットダウンが行なわれる。

【００６８】

【実施例】以下、実施例により本発明をさらに具体的に説明するが、本発明は、これらの実施例に限定されるものではない。実施例および比較例における試験・評価方法または判定基準は、次に示すとおりである。

【００６９】（１）固有粘度

本発明において固有粘度とは、次の測定方法によるものと定義する。９６～９８％硫酸１００ｍｌにパラアラミド重合体０．５ｇを溶解した溶液および９６～９８％硫酸について、それぞれウベローデ型毛細管粘度計により３０℃にて流動時間を測定し、求められた流動時間の比から次式により固有粘度を求めた。

固有粘度＝ｌｎ（Ｔ／T_0）／Ｃ　〔単位：ｄｌ／ｇ〕

ここでＴおよびT_0は、それぞれパラアラミド硫酸溶液および硫酸の流動時間であり、Ｃは、パラアラミド硫酸溶液中のパラアラミド濃度（ｄｌ／ｇ）を示す。

【００７０】（２）塗工膜等の厚み測定

得られた塗工膜等の厚みは、ＪＩＳ規格　Ｋ７１３０－１９９２　に従い測定した。

【００７１】（３）空隙率

塗工膜等を一辺の長さ１０ｃｍの正方形に切り取り、重量（Ｗｇ）と厚み（Ｄｃｍ）を測定した。サンプル中の材質の重量を計算で割りだし、それぞれの材質の重量（Ｗｉ）を真比重で割り、それぞれの材質の体積を仮定して、次式より空隙率（体積％）を求めた。

空隙率（％）＝１００－｛（Ｗ1／真比重１）＋（Ｗ2／真比重２）＋・・＋（Ｗn／真比重ｎ）｝／（１００×Ｄ）

【００７２】

【数１】

$$W=\sum_{i=1}^{n} W_i$$

【００７３】塗工膜等の目付けは、塗工膜等を１０ｃｍ角の正方形に切り出し、その重量を測定して下式より求めた。

塗工膜等の目付け（ｇ／m^2）＝サンプルの重量（ｇ）／０．０１（m^2）

各材料の目付けは、製膜に使用した量、比率より算出した。

【００７４】（４）透気度

ＡＳＴＭ　Ｆ３１６－８６に準拠して、測定面積１１．３cm^2（直径３８ｍｍ）の大きさのサンプルを　米国Ｐｏｒｏｕｓ　Ｍａｔｅｒｉａｌｓ　Ｉｎｃ社のＰｅｒｍ　Ｐｏｒｏｍｅｔｅｒを使い、圧力３ｋｇ/cm^2での空気の流量を測定して透気度（ｃｃ/秒）とした。一般に同一材料系では、透気度が大きければ、イオン透過性が良く、電池特性も良好だと判断できる。

【００７５】（５）引張り強度

得られた塗工膜等からダンベル社製ダンベルカッターにて試験片を打ち抜き、インストロンジャパン社製インス

トロン万能試験機モデル４３０１を用い、ＪＩＳ　Ｋ－７１２７に準じて引張り強度、弾性率および破断ひずみを求めた。

【００７６】（６）引裂き強度の測定

塗工膜等からダンベル社製のＪＩＳ　Ｋ－７１２８－１９９１　Ｃ法（直角形引裂き法）用ダンベルカッターにて試験片を打ち抜き、インストロンジャパン社製インストロン万能引張試験機モデル４３０１を用い、ＪＩＳ　Ｋ－７１２８－１９９１　Ｃ法（直角形引裂き法）に準じて引裂き強度の測定をおこなった。サンプルの両端を万能引張試験機のチャックで掴み、２００ｍｍ／分の速度で引張り、その時の荷重、変位を記録計で記録した。サンプルの引裂きが、開始された時の荷重より、引裂き強さを求めた。その後サンプルが完全に破壊するまでの荷重の平均値より、引裂き伝播抵抗を求めた。引裂き強度および引裂き伝播抵抗は、次式で求めた。

引裂き強度（ｋｇ／ｍｍ）＝サンプルの引裂きが開始された時の最大荷重÷サンプル厚み

引裂き伝播抵抗（ｋｇ／ｍｍ）＝サンプルの引裂き開始後、完全に破壊するまでの荷重の平均値／サンプル厚み

【００７７】（７）平板電池での内部電気抵抗の測定

（セパレーターの電気抵抗測定・シャットダウン作動の評価と耐熱性の評価を目的とする。）

塗工膜等を一辺の長さ２５ｍｍの正方形に切り取り、ＬｉＰＦ$_6$の１Ｎプロピレンカーボネート溶液の電解液を含浸させた。これを厚み０．５ｍｍ、直径１８ｍｍの２枚の白金製円盤の電極の間にはさみ、この電極間に１ＫＨｚで１ボルトの電圧をかけて、平板電池の内部電気抵抗を測定し、２５℃での内部電気抵抗をセパレーターの電気抵抗とした。本平板電池を熱板上に置き、２５℃から２００℃まで、４℃／分で昇温した。この過程で内部電気抵抗が増大する温度をシャットダウン作動温度とした。

【００７８】（８）非水電解質電池用セパレーターとしての評価

正極は、ニッケル酸リチウム粉末と炭素質導電材粉末、およびポリフッ化ビニリデンを重量比８７：１０：３で混合したペースト（Ｎ－メチルピロリドン溶媒）を、２０μｍのアルミニウム箔に塗布し、乾燥、プレスして厚み８５μｍのシートを作製した。負極は、黒鉛粉末とポリフッ化ビニリデンを重量比９０：１０で混合したペースト（Ｎ－メチルピロリドン溶媒）を、１０μｍの銅箔に塗布し、乾燥、プレスして厚み１００μｍのシートを作製した。電解液は、エチレンカーボネート、ジメチルカーボネートおよびエチルメチルカーボネートの混合溶媒（重量比　３０：３５：３５）に、６フッ化リン酸リチウムを溶解（１モル／Ｌ濃度）した液を用いた。セパレーターは、本発明の実施例で述べる非水電解質電池用セパレーターを用いた。

【００７９】電池は、正極面積が２．３４ｃｍ^{2}の平板型構造とし、上記で準備したものをアルゴン雰囲気ボックス内で、負極シート、セパレーター、正極シートの順に重ねた後、セパレーターに電解液を充分に含浸させた。作製した平板電池を充電電圧４．２Ｖ、放電電圧２．７５Ｖで８サイクル繰り返し、８サイクル目の放電容量（放電電流１．５ｍＡ）を測定し、０．２Ｃでの放電容量とした。また、サイクル劣化を測定した。上記の条件で充電し、放電容量（放電電流２２．５ｍＡ）を測定したときにはこれを、３Ｃでの放電容量とした。３Ｃでの電池の負荷特性を下式で求めた。

３Ｃでの電池の負荷特性（％）＝３Ｃでの放電容量／０．２Ｃでの放電容量×１００

【００８０】（９）円筒電池での安全性試験

（８）と同じ方法で作製した正極シート状電極、負極シート状電極を上記のセパレーターを介して、負極、セパレーター、正極、セパレーターの順に積層し、この積層体を一端より巻き取って渦巻形状の電極素子とした。前記の電極素子を電池缶に挿入し、前記の非水電解質溶液を含浸し、安全弁を備えた正極端子を兼ねる電池蓋をガスケットを介してかしめて１８６５０サイズの円筒型電池を得た。

【００８１】（１０）セラミック粉末の平均粒径の測定方法

平均粒径は、電子顕微鏡により得た写真を、ツアイス社製の粒子径計測器ＴＧＺ３で解析して求める。

【００８２】実施例１

１．ポリ（パラフェニレンテレフタルアミド）の製造

撹拌翼、温度計、窒素流入管および粉体添加口を有する、３リットルのセパラブルフラスコを使用して、ポリ（パラフェニレンテレフタルアミド）（以下、ＰＰＴＡと略すことがある。）の製造を行った。フラスコを十分乾燥し，Ｎ－メチル－２－ピロリドン２２００ｇを仕込み、２００℃で２時間真空乾燥した塩化カルシウム粉末１５１．０７ｇを添加し、１００℃に昇温して完全に溶解させた。室温に戻して、パラフェニレンジアミン、６８．２３ｇを添加し完全に溶解させた。この溶液を２０℃±２℃に保ったまま、テレフタル酸ジクロライド、１２４．９７ｇを１０分割して約５分おきに添加した。ただし１０分割したテレフタル酸ジクロライドの１つは、テレフタル酸ジクロライドと同重量のＮＭＰに溶解して最終の添加を行った。その後も撹拌しながら、溶液を２０℃±２℃に保ったまま１時間熟成した。１５００メッシュのステンレス金網でろ過した。得られた溶液は、ＰＰＴＡ濃度６％の液晶相で、光学的異方性を示した。ＰＰＴＡ溶液の一部をサンプリングし、水で再沈して得られたＰＰＴＡの固有粘度は、２．０１ｄｌ／ｇであった。

【００８３】２．塗工用ＰＰＴＡスラリー溶液の調製

上記実施例１の１．のＰＰＴＡ溶液６５ｇを、撹拌翼、温度計、窒素流入管および液体添加口を有する、５００

ｍｌのセパラブルフラスコに秤取し、２３５ｇのＮＭＰを添加し、最終的に、ＰＰＴＡ濃度が１．３重量％の等方相の溶液に調製して６０分間撹拌した。上記の溶液にアルミナ微細粒子（日本アエロジル社製品；アルミナＣ、平均粒子径０．０１３μｍ）３．９ｇを混合し、２４０分間撹拌した。アルミナ微細粒子を十分に分散させたスラリー溶液を１０００メッシュの金網でろ過後、減圧下で脱泡し塗工用スラリー溶液とした。

【００８４】３．塗工膜の作成

直径５５０ｍｍ、長さ３５０ｍｍのドラム上に厚み１００μｍのＰＥＴフィルムを巻いた。ＰＥＴフィルムの上に基材（ポリエステル紙、商品名　０１３２ＴＨ－８細デニールタイプ、目付け８ｇ／ｍ²、厚み２０μｍ、；日本バイリーン社製品）を巻いた。基材の片側をテープでドラムに固定した。もう片方に０．６ｋｇの重りを基材に均等に荷重がかかるように吊り下げた。ドラムの最上部に直径２０ｍｍのステンレス製塗工バーをドラムとのクリアランスが０．３ｍｍになるように平行に配置した。ドラムと塗工バーの間に基材のテープで固定した側の端がくるようにドラムを回転させ、止めた。塗工バー手前の基材上に上記で調製した、塗工用ＰＰＴＡスラリー溶液を供給しながら、ドラムを０．５ｒｐｍで回転させて、基材に塗工した。

【００８５】基材全体を塗工したら、ドラムの回転を止め、そのまま２３℃で湿度５０％の雰囲気に１０分間置き、ＰＰＴＡを析出させた。１００μｍのＰＥＴフィルムと基材にスラリー溶液を塗工・析出させた塗工膜を一体にしたままドラムより取り外してイオン交換水に浸漬し、イオン交換水を流しながら、１２時間洗浄した。洗浄後ＰＥＴフィルムをとり、湿潤塗工膜を、両面からポリエステル布に挟み、さらにアラミド製フェルトで挟んで、厚み３ｍｍのアルミ平板の上に置き、その上から厚み０．１ｍｍのナイロンフィルムを置いて、その回りをシーリング材でシールし、内部を真空に引きながら、１５０℃で２時間乾燥して乾燥塗工膜等を得た。

【００８６】４．ポリオレフィンのサスペンジョンの塗工

ポリオレフィン（以下「ＰＯ」と略することがある。）のサスペンジョン（ケミパールＷＦ６４０とケミパールＷＰ１００（三井石油化学（株）製品））を同量ずつ混合し、イオン交換水を固形分３０％になるように加えて塗工用ポリオレフィンのサスペンジョンを調製した。

ケミパールＷＦ６４０およびケミパールＷＰ１００：粒径　１μｍ（コールター・カウンター法で測定）の低分子量ポリオレフィン

【００８７】直径５５０ｍｍ、長さ３５０ｍｍのドラム上に離型処理をした厚み２５μｍのＰＥＴフィルムを巻いた。該ＰＥＴフィルムの上に幅３００ｍｍ、長さ９００ｍｍに切った上記乾燥塗工膜を巻き、片側をテープでドラムに固定した。もう片方に０．６ｋｇの重りを乾燥塗工膜に均等に荷重がかかるように吊り下げた。ドラムの最上部に直径２０ｍｍのステンレス製塗工バーをドラムとのクリアランスが０．０７５ｍｍになるように平行に配置した。ドラムと塗工バーの間に乾燥塗工膜のテープで固定した側の端がくるようにドラムを回転させ、止めた。塗工バー手前の乾燥塗工膜上に上記で調整した、塗工用ポリオレフィンのサスペンジョンを供給しながら、ドラムを０．５ｒｐｍで回転させて、ポリオレフィンのサスペンジョンを乾燥塗工膜上に塗工した。乾燥塗工膜等全体を塗工したら、ドラムの回転を止め、そのまま６０分間置き乾燥して、非水電解質セパレーターを得た。

【００８８】５．非水電解質電池用セパレーターの物性

上記の非水電解質セパレーターは、厚みが２６．３μｍ、目付け１９．２ｇ／ｍ²（ＰＥＴ紙８ｇ/ｍ²、ＰＰＴＡ３．１ｇ/ｍ²、アルミナ３．１ｇ/ｍ²、ＰＯ５．０ｇ/ｍ²）、空隙率４４．８％であった。走査型電子顕微鏡で該セパレーターを観察したところ、片面は、約０．１μｍ以下のフィブリル状、層状のＰＰＴＡ樹脂からなり、そのフィブリル間に粒径０．０１３μｍ程度のアルミナ微粒子が分散しており、孔径０．０５～０．２μｍの空孔を有する多孔質層であった。もう一方の片面は、粒径１μｍ程度のポリオレフィン粒子が厚み５μｍ程度あった。断面を観察すると、基材の紙のポリエステル繊維の間に、約０．１μｍ以下のフィブリル状のＰＰＴＡ樹脂の間に粒径０．０１３μｍ程度のアルミナ微粒子が分散した状態で充填されていた。本セパレーターの透気度は、１０５ｃｃ／ｓｅｃ、引張り強度４．９ｋｇ/ｍｍ²、破断ひずみ２．８％、引裂き強度は、４．９ｋｇ／ｍｍ、引裂き伝播抵抗は、２．５ｋｇ／ｍｍであった。

【００８９】６．シャットダウン性能の測定と耐熱性の評価

上記セパレーターの加熱前の２５℃における内部電気抵抗は、２５Ωであった。サンプルの温度を上げていくと、内部電気抵抗は、徐々に下がっていくが、１００℃付近より、内部電気抵抗が上がりだして１２０℃付近で１００Ωに上昇した。さらに２００℃まで温度を上げたがメルトダウンによる電気抵抗の低下はなかった。以上の結果より本セパレーターは、温度上昇時に電流を遮断する、シャットダウン機能および耐熱性を有することがわかった。

【００９０】７．非水電解質電池用セパレーターとしての評価

得られたセパレーターの８サイクル目の放電容量は、１８８ｍＡＨ／ｇ（放電電流１．５ｍＡ）であり、サイクル劣化もなく正常に動作した。負荷特性は、３Ｃで４１％であった。以上の結果より本セパレーターは、非水電解質電池用セパレーターとしての性能を有することがわかった。

【００９１】８．円筒電池での安全性試験
前述の方法で得た円筒型電池２個について、定格容量の１５０％の充電を行って過充電状態とした後、釘刺し試験を実施した。釘刺し試験の方法は、（社）日本蓄電池工業会のリチウム二次電池安全性評価基準ガイドライン（日本蓄電池工業会指針ＳＢＡ－Ｇ１１０１－１９９５）にしたがった。試験に供した電池は過充電という苛酷な状態にもかかわらず、破裂せず発火もしなかった。
【００９２】実施例２
１．塗工用ＰＰＴＡスラリー溶液の調製
混合するアルミナ微細粒子の重量が３９ｇである点を除き、実施例１と同じ方法で調製した。
２．塗工膜の作成
ステンレス製塗工バーをドラムとのクリアランスが０．１ｍｍになるように平行に配置する以外は実施例１の３と同じ方法で作製した。
３．ポリオレフィンのサスペンジョンの層の塗工
実施例１の４と同じ方法で非水電解質電池用セパレーターを得た。
【００９３】４．非水電解質電池用セパレーターの物性
上記の非水電解質電池用セパレーターは、厚みが２４．１μｍ、目付け１７．８ｇ／ｍ^2（ＰＥＴ紙８ｇ/ｍ^2、ＰＰＴＡ０．４２ｇ/ｍ^2、アルミナ４．２ｇ/ｍ^2、ＰＯ５．２ｇ/ｍ^2）、空隙率４５．３％であった。走査型電子顕微鏡でセパレーターを観察したところ、片面は、約０．１μｍ以下のフィブリル状、層状のＰＰＴＡ樹脂からなり、そのフィブリル間に粒径０．０１３μｍ程度のアルミナ微粒子が分散しており、孔径０．０５～０．２μｍの空孔を有する多孔質層であった。もう一方の片面は、粒径１μｍ程度のポリオレフィン粒子が厚み５μｍ程度あった。断面を観察すると、基材の紙のポリエステル繊維の間に、約０．１μｍ以下のフィブリル状のＰＰＴＡ樹脂の間に粒径０．０１３μｍ程度のアルミナ微粒子が分散した状態で充填されていた。本セパレーターの透気度は７５０ｃｃ／ｓｅｃであった。
【００９４】５．シャットダウン性能の測定と耐熱性の評価
上記セパレーターの加熱前の２５℃における内部電気抵抗は２０Ωであった。サンプルの温度を上げていくと、内部電気抵抗は、徐々に下がっていくが、１００℃付近より、内部電気抵抗が上がりだして１２０℃付近で２５２Ωに上昇した。さらに２００℃まで温度を上げたがメルトダウンによる電気抵抗の低下はなかった。以上の結果より本セパレーターは、温度上昇時に電流を遮断する、シャットダウン機能および耐熱性を有することがわかった。
【００９５】６．非水電解質電池用セパレーターとしての評価
得られたセパレーターの８サイクル目の放電容量は、１９３ｍＡＨ／ｇ（放電電流１．５ｍＡ）であり、サイクル劣化もなく正常に動作した。負荷特性は、３Ｃで４７％であった。以上の結果より本セパレーターは、非水電解質電池用セパレーターとしての性能を有することがわかった。
【００９６】実施例３
１．塗工用ポリイミド樹脂スラリー溶液の調製
ポリマー濃度２０％の溶媒に可溶なポリイミド樹脂のＮＭＰ溶液（リカコート、ＰＮ－２０；新日本理化（株）製品）１００ｇとアルミナ微細粒子（日本アエロジル社製品；アルミナＣ、平均粒子径０．０１３μｍ）を２ｇを、撹拌翼、温度計、窒素流入管および液体添加口を有する、５００ｍｌのセパラブルフラスコに秤取し、１２０分間撹拌した。ＮＭＰ４５ｍｌを加え１２０分間撹拌した。アルミナ微細粒子を十分に分散させたスラリー溶液を１０００メッシュの金網でろ過後、減圧下で脱泡し塗工用スラリー溶液とした。
２．塗工膜の作成
ステンレス製塗工バーをドラムとのクリアランスが０．１ｍｍになるように平行に配置する以外は、実施例１の３と同じ方法で調製した。
３．ポリオレフィンのサスペンジョンの塗工実施例１と同じ方法で非水電解質電池用セパレーターを得た。
【００９７】４．非水電解質電池用セパレーターの物性
上記の非水電解質電池用セパレーターは、厚みが２７．４μｍ、目付け１８．１ｇ／ｍ^2（ＰＥＴ紙８ｇ/ｍ^2、ポリイミド４．４ｇ/ｍ^2、アルミナ０．４４ｇ/ｍ^2、ＰＯ５．３ｇ/ｍ^2）、空隙率４５．４％であった。走査型電子顕微鏡でセパレーターの断面を観察したところ、基材の紙のポリエステル繊維の間に、多孔質のポリイミド樹脂の中に粒径０．０１３μｍ程度のアルミナ微粒子が分散して、連続気泡になっているもので、充填されている層と粒径１μｍ程度のポリオレフィン粒子が厚み５μｍ程度の層であった。本セパレーターの透気度は、１５０ｃｃ／ｓｅｃであった。
【００９８】５．シャットダウン性能の測定と耐熱性の評価
上記セパレーターの加熱前の２５℃における内部電気抵抗は、３５Ωであった。サンプルの温度を上げていくと、内部電気抵抗は、徐々に下がっていくが、１００℃付近より、内部電気抵抗が上がりだして１２０℃付近で７０Ωに上昇した。さらに２００℃まで温度を上げたがメルトダウンによる電気抵抗の低下はなかった。以上の結果より本セパレーターは、温度上昇時に電流を遮断する、シャットダウン機能および耐熱性を有することがわかった。
【００９９】６．非水電解質電池用セパレーターとしての評価
得られたセパレーターの８サイクル目の放電容量は、１８３ｍＡＨ／ｇ（放電電流１．５ｍＡ）であり、サイクル劣化もなく正常に動作した。負荷特性は３Ｃで８％で

あった。以上の結果より本セパレーターは、非水電解質電池用セパレーターとしての性能を有することがわかった。

【０１００】実施例４

１．塗工用ポリイミド樹脂スラリー溶液の調製

ポリマー濃度２０％のポリイミド樹脂のＮＭＰ溶液（リカコート、ＰＮ－２０；新日本理化（株）製品）１００ｇとアルミナ微細粒子（日本アエロジル社製品；アルミナＣ、平均粒子径０．０１３μｍ　）７ｇを、撹拌翼、温度計、窒素流入管および液体添加口を有する、５００ｍｌのセパラブルフラスコに秤取し、１２０分間撹拌した。ＮＭＰ２８ｍｌを加え１２０分間撹拌した。アルミナ微細粒子を十分に分散させたスラリー溶液を１０００メッシュの金網でろ過後、減圧下で脱泡し塗工用スラリー溶液とした。

２．塗工膜の作成

ステンレス製塗工バーをドラムとのクリアランスが０．１ｍｍになるように平行に配置する以外は実施例１の３と同じ方法で調製した。

３．ポリオレフィンのサスペンジョンの塗工

実施例１の４と同じ方法で非水電解質電池用セパレーターを得た。

【０１０１】４．非水電解質電池用セパレーターの物性

上記の非水電解質電池用セパレーターは、厚みが２６．７μｍ、目付け１７．７ｇ／ｍ²（ＰＥＴ紙８ｇ/ｍ²、ポリイミド３．４ｇ/ｍ²、アルミナ１．２ｇ/ｍ²、ＰＯ５．１ｇ/ｍ²）、空隙率４６．５％であった。走査型電子顕微鏡でセパレーターの断面を観察したところ、基材の紙のポリエステル繊維の間に、多孔質のポリイミド樹脂の中に粒径０．０１３μｍ程度のアルミナ微粒子が分散して、連続気泡になっているもので、充填されている層と粒径１μｍ程度のポリオレフィン粒子が厚み５μｍ程度の層であった。本セパレーターの透気度は６８０ｃｃ／ｓｅｃであった。

【０１０２】５．シャットダウン性能の測定

上記セパレーターの加熱前の２５℃における内部電気抵抗は、２５Ωであった。サンプルの温度を上げていくと、内部電気抵抗は徐々に下がっていくが、１００℃付近より、内部電気抵抗が上がりだして１２０℃付近で７９Ωに上昇した。さらに２００℃まで温度を上げたがメルトダウンによる電気抵抗の低下はなかった。以上の結果より本セパレーターは、温度上昇時に電流を遮断する、シャットダウン機能および耐熱性を有することがわかった。

【０１０３】６．非水電解質電池用セパレーターとしての評価

得られたセパレーターの８サイクル目の放電容量は、１９０ｍＡＨ／ｇ（放電電流１．５ｍＡ）であり、サイクル劣化もなく正常に動作した。負荷特性は３Ｃで２４％であった。以上の結果より本セパレーターは、非水電解質電池用セパレーターとしての性能を有することがわかった。

【０１０４】実施例５

１．塗工用ポリイミド樹脂スラリー溶液の調製

ポリマー濃度２０％のポリイミド樹脂のＮＭＰ溶液（リカコート、ＰＮ－２０；新日本理化（株）製品）１００ｇとアルミナ微細粒子（日本アエロジル社製品；アルミナＣ、平均粒子径０．０１３μｍ　）を１０ｇを、撹拌翼、温度計、窒素流入管および液体添加口を有する、５００ｍｌのセパラブルフラスコに秤取し、１２０分間撹拌した。ＮＭＰ４０ｍｌを加え１２０分間撹拌した。アルミナ微細粒子を十分分散させたスラリー溶液を１０００メッシュの金網でろ過後、減圧下で脱泡し塗工用スラリー溶液を得た。

２．塗工膜の作成

ステンレス製塗工バーをドラムとのクリアランスが０．１ｍｍになるように平行に配置する以外は、実施例１の３と同じ方法で調製した。

３．ポリオレフィンのサスペンジョンの塗工

ステンレス製塗工バーをドラムとのクリアランスが０．０５ｍｍになるように平行に配置する以外は実施例１の４と同じ方法で非水電解質電池用セパレーターを得た。

【０１０５】４．非水電解質電池用セパレーターの物性

上記の非水電解質電池用セパレーターは、厚みが２９．６μｍ、目付け２０．５ｇ／ｍ²（ＰＥＴ紙８ｇ/ｍ²、ポリイミド４．９ｇ/ｍ²、アルミナ２．５ｇ/ｍ²、ＰＯ５．１ｇ/ｍ²）、空隙率４８．１％であった。走査型電子顕微鏡でセパレーターの断面を観察したところ、基材の紙のポリエステル繊維の間に、多孔質のポリイミド樹脂の中に粒径０．０１３μｍ程度のアルミナ微粒子が分散して、連続気泡になっているもので、充填されている層と粒径１μｍ程度のポリオレフィン粒子が厚み５μｍ程度の層であった。

【０１０６】本セパレーターの透気度は３２００ｃｃ／ｓｅｃで、引張り強度４．５ｋｇ/ｍｍ²、破断ひずみ１４．０％、引裂き強度は、７．５ｋｇ／ｍｍ、引裂き伝播抵抗は、３．３ｋｇ／ｍｍであった。

【０１０７】５．シャットダウン性能の測定と耐熱性の評価

上記セパレーターの加熱前の２５℃における内部電気抵抗は３５Ωであった。サンプルの温度を上げていくと、内部電気抵抗は徐々に下がっていくが、１００℃付近より、内部電気抵抗が上がりだして１２０℃付近で２２１Ωに上昇した。さらに２００℃まで温度を上げたがメルトダウンによる電気抵抗の低下はなかった。　以上の結果より本セパレーターは、温度上昇時に電流を遮断する、シャットダウン機能および耐熱性を有することがわかった。

【０１０８】６．非水電解質電池用セパレーターとしての評価

得られたセパレーターの８サイクル目の放電容量は、１８７ｍＡＨ／ｇ（放電電流１．５ｍＡ）であり、サイクル劣化もなく正常に動作した。負荷特性は３Ｃで６３％であった。以上の結果より本セパレーターは、非水電解質電池用セパレーターとしての性能を有することがわかった。

【０１０９】７．円筒電池での安全性試験

上述の方法で得た円筒型電池２個について、定格容量の１５０％の充電を行って過充電状態とした後、釘刺し試験を実施した。釘刺し試験の方法は（社）日本蓄電池工業会のリチウム二次電池安全性評価基準ガイドライン（日本蓄電池工業会指針ＳＢＡ－Ｇ１１０１－１９９５）にしたがった。試験に供した電池は過充電という苛酷な状態にもかかわらず、破裂せず発火もしなかった。

【０１１０】実施例６

１．塗工用ポリイミド樹脂スラリー溶液の調製

ポリマー濃度２０％のポリイミド樹脂のＮＭＰ溶液（リカコート、ＰＮ－２０；新日本理化（株）製品）１００ｇと平均粒径０．４μｍのアルミナ細粒子（ＡＭＳ－１２；住友化学（株）社製品）１０ｇを、撹拌翼、温度計、窒素流入管および液体添加口を有する、５００ｍｌのセパラブルフラスコに秤取し、１２０分間撹拌した。ＮＭＰ４５ｍｌを加え１２０分間撹拌した後、減圧下で脱泡し塗工用スラリー溶液とした。このスラリー溶液を２４時間静置したところ、アルミナ細粒子の一部が沈降していた。

２．塗工膜の作成

ステンレス製塗工バーをドラムとのクリアランスが０．１ｍｍになるように平行に配置する以外は実施例１の３と同じ方法で調製した。

３．ポリオレフィンのサスペンジョンの塗工

実施例１の４と同じ方法で非水電解質電池用セパレーターを得た。

【０１１１】４．非水電解質電池用セパレーターの物性

上記の非水電解質電池用セパレーターは、厚みが２６．５μｍ、目付け１７．８ｇ／ｍ^2（ＰＥＴ紙８ｇ/ｍ^2、３．０ｇ/ｍ^2、アルミナ１．５ｇ/ｍ^2、ＰＯ５．３ｇ/ｍ^2）、空隙率４６．０％であった。走査型電子顕微鏡でセパレーターの断面を観察したところ、基材の紙のポリエステル繊維の間に、多孔質のポリイミド樹脂の中に平均粒径０．４μｍ程度のアルミナ微粒子が分散して、連続気泡になっているもので、充填されている層と粒径１μｍ程度のポリオレフィン粒子が厚み５μｍ程度の層であった。本セパレーターの透気度は１２０ｃｃ／ｓｅｃから２７０ｃｃ／ｓｅｃで場所ムラがあった。

【０１１２】比較例１

１．塗工用ポリイミド樹脂溶液の調製

ポリマー濃度２０％のＮＭＰ溶液のポリイミド樹脂（リカコート、ＰＮ－２０；新日本理化（株）製品）１００ｇを、撹拌翼、温度計、窒素流入管および液体添加口を有する、５００ｍｌのセパラブルフラスコに秤取し、減圧下で脱泡し塗工用溶液とした。

２．塗工膜の作成

ステンレス製塗工バーをドラムとのクリアランスが０．０５ｍｍになるように平行に配置する以外は、実施例１の３と同じ方法で調製した。

３．ポリオレフィンのサスペンジョンの塗工

実施例１の４と同じ方法で非水電解質電池用セパレーターを得た。

【０１１３】４．非水電解質電池用セパレーターの物性

上記の非水電解質電池用セパレーターは、厚みが２８．０μｍ、目付け１７．７ｇ／ｍ^2（ＰＥＴ紙８ｇ/ｍ^2、ポリイミド４．６ｇ/ｍ^2、ＰＯ５．１ｇ/ｍ^2）、空隙率４７．３％であった。走査型電子顕微鏡で非水電解質電池用セパレーターの断面を観察したところ、基材の紙のポリエステル繊維の間に、多孔質のポリイミド樹脂で、充填されている層と粒径１μｍ程度のポリオレフィン粒子が厚み５μｍ程度の層であった。本セパレーターの透気度は３ｃｃ／ｓｅｃと低かった。

５．シャットダウン性能の測定、電池用セパレーターとしての評価

電解液の含浸不良のため測定不可であった。

【０１１４】実施例７

１．塗工用ＰＰＴＡドープの調製

塗工用ＰＰＴＡドープ①

上記実施例１の１．のＰＰＴＡドープ１００ｇを、撹拌翼、温度計、窒素流入管および液体添加口を有する、５００ｍｌのセパラブルフラスコに秤取し、１４０ｇのＮＭＰを添加し、最終的に、ＰＰＴＡ濃度が２．５重量％の等方相の溶液に調製して６０分間撹拌した。上記のＰＰＴＡ濃度が２．５重量％溶液にアルミナ微細粒子（日本アエロジル社製品；アルミナＣ）を６ｇ混合し、２４０分間撹拌した。ナノマイザーに３回通し、アルミナ微細粒子を十分分散させた塗工ドープを１０００メッシュの金網でろ過した。その後、減圧下で脱泡し塗工用ドープとした。

【０１１５】２．多孔質フィルム層の作製

直径５５０ｍｍ、長さ３５０ｍｍのドラム上に厚み１００μｍのＰＥＴフィルムを巻いた。ＰＥＴフィルムの上に基材（ポリエチレンセパレーター、目付け１０．５ｇ／ｍ^2、厚み１６μｍ、空隙率４０％）を巻いた。基材の片側をテープでドラムに固定した。もう片方に０．６ｋｇの重りを基材に均等に荷重がかかるように吊り下げた。ドラムの最上部に直径２５ｍｍのステンレス製塗工バーをドラムとのクリアランスが０．１５ｍｍになるように平行に配置した。ドラムと塗工バーの間に基材のテープで固定した側の端がくるようにドラムを回転させ、止めた。塗工バー手前の基材上に上記で調整した、塗工ドープを供給しながら、ドラムを０．５ｒｐｍで回転させて、基材に塗工した。基材全体を塗工し、さらに

ドラムを回転させながら、そのまま２３℃で湿度５０％の雰囲気に１０分間置き、ＰＰＴＡを析出させた。１００μｍのＰＥＴフィルムと基材にドープを塗工・析出させたフィルムを一体にしたままドラムより取り外してイオン交換水に浸漬し、イオン交換水を流しながら、１２時間洗浄した。洗浄後ＰＥＴフィルムをとり、湿潤フィルムを、両面からポリエステル布に挟み、さらにアラミド製フェルトで挟んで、厚み３ｍｍのアルミ平板の上に置き、その上から厚み０．１ｍｍのナイロンフィルムを置いて、その回りをシーリング材でシールし、内部を真空に引きながら、７０℃で６時間乾燥して非水電解質電池用セパレーターを得た。

【０１１６】３．非水電解質電池用セパレーターの物性

上記の非水電解質電池用セパレーターは、厚みが２４．０μｍ、目付け１７．０ｇ／ｍ^2（ポリエチレンセパレーター１０．５ｇ/ｍ^2、ＰＰＴＡ３．２ｇ/ｍ^2、アルミナ３．２ｇ/ｍ^2）、耐熱層の空隙率５９．４％であった。走査型電子顕微鏡でフィルムを観察したところ、片面は約０．１μｍ以下のフィブリル状、層状のＰＰＴＡ樹脂からなり、そのフィブリル間に粒径０．０１３μｍ程度のアルミナ微粒子が分散しており、孔径０．０５～０．２μｍの空孔を有する多孔質層であった。断面を観察すると、基材のポリエチレンセパレーターにＰＰＴＡ樹脂が入り込んで接着した状態で２層構造となっていた。本フィルムの透気度は４３ｃｃ／ｓｅｃであった。

【０１１７】４．シャットダウン性能の測定

上記フィルムの加熱前の２５℃における内部電気抵抗は２０Ωであった。サンプルの温度を上げていくと、内部電気抵抗は徐々に下がっていくが、１３０℃付近より、内部電気抵抗が上がりだして１３５℃付近で２ＫΩに上昇した。さらに２００℃まで温度を上げたがメルトダウンによる電気抵抗の低下はなかった。以上の結果より本セパレーターは温度上昇時に電流を遮断する、シャットダウン機能および耐熱性を有することがわかった。

【０１１８】５．非水電解質電池用セパレーターとしての評価

得られたフィルムの８サイクル目の放電容量は、１９３ｍＡＨ／ｇ（放電電流１．５ｍＡ）であり、サイクル劣化もなく正常に動作した。負荷特性は３Ｃで５３％ であった。 以上の結果より本セパレーターは、非水電解質電池用セパレーターとしての性能を有することがわかった。

【０１１９】実施例８

１．塗工用ポリイミド樹脂ドープの調製

ポリマー濃度２０％のＮＭＰ溶液のポリイミド樹脂（ＰＮ２０、；新日本理化（株）製品）１００ｇとアルミナ微細粒子（日本アエロジル社製品；アルミナＣ）を１０ｇを、撹拌翼、温度計、窒素流入管および液体添加口を有する、５００ｍｌのセパラブルフラスコに秤取し、１２０分間攪拌した。ＮＭＰ６０ｍｌを加え１２０分間攪拌した。ナノマイザーに3回通し、アルミナ微細粒子を十分分散させ、塗工ドープを１０００メッシュの金網でろ過した。その後、減圧下で脱泡し塗工用ドープとした。

【０１２０】２．多孔質フィルム層の作製

直径５５０ｍｍ、長さ３５０ｍｍのドラム上に厚み１００μｍのＰＥＴフィルムを巻いた。 ＰＥＴフィルムの上に基材（ポリエチレンセパレーター 、目付け１０．５ｇ／ｍ^2、厚み１６μｍ、空隙率４０％）を巻いた。基材の片側をテープでドラムに固定した。もう片方に０．６ｋｇの重りを基材に均等に荷重がかかるように吊り下げた。ドラムの最上部に直径２５ｍｍのステンレス製塗工バーをドラムとのクリアランスが０．０３ｍｍになるように平行に配置した。ドラムと塗工バーの間に基材のテープで固定した側の端がくるようにドラムを回転させ、止めた。塗工バー手前の基材上に上記で調整した、塗工ドープを供給しながら、ドラムを０．５ｒｐｍで回転させて、基材に塗工した。

【０１２１】基材全体を塗工し、さらにドラムを回転させながら、そのまま２３℃で湿度５０％の雰囲気に１０分間置き、ＰＰＴＡを析出させた。１００μｍのＰＥＴフィルムと基材にドープを塗工・析出させたフィルムを一体にしたままドラムより取り外してイオン交換水に浸漬し、イオン交換水を流しながら、１２時間洗浄した。洗浄後ＰＥＴフィルムをとり、湿潤フィルムを、両面からポリエステル布に挟み、さらにアラミド製フェルトで挟んで、厚み３ｍｍのアルミ平板の上に置き、その上から厚み０．１ｍｍのナイロンフィルムを置いて、その回りをシーリング材でシールし、内部を真空に引きながら、７０℃で６時間乾燥して非水電解質電池用セパレーターを得た。

【０１２２】３．非水電解質電池用セパレーターの物性

上記の乾燥フィルムは、厚みが２８．０μｍ、目付け１７．５ｇ／ｍ^2（ポリエチレンセパレーター１０．５ｇ/ｍ^2、ＰＩ４．７ｇ/ｍ^2、アルミナ ２．３ｇ/ｍ^2）耐熱層の空隙率 ６５．９％）であった。走査型電子顕微鏡でフィルムの断面を観察したところ、多孔質のポリイミド樹脂の中にアルミナ微粒子が分散して、連続気泡になっているものが基材のポリエチレンセパレーターに入り込んで接着した状態で２層構造となっていた。本フィルムの透気度は６０ｃｃ／ｓｅｃであった。

【０１２３】４．シャットダウン性能の測定

上記フィルムの加熱前の２５℃における内部電気抵抗は、３５Ωであった。サンプルの温度を上げていくと、内部電気抵抗は徐々に下がっていくが、１３０℃付近より、内部電気抵抗が上がりだして１３５℃付近で２．５ＫΩに上昇した。さらに２００℃まで温度を上げたがメルトダウンによる電気抵抗の低下はなかった。以上の結果より本セパレーターは、温度上昇時に電流を遮断する、シャットダウン機能および耐熱性を有することがわ

かった。

【０１２４】５．非水電解質電池用セパレーターとしての評価

得られたフィルムの８サイクル目の放電容量は、１８３ｍＡＨ／ｇ（放電電流１．５ｍＡ）であり、サイクル劣化もなく正常に動作した。負荷特性は３Ｃで６１％ であった。 以上の結果より本セパレーターは、非水電解質電池用セパレーターとしての性能を有することがわかった。

【０１２５】実施例９

１．塗工用ポリイミド樹脂ドープの調製

ポリマー濃度２０％のＮＭＰ溶液のポリイミド樹脂（ＰＮ２０、；新日本理化（株）製品）５０ｇとアルミナ微細粒子（住友化学社製品；スミコランダム、平均粒径０．３μｍ、粒径分布０．１～１．０μｍ）を１５０ｇを、撹拌翼、温度計、窒素流入管および液体添加口を有する、５００ｍｌのセパラブルフラスコに秤取し、ＮＭＰ３５０ｍｌを加え１２０分間撹拌した。ナノマイザーに３回通し、アルミナ微細粒子を十分分散させ、塗工ドープを減圧下で脱泡し塗工用ドープとした。

【０１２６】２．多孔質フィルム層の作製

直径５５０ｍｍ、長さ３５０ｍｍのドラム上に厚み１００μｍのＰＥＴフィルムを巻いた。 ＰＥＴフィルムの上に基材（ポリエチレンセパレーター、目付け１０．５ｇ／m^2、厚み１６μｍ、空隙率４０％）を巻いた。基材の片側をテープでドラムに固定した。もう片方に０．６ｋｇの重りを基材に均等に荷重がかかるように吊り下げた。ドラムの最上部に直径２５ｍｍのステンレス製塗工バーをドラムとのクリアランスが０．０５ｍｍになるように平行に配置した。ドラムと塗工バーの間に基材のテープで固定した側の端がくるようにドラムを回転させ、止めた。塗工バー手前の基材上に上記で調整した、塗工ドープを供給しながら、ドラムを０．５ｒｐｍで回転させて、基材に塗工した。基材全体を塗工した後、さらにドラムを回転させながら、７０℃で２時間加熱して溶媒を蒸発させて、非水電解質電池用セパレーターを得た。

【０１２７】３．非水電解質電池用セパレーターの物性

上記の乾燥フィルムは、厚みが２４．０μｍ、目付け２８．１ｇ／m^2（ポリエチレンセパレーター１０．５ｇ/m^2、ＰＩ１．１ｇ/m^2、アルミナ １６．５ｇ/m^2）、耐熱層の空隙率 ２５．７％であった。走査型電子顕微鏡でフィルムの断面を観察したところ、多孔質のポリイミド樹脂の中にアルミナ微粒子が分散して、連続気泡になっているものが基材のポリエチレンセパレーターに入り込んで接着した状態で２層構造となっていた。本フィルムの透気度は３８ｃｃ／ｓｅｃであった。

【０１２８】４．シャットダウン性能の測定

上記フィルムの加熱前の２５℃における内部電気抵抗は、３１Ωであった。サンプルの温度を上げていくと、内部電気抵抗は徐々に下がっていくが、１３０℃付近より、内部電気抵抗が上がりだして１３５℃付近で２．８ＫΩに上昇した。さらに２００℃まで温度を上げたがメルトダウンによる電気抵抗の低下はなかった。以上の結果より本セパレーターは、温度上昇時に電流を遮断する、シャットダウン機能および耐熱性を有することがわかった。

【０１２９】５．非水電解質電池用セパレーターとしての評価

得られたフィルムの８サイクル目の放電容量は、１８３ｍＡＨ／ｇ（放電電流１．５ｍＡ）であり、サイクル劣化もなく正常に動作した。負荷特性は３Ｃで４０％ であった。 以上の結果より本セパレーターは、非水電解質電池用セパレーターとしての性能を有することがわかった。

【０１３０】

【発明の効果】本発明の非水電解質電池用セパレーターは、高耐熱性でショート温度が高いという耐熱性含窒素芳香族重合体の特長を生かしつつ、さらにイオン透過性が良好で電池特性が良い。また、本発明の非水電解質電池用セパレーターは、過熱時にシャットダウンする安全性を備え、さらに加熱されても溶融せず、ショート温度が高いので、より安全性に優れている。さらに本発明のリチウム二次電池は、該セパレーターを使用することにより、ショート温度が高く、より安全性に優れている。

Electronic Acknowledgement Receipt

EFS ID:	14450524
Application Number:	12673961
International Application Number:	
Confirmation Number:	2754
Title of Invention:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY
First Named Inventor/Applicant Name:	Hideaki Katayama
Customer Number:	2292
Filer:	John Wayne Bailey/Yerin Cho
Filer Authorized By:	John Wayne Bailey
Attorney Docket Number:	5271-0195PUS1
Receipt Date:	12-DEC-2012
Filing Date:	17-FEB-2010
Time Stamp:	16:06:08
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		5271-0195PUS1_IDS.pdf	3945454 d033351fcfede22a11575cd135d2a180236a84a9	yes	8

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Transmittal Letter	1	6
	Information Disclosure Statement (IDS) Form (SB08)	7	8

Warnings:					
Information:					
2	Foreign Reference	5271-0195PUS1_KR-10-2007-0083975.pdf	1457199 b48c4eba2229b10e03d4348c4a793570428 2203d	no	28
Warnings:					
Information:					
3	Foreign Reference	5271-0195PUS1_JP-2000-30686.pdf	1041731 d1fedd6238e14c183a9d7d3b545e90c6d14 58375	no	16
Warnings:					
Information:					
4	Other Reference-Patent or Application Document	5271-0195PUS1_KROA.pdf	465155 7655d148c9fdacac7ff7bd29287ed49f9239 daac	no	7
Warnings:					
Information:					
		Total Files Size (in bytes):	6909539		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:	Hideaki KATAYAMA et al.		
Application No.:	12/673,961	Confirmation No.:	2754
Filed:	February 17, 2010	Art Unit:	1728
For:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY	Examiner:	J. S. MAPLES

INFORMATION DISCLOSURE STATEMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

Applicants hereby submit an Information Disclosure Statement for consideration by the Examiner.

I. LIST OF PATENTS, PUBLICATIONS OR OTHER INFORMATION

The patents, publications, or other information submitted for consideration by the Office are listed on the attached PTO/SB/08.

II. COPIES

☑ a. **Copies of foreign patent documents, non-patent literature and other information are provided.**

☐ b. REFERENCES PREVIOUSLY CITED OR SUBMITTED: Copies of any information not provided can be found in one or more of the following applications which has been relied upon for an earlier filing date under 35 U.S.C. § 120:

U.S. Application No. and U.S. Filing Date
filed

III. CONCISE EXPLANATION OF THE RELEVANCE/OTHER INFORMATION

☑ a. NON-ENGLISH LANGUAGE DOCUMENTS: A concise explanation of the relevance of all non-English language patents, publications, or other information listed is as follows:

An English language abstract is provided (as a partial translation) for the non-English language references.

☐ b. ENGLISH LANGUAGE SEARCH REPORT OR FOREIGN PATENT OFFICE COMMUNICATION: An English language version of the search report or Foreign Patent Office communication that indicates the degree of relevance is attached.

☑ c. OTHER: The following additional information is provided.

US-6,447,958-B1 corresponds to JP-2000-30686-A.

US-2007/0264577-A1, which corresponds to KR-10-2007-0083975-A, was previously cited with an earlier-filed Information Disclosure Statement on February 17, 2010.

Reference JP-2006-139978-A was previously submitted with an earlier-filed Information Disclosure Statement on February 17, 2010.

IV. STATEMENT UNDER 37 C.F.R. § 1.97(e)

The undersigned hereby states that:

☐ a. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **30 days** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language

counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☑ b. Each item of information contained in the IDS was first cited in any communication from a foreign patent office in a counterpart foreign application not more than **three months** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office; or

☐ c. No item of information contained in the IDS was cited in a communication from a foreign patent office in a counterpart foreign application, and, to the knowledge of the person signing the certification after making reasonable inquiry, no item of IDS was known to any individual designated in 37 C.F.R. § 1.56(c) more than **three months** prior to the filing of the IDS; or

☐ d. Some of the items of information in the IDS were cited in a communication from a foreign patent office. Such items were first cited in a communication from a foreign patent office in a counterpart foreign application not more than **three months** prior to the filing of this IDS. This statement does not relate to English language counterparts not listed in a communication from the foreign patent office. Such English language counterparts are provided to aid the Examiner's consideration of non-English items first cited in the communication from the foreign patent office. As to the remaining items of information, to the knowledge of the person signing the certification after making reasonable inquiry, such remaining items were not known to any individual designated in 37 C.F.R. § 1.56(c) more than **three months** prior to the filing of this statement.

V. STATEMENT UNDER 37 C.F.R. § 1.704(d)(1)

Patent Term Adjustment Reduction Should Not Apply

☐ The undersigned hereby states:

This Information Disclosure Statement is in compliance with 37 C.F.R. §§ 1.97 and 1.98 and will not be considered a failure to engage in reasonable efforts to conclude prosecution (processing or examination) of the present application under 37 C.F.R. § 1.704(c)(6), (c)(8), (c)(9), or (c)(10), because each item of information contained in the Information Disclosure Statement:

☐ (i) Was first cited in any communication from a patent office in a counterpart foreign or international application or from the Office, and this communication was not received by any individual designated in § 1.56(c) more than thirty days prior to the filing of the information disclosure statement; or

☐ (ii) Is a communication that was issued by a patent office in a counterpart foreign or international application or by the Office, and this communication was not received by any individual designated in § 1.56(c) more than thirty days prior to the filing of the information disclosure statement.

VI. FEES

☐ a. This Information Disclosure Statement is being filed concurrently with the filing of a new patent application or Request for Continued Examination. No fee is required.

☐ b. This Information Disclosure Statement is being filed within three months of the filing date of an application. No fee is required.

☐ c. This Information Disclosure Statement is being filed before the mailing date of a first Action on the merits. No fee is required. If a first Office Action on the merits has issued, please consider this IDS under 37 C.F.R. § 1.97(c) and see the statement under 37 C.F.R. § 1.97(e) above. If no statement has been made, charge our deposit account for the required fee.

☑ d. **This Information Disclosure Statement is being filed before the mailing date of a Final Office Action or before the mailing date of a Notice of Allowance or before an action that otherwise closes prosecution in the application (see 37 C.F.R. § 1.97(c)(1)).**

☐ No statement. The fee as required by 37 C.F.R. § 1.17(p) is provided.

or

☑ **See the above statement. No fee is required.**

☐ e. This Information Disclosure Statement is being filed after the mailing date of a Final Office Action or after the mailing date of a Notice of Allowance or after an action that otherwise closes prosecution in the application (see 37 C.F.R. § 1.97(d)), see the statement above. The fee as required by 37 C.F.R. § 1.17(p) is provided.

VII. PAYMENT OF FEES

☐ The required fee is listed on the attached Fee Transmittal.

☑ **No fee is required.**

If the Examiner has any questions concerning this IDS, please contact the undersigned. If it is determined that this IDS has been filed under the wrong rule, the USPTO is requested to consider this IDS under the proper rule and charge the appropriate fee to Deposit Account No. 02-2448.

Dated: DEC 12 2012

Respectfully submitted,

By _____

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Attachments:

- ☑ **PTO/SB/08**
- ☑ **Documents**
- ☑ **Foreign Patent Office Communication**
- ☐ Foreign Search Report
- ☐ Fee
- ☐ Other:

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:	Hideaki KATAYAMA et al.		
Application No.:	12/673,961	Confirmation No.:	2754
Filed:	February 17, 2010	Art Unit:	1728
For:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY	Examiner:	J. S. MAPLES

AMENDMENT UNDER 37 C.F.R. § 1.111

MS AMENDMENT
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

INTRODUCTORY COMMENTS

In reply to the Office Action dated August 30, 2012, the following amendments and remarks are respectfully submitted in connection with the above-identified application:

Amendments to the Specification begin on page 2.

Amendments to the Claims begin on page 3.

Remarks begin on page 10.

AMENDMENTS TO THE SPECIFICATION

Please insert the following paragraph on page 1, line 4 of the specification (after the Title but before paragraph **[0001]** and its heading):

Cross Reference to Related Applications:

[0000.1] This application is a National Phase application of PCT/JP2008/067757 filed on September 30, 2008, which claims the benefit under 35 U.S.C. §119(a) to Japanese Patent Application Nos. 2007-259575 (filed on October 3, 2007), and 2008-039527 (filed on February 21, 2008). The entire contents of all of the above applications are hereby incorporated by reference.

AMENDMENTS TO THE CLAIMS

1. (**Currently Amended**) A battery separator comprising:

heat-resistant fine particles; and

a thermoplastic resin,

wherein the heat-resistant fine particles along with a binder constitute a heat-resistant layer,

the thermoplastic resin constitutes a shutdown layer formed of a microporous film,

the heat-resistant layer and the shutdown layer are integrated into a multilayer structure,

a content of the heat-resistant fine particles in the heat-resistant layer is 50 vol% or more of a total volume of components in the heat-resistant layer,

a proportion of particles with a particle size of 0.2 μm or less in the heat-resistant fine particles is 10 vol% or less and a proportion of particles with a particle size of 2 μm or more in the heat-resistant fine particles is 10 vol% or less, and

a shutdown is effected in a range of 135°C to 150°C.

2. (Original) The battery separator according to claim 1, wherein a thermal shrinkage ratio in a width direction is 10% or less at 200°C.

3. (**Currently Amended**) The battery separator according to claim 1, wherein [[a]] the content of the heat-resistant fine particles in the heat-resistant layer is [[20]] 80 vol% or more of [[a]] the total volume of components in the heat-resistant layer.

4. (Original) The battery separator according to claim 1, wherein the heat-resistant fine particles are inorganic fine particles.

5. (Previously Presented) The battery separator according to claim 4, wherein the inorganic fine particles include fine particles of at least one selected from the group consisting of alumina, silica, $BaTiO_3$, boehmite, zeolite, and kaoline.

6. (Previously Presented) The battery separator according to claim 1, wherein the heat-resistant fine particles include plate-like particles.

7. (Previously Presented) The battery separator according to claim 1, wherein the heat-resistant layer has a thickness of 1 μm to 10 μm.

8. (Original) The battery separator according to claim 1, wherein the thermoplastic resin includes polyolefin.

9. (Previously Presented) The battery separator according to claim 1, wherein the heat-resistant fine particles have an average particle size of 1.5 μm or less.

10. (Previously Presented) A nonaqueous electrolyte battery comprising:

a positive electrode having a positive active material capable of intercalating and deintercalating a lithium ion;

a negative electrode having a negative active material capable of intercalating and deintercalating a lithium ion;

a separator interposed between the positive electrode and the negative electrode; and

a nonaqueous electrolyte,

wherein a heat generation starting temperature of the positive electrode is 180°C or higher, and

wherein the separator is the battery separator according to claim 1.

11. (Original) The nonaqueous electrolyte battery according to claim 10, wherein a thermal shrinkage ratio of the separator is 10% or less at a temperature T (°C) that is 10°C lower than the heat generation starting temperature of the positive electrode (where an upper limit of T is 200°C).

12. (Original) The nonaqueous electrolyte battery according to claim 10, wherein a width of the separator is larger than that of the negative electrode at a temperature T (°C) that is 10°C lower than the heat generation starting temperature of the positive electrode (where an upper limit of T is 200°C).

13. (Original) The nonaqueous electrolyte battery according to claim 10, wherein the positive active material is at least one selected from the group consisting of the following: a spinel-type lithium-containing complex oxide expressed as a general formula $Li_{1+t}Mn_{(2-x)}M^1{}_xO_4$ (where M^1 is at least one element selected from the group consisting of Fe, Ni, Mg, Zn, Co, Cr, Al, B, V, Si, Sn, Nb, Ta, Cu, Mo, Ti, and W, $-0.1 \leq t \leq 0.1$, and $0 \leq x \leq 0.6$); an olivine-type

lithium-containing complex oxide expressed as a general formula LiM^2PO_4 (where M^2 is Co, Ni, Mn, or Fe); a lithium-containing complex oxide having a layered crystal structure expressed as a general formula $Li_{(1+a)}M^3_{2b}Mn_{(0.5-b)}Ni_{(0.5-b)}O_2$ (where M^3 is at least one element selected from the group consisting of Fe, Mg, Zn, Co, Cr, Al, B, V, Si, Sn, Nb, Ta, Cu, Mo, Ti, and W, $-0.1 < a < 0.1$, and $0 \leq b \leq 0.05$); and a lithium-containing complex oxide expressed as a general formula $Li_{(1+y+\alpha)}Ni_{(1-y-z+\delta)/2}Mn_{(1-y-z-\delta)/2}M^4_zO_2$ (where M^4 is at least one element selected from the group consisting of Ti, Cr, Fe, Co, Cu, Zn, Al, Ge, Sn, Mg, and Zr, $-0.1 \leq y \leq 0.1$, $-0.05 \leq \alpha \leq 0.05$, $0 \leq z < 0.45$, and $-0.24 \leq \delta \leq 0.6$).

14. (**Currently Amended**) The nonaqueous electrolyte battery according to claim 10, wherein a content of the heat-resistant fine particles in the heat-resistant layer of the separator is [[20]] 80 vol% or more of a total volume of components in the heat-resistant layer.

15. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator are inorganic fine particles.

16. (Previously Presented) The nonaqueous electrolyte battery according to claim 15, wherein the inorganic fine particles include fine particles of at least one selected from the group consisting of alumina, silica, $BaTiO_3$, boehmite, zeolite, and kaoline.

17. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator include plate-like particles.

18. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant layer of the separator has a thickness of 1 μm to 10 μm.

19. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the thermoplastic resin of the separator includes polyolefin.

20. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator is located on a negative electrode side.

21. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator is not in contact with the positive active material.

22. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator have an average particle size of 1.5 μm or less.

23. (Previously Presented) The battery separator according to claim 1, wherein the shutdown layer has a thickness of 5 μm to 30 μm.

24. (Previously Presented) The battery separator according to claim 1, wherein a ratio A/B is 1/2 to 5, where A (μm) represents a thickness of the shutdown layer, and B (μm) represents a thickness of the heat-resistant layer.

25. (Previously Presented) The battery separator according to claim 1, wherein a content of the binder in the heat-resistant layer is 1 to 20 vol% of a total volume of components in the heat-resistant layer.

26. (**Canceled**)

27. (Previously Presented) The battery separator according to claim 1, wherein the binder includes at least one selected from the group consisting of an ethylene-vinyl acetate copolymer (having 20 to 35 mol% of a structural unit derived from vinyl acetate); an ethylene-acrylic acid copolymer; fluoro-rubber; styrene-butadiene rubber; carboxymethyl cellulose; hydroxyethyl cellulose; polyvinyl alcohol; polyvinyl butyral; polyvinyl pyrrolidone; poly-N-vinylacetamide; a cross-linked acrylic resin; polyurethane; and an epoxy resin.

28. (Previously Presented) The battery separator according to claim 1, wherein the heat-resistant fine particles have an average particle size of 0.3 μm or more.

29. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator has a thickness of 5 μm to 30 μm.

30. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein a ratio A/B is 1/2 to 5, wherein A (μm) represents a thickness of the shutdown layer of the separator, and B (μm) represents a thickness of the heat-resistant layer of the separator.

31. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein a content of the binder in the heat-resistant layer of the separator is 1 to 20 vol% of a total volume of components in the heat-resistant layer.

32. **(Canceled)**

33. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the binder of the separator includes at least one selected from the group consisting of an ethylene-vinyl acetate copolymer (having 20 to 35 mol% of a structural unit derived from vinyl acetate); an ethylene-acrylic acid copolymer; fluoro-rubber; styrene-butadiene rubber; carboxymethyl cellulose; hydroxyethyl cellulose; polyvinyl alcohol; polyvinyl butyral; polyvinyl pyrrolidone; poly-N-vinylacetamide; a cross-linked acrylic resin; polyurethane; and an epoxy resin.

34. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator have an average particle size of 0.3 μm or more.

REMARKS

Upon entry of the instant amendment, claims 1-25, 27-31, 33, and 34 remain pending in the above-identified application and stand ready for further action on the merits.

In the instant amendment, claims 1, 3, and 14 have been amended based on the disclosure in paragraph **[0050]** of the **US 20110052987 A1** publication of the present specification (*reproduced below*). Claims 26 and 32 have been canceled without prejudice or disclaimer of the subject matter contained therein. The instant amendments put the pending claims in condition for allowance and into a more proper format for issuance in a United States patent, by overcoming all outstanding rejections of record.

> **[0050]** The content of the heat-resistant fine particles in the heat-resistant layer is preferably 20 vol % or more, more preferably 50 vol % or more, and further preferably 80 vol % or more of the total volume of components in the heat-resistant layer. By increasing the content of the heat-resistant fine particles in the heat-resistant layer, thermal shrinkage of the heat-resistant layer or the whole separator can be favorably suppressed. As described above, the heat-resistant layer preferably includes a binder. In view of this, the preferred upper limit of the content of the heat-resistant fine particles in the heat-resistant layer is, e.g., 99 vol % of the total volume of components in the heat-resistant layer. If the content of the heat-resistant fine particles in the heat-resistant layer is too small, e.g., the content of the binder in the heat-resistant layer should be increased. In such a case, however, the pores of the heat-resistant layer are filled with the binder, which may impair, e.g., the function of the separator. On the other hand, if a hole-opening agent or the like is used to provide a porous heat-resistant layer, the space between the heat-resistant fine particles becomes extremely large, so that the effect of suppressing thermal shrinkage may be reduced.

Accordingly, the present amendments to the claims do not introduce new matter into the application as originally filed. As such, entry of the instant amendment and favorable action on the merits are earnestly solicited at present.

Priority under 35 U.S.C. § 119

Applicants thank the Examiner for acknowledging Applicants' claim for foreign priorities under 35 U.S.C. § 119, and receipt of the certified priority documents.

Information Disclosure Citation

Applicants thank the Examiner for considering most of the references supplied with the Information Disclosure Statements filed February 17, 2010; April 27, 2012; and June 28, 2012, and for providing Applicants with initialed copies of the PTO-SB08 forms filed therewith.

Drawings

Applicants thank the Examiner for indicating that the drawings are accepted.

Restriction Requirement

Applicants thank the Examiner in considering the prior amendments and arguments set forth in the response filed June 28, 2012 and dropping the lack of unity requirement.

Objection to the Specification

The Examiner has objected to the specification because it lacks information regarding the priority information. Applicants have included a paragraph including the priority information of the present application. Reconsideration and withdrawal of this objection are respectfully requested.

Claim Rejection under 35 U.S.C. § 103(a)

Claims 1-34 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over **Nakura et al. US '631** (US 2008/0038631) in view of **Katayama et al. US '577** (US 2007/0264577).

This rejection is respectfully traversed based on the following considerations. Reconsideration and withdrawal of the rejection are respectfully requested.

Legal Standard for Determining Prima Facie Obviousness

M.P.E.P. § 2141 sets forth the guidelines in determining obviousness. First, the USPTO has to take into account the factual inquiries set forth in *Graham v. John Deere*, 383 U.S. 1, 17, 148 USPQ 459, 467 (1966), which has provided the controlling framework for an obviousness analysis. The four *Graham* factors are:

(a) determining the scope and content of the prior art;

(b) ascertaining the differences between the prior art and the claims in issue;

(c) resolving the level of ordinary skill in the pertinent art; and

(d) evaluating any evidence of secondary considerations.

Graham v. John Deere, 383 U.S. 1, 17, 148 USPQ 459, 467 (1966).

Second, the USPTO has to provide some rationale for determining obviousness. MPEP § 2143 sets forth some rationales that were established in the recent decision of *KSR International Co. v Teleflex Inc.*, 82 USPQ2d 1385 (U.S. 2007). Exemplary rationales that may support a conclusion of obviousness include:

(a) combining prior art elements according to known methods to yield predictable results;

(b) simple substitution of one known element for another to obtain predictable results;

(c) use of known technique to improve similar devices (methods, or products) in the same way;

(d) applying a known technique to a known device (method, or product) ready for improvement to yield predictable results;

(e) "obvious to try" – choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success

(f) known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art;

(g) some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

As the M.P.E.P. directs, all claim limitations must be considered in view of the cited prior art in order to establish a *prima facie* case of obviousness. *See* M.P.E.P. § 2143.03.

Distinctions over the Cited Art

The separator recited in **Nakura et al. US '631** includes at least one heat-resistant porous film and at least one shut-down layer, and it is characterized in that conductive paths of lithium metal are formed by depositing lithium in the event of an overcharge, and thus, the internal short-circuit mechanism is allowed to function effectively (see paragraphs **[0021]** and **[0027]**, *reproduced below*).

> Effects of the Invention
>
> **[0021]** According to the present invention, even when a heat-resistant porous film is used to heighten safety under internal short-circuit conditions, an internal short-circuit mechanism is allowed to function effectively in the event of an overcharge. As a result, the safety under internal short-circuit conditions and the safety under overcharge conditions become mutually compatible, so that a highly reliable lithium ion battery can be obtained.

> [0027] On the other hand, in the case of using a separator that comprises a heat-resistant porous film and a shut-down layer, larger (lower-resistant) conductive paths of lithium metal can be formed more locally than the case of using a separator including only a heat-resistant porous film. The reason is as follows. In the case of the separator including a shut-down layer, its thickness decreases due to heat generated by a short-circuit. Thus, the distance between the positive electrode and the negative electrode decreases, and an overcharge current is concentrated onto only the lithium deposited in an early stage. As a result, the scattering of deposited lithium is suppressed, and even if dissolution reaction takes place, firm short-circuit paths can be formed. That is, although the deposition reaction of lithium metal takes place simultaneously with the dissolution reaction thereof, the deposited lithium can function sufficiently as the firm short-circuit paths.

On the other hand, for the separator in **Katayama et al. US '577**, it is recited that the preferred content of the filler is at least 20 vol% or, more preferably, at least 50 vol% of the total volume of the whole ingredients of the separator such that the effect of preventing the internal short circuit will be improved (see paragraph **[0085]**, *reproduced below*).

> [0085] For improving the effect of preventing the internal short-circuit, preferred content of the filler particles is at least 20 vol. % in the whole ingredients of the separator, and more preferably at least 50 vol. %. Preferably the content is suppressed not to exceed 80 vol. % for securing the content of the shutdown resin and to maintain the shutdown characteristic.

Therefore, it is not suitable to combine **Nakura et al. US '631** that causes an internal short circuit in a separator and **Katayama et al. US '577** that uses a separator for preventing an internal short circuit.

Further, **Nakura et al. US '631** recites that the ratio of the inorganic oxide filler to the total of the heat-resistant resin and the inorganic oxide filler in a heat-resistant porous film is

desirably 33 to 98% by weight (see paragraph [**0031**], *reproduced below*). However, **Katayama et al. US '577** recites that by increasing the content of filler in the separator, the effect of preventing the internal short circuit is improved, and that the content of the filler is to be at least 50 vol%. Taking the recitation into consideration, a person skilled in the art referring to **Katayama et al. US '577** would be motivated to make the ratio of the inorganic oxide filler in the heat-resistant porous film to be less than 50 vol% in **Nakura et al. US '631** (that preferably causes such an internal short circuit). In fact, in the heat-resistant porous film as recited in paragraph [**0055**] of **Nakura et al. US '631** (*reproduced below*), 10 g of inorganic oxide filler (alumina) is used with respect to 200 g of heat-resistant resin (polyphenylene sulfide). As a result, the ratio of the inorganic oxide filler (volume ratio), calculated by using the specific gravity of polyphenylene sulfide (about 1.4) and the specific gravity of alumina (about 4), is 1.7 vol%. This implies that the ratio of the inorganic oxide filler is decreased considerably.

> [**0031**] The heat-resistant porous film preferably contains an inorganic oxide filler in addition to the heat-resistant resin. However, the ratio of the inorganic oxide filler to the total of the heat-resistant resin and the inorganic oxide filler is desirably 33 to 98% by weight. If the ratio of the inorganic oxide filler is too high, the separator has high hardness, so that it is difficult to obtain a flexible separator.

> (iii) Preparation of Heat-Resistant Porous Film

> [**0055**] 200 g of drawn short fibers of polyphenylene sulfide were dissolved as a heat-resistant resin in 1-chloronaphthalene at 210 to 220° C. The resultant solution was mixed with 10 g of alumina with a median diameter of 0.3 μm as a filler. The resultant mixture was fully stirred and applied onto a 210° C. glass plate with a bar coater with a gap of 200 μm, and the coating film was dried in a drying furnace at 250° C. for 3 hours. As a result, a dark brown film was obtained. This dark brown film was sequentially washed

> with N,N-dimethylformamide and methanol, and finally washed with pure water to obtain a heat-resistant porous film. The heat-resistant porous film had a thickness of 30 μm.

Therefore, application of the constitution of **Katayama et al. US '577** to the separator of **Nakura et al. US '631** would inhibit the functions of the separator according to **Nakura et al. US '631** (function of causing internal short circuit), and thus, it is impossible to obtain the constitution of the present invention from the combination of **Nakura et al. US '631** and **Katayama et al. US '577**.

In conclusion, pending independent claim 1 and its dependent claims (either directly or indirectly) cannot be regarded as being obvious from **Nakura et al. US '631** and **Katayama et al. US '577**.

Apart from the above considerations, the cited art being applied by the USPTO fails to either teach or disclose each of the limitations found in the pending claims, and also fails to provide any motivation, or reasoning or rationale that would allow one having ordinary skill in the art to arrive at the instant invention as claimed. As such, the cited art of record is incapable of either anticipating or rendering the instant invention as claimed obvious. Any contentions of the USPTO to the contrary are respectfully requested to be reconsidered at once.

CONCLUSION

All of the stated grounds of rejection have been properly traversed, accommodated, or rendered moot. It is believed that a full and complete response has been made to the outstanding Office Action, and as such, the present application is in condition for allowance.

Accordingly, the USPTO is respectfully requested to issue a Notice of Allowance in the matter of the instant application, clearly indicating that each one of pending claims 1-25, 27-31, 33, and 34 is allowed and patentable under the provisions of Title 35 of the United States Code.

Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact John W. Bailey, Registration No. 32881, at the telephone number of the undersigned below to conduct an interview in an effort to expedite prosecution in connection with the present application.

If necessary, the Director is hereby authorized in this, concurrent, and future replies to charge any fees required during the pendency of the above-identified application or credit any overpayment to Deposit Account No. 02-2448.

Dated: DEC 28 2012

Respectfully submitted,

By _____

John W. Bailey
Registration No.: 32881
BIRCH, STEWART, KOLASCH & BIRCH, LLP
8110 Gatehouse Road, Suite 100 East
P.O. Box 747
Falls Church, VA 22040-0747
703-205-8000

Electronic Patent Application Fee Transmittal

Application Number:	12673961
Filing Date:	17-Feb-2010
Title of Invention:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY
First Named Inventor/Applicant Name:	Hideaki Katayama
Filer:	John Wayne Bailey/Yerin Cho
Attorney Docket Number:	5271-0195PUS1

Filed as Large Entity

U.S. National Stage under 35 USC 371 Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 1 month with $0 paid	1251	1	150	150

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
			Total in USD ($)	**150**

Electronic Acknowledgement Receipt

EFS ID:	14578066
Application Number:	12673961
International Application Number:	
Confirmation Number:	2754
Title of Invention:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY
First Named Inventor/Applicant Name:	Hideaki Katayama
Customer Number:	2292
Filer:	John Wayne Bailey/Yerin Cho
Filer Authorized By:	John Wayne Bailey
Attorney Docket Number:	5271-0195PUS1
Receipt Date:	28-DEC-2012
Filing Date:	17-FEB-2010
Time Stamp:	14:32:25
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$150
RAM confirmation Number	847
Deposit Account	022448
Authorized User	BAILEY, JOHN

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. 1.492 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)					
File Listing:					
Document Number	**Document Description**	**File Name**	**File Size(Bytes)/ Message Digest**	**Multi Part /.zip**	**Pages (if appl.)**
1	Miscellaneous Incoming Letter	5271-0195PUS1_FeeTransm.pdf	756510 42cbc45163ed04a43e2a8bcd07f993074b681c9f	no	1
Warnings:					
Information:					
2	Extension of Time	5271-0195PUS1_Ext.pdf	665905 88d4618b25a6303f2e227b8ee9c7ebc53a8b24da	no	1
Warnings:					
Information:					
3		5271-0195PUS1_Amendment.pdf	8052101 7a806bfce0893fc06165222ff86f73ef955f1adc	yes	17

Multipart Description/PDF files in .zip description

Document Description	Start	End
Amendment/Req. Reconsideration-After Non-Final Reject	1	1
Specification	2	2
Claims	3	9
Applicant Arguments/Remarks Made in an Amendment	10	17

Warnings:					
Information:					
4	Fee Worksheet (SB06)	fee-info.pdf	30477 c15db9c35f81fa8cc9a0223d68cf21c0372397e4	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	9504993	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/17 (10-12)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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FEE TRANSMITTAL

Complete if known	
Application Number	12/673,961 Conf. No.: 2754
Filing Date	February 17, 2010
First Named Inventor	Hideaki KATAYAMA
Examiner Name	J. S. MAPLES
Art Unit	1728
Practitioner Docket No.	5271-0195PUS1

☐ Applicant claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT ($) 150.00

METHOD OF PAYMENT (check all that apply)

☐ Check ☑ Credit Card ☐ Money Order ☐ None ☐ Other (please identify): _____

☑ Deposit Account Deposit Account Number: 02-2448 Deposit Account Name: Birch, Stewart, Kolasch & Birch, LLP

For the above-identified deposit account, the Director is hereby authorized to (check all that apply):

☐ Charge fee(s) indicated below ☐ Charge fee(s) indicated below, **except for the filing fee**

☑ Charge any additional fee(s) or underpayment of fee(s) under 37 CFR 1.16 and 1.17 ☑ Credit any overpayment of fee(s)

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES

	FILING FEES		SEARCH FEES		EXAMINATION FEES		
Application Type	Fee ($)	Small Entity Fee ($)	Fee ($)	Small Entity Fee ($)	Fee ($)	Small Entity Fee ($)	Fees Paid ($)
Utility	390	195	620	310	250	125	
Design	250	125	120	60	160	80	
Plant	250	125	380	190	200	100	
Reissue	390	195	620	310	760	380	
Provisional	250	125	0	0	0	0	

2. EXCESS CLAIM FEES

Fee Description	Fee ($)	Small Entity Fee ($)
Each claim over 20 (including Reissues)	62	31
Each independent claim over 3 (including Reissues)	250	125
Multiple dependent claims	460	230

Total Claims		Extra Claims	Fee ($)		Fee Paid ($)
32	-20 or HP =	_____ x	_____	=	_____

HP = highest number of total claims paid for, if greater than 20.

Indep. Claims		Extra Claims	Fee ($)		Fee Paid ($)
1	-3 or HP =	_____ x	_____	=	_____

HP = highest number of independent claims paid for, if greater than 3.

Multiple Dependent Claims	
Fee ($)	Fee Paid ($)
_____	_____

3. APPLICATION SIZE FEE

If the specification and drawings exceed 100 sheets of paper (excluding electronically filed sequence or computer listings under 37 CFR 1.52(e)), the application size fee due is $320 ($160 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

Total Sheets		Extra Sheets		Number of each additional 50 or fraction thereof		Fee ($)		Fee Paid ($)
_____	- 100 =	_____	/ 50 =	_____ (round up to a whole number)	x	_____	=	_____

4. OTHER FEE(S) Fees Paid ($)

Non-English specification, $130 fee (no small entity discount) _____

Non-electronic filing fee under 37 CFR 1.16(t) for a utility application, $400 fee ($200 small entity) _____

Other (e.g., late filing surcharge): One-Month Extension Fee 150.00

SUBMITTED BY

Signature		Registration No. (Attorney/Agent) 32881	Telephone 703-205-8000
Name (Print/Type)	John W. Bailey		Date December 28, 2012

This collection of information is required by 37 CFR 1.136. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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PTO/AIA/22 (10-12)
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PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a)

Docket Number (Optional): 5271-0195PUS1

Application Number: 12/673,961 | Filed: February 17, 2010

For: BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY

Art Unit: 1728 | Examiner: J. S. MAPLES

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above-identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

	Fee	Small Entity Fee	
☑ One month (37 CFR 1.17(a)(1))	$150	$75	$ 150.00
☐ Two months (37 CFR 1.17(a)(2))	$570	$285	$
☐ Three months (37 CFR 1.17(a)(3))	$1,290	$645	$
☐ Four months (37 CFR 1.17(a)(4))	$2,010	$1,005	$
☐ Five months (37 CFR 1.17(a)(5))	$2,730	$1,365	$

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check in the amount of the fee is enclosed.

☑ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☑ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 02-2448.

☐ Payment made via EFS-Web.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the

☐ applicant.

☑ attorney or agent of record. Registration number 32881.

☐ attorney or agent acting under 37 CFR 1.34. Registration number _____.

Signature	December 28, 2012 (Date)
John W. Bailey (Typed or printed name)	703-205-8000 (Telephone Number)

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.

☑ * Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.136(a). The information is required to obtain or retain a benefit by the public, which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 6 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

PTO/SB/06 (07-06)
Approved for use through 1/31/2007. OMB 0651-0032
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PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number	Filing Date	☐ To be Mailed
12/673,961	02/17/2010	

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY ☐ RATE ($)	SMALL ENTITY ☐ FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A			N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =		OR	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =			X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $250 ($125 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT 12/28/2012	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE ($)	SMALL ENTITY ADDITIONAL FEE ($)	OR	OTHER THAN SMALL ENTITY RATE ($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 32	Minus	** 34	= 0	X $ =		OR	X $62=	0
Independent (37 CFR 1.16(h))	* 1	Minus	***3	= 0	X $ =		OR	X $250=	0
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	0

AMENDMENT	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)		RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =		OR	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =		OR	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))									
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

Legal Instrument Examiner:
/SHEILA CHAPMAN/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/673,961	02/17/2010	Hideaki Katayama	5271-0195PUS1	2754

2292 7590 01/18/2013

BIRCH STEWART KOLASCH & BIRCH
PO BOX 747
FALLS CHURCH, VA 22040-0747

EXAMINER	
MAPLES, JOHN S	

ART UNIT	PAPER NUMBER
1723	

NOTIFICATION DATE	DELIVERY MODE
01/18/2013	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

mailroom@bskb.com

Office Action Summary	Application No.	Applicant(s)	
	12/673,961	KATAYAMA ET AL.	
	Examiner	Art Unit	
	John S. Maples	1723	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *28 December 2012*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

5)☒ Claim(s) *1-25,27-31,33 and 34* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-25, 27-31, 33, 34* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☒ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date *12/12/2012*.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

1. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

2. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

3. Claims 1-25, 27-31 and 33-34 are rejected under 35 U.S.C. 103(a) as being unpatentable over Nakura et al.-US 2008/0038631 (Nakura) in view of Katayama et al.-US 2007/0264577. (Katayama)

For claim 1, Nakura teaches a battery separator comprising a shutdown layer formed of a microporous film and a heat-resistant layer comprising fine particles and a binder-see the Abstract in Nakura along with paragraphs 22-49 where paragraphs 31 and 44 recite the content of the fine particlees. As paragraphs 19 and 30 in Nakura recite, the shutdown is effected in the claimed range of 135-150 degrees C. The only

claimed features not shown by Nakura are the proportion of particle sizes. Katayama discloses a separator for a lithium secondary battery that includes a heat-resistant layer comprising fine particles, where the sizes thereof fall within that range claimed by applicant-see Example 1 in Katayama where the particles are in a size distribution of 0.3-0.7 micron size. To include the sized particles of Katayama in the separator of Nakura would have been obvious to one of ordinary skill in this art at the time the invention was made because the same would allow for greater transport across the separator.

For claim 2, paragraph 28 in Nakura teaches the claimed temperature for the shrinkage ratio which would inherently fall within the claimed range.

For claims 3, 14, 25 and 31, paragraph 44 in Nakura recite the content of the fine particles and the binder.

Paragraph 42 in Nakura disclose alumina fine particles thus meeting claims 4, 5, 15 and 16.

For claims 6 and 17, Katayama recites plate shaped particles in paragraph 77 and to include the same in Nakura would have been obvious so that short-circuiting would be hindered.

For claims 7, 18, 23, 24, 29, 30, paragraphs 30 and 36 in Nakura teach the claimed thicknesses of both the shut-down layer and the heat-resistant layers.

With regard to claims 8 and 19, paragraph 38 in Nakura teaches the claimed thermoplastic resin.

For claims 9, 22, 28 and 34, the claimed particle size is taught in Example 1 of Katayama and to include the same in Nakura would have been obvious to allow greater compacting in the separator.

Claims 10-13 are met by the specific first compound recited in the next to the last line of paragraph 100 in Katayama. It is noted that this compound is the same compound set forth in applicant's Example 1 so the properties set forth in claims 11 and 12 would inherently be met and to utilize this compound of Katayama in Nakura would have been obvious because, as set forth in paragraph 46 of Nakura, provision of made for the lithium manganese nickel cobalt oxide.

For claims 20 and 21, reference is made to the Abstract and paragraph 37 for the shutdown layer located on the negative electrode side.

For claims 27 and 33, paragraph 49 in Nakura discloses the claimed binder.

Applicant's arguments have all been considered but are not deemed persuasive. Applicant argues that it is not proper to combine Katayama with Nakura and more specifically that if the two references were combined then a person of ordinary skill in this art would be motivated to make the ratio of the inorganic oxide filler in the film to be less than 50 vol%. This is not convincing in view of the fact that both Nakura and Katayama recite an amount of the filler in the separator to be at least 50 vol% as noted by the examiner in the above discussion with regard to Nakura and noted by applicant in the remarks with regard to both Nakura and Katayama.

Applicant further points to a paragraph 55 of Nakura that teaches a decreased amount of filler in the separator. This may be true, however, as set forth above in the

rejection by the examiner, Nakura teaches in both paragraphs 31 and 44 an amount of filler in the separator of at least 50 vol% and thus the claimed subject matter is met by this teaching (which is combined with Katayama to meet other claimed recitations).

Finally, applicant argues that combining Katayama with Nakura would result in causing an internal short circuit. It is not known where the applicant finds basis for this argument noting, as set forth previously in this action, that both Nakura and Katayama teach in their respective documents, a filler vol% of at least 50 which meets the claimed subject matter and which would in fact help to prevent short circuiting of the battery.

4. **THIS ACTION IS MADE FINAL.** Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

5. Any inquiry concerning this communication or earlier communications from the examiner should be directed to John S. Maples whose telephone number is (571)272-1287. The examiner can normally be reached on Monday-Friday, 8:30-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Milton Cano can be reached on 571-272-1398. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/John S. Maples/
Primary Examiner
Art Unit 1723

JSM/1-9-2013

PTO/SB/08a (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE
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Substitute for form 1449A/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet 1 of 2

Complete if Known	
Application Number	12/673,961
Filing Date	02-17-10
First Named Inventor	Hideaki Katayama
Art Unit	1728
Examiner Name	J. S. MAPLES
Attorney Docket Number	5271-0195PUS1

U.S. PATENT DOCUMENTS

Examiner Initial *	Cite No.	Document Number: Number - Kind Code [2] (if known)	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear
	1	US-6,447,958 - B1	09-10-2002	SHINOHARA et al.	

FOREIGN PATENT DOCUMENTS

Examiner Initial *	Cite No. 1	Foreign Patent Document: Country Code [3] Number [4] Kind Code (if known) [5]	Publication Date MM-DD-YYYY	Name of Patentee or Applicant of Cited Document	Pages, columns, Lines, Where Relevant Passages or Relevant Figures Appear	T
	2	KR 10-2007-0083975 - A	08-24-2007			☑
	3	JP 2000-30686 - A	01-28-2000			☑

Examiner Signature	/John Maples/	Date Considered	01/09/2013

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not Considered. Include copy of this form with next communication to applicant. 1. Applicant's unique citation design number (optional). 2 See Kinds Codes of USPTO patent Documents. at www.uspto.gov or MPEP 901.04. 3. Enter Office that issued the document, by the two-letter code (WIPO Standard ST.3). 4. For Japanese patent documents, the indication of the year of the reign of the Emperor must precede the serial number of the patent document. 5. Kind of document by the appropriate symbols as indicated on the document under WIPO Standard ST. 16 if possible. 6. Applicant is to place a check mark here if English language Translation is attached.

This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450 Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS.
SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.
If you need assistance in completing the form, call 1-800-PTO-9199 (1-800-786 9199) and select option 2.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.M./

PTO/SB/08b (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
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Substitute for form 1449B/PTO

INFORMATION DISCLOSURE STATEMENT BY APPLICANT

(Use as many sheets as necessary)

Sheet	2	of	2

Complete if Known	
Application Number	12/673,961
Filing Date	02-17-10
First Named Inventor	Hideaki Katayama
Art Unit	1728
Examiner Name	J. S. MAPLES
Attorney Docket Number	5271-0196PUS1

NON PATENT LITERATURE DOCUMENTS

Examiner initial *	Cite No.[1]	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[2]
	4	~~Office Action for corresponding Korean Patent Application No. 10-2010-7004869, mailed October 4, 2012.~~	

Examiner Signature	/John Maples/	Date Considered	01/09/2013

* EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.
1. Applicants unique citation designation number. (optional) 2. Applicant is to place a check mark here if English language Translation is attached.
This collection of information is required by 37 CFR 1.97 and 1.98. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 2 hours to complete, including gathering, preparing, and submitting the completed application form the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, P.O. Box 1450 Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS.
SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assisstance in completing the form, call 1-800-PTO-9199 and select option 2.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /J.M./

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:	Hideaki KATAYAMA et al.		
Application No.:	12/673,961	Confirmation No.:	2754
Filed:	February 17, 2010	Art Unit:	1723
For:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY	Examiner:	J. S. MAPLES

REPLY UNDER 37 C.F.R. § 1.116

MS AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

INTRODUCTORY COMMENTS

In reply to the Office Action dated January 18, 2013, the following amendments and remarks are respectfully submitted in connection with the above-identified application.

Remarks begin on page 2.

REMARKS

Claims 1-25, 27-31, 33, and 34 are pending in the present application. No amendments are made in this response. In view of the following remarks, Applicants respectfully request that the Examiner withdraw all rejections and allow the currently pending claims.

Information Disclosure Citation

Applicants thank the USPTO Examiner for considering some of the references supplied with the Information Disclosure Statement filed December 12, 2012, and for providing Applicants with an initialed copy of the PTO-SB08 form filed therewith.

Claim Rejections under 35 U.S.C. § 103(a)

Claims 1-25, 27-31, 33, and 34 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over **Nakura et al. US '631** (US 2008/0038631) in view of **Katayama et al. US '577** (US 2007/0264577).

This rejection is respectfully traversed based on the following considerations. Reconsideration and withdrawal of the rejection are respectfully requested.

Legal Standard for Determining Prima Facie Obviousness

M.P.E.P. § 2141 sets forth the guidelines in determining obviousness. First, the USPTO has to take into account the factual inquiries set forth in *Graham v. John Deere*, 383 U.S. 1, 17, 148 USPQ 459, 467 (1966), which has provided the controlling framework for an obviousness analysis. The four *Graham* factors are:

(a) determining the scope and content of the prior art;

(b) ascertaining the differences between the prior art and the claims in issue;

(c) resolving the level of ordinary skill in the pertinent art; and

(d) evaluating any evidence of secondary considerations.

Graham v. John Deere, 383 U.S. 1, 17, 148 USPQ 459, 467 (1966).

Second, the USPTO has to provide some rationale for determining obviousness. MPEP § 2143 sets forth some rationales that were established in the recent decision of *KSR International Co. v Teleflex Inc.*, 82 USPQ2d 1385 (U.S. 2007). Exemplary rationales that may support a conclusion of obviousness include:

(a) combining prior art elements according to known methods to yield predictable results;

(b) simple substitution of one known element for another to obtain predictable results;

(c) use of known technique to improve similar devices (methods, or products) in the same way;

(d) applying a known technique to a known device (method, or product) ready for improvement to yield predictable results;

(e) "obvious to try" – choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success

(f) known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art;

(g) some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

As the M.P.E.P. directs, all claim limitations must be considered in view of the cited prior art in order to establish a *prima facie* case of obviousness. *See* M.P.E.P. § 2143.03.

Distinctions over the Cited Art

Nakura et al. US '631 discloses a lithium ion secondary battery that includes a positive electrode, a negative electrode, a separator, and a non-aqueous electrolyte. The separator includes at least one heat-resistant porous film and at least one shut-down layer. Moreover, a porous membrane is bonded to the surface of at least one selected from the positive electrode and the negative electrode, and the porous membrane includes an inorganic oxide filler and a binder (see claim 1, *reproduced below*).

> 1. A lithium ion secondary battery comprising: a positive electrode comprising a composite lithium oxide; a negative electrode capable of charge and discharge; a separator; and a non-aqueous electrolyte comprising a non-aqueous solvent and a solute dissolved therein,
>
> wherein said separator comprises at least one heat-resistant porous film and at least one shut-down layer,
>
> a porous membrane is bonded to a surface of at least one selected from said positive electrode and said negative electrode, and
>
> said porous membrane comprises an inorganic oxide filler and a binder.

The lithium ion secondary battery of **Nakura et al. US '631** includes the porous membrane that is integrated with the positive electrode or the negative electrode other than the separator in which the heat-resistant porous film is integrated with the shut-down layer.

The USPTO Examiner refers to paragraph **[0044]** of **Nakura et al. US '631** (*reproduced below*) and asserts that **Nakura et al. US '631** teaches that the content of the fine particles in the heat-resistant layer of the separator is 50 vol% or more.

> **[0044]** The ratio of the inorganic oxide filler to the total of the inorganic oxide filler and the binder contained in the porous membrane is preferably 50% by weight or more and 99% by weight or less, and more preferably 95 to 98% by weight. If the ratio of the inorganic oxide filler is less than 50% by weight, the amount of the binder is too large, so that it is difficult to control the pore structure of the porous membrane. If the ratio of the inorganic oxide filler exceeds 99% by weight, the amount of the binder is too small, so that the adhesion of the porous membrane to the electrode surface decreases. Thus, the porous membrane may separate therefrom.

Paragraph **[0044]**, however, states that the ratio of the filler in the porous membrane that is integrated with the positive electrode or the negative electrode is 50% by weight or more. Therefore, **Nakura et al. US '631** does not disclose that the lower limit of the content of the fine particles in the heat-resistant layer of the separator is set to 50 vol%.

In the heat-resistant porous film that is specifically described in paragraph **[0055]** of **Nakura et al. US '631** (*reproduced below*), 10 g of the inorganic oxide filler (alumina) is used with respect to 200 g of the heat-resistant resin (polyphenylene sulfide). The volume ratio of the inorganic oxide filler, calculated by using the specific gravity of polyphenylene sulfide (about 1.4) and the specific gravity of alumina (about 4), is as low as 1.7 vol%. In **Nakura et al. US '631**, the ratio of the filler in the porous membrane that is integrated with the positive electrode or the negative electrode is 50% by weight or more, while the ratio of the inorganic oxide filler contained in the heat-resistant porous film of the separator is decreased considerably. This configuration allows the deposited lithium to penetrate the separator and cause an internal short-circuit, thereby ensuring the overcharge safety (see paragraph **[0093]** of **Nakura et al. US '631**, *reproduced below*).

> (iii) Preparation of Heat-Resistant Porous Film
>
> [0055] 200 g of drawn short fibers of polyphenylene sulfide were dissolved as a heat-resistant resin in 1-chloronaphthalene at 210 to 220° C. The resultant solution was mixed with 10 g of alumina with a median diameter of 0.3 μm as a filler. The resultant mixture was fully stirred and applied onto a 210° C. glass plate with a bar coater with a gap of 200 μm, and the coating film was dried in a drying furnace at 250° C. for 3 hours. As a result, a dark brown film was obtained. This dark brown film was sequentially washed with N,N-dimethylformamide and methanol, and finally washed with pure water to obtain a heat-resistant porous film. The heat-resistant porous film had a thickness of 30 μm.
>
> [0093] After the evaluation of overcharge safety, the batteries were disassembled for examination. As a result, Examples 1 to 13 did not exhibit thermal shrinkage of the separator caused by heat generated upon overcharge or internal short-circuiting due to deposited lithium. Also, local deposition of lithium was found, and an internal short-circuit between the positive electrode and the negative electrode was found wherever there was deposited lithium. This indicates that the deposited lithium effectively penetrated the heat-resistant separator, causing an internal short-circuit.

On the other hand, **Katayama et al. US '577** teaches that the content of the filler particles is preferably at least 20 vol%, and more preferably at least 50 vol% of the total volume of the whole ingredients of the separator so as to improve the effect of preventing the internal short-circuit (see paragraph **[0085]** of **Katayama et al. US '577**, *reproduced below*). Moreover, **Katayama et al. US '577** teaches that the separator containing the filler particles in the above range has a charging efficiency of substantially 100% and suppressed the formation of lithium dendrite, *i.e.*, prevents the occurrence of an internal short-circuit at the time of charging (see paragraph **[0157]** of **Katayama et al. US '577**, *reproduced below*).

> **[0085]** For improving the effect of preventing the internal short-circuit, preferred content of the filler particles is at least 20 vol. % in the whole ingredients of the separator, and more preferably at least 50 vol. %. Preferably the content is suppressed not to exceed 80 vol. % for securing the content of the shutdown resin and to maintain the shutdown characteristic.
>
> **[0157]** The batteries in Examples 4A-7A and 9A had charging efficiencies of substantially 100% similarly to the case of Comparative Example 1A, and formation of lithium dendrite at the time of charging was suppressed. In contrast, for the battery in Comparative Example 2A including only the filler particles in the pores of the porous base, the charging efficiency was poor and internal short-circuit due to the formation of lithium dendrite at the time of charging was found. It was considered that since the alumina fine particles used as the filler particles were shaped differently from the plate shape that provides excellent effect in suppressing formation of lithium dendrite, formation of the lithium dendrite might not be suppressed in a case where shutdown resin particles do not coexist.

As indicated by the USPTO Examiner, **Nakura et al. US '631** teaches that the content of the fine particles in the heat-resistant layer of the separator may be 33 to 98% by weight (see paragraph [**0031**] of **Nakura et al. US '631**, *reproduced below*). In **Nakura et al. US '631**, however, an internal short-circuit is actually caused by reducing the volume ratio of the inorganic oxide filler, as described above.

> **[0031]** The heat-resistant porous film preferably contains an inorganic oxide filler in addition to the heat-resistant resin. However, the ratio of the inorganic oxide filler to the total of the heat-resistant resin and the inorganic oxide filler is desirably 33 to 98% by weight. If the ratio of the inorganic oxide filler is too high, the separator has high hardness, so that it is difficult to obtain a flexible separator.

Therefore, since **Katayama et al. US '577** requires that the content of the filler particles be at least 20 vol% of the total volume of the whole ingredients of the separator so as to improve the function of preventing the internal short-circuit of the separator, it is not appropriate that the configuration of **Katayama et al. US '577** is applied to the separator of **Nakura et al. US '631**, in which the objective of the invention is achieved by causing an internal short-circuit. Even if **Nakura et al. US '631** and **Katayama et al. US '577** are combined, there is no motivation to modify **Nakura et al. US '631** so that the content of the fine particles in the heat-resistant layer of the separator is 50 vol% or more.

Katayama et al. US '577 teaches that if the shutdown temperature of the separator is in the range of 90 °C to 125 °C, a shutdown occurs at a temperature suitable for securing safety of the battery at high temperatures, and that if the shutdown temperature of the separator exceeds 130 °C, a shutdown occurs at a temperature closer to the thermal runaway temperature of the battery (see paragraph **[0152]** of **Katayama et al. US '577**, *reproduced below*).

> **[0152]** Tables 3 and 4 show that, regarding the separators in Examples 1-15 of the present invention, the shutdown temperatures are in a range of 90 to 125° C., namely, a shutdown occurs in a temperature range suitable for securing safety of the battery at high temperature. On the other hand, the shutdown temperature for the separator in Comparative Example 1 exceeded 130° C., and thus the shutdown occurred at a temperature closer to the thermal runaway temperature of the battery. For the separator in Comparative Example 2, no shutdown occurred because the separator had no shutdown resin.

Thus, if **Nakura et al. US '631** and **Katayama et al. US '577** are combined, the shutdown temperature of the separator cannot be in the range of 135 °C to 150 °C.

As is evident from the above arguments, the present invention cannot be obvious from the combination of **Nakura et al. US '631** and **Katayama et al. US '577**.

Apart from the above considerations, the cited art being applied by the USPTO fails to either teach or disclose each of the limitations found in the pending claims, and also fails to provide any motivation, or reasoning or rationale that would allow one having ordinary skill in the art to arrive at the instant invention as claimed. As such, the cited art of record is incapable of either anticipating or rendering the instant invention as claimed obvious. Any contentions of the USPTO to the contrary are respectfully requested to be reconsidered at once.

CONCLUSION

All of the stated grounds of rejection have been properly traversed, accommodated, or rendered moot. It is believed that a full and complete response has been made to the outstanding Office Action, and as such, the present application is in condition for allowance.

Accordingly, the USPTO is respectfully requested to issue a Notice of Allowance in the matter of the instant application, which clearly indicates that each one of pending claims 1-25, 27-31 and 33-34 is allowed and patentable under the provisions of Title 35 of the United States Code.

Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact John W. Bailey, Registration No. 32881, at the telephone number of the undersigned below to conduct an interview in an effort to expedite prosecution in connection with the present application.

If necessary, the Director is hereby authorized in this, concurrent, and future replies to charge any fees required during the pendency of the above-identified application or credit any overpayment to Deposit Account No. 02-2448.

Dated: APR 18 2013

Respectfully submitted,

By _____

John W. Bailey
Registration No.: 32881
BIRCH, STEWART, KOLASCH & BIRCH, LLP
8110 Gatehouse Road, Suite 100 East
P.O. Box 747
Falls Church, VA 22040-0747
703-205-8000

Electronic Acknowledgement Receipt

EFS ID:	15555617
Application Number:	12673961
International Application Number:	
Confirmation Number:	2754
Title of Invention:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY
First Named Inventor/Applicant Name:	Hideaki Katayama
Customer Number:	2292
Filer:	John Wayne Bailey/Yerin Cho
Filer Authorized By:	John Wayne Bailey
Attorney Docket Number:	5271-0195PUS1
Receipt Date:	18-APR-2013
Filing Date:	17-FEB-2010
Time Stamp:	15:48:30
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Miscellaneous Incoming Letter	5271-0195PUS1_Transmittal.pdf	548983 29d754383d0c0bb9b666a9c1410654dba575bfd8	no	1

Warnings:	
Information:	

2		5271-0195PUS1_Reply.pdf	5072501 596e27f4f13ecf5fefcaa237282a8728e905063e	yes	10

Multipart Description/PDF files in .zip description		
Document Description	**Start**	**End**
Amendment After Final	1	1
Applicant Arguments/Remarks Made in an Amendment	2	10

Warnings:	
Information:	
Total Files Size (in bytes):	5621484

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

AMENDMENT TRANSMITTAL LETTER

Docket No. 5271-0195PUS1			
Application No. 12/673,961 - Conf. #2754	Filing Date February 17, 2010	Examiner J. S. MAPLES	Art Unit 1723

Applicants: Hideaki KATAYAMA et al.

Invention: BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Transmitted herewith is an amendment in the above-identified application.

The fee has been calculated and is transmitted as shown below.

CLAIMS AS AMENDED

	Claims Remaining After Amendment	Highest Number Previously Paid	Number Extra Claims Present	Rate	
Total Claims	32	- 20 =	12	x 80	960.00
Independent Claims	1	- 3 =	0	x 420	0.00
Multiple Dependent Claims (check if applicable)		☐		780	0.00
Other fee (please specify):					0.00
TOTAL ADDITIONAL FEE FOR THIS AMENDMENT:					960.00

☒ Large Entity ☐ Small Entity

☒ No additional fee is required for this amendment.

☐ Please charge Deposit Account No. 02-2448 in the amount of $ 960.00.

☐ A check in the amount of $ 960.00 is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☒ The Director is hereby authorized to charge and credit Deposit Account No. 02-2448 as described below.

☒ Credit any overpayment.

☒ Charge any additional filing or application processing fees required under 37 C.F.R. §§ 1.16 and 1.17.

Dated: APR 18 2013

John W. Bailey
Attorney Reg. No.: 32881

BIRCH, STEWART, KOLASCH & BIRCH, LLP
8110 Gatehouse Road, Suite 100 East
P.O. Box 747
Falls Church, VA 22040-0747
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UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/673,961	02/17/2010	Hideaki Katayama	5271-0195PUS1	2754

2292 7590 05/16/2013

BIRCH STEWART KOLASCH & BIRCH, LLP
PO BOX 747
FALLS CHURCH, VA 22040-0747

EXAMINER	
MAPLES, JOHN S	

ART UNIT	PAPER NUMBER
1723	

NOTIFICATION DATE	DELIVERY MODE
05/16/2013	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

mailroom@bskb.com

Advisory Action Before the Filing of an Appeal Brief	**Application No.** 12/673,961	**Applicant(s)** KATAYAMA ET AL.
	Examiner John S. Maples	**Art Unit** 1723

--The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

THE REPLY FILED 18 April 2013 FAILS TO PLACE THIS APPLICATION IN CONDITION FOR ALLOWANCE.

NO NOTICE OF APPEAL FILED

1. ☒ The reply was filed after a final rejection. No Notice of Appeal has been filed. To avoid abandonment of this application, applicant must timely file one of the following replies: (1) an amendment, affidavit, or other evidence, which places the application in condition for allowance; (2) a Notice of Appeal (with appeal fee) in compliance with 37 CFR 41.31; or (3) a Request for Continued Examination (RCE) in compliance with 37 CFR 1.114 if this is a utility or plant application. Note that RCEs are not permitted in design applications. The reply must be filed within one of the following time periods:
   a) ☒ The period for reply expires *3* months from the mailing date of the final rejection.
   b) ☐ The period for reply expires on: (1) the mailing date of this Advisory Action; or (2) the date set forth in the final rejection, whichever is later. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of the final rejection.
   c) ☐ A prior Advisory Action was mailed more than 3 months after the mailing date of the final rejection in response to a first after-final reply filed within 2 months of the mailing date of the final rejection. The current period for reply expires months from the mailing date of *the prior Advisory Action* or SIX MONTHS from the mailing date of the final rejection, whichever is earlier.
   Examiner Note: If box 1 is checked, check either box (a), (b) or (c). ONLY CHECK BOX (b) WHEN THIS ADVISORY ACTION IS THE FIRST RESPONSE TO APPLICANT'S FIRST AFTER-FINAL REPLY WHICH WAS FILED WITHIN TWO MONTHS OF THE FINAL REJECTION. ONLY CHECK BOX (c) IN THE LIMITED SITUATION SET FORTH UNDER BOX (c). See MPEP 706.07(f).

Extensions of time may be obtained under 37 CFR 1.136(a). The date on which the petition under 37 CFR 1.136(a) and the appropriate extension fee have been filed is the date for purposes of determining the period of extension and the corresponding amount of the fee. The appropriate extension fee under 37 CFR 1.17(a) is calculated from: (1) the expiration date of the shortened statutory period for reply originally set in the final Office action; or (2) as set forth in (b) or (c) above, if checked. Any reply received by the Office later than three months after the mailing date of the final rejection, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

NOTICE OF APPEAL

2. ☐ The Notice of Appeal was filed on _____. A brief in compliance with 37 CFR 41.37 must be filed within two months of the date of filing the Notice of Appeal (37 CFR 41.37(a)), or any extension thereof (37 CFR 41.37(e)), to avoid dismissal of the appeal. Since a Notice of Appeal has been filed, any reply must be filed within the time period set forth in 37 CFR 41.37(a).

AMENDMENTS

3. ☐ The proposed amendments filed after a final rejection, but prior to the date of filing a brief, will not be entered because
   a) ☐ They raise new issues that would require further consideration and/or search (see NOTE below);
   b) ☐ They raise the issue of new matter (see NOTE below);
   c) ☐ They are not deemed to place the application in better form for appeal by materially reducing or simplifying the issues for appeal; and/or
   d) ☐ They present additional claims without canceling a corresponding number of finally rejected claims.
   NOTE: _____. (See 37 CFR 1.116 and 41.33(a)).
4. ☐ The amendments are not in compliance with 37 CFR 1.121. See attached Notice of Non-Compliant Amendment (PTOL-324).
5. ☐ Applicant's reply has overcome the following rejection(s): _____.
6. ☐ Newly proposed or amended claim(s) _____ would be allowable if submitted in a separate, timely filed amendment canceling the non-allowable claim(s).
7. ☐ For purposes of appeal, the proposed amendment(s): (a) ☐ will not be entered, or (b) ☐ will be entered, and an explanation of how the new or amended claims would be rejected is provided below or appended.

AFFIDAVIT OR OTHER EVIDENCE

8. ☐ The affidavit or other evidence filed after final action, but before or on the date of filing a Notice of Appeal will not be entered because applicant failed to provide a showing of good and sufficient reasons why the affidavit or other evidence is necessary and was not earlier presented. See 37 CFR 1.116(e).
9. ☐ The affidavit or other evidence filed after the date of filing the Notice of Appeal, but prior to the date of filing a brief, will not be entered because the affidavit or other evidence failed to overcome all rejections under appeal and/or appellant fails to provide a showing of good and sufficient reasons why it is necessary and was not earlier presented. See 37 CFR 41.33(d)(1).
10. ☐ The affidavit or other evidence is entered. An explanation of the status of the claims after entry is below or attached.

REQUEST FOR RECONSIDERATION/OTHER

11. ☒ The request for reconsideration has been considered but does NOT place the application in condition for allowance because: See Continuation Sheet.
12. ☐ Note the attached Information *Disclosure Statement*(s). (PTO/SB/08) Paper No(s). _____
13. ☐ Other: _____.

STATUS OF CLAIMS

14. The status of the claim(s) is (or will be) as follows:
    Claim(s) allowed: .
    Claim(s) objected to: .
    Claim(s) rejected: .
    Claim(s) withdrawn from consideration: .

JSM/5-13-2013	/John S. Maples/ Primary Examiner Art Unit: 1723

Continuation of 11. does NOT place the application in condition for allowance because: of the reasons set forth in the Final Rejection and for the reasons that follow. Applicant argues that Nakura does not disclose a lower limit of the content of the fine particles in the heat resistant layer of the separator to be set at 50 vol%. This argument is deemed moot because applicant has not currently claimed this specific subject matter. Applicant further argues paragraph 55 in Nakura, however, it is noted that this paragraph 55 in Nakura refers to a comparative example and is thus not applicable to the currently claimed subject matter. Applicant then refers to various portions of both Nakura and Katayama and argues that the combination of these two references does not teach a content of fine particles in the heat resistant layer of the separator to be 50 %vol or more. This again is not convincing because as set forth in section 3 of the Final Rejection, Nakura, by itself, teaches this content of fine particles in paragraph 44 therein. Finally, applicant argues that combining both Nakura and Katayama does not result in the claimed shutdown temperature. Again, the teachings in Nakura in paragraphs 19 and 30 teach a shutdown temperature that encompasses applicant's claimed temperature.

OK TO ENTER: /J.M./

05/13/2013

Docket No.: 5271-0195PUS1
(Patent)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:
Hideaki KATAYAMA et al.

Application No.:	12/673,961	Confirmation No.:	2754
Filed:	February 17, 2010	Art Unit:	1723
For:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY	Examiner:	J. S. MAPLES

REPLY UNDER 37 C.F.R. § 1.116

MS AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

INTRODUCTORY COMMENTS

In reply to the Office Action dated January 18, 2013, the following amendments and remarks are respectfully submitted in connection with the above-identified application.

Remarks begin on page 2.

PTO/SB/30 (07-09)
Approved for use through 07/31/2012. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Request for Continued Examination (RCE) Transmittal

Address to:
Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Application Number	12/673,961
Filing Date	February 17, 2010
First Named Inventor	Hideaki KATAYAMA
Art Unit	1723
Examiner Name	J. S. MAPLES
Attorney Docket Number	5271-0195PUS1

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. See Instruction Sheet for RCEs (not to be submitted to the USPTO) on page 2.

1. Submission required under 37 CFR 1.114 Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

   a. [✓] Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

      i. [ ] Consider the arguments in the Appeal Brief or Reply Brief previously filed on _____

      ii. [✓] Other Reply under 37 C.F.R. 1.116 filed on April 18, 2013

   b. [✓] Enclosed

      i. [✓] Amendment/Reply

      ii. [ ] Affidavit(s)/ Declaration(s)

      iii. [ ] Information Disclosure Statement (IDS)

      iv. [ ] Other _____

2. Miscellaneous

   a. [ ] Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of _____ months. (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

   b. [ ] Other _____

3. Fees The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.

   a. [✓] The Director is hereby authorized to charge the following fees, any underpayment of fees, or credit any overpayments, to Deposit Account No. 02-2448.

      i. [ ] RCE fee required under 37 CFR 1.17(e)

      ii. [ ] Extension of time fee (37 CFR 1.136 and 1.17)

      iii. [ ] Other _____

   b. [ ] Check in the amount of $ _____ enclosed

   c. [✓] Payment by credit card (Form PTO-2038 enclosed)

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

Signature		Date	JUN 18 2013
Name (Print/Type)	John W. Bailey	Registration No.	32,881

CERTIFICATE OF MAILING OR TRANSMISSION

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Mail Stop RCE, Commissioner for Patents, P. O. Box 1450, Alexandria, VA 22313-1450 or facsimile transmitted to the U.S. Patent and Trademark Office on the date shown below.

Signature			
Name (Print/Type)		Date	

This collection of information is required by 37 CFR 1.114. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Mail Stop RCE, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/AIA/22 (03-13)
Approved for use through 3/31/2013. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PETITION FOR EXTENSION OF TIME UNDER 37 CFR 1.136(a)

Docket Number (Optional): 5271-0195PUS1

Application Number	Filed
12/673,961	February 17, 2010

For BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY

Art Unit	Examiner
1723	J. S. MAPLES

This is a request under the provisions of 37 CFR 1.136(a) to extend the period for filing a reply in the above-identified application.

The requested extension and fee are as follows (check time period desired and enter the appropriate fee below):

	Fee	Small Entity Fee	Micro Entity Fee	
☐ One month (37 CFR 1.17(a)(1))	$200	$100	$50	$
☑ Two months (37 CFR 1.17(a)(2))	$600	$300	$150	$ 600.00
☐ Three months (37 CFR 1.17(a)(3))	$1,400	$700	$350	$
☐ Four months (37 CFR 1.17(a)(4))	$2,200	$1,100	$550	$
☐ Five months (37 CFR 1.17(a)(5))	$3,000	$1,500	$750	$

☐ Applicant asserts small entity status. See 37 CFR 1.27.

☐ Applicant certifies micro entity status. See 37 CFR 1.29.
Form PTO/SB/15A or B or equivalent must either be enclosed or have been submitted previously.

☐ A check in the amount of the fee is enclosed.

☑ Payment by credit card. Form PTO-2038 is attached.

☐ The Director has already been authorized to charge fees in this application to a Deposit Account.

☑ The Director is hereby authorized to charge any fees which may be required, or credit any overpayment, to Deposit Account Number 02-2448.

☐ Payment made via EFS-Web.

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

I am the

☐ applicant.

☑ attorney or agent of record. Registration number 32,881.

☐ attorney or agent acting under 37 CFR 1.34. Registration number _____.

Signature	Date
	JUN 18 2013
John W. Bailey	703-205-8000
Typed or printed name	Telephone Number

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. Submit multiple forms if more than one signature is required, see below*.

☑ * Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.136(a). The information is required to obtain or retain a benefit by the public, which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 6 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Mail Stop PCT, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:
Hideaki KATAYAMA et al.

Application No.:	12/673,961	Confirmation No.:	2754
Filed:	February 17, 2010	Art Unit:	1723
For:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY	Examiner:	J. S. MAPLES

AMENDMENT UNDER 37 C.F.R. § 1.114

MS RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

INTRODUCTORY COMMENTS

In reply to the Advisory Action dated May 16, 2013 and the Office Action dated January 18, 2013, the following amendments and remarks are respectfully submitted in connection with the above-identified application.

Amendments to the Claims begin on page 2.

Remarks begin on page 9.

AMENDMENTS TO THE CLAIMS

1. (Previously Presented) A battery separator comprising:

heat-resistant fine particles; and

a thermoplastic resin,

wherein the heat-resistant fine particles along with a binder constitute a heat-resistant layer,

the thermoplastic resin constitutes a shutdown layer formed of a microporous film,

the heat-resistant layer and the shutdown layer are integrated into a multilayer structure,

a content of the heat-resistant fine particles in the heat-resistant layer is 50 vol% or more of a total volume of components in the heat-resistant layer,

a proportion of particles with a particle size of 0.2 μm or less in the heat-resistant fine particles is 10 vol% or less and a proportion of particles with a particle size of 2 μm or more in the heat-resistant fine particles is 10 vol% or less, and

a shutdown is effected in a range of 135°C to 150°C.

2. (Original) The battery separator according to claim 1, wherein a thermal shrinkage ratio in a width direction is 10% or less at 200°C.

3. (Previously Presented) The battery separator according to claim 1, wherein the content of the heat-resistant fine particles in the heat-resistant layer is 80 vol% or more of the total volume of components in the heat-resistant layer.

4. (Original) The battery separator according to claim 1, wherein the heat-resistant fine particles are inorganic fine particles.

5. (Previously Presented) The battery separator according to claim 4, wherein the inorganic fine particles include fine particles of at least one selected from the group consisting of alumina, silica, $BaTiO_3$, boehmite, zeolite, and kaoline.

6. (Previously Presented) The battery separator according to claim 1, wherein the heat-resistant fine particles include plate-like particles.

7. (Previously Presented) The battery separator according to claim 1, wherein the heat-resistant layer has a thickness of 1 μm to 10 μm.

8. (Original) The battery separator according to claim 1, wherein the thermoplastic resin includes polyolefin.

9. (Previously Presented) The battery separator according to claim 1, wherein the heat-resistant fine particles have an average particle size of 1.5 μm or less.

10. (Previously Presented) A nonaqueous electrolyte battery comprising:

a positive electrode having a positive active material capable of intercalating and deintercalating a lithium ion;

a negative electrode having a negative active material capable of intercalating and deintercalating a lithium ion;

a separator interposed between the positive electrode and the negative electrode; and

a nonaqueous electrolyte,

wherein a heat generation starting temperature of the positive electrode is 180°C or higher, and

wherein the separator is the battery separator according to claim 1.

11. (Original) The nonaqueous electrolyte battery according to claim 10, wherein a thermal shrinkage ratio of the separator is 10% or less at a temperature T (°C) that is 10°C lower than the heat generation starting temperature of the positive electrode (where an upper limit of T is 200°C).

12. (Original) The nonaqueous electrolyte battery according to claim 10, wherein a width of the separator is larger than that of the negative electrode at a temperature T (°C) that is 10°C lower than the heat generation starting temperature of the positive electrode (where an upper limit of T is 200°C).

13. (Original) The nonaqueous electrolyte battery according to claim 10, wherein the positive active material is at least one selected from the group consisting of the following: a spinel-type lithium-containing complex oxide expressed as a general formula $Li_{1+t}Mn_{(2-x)}M^1{}_xO_4$ (where M^1 is at least one element selected from the group consisting of Fe, Ni, Mg, Zn, Co, Cr, Al, B, V, Si, Sn, Nb, Ta, Cu, Mo, Ti, and W, $-0.1 \leq t \leq 0.1$, and $0 \leq x \leq 0.6$); an olivine-type

lithium-containing complex oxide expressed as a general formula LiM^2PO_4 (where M^2 is Co, Ni, Mn, or Fe); a lithium-containing complex oxide having a layered crystal structure expressed as a general formula $Li_{(1+a)}M^3_{2b}Mn_{(0.5-b)}Ni_{(0.5-b)}O_2$ (where M^3 is at least one element selected from the group consisting of Fe, Mg, Zn, Co, Cr, Al, B, V, Si, Sn, Nb, Ta, Cu, Mo, Ti, and W, $-0.1 < a < 0.1$, and $0 \leq b \leq 0.05$); and a lithium-containing complex oxide expressed as a general formula $Li_{(1+y+\alpha)}Ni_{(1-y-z+\delta)/2}Mn_{(1-y-z-\delta)/2}M^4_zO_2$ (where M^4 is at least one element selected from the group consisting of Ti, Cr, Fe, Co, Cu, Zn, Al, Ge, Sn, Mg, and Zr, $-0.1 \leq y \leq 0.1$, $-0.05 \leq \alpha \leq 0.05$, $0 \leq z < 0.45$, and $-0.24 \leq \delta \leq 0.6$).

14. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein a content of the heat-resistant fine particles in the heat-resistant layer of the separator is 80 vol% or more of a total volume of components in the heat-resistant layer.

15. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator are inorganic fine particles.

16. (Previously Presented) The nonaqueous electrolyte battery according to claim 15, wherein the inorganic fine particles include fine particles of at least one selected from the group consisting of alumina, silica, $BaTiO_3$, boehmite, zeolite, and kaoline.

17. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator include plate-like particles.

18. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant layer of the separator has a thickness of 1 μm to 10 μm.

19. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the thermoplastic resin of the separator includes polyolefin.

20. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator is located on a negative electrode side.

21. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator is not in contact with the positive active material.

22. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator have an average particle size of 1.5 μm or less.

23. (Previously Presented) The battery separator according to claim 1, wherein the shutdown layer has a thickness of 5 μm to 30 μm.

24. (Previously Presented) The battery separator according to claim 1, wherein a ratio A/B is 1/2 to 5, where A (μm) represents a thickness of the shutdown layer, and B (μm) represents a thickness of the heat-resistant layer.

25. (Previously Presented) The battery separator according to claim 1, wherein a content of the binder in the heat-resistant layer is 1 to 20 vol% of a total volume of components in the heat-resistant layer.

26. (Canceled)

27. (Previously Presented) The battery separator according to claim 1, wherein the binder includes at least one selected from the group consisting of an ethylene-vinyl acetate copolymer (having 20 to 35 mol% of a structural unit derived from vinyl acetate); an ethylene-acrylic acid copolymer; fluoro-rubber; styrene-butadiene rubber; carboxymethyl cellulose; hydroxyethyl cellulose; polyvinyl alcohol; polyvinyl butyral; polyvinyl pyrrolidone; poly-N-vinylacetamide; a cross-linked acrylic resin; polyurethane; and an epoxy resin.

28. (Previously Presented) The battery separator according to claim 1, wherein the heat-resistant fine particles have an average particle size of 0.3 μm or more.

29. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator has a thickness of 5 μm to 30 μm.

30. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein a ratio A/B is 1/2 to 5, wherein A (μm) represents a thickness of the shutdown layer of the separator, and B (μm) represents a thickness of the heat-resistant layer of the separator.

31. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein a content of the binder in the heat-resistant layer of the separator is 1 to 20 vol% of a total volume of components in the heat-resistant layer.

32. (Canceled)

33. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the binder of the separator includes at least one selected from the group consisting of an ethylene-vinyl acetate copolymer (having 20 to 35 mol% of a structural unit derived from vinyl acetate); an ethylene-acrylic acid copolymer; fluoro-rubber; styrene-butadiene rubber; carboxymethyl cellulose; hydroxyethyl cellulose; polyvinyl alcohol; polyvinyl butyral; polyvinyl pyrrolidone; poly-N-vinylacetamide; a cross-linked acrylic resin; polyurethane; and an epoxy resin.

34. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator have an average particle size of 0.3 μm or more.

35. (**New**) The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator is not in contact with the positive active material, and a charging potential of the positive electrode is 4.3 V or more.

REMARKS

Upon entry of the instant filing, claims 1-25, 27-31, and 33-35 remain pending in the above-identified application and stand ready for further action on the merits.

In the instant filing, claim 35 has been added based on the description of paragraph **[0074]** of the present specification (*reproduced below*).

> **[0074]** When the shutdown layer is made of a material having somewhat inferior resistance to oxidation such as polyolefin, it is desirable to avoid contact between the shutdown layer and the positive active material so as to prevent degradation of the separator caused by oxidation and improve the charge-discharge cycle life and the high-temperature storage characteristics of the battery. In particular, when the charging potential is 4.3 V or more, the oxidation action becomes prominent. Moreover, when the shutdown layer is located on the negative electrode side, particularly is brought into contact with the negative electrode mixture layer, a film of the thermoplastic resin of the shutdown layer is formed on the surface of the negative electrode mixture layer after a shutdown is effected. This can suppress a reaction between the air that flows into the battery, e.g., after a cleavable vent has opened (as will be described later) and the negative active material, and thus can further improve the safety at high temperatures.

Accordingly, the present amendments to the claims do not introduce new matter into the application as originally filed. As such, entry of the instant amendment and favorable action on the merits are earnestly solicited at present.

Provisional Examiner Interview Request

Should the instant reply not result in an allowance of each of the pending claims currently under consideration, the USPTO Examiner is respectfully requested to contact Mr. John W. Bailey (Reg. No. 32,881) in the Washington D.C. area at 703-205-8031, in order to schedule a personal interview at the Examiner's earliest convenience. It is submitted that such an interview

would be valuable in helping to further prosecution of the instant application towards issuance of a Notice of Allowance, or alternatively, to further clarity and/or simplify outstanding issues for purposes of a future Appeal to the USPTO Board of Patent Appeals and Interferences.

Claim Rejections under 35 U.S.C. § 103(a)

Claims 1-25, 27-31, 33, and 34 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over **Nakura et al. US '631** (US 2008/0038631) in view of **Katayama et al. US '577** (US 2007/0264577).

This rejection is respectfully traversed based on the following considerations. Reconsideration and withdrawal of the rejection are respectfully requested.

Legal Standard for Determining Prima Facie Obviousness

M.P.E.P. § 2141 sets forth the guidelines in determining obviousness. First, the USPTO has to take into account the factual inquiries set forth in *Graham v. John Deere*, 383 U.S. 1, 17, 148 USPQ 459, 467 (1966), which has provided the controlling framework for an obviousness analysis. The four *Graham* factors are:

(a) determining the scope and content of the prior art;

(b) ascertaining the differences between the prior art and the claims in issue;

(c) resolving the level of ordinary skill in the pertinent art; and

(d) evaluating any evidence of secondary considerations.

Graham v. John Deere, 383 U.S. 1, 17, 148 USPQ 459, 467 (1966).

Second, the USPTO has to provide some rationale for determining obviousness. MPEP § 2143 sets forth some rationales that were established in the recent decision of *KSR International*

Co. v Teleflex Inc., 82 USPQ2d 1385 (U.S. 2007). Exemplary rationales that may support a conclusion of obviousness include:

(a) *combining prior art elements according to known methods to yield predictable results;*

(b) *simple substitution of one known element for another to obtain predictable results;*

(c) *use of known technique to improve similar devices (methods, or products) in the same way;*

(d) *applying a known technique to a known device (method, or product) ready for improvement to yield predictable results;*

(e) *"obvious to try" – choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success*

(f) *known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art;*

(g) *some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.*

As the M.P.E.P. directs, all claim limitations must be considered in view of the cited prior art in order to establish a *prima facie* case of obviousness. *See* M.P.E.P. § 2143.03.

Distinctions over the Cited Art

In the Advisory Action dated May 16, 2013[1], the USPTO Examiner asserts that "*the applicant has not currently claimed the content of the fine particles in the heat resistant layer to be set at 50 vol% or more*". However, claim 1 of the present application recites that "a content of

[1] Paper No. 20130513

the heat-resistant fine particles in the heat-resistant layer is 50 vol% or more of a total volume of components in the heat-resistant layer". Therefore, the USPTO Examiner's assertion is incorrect.

In the Advisory Action, the USPTO Examiner also asserts that paragraph [**0055**] of **Nakura et al. US '631** refers to a comparative example and is thus not applicable to the configuration of the invention of **Nakura et al. US '631**. However, the batteries of Examples 1 and 2 use the separator of Comparative Example 4 (see paragraph [**0061**] (*reproduced below*)), and the separator of Comparative Example 4 is produced using the same heat-resistant porous film as that of Comparative Example 1 except that the thickness is changed to 5 μm (see paragraph [**0060**] (*reproduced below*)).

COMPARATIVE EXAMPLE 4

[0060] A heat-resistant porous film comprising polyphenylene sulfide was prepared in the same manner as in Comparative Example 1 except that the thickness was changed to 5 μm. This heat-resistant porous film and a 25-μm thick shut-down layer were layered and bonded together by passing them through a thermal roll press heated to 90° C., to obtain a separator comprising the heat-resistant porous film and the shut-down layer. This separator had a thickness of 30 μm. A battery was produced in the same manner as in Comparative Example 1 except for the use of this separator comprising the heat-resistant porous film and the shut-down layer. The shut-down layer used was a composite film of polyethylene and polypropylene (2300 available from Celgard K. K.). The shut down temperature of this composite film is 120° C.

EXAMPLES 1 AND 2

[0061] Batteries of Examples 1 and 2 were produced in the same manner as in Comparative Examples 2 and 3, respectively, except for the use of the separator of Comparative Example 4 comprising the heat-resistant porous film and the shut-down layer.

Accordingly, the heat-resistant porous film of the separator for the batteries of Examples 1 and 2 has the same composition as that of the heat-resistant porous film of Comparative Example 1. Thus, it is respectfully submitted that the USPTO Examiner's assertion is incorrect.

In the Advisory Action, the USPTO Examiner further asserts that **Nakura et al. US '631**, teaches that the content of fine particles is 50 wt% or more in paragraph **[0044]**. However, paragraph **[0044]** (*reproduced below*) refers to the configuration of the "porous membrane" that is integrated with the electrode, and does not refer to the configuration of the "heat-resistant porous film" that is integrated with the shut-down layer.

> **[0044]** The ratio of the inorganic oxide filler to the total of the inorganic oxide filler and the binder contained in the porous membrane is preferably 50% by weight or more and 99% by weight or less, and more preferably 95 to 98% by weight. If the ratio of the inorganic oxide filler is less than 50% by weight, the amount of the binder is too large, so that it is difficult to control the pore structure of the porous membrane. If the ratio of the inorganic oxide filler exceeds 99% by weight, the amount of the binder is too small, so that the adhesion of the porous membrane to the electrode surface decreases. Thus, the porous membrane may separate therefrom.

As the layers containing the inorganic oxide filler, **Nakura et al. US '631** disclose both the "heat-resistant porous film" (see paragraph **[0031]** (*reproduced below*)) that is integrated with the shut-down layer to form the separator and the "porous membrane" (see paragraph **[0044]**) that is integrated with the positive electrode or the negative electrode so as to be present on the surface of the electrode.

> [**0031**] The heat-resistant porous film preferably contains an inorganic oxide filler in addition to the heat-resistant resin. However, the ratio of the inorganic oxide filler to the total of the heat-resistant resin and the inorganic oxide filler is desirably 33 to 98% by weight. If the ratio of the inorganic oxide filler is too high, the separator has high hardness, so that it is difficult to obtain a flexible separator.

In the heat-resistant porous film that is specifically described in paragraph [**0055**] of **Nakura et al. US '631**, 10 g of the inorganic oxide filler (alumina with a median diameter of 0.3 μm) is used with respect to 200 g of the heat-resistant resin (polyphenylene sulfide). The volume ratio of the inorganic oxide filler, calculated by using the specific gravity of polyphenylene sulfide (1.4) and the specific gravity of alumina (4), is 1.7 vol%. In other words, Examples 1 and 2 of **Nakura et al. US '631** disclose the batteries, each of which uses the separator that includes the heat-resistant porous film containing 1.7 vol% of the alumina with a median diameter of 0.3 μm. With this configuration, lithium is locally deposited during overcharge, and the deposited lithium effectively penetrates the heat-resistant separator and causes an internal short-circuit, so that the heat generation of the battery is significantly suppressed, and the safety is improved (see paragraphs [**0089**] and [**0093**] (*reproduced below*)).

> [**0089**] In Examples 1 to 13 with the porous membranes and the shut-down layer, the heat generation of the batteries upon overcharge is significantly suppressed in comparison with Comparative Examples 1, 5, and 9 having neither porous membrane nor shut-down layer. Generally, when the battery temperature exceeds 140° C. upon overcharge, the overcharged positive electrode starts to generate heat, but this phenomenon can be avoided in Examples.

> **[0093]** After the evaluation of overcharge safety, the batteries were disassembled for examination. As a result, Examples 1 to 13 did not exhibit thermal shrinkage of the separator caused by heat generated upon overcharge or internal short-circuiting due to deposited lithium. Also, local deposition of lithium was found, and an internal short-circuit between the positive electrode and the negative electrode was found wherever there was deposited lithium. This indicates that the deposited lithium effectively penetrated the heat-resistant separator, causing an internal short-circuit.

On the other hand, Example 4 of **Katayama et al. US '577** discloses the separator that uses 3 kg of alumina fine particles having a particle size distribution of 0.3 to 0.7 μm, which are similar to those of Example 1, and 1 kg of cross-linked PMMA fine particles. The volume ratio of the alumina fine particles in the separator, calculated by using the specific gravity of alumina (4) and the specific gravity of the cross-linked PMMA (1.2), is 47 vol%.

Katayama et al. US '577 also teach that the charging efficiency of the battery of Example 4A produced by using the separator of Example 4 is substantially 100%, and the formation of lithium dendrite at the time of charging can be suppressed (see paragraphs **[0148]** and **[0157]** (*reproduced below*)).

> **[0148]** Each of the separators in Examples 1-9 and Comparative Examples 1-3 was wound spirally with the above-described positive electrode and negative electrode to produce a wound electrode. This wound electrode was crushed and flattened to be loaded in a battery container. After injection of the above-described nonaqueous electrolyte, the container was sealed to produce a lithium secondary battery as in any of Examples 1A-9A and Comparative Examples 1A-3A.

> **[0157]** The batteries in Examples 4A-7A and 9A had charging efficiencies of substantially 100% similarly to the case of Comparative Example 1A, and formation of lithium dendrite at the time of charging was suppressed. In contrast, for the battery in Comparative Example 2A including only the filler particles in the pores of the porous base, the charging efficiency was poor and internal short-circuit due to the formation of lithium dendrite at the time of charging was found. It was considered that since the alumina fine particles used as the filler particles were shaped differently from the plate shape that provides excellent effect in suppressing formation of lithium dendrite, formation of the lithium dendrite might not be suppressed in a case where shutdown resin particles do not coexist.

In other words, **Katayama et al. US '577** teach that the deposition of lithium cannot be found on the heat-resistant porous film containing about 50 vol% of the alumina fine particles having a particle size distribution of 0.3 to 0.7 μm, and consequently an internal short-circuit penetrating the separator cannot be formed.

Therefore, it is impossible for a person skilled in the art to apply the configuration of the separator of **Katayama et al. US '577** to the separator of **Nakura et al. US '631**, since the separator of **Katayama et al. US '577** would interfere with the function (of forming an internal short-circuit) of the separator of **Nakura et al. US '631**. Thus, the present invention cannot be obvious from the combination of **Nakura et al. US '631** and **Katayama et al. US '577**.

Apart from the above considerations, the cited art being applied by the USPTO fails to either teach or disclose each of the limitations found in the pending claims, and also fails to provide any motivation, or reasoning or rationale that would allow one having ordinary skill in the art to arrive at the instant invention as claimed. As such, the cited art of record is incapable of either anticipating or rendering the instant invention as claimed obvious. Any contentions of the USPTO to the contrary are respectfully requested to be reconsidered at once.

New Claims

Applicants submit that claim 35 depends, either directly or indirectly, from independent claim 1, and are therefore allowable based on their dependence from claim 1 which is believed to be allowable.

CONCLUSION

All of the stated grounds of rejection have been properly traversed, accommodated, or rendered moot. It is believed that a full and complete response has been made to the outstanding Office Action, and as such, the present application is in condition for allowance.

Based upon the amendments and remarks presented herein, the USPTO Examiner is respectfully requested to issue a Notice of Allowance clearly indicating that each of the pending claims 1-25, 27-31, and 33-35 is allowable under the provisions of Title 35 of the United States Code.

Should there be any outstanding matters that need to be resolved in the present application, the USPTO Examiner is respectfully requested to contact John W. Bailey, Registration No. 32,881, at the telephone number of the undersigned below to conduct an interview in an effort to expedite prosecution in connection with the present application.

If necessary, the Director is hereby authorized in this, concurrent, and future replies to charge any fees required during the pendency of the above-identified application or credit any overpayment to Deposit Account No. 02-2448.

Dated: JUN 18 2013

Respectfully submitted,

By _____

John W. Bailey
Registration No.: 32,881
BIRCH, STEWART, KOLASCH & BIRCH, LLP
8110 Gatehouse Road, Suite 100 East
P.O. Box 747
Falls Church, VA 22040-0747
703-205-8000

Electronic Patent Application Fee Transmittal

Application Number:	12673961
Filing Date:	17-Feb-2010
Title of Invention:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY
First Named Inventor/Applicant Name:	Hideaki Katayama
Filer:	John Wayne Bailey/Phila Ly
Attorney Docket Number:	5271-0195PUS1

Filed as Large Entity

U.S. National Stage under 35 USC 371 Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 2 months with $0 paid	1252	1	600	600

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
Request for Continued Examination	1801	1	1200	1200
		Total in USD ($)		**1800**

Electronic Acknowledgement Receipt

EFS ID:	16074236
Application Number:	12673961
International Application Number:	
Confirmation Number:	2754
Title of Invention:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY
First Named Inventor/Applicant Name:	Hideaki Katayama
Customer Number:	2292
Filer:	John Wayne Bailey/Phila Ly
Filer Authorized By:	John Wayne Bailey
Attorney Docket Number:	5271-0195PUS1
Receipt Date:	18-JUN-2013
Filing Date:	17-FEB-2010
Time Stamp:	16:24:10
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$1800
RAM confirmation Number	3660
Deposit Account	022448
Authorized User	BAILEY, JOHN

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. 1.492 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)					
File Listing:					
Document Number	**Document Description**	**File Name**	**File Size(Bytes)/ Message Digest**	**Multi Part /.zip**	**Pages (if appl.)**
1		2013-06-18_RCE_Amendment_Transmittals_5271-0195PUS1.pdf	960779 8fc5cfa1f0d95529c19c1164a1a696444cb55ae6	yes	21

Multipart Description/PDF files in .zip description

Document Description	Start	End
Miscellaneous Incoming Letter	1	1
Request for Continued Examination (RCE)	2	2
Extension of Time	3	3
Amendment Submitted/Entered with Filing of CPA/RCE	4	4
Claims	5	11
Applicant Arguments/Remarks Made in an Amendment	12	21

Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	32598 768bc2cde79a7ec914ccf1959a31f2102090d128	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	993377		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/17 (03-13)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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FEE TRANSMITTAL

Complete if known	
Application Number	12/673,961 Conf. No.: 2754
Filing Date	February 17, 2010
First Named Inventor	Hideaki KATAYAMA
Examiner Name	J. S. MAPLES
Art Unit	1723
Practitioner Docket No.	5271-0195PUS1

☐ Applicant asserts small entity status. See 37 CFR 1.27.

☐ Applicant certifies micro entity status. See 37 CFR 1.29. Form PTO/SB/15A or B or equivalent must either be enclosed or have been submitted previously.

TOTAL AMOUNT OF PAYMENT ($) 1,800.00

METHOD OF PAYMENT (check all that apply)

☐ Check ☑ Credit Card ☐ Money Order ☐ None ☐ Other (please identify): _____

☑ Deposit Account Deposit Account Number: 02-2448 Deposit Account Name: Birch, Stewart, Kolasch & Birch, LLP

For the above-identified deposit account, the Director is hereby authorized to (check all that apply):

☐ Charge fee(s) indicated below ☐ Charge fee(s) indicated below, **except for the filing fee**

☑ Charge any additional fee(s) or underpayment of fee(s) under 37 CFR 1.16 and 1.17 ☑ Credit any overpayment of fee(s)

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES (U = undiscounted fee; S = small entity fee; M = micro entity fee)

	FILING FEES			SEARCH FEES			EXAMINATION FEES			
Application Type	**U ($)**	**S ($)**	**M ($)**	**U ($)**	**S ($)**	**M ($)**	**U ($)**	**S ($)**	**M ($)**	**Fees Paid ($)**
Utility	280	140*	70	600	300	150	720	360	180	
Design	180	90	45	120	60	30	460	230	115	
Plant	180	90	45	380	190	95	580	290	145	
Reissue	280	140	70	600	300	150	2,160	1,080	540	
Provisional	260	130	65	0	0	0	0	0	0	

* The $140 small entity status filing fee for a utility application is further reduced to $70 for a small entity status applicant who files the application via EFS-Web.

2. EXCESS CLAIM FEES

Fee Description	**Undiscounted Fee ($)**	**Small Entity Fee ($)**	**Micro Entity Fee ($)**
Each claim over 20 (including Reissues)	80	40	20
Each independent claim over 3 (including Reissues)	420	210	105
Multiple dependent claims	780	390	195

Total Claims		**Extra Claims**	**Fee ($)**		**Fee Paid ($)**
33	-20 or HP =	_____ x	_____	=	_____

HP = highest number of total claims paid for, if greater than 20.

Indep. Claims		**Extra Claims**	**Fee ($)**		**Fee Paid ($)**
1	-3 or HP =	_____ x	_____	=	_____

HP = highest number of independent claims paid for, if greater than 3.

Multiple Dependent Claims

Fee ($)	**Fee Paid ($)**
_____	_____

3. APPLICATION SIZE FEE

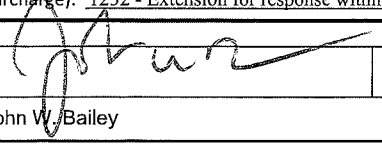
If the specification and drawings exceed 100 sheets of paper (excluding electronically filed sequence or computer listings under 37 CFR 1.52(e)), the application size fee due is $400 ($200 for small entity) ($100 for micro entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

Total Sheets		**Extra Sheets**		**Number of each additional 50 or fraction thereof**		**Fee ($)**		**Fee Paid ($)**
_____	- 100 =	_____	/ 50 =	_____ (round **up** to a whole number)	x	_____	=	_____

4. OTHER FEE(S)

	Fees Paid ($)
Non-English specification, $130 fee (no small or micro entity discount)	
Non-electronic filing fee under 37 CFR 1.16(t) for a utility application, $400 fee ($200 small or micro entity)	
Other (e.g., late filing surcharge): 1801 - Request for continued examination (RCE) - 1st request 1252 - Extension for response within second month	1,800.00

SUBMITTED BY

Signature		Registration No. (Attorney/Agent) 32,881	Telephone 703-205-8000
Name (Print/Type)	John W. Bailey		Date JUN 18 2013

This collection of information is required by 37 CFR 1.136. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 12/673,961	Filing Date 02/17/2010	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT **06/18/2013**

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 33	Minus	** 34	= 0	X $80 =	0
Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $420 =	0
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	0

AMENDMENT

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/PAMELA v. THERATT/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/673,961	02/17/2010	Hideaki Katayama	5271-0195PUS1	2754

2292 7590 12/27/2013

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EXAMINER	
MAPLES, JOHN S	

ART UNIT	PAPER NUMBER
1723	

NOTIFICATION DATE	DELIVERY MODE
12/27/2013	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

mailroom@bskb.com

Office Action Summary	Application No. 12/673,961	Applicant(s) KATAYAMA ET AL.	
	Examiner John S. Maples	Art Unit 1723	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *18 June 2013*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *1-25,27-31 and 33-35* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-25, 27-31 and 33-35* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

1. The present application is being examined under the pre-AIA first to invent provisions.

2. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

3. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

4. Claims 1-25, 27-31 and 33-35 are rejected under 35 U.S.C. 103(a) as being unpatentable over Nakura et al.-US 2008/0038631 (Nakura) in view of Katayama et al.-US 2007/0264577. (Katayama) (New Rejection with regard to claim 35)

For claim 1, Nakura teaches a battery separator comprising a shutdown layer formed of a microporous film and a heat-resistant layer comprising fine particles and a

binder-see the Abstract in Nakura along with paragraphs 22-49 where paragraph 31 recite the content of the fine particles. As paragraphs 19 and 30 in Nakura recite, the shutdown is effected in the claimed range of 135-150 degrees C. The only claimed features not shown by Nakura are the proportion of particle sizes. Katayama discloses a separator for a lithium secondary battery that includes a heat-resistant layer comprising fine particles, where the sizes thereof fall within that range claimed by applicant-see Example 1 in Katayama where the particles are in a size distribution of 0.3-0.7 micron size. To include the sized particles of Katayama in the separator of Nakura would have been obvious to one of ordinary skill in this art at the time the invention was made because the same would allow for greater transport across the separator.

For claim 2, paragraph 28 in Nakura teaches the claimed temperature for the shrinkage ratio which would inherently fall within the claimed range.

For claims 3, 14, 25 and 31, paragraph 31 in Nakura recite the content of the fine particles and the binder.

Paragraph 42 in Nakura disclose alumina fine particles thus meeting claims 4, 5, 15 and 16.

For claims 6 and 17, Katayama recites plate shaped particles in paragraph 77 and to include the same in Nakura would have been obvious so that short-circuiting would be hindered.

For claims 7, 18, 23, 24, 29, 30, paragraphs 30 and 36 in Nakura teach the claimed thicknesses of both the shut-down layer and the heat-resistant layers.

With regard to claims 8 and 19, paragraph 38 in Nakura teaches the claimed thermoplastic resin.

For claims 9, 22, 28 and 34, the claimed particle size is taught in Example 1 of Katayama and to include the same in Nakura would have been obvious to allow greater compacting in the separator.

Claims 10-13 are met by the specific first compound recited in the next to the last line of paragraph 100 in Katayama. It is noted that this compound is the same compound set forth in applicant's Example 1 so the properties set forth in claims 11 and 12 would inherently be met and to utilize this compound of Katayama in Nakura would have been obvious because, as set forth in paragraph 46 of Nakura, provision of made for the lithium manganese nickel cobalt oxide.

For claims 20 and 21, reference is made to the Abstract and paragraph 37 for the shutdown layer located on the negative electrode side.

For claims 27 and 33, paragraph 49 in Nakura discloses the claimed binder.

For claim 35, paragraph 86 in Nakura describes a charging potential of the positive electrode being 4.3 V.

Applicant's arguments have all been considered but are not deemed persuasive. Applicant argues that in the Advisory action, the examiner argued that the applicant has not currently claimed the content of the fine particles in the heat resistant layer to be at 50 vol% or more. This argument is incorrect because the examiner stated that the applicant argued that Nakura does not disclose a lower limit of (underlining added) the content of the fine particles in the heat resistant layer of the separator to be set at 50

vol%. Applicant did not claim this specific language in the claims and so no rebuttal is necessary.

With regard to applicant's argument relating to paragraph 55 in Nakura that the volumn ratio of the inorganic oxide filler is as low as 1.7 vol%. This may be true, however, as set forth previously in this action, Nakura teaches the claimed amount of 50 vol% or more of the heat-resistant fine particles and so this portion of the claimed subject matter is met by the teachings to Nakura.

Applicant further asserts that paragraph 44 in Nakura is referencing the porous membrane and the heat-resistant porous film. Applicant is correct, however, paragraph 31 in Nakura, as previously noted in this action, does teach the claimed amount of the fiine particles in the heat-resistant layer.

Applicant goes on the further argue that paragraph 55 in Nakura only teaches alumina in an amount of 1.7 vol% and with such amount, as paragraphs 89 and 93 set forth, battery safety is improved. This may be true, however, as stated previously in this action, Nakura clearly teaches the claimed amount of the fine particles in the heat-resistant layer therein.

Applicant's final argument relating to the application of Katayama states that with the heat-resistant porous film containing about 50 vol% of alumina particles, an internal short-circuit penetrating the separator cannot be formed. First of all, it is unclear where the applicant arrived at the amount of the alumina particles? Secondly, with no short-circuit formed, that is exactly the goal of both the Nakura and the Katayama references

are for use as a battery separator-to render the same safe as possible and to not short-circuit.

Finally applicant argues that it is not proper to combine Katayama with Nakura since an internal short circuit would occur. This is unclear reasoning especially since applicant previously stated that no internal short-circuit would occur. In any event, it would have been obvious to have combined the teachings of Katayama with Nakura since both references are directed to the same technology and Nakura is being modified by Katayama with only the size of the fine particles. The case *KSR*, 82 USPQ2d at 1396 supports this position, because all that is being done here is combining prior art elements and substituting one known element for another.

5. Any inquiry concerning this communication or earlier communications from the examiner should be directed to John S. Maples whose telephone number is (571)272-1287. The examiner can normally be reached on Monday-Friday, 8:30-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Milton Cano can be reached on 571-272-1398. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/John S. Maples/
Primary Examiner
Art Unit 1723

JSM/12-16-2013

Search Notes	Application/Control No.	Applicant(s)/Patent under Reexamination	
	12/673,961	KATAYAMA ET AL.	
	Examiner	Art Unit	
	John S. Maples	1723	

SEARCHED			
Class	Subclass	Date	Examiner

INTERFERENCE SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES (INCLUDING SEARCH STRATEGY)		
	DATE	EXMR
EAST-USOCR,USPAT,USPGPUB see search history printout	12/16/2013	JSM

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	402	(429/144 or 429/145).ccls. and (shutdown or (shut adj down))	US-PGPUB; USPAT; USOCR	OR	ON	2013/12/16 11:16
L2	194	L1 and (inorganic near2 (filler or particle))	US-PGPUB; USPAT; USOCR	OR	ON	2013/12/16 11:16
L3	58	2 and @pd>"20120808"	US-PGPUB; USPAT; USOCR	OR	ON	2013/12/16 11:16

12/ 16/ 2013 11:20:50 AM
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:	Hideaki KATAYAMA et al.		
Application No.:	12/673,961	Confirmation No.:	2754
Filed:	February 17, 2010	Art Unit:	1723
For:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY	Examiner:	John S. Maples

AMENDMENT UNDER 37 C.F.R. § 1.111

MS AMENDMENT
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

INTRODUCTORY COMMENTS

In reply to the Office Action dated December 27, 2013, the following amendments and remarks are respectfully submitted in connection with the above-identified application:

Amendments to the Claims begin on page 2.

Remarks begin on page 10.

AMENDMENTS TO THE CLAIMS

1. (**Currently Amended**) A battery separator comprising:

heat-resistant fine particles; and

a thermoplastic resin,

wherein the heat-resistant fine particles along with a binder constitute a heat-resistant layer,

the thermoplastic resin constitutes a shutdown layer formed of a heat-shrinkable microporous film,

the heat-resistant layer and the shutdown layer are integrated into a multilayer structure,

the shutdown layer has a thickness A (μm) of 5 to 30, the heat-resistant layer has a thickness B (μm) of 1 to 10, a sum of A and B is 6 to 23, and a ratio A/B is 1/2 to 4,

a content of the heat-resistant fine particles in the heat-resistant layer is 50 vol% or more of a total volume of components in the heat-resistant layer,

a proportion of particles with a particle size of 0.2 μm or less in the heat-resistant fine particles is 10 vol% or less and a proportion of particles with a particle size of 2 μm or more in the heat-resistant fine particles is 10 vol% or less, and

a shutdown is effected in a range of 135°C to 150°C.

2. (Original) The battery separator according to claim 1, wherein a thermal shrinkage ratio in a width direction is 10% or less at 200°C.

3. (Previously Presented) The battery separator according to claim 1, wherein the content of the heat-resistant fine particles in the heat-resistant layer is 80 vol% or more of the total volume of components in the heat-resistant layer.

4. (Original) The battery separator according to claim 1, wherein the heat-resistant fine particles are inorganic fine particles.

5. (Previously Presented) The battery separator according to claim 4, wherein the inorganic fine particles include fine particles of at least one selected from the group consisting of alumina, silica, $BaTiO_3$, boehmite, zeolite, and kaoline.

6. (Previously Presented) The battery separator according to claim 1, wherein the heat-resistant fine particles include plate-like particles.

7. **(Currently Amended)** The battery separator according to claim 1, wherein the heat-resistant layer has a thickness of ~~[[1]]~~ 2 μm to ~~[[10]]~~ 6 μm.

8. (Original) The battery separator according to claim 1, wherein the thermoplastic resin includes polyolefin.

9. (Previously Presented) The battery separator according to claim 1, wherein the heat-resistant fine particles have an average particle size of 1.5 μm or less.

10. (Previously Presented) A nonaqueous electrolyte battery comprising:

a positive electrode having a positive active material capable of intercalating and deintercalating a lithium ion;

a negative electrode having a negative active material capable of intercalating and deintercalating a lithium ion;

a separator interposed between the positive electrode and the negative electrode; and

a nonaqueous electrolyte,

wherein a heat generation starting temperature of the positive electrode is 180°C or higher, and

wherein the separator is the battery separator according to claim 1.

11. (Original) The nonaqueous electrolyte battery according to claim 10, wherein a thermal shrinkage ratio of the separator is 10% or less at a temperature T (°C) that is 10°C lower than the heat generation starting temperature of the positive electrode (where an upper limit of T is 200°C).

12. (Original) The nonaqueous electrolyte battery according to claim 10, wherein a width of the separator is larger than that of the negative electrode at a temperature T (°C) that is 10°C lower than the heat generation starting temperature of the positive electrode (where an upper limit of T is 200°C).

13. (Original) The nonaqueous electrolyte battery according to claim 10, wherein the positive active material is at least one selected from the group consisting of the following: a

spinel-type lithium-containing complex oxide expressed as a general formula $Li_{1+t}Mn_{(2-x)}M^1{}_xO_4$ (where M^1 is at least one element selected from the group consisting of Fe, Ni, Mg, Zn, Co, Cr, Al, B, V, Si, Sn, Nb, Ta, Cu, Mo, Ti, and W, $-0.1 \leq t \leq 0.1$, and $0 \leq x \leq 0.6$); an olivine-type lithium-containing complex oxide expressed as a general formula LiM^2PO_4 (where M^2 is Co, Ni, Mn, or Fe); a lithium-containing complex oxide having a layered crystal structure expressed as a general formula $Li_{(1+a)}M^3{}_{2b}Mn_{(0.5-b)}Ni_{(0.5-b)}O_2$ (where M^3 is at least one element selected from the group consisting of Fe, Mg, Zn, Co, Cr, Al, B, V, Si, Sn, Nb, Ta, Cu, Mo, Ti, and W, $-0.1 < a < 0.1$, and $0 \leq b \leq 0.05$); and a lithium-containing complex oxide expressed as a general formula $Li_{(1+y+\alpha)}Ni_{(1-y-z+\delta)/2}Mn_{(1-y-z-\delta)/2}M^4{}_zO_2$ (where M^4 is at least one element selected from the group consisting of Ti, Cr, Fe, Co, Cu, Zn, Al, Ge, Sn, Mg, and Zr, $-0.1 \leq y \leq 0.1$, $-0.05 \leq \alpha \leq 0.05$, $0 \leq z < 0.45$, and $-0.24 \leq \delta \leq 0.6$).

14. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein a content of the heat-resistant fine particles in the heat-resistant layer of the separator is 80 vol% or more of a total volume of components in the heat-resistant layer.

15. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator are inorganic fine particles.

16. (Previously Presented) The nonaqueous electrolyte battery according to claim 15, wherein the inorganic fine particles include fine particles of at least one selected from the group consisting of alumina, silica, $BaTiO_3$, boehmite, zeolite, and kaoline.

17. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator include plate-like particles.

18. (**Currently Amended**) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant layer of the separator has a thickness of [[1]] 2 μm to [[10]] 6 μm.

19. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the thermoplastic resin of the separator includes polyolefin.

20. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator is located on a negative electrode side.

21. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator is not in contact with the positive active material.

22. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator have an average particle size of 1.5 μm or less.

23. (**Currently Amended**) The battery separator according to claim 1, wherein the shutdown layer has a thickness of ~~5 μm to 30~~ 16 μm or less.

24. (**Canceled**)

25. (Previously Presented) The battery separator according to claim 1, wherein a content of the binder in the heat-resistant layer is 1 to 20 vol% of a total volume of components in the heat-resistant layer.

26. (Canceled)

27. (Previously Presented) The battery separator according to claim 1, wherein the binder includes at least one selected from the group consisting of an ethylene-vinyl acetate copolymer (having 20 to 35 mol% of a structural unit derived from vinyl acetate); an ethylene-acrylic acid copolymer; fluoro-rubber; styrene-butadiene rubber; carboxymethyl cellulose; hydroxyethyl cellulose; polyvinyl alcohol; polyvinyl butyral; polyvinyl pyrrolidone; poly-N-vinylacetamide; a cross-linked acrylic resin; polyurethane; and an epoxy resin.

28. (Previously Presented) The battery separator according to claim 1, wherein the heat-resistant fine particles have an average particle size of 0.3 μm or more.

29. **(Currently Amended)** The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator has a thickness of ~~5 μm to 30~~ 16 μm or less.

30. **(Canceled)**

31. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein a content of the binder in the heat-resistant layer of the separator is 1 to 20 vol% of a total volume of components in the heat-resistant layer.

32. (Canceled)

33. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the binder of the separator includes at least one selected from the group consisting of an ethylene-vinyl acetate copolymer (having 20 to 35 mol% of a structural unit derived from vinyl acetate); an ethylene-acrylic acid copolymer; fluoro-rubber; styrene-butadiene rubber; carboxymethyl cellulose; hydroxyethyl cellulose; polyvinyl alcohol; polyvinyl butyral; polyvinyl pyrrolidone; poly-N-vinylacetamide; a cross-linked acrylic resin; polyurethane; and an epoxy resin.

34. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant fine particles of the separator have an average particle size of 0.3 μm or more.

35. (Previously Presented) The nonaqueous electrolyte battery according to claim 10, wherein the shutdown layer of the separator is not in contact with the positive active material, and a charging potential of the positive electrode is 4.3 V or more.

36. (New) The battery separator according to claim 1, wherein the heat-resistant layer has a porosity of 20% to 60%.

37. (New) The battery separator according to claim 1, wherein the whole separator has a porosity of 30% to 70%.

38. (New) The nonaqueous electrolyte battery according to claim 10, wherein the heat-resistant layer has a porosity of 20% to 60%.

39. (New) The nonaqueous electrolyte battery according to claim 10, wherein the whole separator has a porosity of 30% to 70%.

40. (New) The battery separator according to claim 1, wherein the microporous film is formed by a solvent extraction method, a dry drawing method, or a wet drawing method.

41. (New) The nonaqueous electrolyte battery according to claim 10, wherein the microporous film is formed by a solvent extraction method, a dry drawing method, or a wet drawing method.

REMARKS

Upon entry of the instant filing, claims 1-23, 25, 27-29, 31, and 33-41 remain pending in the above-identified application and stand ready for further action on the merits.

In the instant filing, claims 1, 7, 18, 23, and 29 have been amended. Claims 24 and 30 have been cancelled. All amendments and cancellations are made without prejudice or disclaimer. Further, new claims 36-41 have been added. No new matter is added to the application by way of these amendments. More specifically, claim 1 has been amended to recite limitations previously recited in claims 7, 23, and 24. Support for the amendments of the claims can be found at least in paragraphs **[0037]**, **[0052]** to **[0054]**, **[0084]**, **[0087]**, and **[0094]** of the as-filed specification. Support for the newly added claims 36-41 can be found at least in paragraphs **[0047]**, **[0056]**, and **[0060]** of the present specification.

Accordingly, the present amendments to the claims do not introduce new matter into the application as originally filed. As such, entry of the instant amendment and favorable action on the merits are earnestly solicited at present.

Claim Rejections under 35 U.S.C. §103(a)

Claims 1-25, 27-31, and 33-35 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Nakura et al., U.S. Patent Application Publication No. 2008/0038631 (hereinafter, "Nakura"), in view of Katayama et al., U.S. Patent Application Publication No. 2007/0264577 (hereinafter, "Katayama"). Applicants note that claims 24 and 30 have been cancelled, thereby obviating the rejection of these claims.

This rejection as to the remaining claims is respectfully traversed based on the following considerations. Reconsideration and allowance thereof are respectfully requested.

Legal Standard for Determining Prima Facie Obviousness

M.P.E.P. § 2141 sets forth the guidelines in determining obviousness. First, the USPTO has to take into account the factual inquiries set forth in *Graham v. John Deere*, 383 U.S. 1, 17, 148 USPQ 459, 467 (1966), which has provided the controlling framework for an obviousness analysis. The four *Graham* factors are:

(a) determining the scope and content of the prior art;

(b) ascertaining the differences between the prior art and the claims in issue;

(c) resolving the level of ordinary skill in the pertinent art; and

(d) evaluating any evidence of secondary considerations.

Graham v. John Deere, 383 U.S. 1, 17, 148 USPQ 459, 467 (1966).

Second, the USPTO has to provide some rationale for determining obviousness. MPEP § 2143 sets forth some rationales that were established in the recent decision of *KSR International Co. v Teleflex Inc.*, 82 USPQ2d 1385 (U.S. 2007). Exemplary rationales that may support a conclusion of obviousness include:

(a) combining prior art elements according to known methods to yield predictable results;

(b) simple substitution of one known element for another to obtain predictable results;

(c) use of known technique to improve similar devices (methods, or products) in the same way;

(d) applying a known technique to a known device (method, or product) ready for improvement to yield predictable results;

(e) "obvious to try" – choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success

(f) known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other

market forces if the variations are predictable to one of ordinary skill in the art;

(g) *some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.*

As the M.P.E.P. directs, all claim limitations must be considered in view of the cited prior art in order to establish a *prima facie* case of obviousness. *See* M.P.E.P. § 2143.03.

The Present Invention

Independent claim 1 of the present application recites as follows (*emphasis added*):

1. A battery separator comprising:
heat-resistant fine particles; and
a thermoplastic resin,
wherein the heat-resistant fine particles along with a binder constitute a heat-resistant layer,
the thermoplastic resin constitutes a shutdown layer formed of a ***heat-shrinkable*** *microporous film,*
the heat-resistant layer and the shutdown layer are integrated into a multilayer structure,
the shutdown layer has a thickness A (μm) of 5 to 30, the heat-resistant layer has a thickness B (μm) of 1 to 10, a sum of A and B is 6 to 23, and a ratio A/B is 1/2 to 4,
a content of the heat-resistant fine particles in the heat-resistant layer is 50 vol% or more of a total volume of components in the heat-resistant layer,
a proportion of particles with a particle size of 0.2 μm or less in the heat-resistant fine particles is 10 vol% or less and a proportion of particles with a particle size of 2 μm or more in the heat-resistant fine particles is 10 vol% or less, and
a shutdown is effected in a range of 135°C to 150°C.

Distinctions over the Cited Art

Nakura discloses that the heat-resistant porous film has a thickness of 1 to 16 μm and the total thickness of the heat-resistant porous film and the shutdown layer is 5 to 35 μm. (*See*, Nakura, at paragraph [0036]). However, **Nakura** does not disclose that "the shutdown layer has

a thickness A (μm) of 5 to 30, the heat-resistant layer has a thickness B (μm) of 1 to 10, a sum of A and B is 6 to 23, and a ratio A/B is 1/2 to 4," as required by claim 1, as amended, of the present application. Therefore, for at least this reason, the presently claimed invention cannot be obvious in light of the combined disclosures of **Nakura** and **Katayama**.

Example 4 of **Katayama** discloses a separator (heat-resistant layer) comprised of 3 kg of alumina fine particles having a particle size distribution of 0.3 to 0.7 μm, which are similar to those of Example 1, which is comprised of 1 kg of cross-linked PMMA fine particles and a binder (PVB). (*See*, Katayama, at paragraphs [0121] and [0118], respectively). The volume ratio of the alumina fine particles to the total fine particles in the separator, calculated by using the specific gravity of alumina (4) and the specific gravity of the cross-linked PMMA (1.2), is 47 vol%. Therefore, the alumina content is less than 47 vol% of the total volume of components in the separator including the binder (PVB).

On the other hand, like Example 4, Comparative Example 2 of **Katayama** discloses a separator (heat-resistant layer) that uses 3 kg of alumina fine particles having a particle size distribution of 0.3 to 0.7 μm and 375 g of a binder (PVB). (*See*, *Id.*, at paragraph [0136]). In this case, the alumina content is more than 50 vol% of the total volume of components in the separator.

In **Katayama**, the above two separators are used to produce the lithium secondary batteries of Example 4A and Comparative Example 2A, respectively. These batteries are charged, and then the rates of the discharging capacities to the charging capacities are evaluated as the charging efficiencies. Table 6 shows the results of the evaluation. (*See*, *Id.*, at paragraph [**0156**], *next page*).

TABLE 6

Battery	Charging efficiency (capacity rate) (%)
Example 4A	99.5
Example 5A	99.9
Example 6A	99.6
Example 7A	99.3
Example 9A	99.5
Comparative Example 1A	99.5
Comparative Example 2A	56

As is evident from Table 6, the battery of Example 4A comprised of a separator containing less than 50 vol% of alumina fine particles has a charging efficiency which is substantially 100%, while the battery of Comparative Example 2A which uses a separator containing 50 vol% or more of alumina fine particles has a charging efficiency which is as low as 56%. This is likely due to an internal short circuit which occurs during charge. (*See, Id.*, at paragraph [**0157**]).

> [**0157**] The batteries in Examples 4A-7A and 9A had charging efficiencies of substantially 100% similarly to the case of Comparative Example 1A, and formation of lithium dendrite at the time of charging was suppressed. In contrast, for the battery in Comparative Example 2A including only the filler particles in the pores of the porous base, the charging efficiency was poor and internal short-circuit due to the formation of lithium dendrite at the time of charging was found. It was considered that since the alumina fine particles used as the filler particles were shaped differently from the plate shape that provides excellent effect in suppressing formation of lithium dendrite, formation of the lithium dendrite might not be suppressed in a case where shutdown resin particles do not coexist.

This disclosure of **Katayama** indicates the same state as that described in paragraph [**0107**] of the present specification, which describes the following:

> [**0107**] As a result of the evaluation of the charge/discharge characteristics, the batteries of Examples 1 to 4 and Comparative Examples 1 to 2 had good charge/discharge characteristics. However, the battery of Comparative Example 3 caused a short circuit during the initial charge and could not be charged.

> Therefore, the subsequent evaluation of the battery of Comparative Example 3 ceased.

Thus, if the particle size of the filler described in Example 1 of **Katayama** is used with the inorganic oxide filler included in the heat-resistant porous film of the separator taught by **Nakura**, one of ordinary skill in the art would not select an amount of inorganic oxide filler to be 50 vol% or more, based on this disclosure. Thus, as described above, the presently claimed invention cannot be obvious in light of the combined disclosures of **Nakura** and **Katayama**, because these disclosures, when considered in combination, actually teach away from the presently claimed invention.

In this regard, the Examiner is respectfully reminded that a reference which leads one of ordinary skill in the art away from the claimed invention cannot render it unpatentably obvious. (*See*, *Dow Chem. Co. v. American Cyanamid Co.* 816 F.2d 617, 623 (Fed. Cir. 1987)). In determining the scope and content of the prior art, and determining whether the prior art suggested the claimed invention, the references "must be read as a whole and consideration must be given where the references diverge and teach away from the claimed invention." (*See*, *Akzo N.V. v. United States Int'l Trade Comm'n*, 1 U.S.P.Q.2d 1241, 1246 (Fed. Cir. 1986); *In re Fine*, 5 U.S.P.Q.2d 1596, 1598-99 (Fed. Cir. 1988)).

Additionally, Applicants note that the cited references fail to either disclose or suggest all of the limitations recited in the present claims. These references, even when considered in combination, provide no motivation, reasoning or rationale that would allow one of ordinary skill in the art to derive the instantly claimed invention. As such, the cited art of record is incapable of rendering the instantly claimed invention obvious.

New claims 36-41 have been added for consideration. Applicants believe that new claims 36-41 are allowable based on their dependence, either directly or indirectly, from claim 1 which is believed to be allowable. In addition, claims 36-41 recite further limitations which are not disclosed or suggested by the combined disclosures of the cited references. Therefore, consideration and allowance of claims 36-41 are respectfully requested.

Additionally, reconsideration and withdrawal of the obviousness rejection of claims 1-23, 25, 27-29, 31 and 33-35 are respectfully requested.

CONCLUSION

All of the stated grounds of rejection have been properly traversed, accommodated, or rendered moot. It is believed that a full and complete response has been made to the outstanding Office Action, and as such, the present application is in condition for allowance.

Based upon the amendments and remarks presented herein, the USPTO Examiner is respectfully requested to issue a Notice of Allowance clearly indicating that each of the pending claims 1-23, 25, 27-29, 31, and 33-41 is allowable under the provisions of Title 35 of the United States Code.

Should there be any outstanding matters that need to be resolved in the present application, the USPTO Examiner is respectfully requested to contact John W. Bailey, Registration No. 32,881, at the telephone number of the undersigned below to conduct an interview in an effort to expedite prosecution in connection with the present application.

If necessary, the Director is hereby authorized in this, concurrent, and future replies to charge any fees required during the pendency of the above-identified application or credit any overpayment to Deposit Account No. 02-2448.

Dated: March 27, 2014

Respectfully submitted,

By _____ #58,258

John W. Bailey
Registration No.: 32881
BIRCH, STEWART, KOLASCH & BIRCH, LLP
8110 Gatehouse Road, Suite 100 East
P.O. Box 747
Falls Church, VA 22040-0747
703-205-8000

Electronic Patent Application Fee Transmittal

Application Number:	12673961
Filing Date:	17-Feb-2010
Title of Invention:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY
First Named Inventor/Applicant Name:	Hideaki Katayama
Filer:	John Wayne Bailey/Thien Hoang-Chau
Attorney Docket Number:	5271-0195PUS1

Filed as Large Entity

U.S. National Stage under 35 USC 371 Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Claims in excess of 20	1615	3	80	240
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
		Total in USD ($)		**240**

Electronic Acknowledgement Receipt

EFS ID:	18604566
Application Number:	12673961
International Application Number:	
Confirmation Number:	2754
Title of Invention:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY
First Named Inventor/Applicant Name:	Hideaki Katayama
Customer Number:	2292
Filer:	John Wayne Bailey/Thien Hoang-Chau
Filer Authorized By:	John Wayne Bailey
Attorney Docket Number:	5271-0195PUS1
Receipt Date:	27-MAR-2014
Filing Date:	17-FEB-2010
Time Stamp:	16:50:34
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$240
RAM confirmation Number	5776
Deposit Account	022448
Authorized User	BAILEY, JOHN

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. 1.492 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)					

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		2014-3-27_PTO-AMENDMENT_5271-0195PUS1.pdf	8168489 8bd180a962b6a08625e9b7615cf6a4dc73b2f188	yes	18

Multipart Description/PDF files in .zip description

Document Description	Start	End
Miscellaneous Incoming Letter	1	1
Amendment/Req. Reconsideration-After Non-Final Reject	2	2
Claims	3	10
Applicant Arguments/Remarks Made in an Amendment	11	18

Warnings:

Information:

2	Fee Worksheet (SB06)	fee-info.pdf	30696 a004ad6073774117a286f96b5daeb661b9461397	no	2

Warnings:

Information:

Total Files Size (in bytes):	8199185

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PTO/SB/17 (03-13)
Approved for use through 01/31/2014. OMB 0651-0032
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FEE TRANSMITTAL

Complete if known	
Application Number	12/673,961 Conf. No.: 2754
Filing Date	February 17, 2010
First Named Inventor	Hideaki KATAYAMA
Examiner Name	John S. Maples
Art Unit	1723
Practitioner Docket No.	6271-0195PUS1

☐ Applicant asserts small entity status. See 37 CFR 1.27.

☐ Applicant certifies micro entity status. See 37 CFR 1.29. Form PTO/SB/15A or B or equivalent must either be enclosed or have been submitted previously

TOTAL AMOUNT OF PAYMENT ($) 240.00

METHOD OF PAYMENT (check all that apply)

☐ Check ☑ Credit Card ☐ Money Order ☐ None ☐ Other (please identify): .....

☑ Deposit Account Deposit Account Number: 02-2448 Deposit Account Name: Birch, Stewart, Kolasch & Birch, LLP

For the above-identified deposit account, the Director is hereby authorized to (check all that apply):

☐ Charge fee(s) indicated below ☐ Charge fee(s) indicated below, **except for the filing fee**

☑ Charge any additional fee(s) or underpayment of fee(s) under 37 CFR 1.16 and 1.17 ☑ Credit any overpayment of fee(s)

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

FEE CALCULATION

1. BASIC FILING, SEARCH, AND EXAMINATION FEES (U = undiscounted fee; S = small entity fee; M = micro entity fee)

	FILING FEES			SEARCH FEES			EXAMINATION FEES			
Application Type	U ($)	S ($)	M ($)	U ($)	S ($)	M ($)	U ($)	S ($)	M ($)	Fees Paid ($)
Utility	280	140*	70	600	300	150	720	360	180	0.00
Design	180	90	45	120	60	30	460	230	115	0.00
Plant	180	90	45	380	190	95	580	290	145	0.00
Reissue	280	140	70	600	300	150	2,160	1,080	540	0.00
Provisional	260	130	65	0	0	0	0	0	0	0.00

* The $140 small entity status filing fee for a utility application is further reduced to $70 for a small entity status applicant who files the application via EFS-Web.

2. EXCESS CLAIM FEES

Fee Description	Undiscounted Fee ($)	Small Entity Fee ($)	Micro Entity Fee ($)
Each claim over 20 (including Reissues)	80	40	20
Each independent claim over 3 (including Reissues)	420	210	105
Multiple dependent claims	780	390	195

Total Claims		Extra Claims	Fee ($)		Fee Paid ($)
37	-20 or HP =	3	x 80.00	=	240.00

HP = highest number of total claims paid for, if greater than 20.

Multiple Dependent Claims	
Fee ($)	Fee Paid ($)
0.00	0.00

Indep. Claims		Extra Claims	Fee ($)		Fee Paid ($)
1	-3 or HP =	0	x 420.00	=	0.00

HP = highest number of independent claims paid for, if greater than 3.

3. APPLICATION SIZE FEE

If the specification and drawings exceed 100 sheets of paper (excluding electronically filed sequence or computer listings under 37 CFR 1.52(e)), the application size fee due is $400 ($200 for small entity) ($100 for micro entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).

Total Sheets		Extra Sheets		Number of each additional 50 or fraction thereof		Fee ($)		Fee Paid ($)
.....	- 100 =	.....	/ 50 =	..... (round up to a whole number)	x	.....	=	0.00

4. OTHER FEE(S)

	Fees Paid ($)
Non-English specification, $130 fee (no small or micro entity discount)	0.00
Non-electronic filing fee under 37 CFR 1.16(t) for a utility application, $400 fee ($200 small or micro entity)	.....
Other (e.g., late filing surcharge):	.....

SUBMITTED BY

Signature	/John W. Bailey/ 32,881	Registration No. (Attorney/Agent) 32,881	Telephone 703-205-8000
Name (Print/Type)	John W. Bailey		Date March 27, 2014

This collection of information is required by 37 CFR 1.136. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 12/673,961	Filing Date 02/17/2010	☐ To be Mailed

ENTITY: ☒ LARGE ☐ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT **03/27/2014**

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 37	Minus	** 34	= 3	X $80 =	240
Independent (37 CFR 1.16(h))	* 1	Minus	***3	= 0	X $420 =	0
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	**240**

AMENDMENT

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
/helena payton/

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**
If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

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APPLICATION NUMBER	PATENT NUMBER	GROUP ART UNIT	FILE WRAPPER LOCATION
12/673,961		1723	

OC000000070948873

Correspondence Address/Fee Address Change

The following fields have been set to Customer Number 127226 on 09/23/2014

- **Correspondence Address**

The address of record for Customer Number 127226 is:

127226
Birch, Stewart, Kolasch & Birch, LLP
P.O. Box 747
Falls Church, VA 22040-0747

PART 1 - ATTORNEY/APPLICANT COPY
page 1 of 1

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www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/673,961	02/17/2010	Hideaki Katayama	5271-0195PUS1	2754

127226 7590 02/12/2015

Birch, Stewart, Kolasch & Birch, LLP
P.O. Box 747
Falls Church, VA 22040-0747

EXAMINER
GODO, OLATUNJI A

ART UNIT	PAPER NUMBER
1721	

NOTIFICATION DATE	DELIVERY MODE
02/12/2015	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

mailroom@bskb.com

Office Action Summary	Application No. 12/673,961	Applicant(s) KATAYAMA ET AL.	
	Examiner OLATUNJI GODO	Art Unit 1721	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *3/27/14*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *1-23,25,27-29,31 and 33-41* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *1-23,25,27-29,31 and 33-41* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☒ The drawing(s) filed on *2/17/10* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☒ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☒ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)

2) ☐ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

The present application is being examined under the pre-AIA first to invent provisions.

DETAILED ACTION

Response to Arguments

The response of the applicant which was filed on 3/27/14 has been received and given full consideration. Claims 1, 7, 18, and 23 have been amended, claims 24, 26, 30, 32, have been cancelled, and new claims 36-41 have been added by the applicant.

The Examiner agrees with some of the arguments provided by the Applicant in the Remarks of 3/27/14. However, the Examiner is maintaining the previous rejection of 12/27/13 because the Applicant has not provided enough scientific evidence and facts regarding some other arguments.

The Applicant has argued in Example 4 of Katayama (secondary reference), “the volume ratio of the alumina fine particles to the total fine particles in the separator, calculated by using specific gravity of alumina (4) and the specific gravity of the cross-linked PMMA (1.2), is 47 vol%. Therefore, the alumina content is less than 47 vol% of the total volume of components in the separator including the binder (PVB)….on the other hand, in comparative Example 2 of Katayama, the alumina content is more than 50 vol% of the total volume of components in the separator”

However, according to MPEP, arguments of counsel cannot take the place of facts, and objective evidence must be factually supported. For the record, the Applicant needs to provide clear and detailed explanations/formulae about how the Applicant obtained calculations of less than 47 vol% and more than 50 vol% of alumina in the

separator. The Applicant is also encouraged to include the limitations of claims 36 and 37 into the independent claim 1, and also provide arguments about why the porosity is unobvious.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 1-23, 25, 27-29, 31, 33-41 are rejected under 35 U.S.C. 103(a) as being unpatentable over Nakura et al.-US 2008/0038631 (Nakura) in view of Katayama et al.-US 2007/0264577.

For claims 1, and 36-41, Nakura teaches a battery separator comprising a shutdown layer formed of a microporous film and a heat-resistant porous layer comprising fine particles and a binder-see the Abstract in Nakura along with paragraphs 22-49 where paragraph 31 recite the content of the fine particles. As paragraphs 19 and 30 in Nakura recite, the shutdown is effected in the claimed range of 135-150 degrees C. The only claimed features not shown by Nakura are the proportion of particle sizes. Katayama discloses a separator for a lithium secondary battery that includes a heat-resistant layer comprising fine particles, where the sizes thereof fall

within that range claimed by applicant-see Example 1 in Katayama where the particles are in a size distribution of 0.3-0.7 micron size. To include the sized particles of Katayama in the separator of Nakura would have been obvious to one of ordinary skill in this art at the time the invention was made because the same would allow for greater transport across the separator.

For claim 2, paragraph 28 in Nakura teaches the claimed temperature for the shrinkage ratio which would inherently fall within the claimed range.

For claims 3, 14, 25 and 31, paragraph 31 in Nakura recite the content of the fine particles and the binder.

Paragraph 42 in Nakura disclose alumina fine particles thus meeting claims 4, 5, 15 and 16.

For claims 6 and 17, Katayama recites plate shaped particles in paragraph 77 and to include the same in Nakura would have been obvious so that short-circuiting would be hindered.

For claims 7, 18, 23, 24, 29, 30, paragraphs 30 and 36 in Nakura teach the claimed thicknesses of both the shut-down layer and the heat-resistant layers.

With regard to claims 8 and 19, paragraph 38 in Nakura teaches the claimed thermoplastic resin.

For claims 9, 22, 28 and 34, the claimed particle size is taught in Example 1 of Katayama and to include the same in Nakura would have been obvious to allow greater compacting in the separator.

Claims 10-13 are met by the specific first compound recited in the next to the last line of paragraph 100 in Katayama. It is noted that this compound is the same compound set forth in applicant's Example 1 so the properties set forth in claims 11 and 12 would inherently be met and to utilize this compound of Katayama in Nakura would have been obvious because, as set forth in paragraph 46 of Nakura, provision of made for the lithium manganese nickel cobalt oxide.

For claims 20 and 21, reference is made to the Abstract and paragraph 37 for the shutdown layer located on the negative electrode side.

For claims 27 and 33, paragraph 49 in Nakura discloses the claimed binder.

For claim 35, paragraph 86 in Nakura describes a charging potential of the positive electrode being 4.3 V.

Conclusion

Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any

extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to OLATUNJI GODO whose telephone number is (571)272-3104. The examiner can normally be reached on Monday-Friday (8:30-5 pm).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Cynthia Kelly can be reached on 571 272 1526. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/OLATUNJI GODO/
Examiner, Art Unit 1721

/STEWART FRASER/
Primary Examiner, Art Unit 1721

Docket No.: 5271-0195PUS1
(Patent)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:
Hideaki KATAYAMA et al.

Application No.:	12/673,961	Confirmation No.:	2754
Filed:	February 17, 2010	Art Unit:	1721
For:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY	Examiner:	Olatunji A. Godo

REPLY UNDER 37 C.F.R. § 1.116

MS AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

INTRODUCTORY COMMENTS

In reply to the Office Action dated February 12, 2015, the following remarks are respectfully submitted in connection with the above-identified application.

Remarks begin on page 2.

REMARKS

Claims 1-23, 25, 27-29, 31, and 33-41 are pending in the present application. No amendments to the claims are made in this response. In view of the following remarks, Applicants respectfully request that the USPTO Examiner withdraw all rejections and allow the currently pending claims.

Information Disclosure Citation

Each of the Information Disclosure Statements filed by Applicants to date has been considered by the USPTO Examiner, and initialed PTO-SB08 forms have been provided by the USPTO Examiner. Therefore, no outstanding issues remain with respect to the consideration of Information Disclosure Statements.

Claim Rejection under 35 U.S.C. § 103(a)

Claims 1-23, 25, 27-29, 31, and 33-41 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over **Nakura et al. US '631** (US 2008/0038631) in view of **Katayama et al. US '577** (US 2007/0264577).

This rejection is respectfully traversed based on the following considerations. Reconsideration and allowance thereof are respectfully requested.

Legal Standard for Determining Prima Facie Obviousness

M.P.E.P. § 2141 sets forth the guidelines in determining obviousness. First, the USPTO has to take into account the factual inquiries set forth in *Graham v. John Deere*, 383 U.S. 1, 17, 148 USPQ 459, 467 (1966), which has provided the controlling framework for an obviousness analysis. The four *Graham* factors are:

(a) determining the scope and content of the prior art;

(b) ascertaining the differences between the prior art and the claims in issue;

(c) resolving the level of ordinary skill in the pertinent art; and

(d) evaluating any evidence of secondary considerations.

Graham v. John Deere, 383 U.S. 1, 17, 148 USPQ 459, 467 (1966).

Second, the USPTO has to provide some rationale for determining obviousness. MPEP § 2143 sets forth some rationales that were established in the recent decision of *KSR International Co. v Teleflex Inc.*, 82 USPQ2d 1385 (U.S. 2007). Exemplary rationales that may support a conclusion of obviousness include:

(a) combining prior art elements according to known methods to yield predictable results;

(b) simple substitution of one known element for another to obtain predictable results;

(c) use of known technique to improve similar devices (methods, or products) in the same way;

(d) applying a known technique to a known device (method, or product) ready for improvement to yield predictable results;

(e) "obvious to try" – choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success

(f) known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art;

(g) some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

As the M.P.E.P. directs, all claim limitations must be considered in view of the cited prior art in order to establish a *prima facie* case of obviousness. *See* M.P.E.P. § 2143.03.

The Present Invention

Independent claim 1 of the present application recites as follows (***emphasis added***):

A battery separator comprising:

heat-resistant fine particles; and

a thermoplastic resin,

wherein the heat-resistant fine particles along with a binder constitute a heat-resistant layer,

the thermoplastic resin constitutes a shutdown layer formed of a heat-shrinkable microporous film,

the heat-resistant layer and the shutdown layer are integrated into a multilayer structure,

the shutdown layer has a thickness A (μm) of 5 to 30, the heat-resistant layer has a thickness B (μm) of 1 to 10, a sum of A and B is 6 to 23, and a ratio A/B is 1/2 to 4,

a content of the heat-resistant fine particles in the heat-resistant layer is 50 vol% or more of a total volume of components in the heat-resistant layer,

a proportion of particles with a particle size of 0.2 μm or less in the heat-resistant fine particles is 10 vol% or less and a proportion of particles with a particle size of 2 μm or more in the heat-resistant fine particles is 10 vol% or less, and

a shutdown is effected in a range of 135°C to 150°C.

Distinctions over the Cited Art

Nakura et al. US '631 discloses that the heat-resistant porous film has a thickness of 1 to 16 μm and the total thickness of the heat-resistant porous film and the shutdown layer is 5 to 35 μm. However, **Nakura et al. US '631** does not disclose the following combination of the

thickness A (μm) of the shutdown layer and the thickness B (μm) of the heat-resistant layer. Thus, claim 1 cannot be obvious from **Nakura et al. US '631**.

A: 5 to 30,

B: 1 to 10,

A+ B: 6 to 23,

A/B: 1/2 to 4

Nakura et al. US '631 discloses a separator including at least one heat-resistant porous film and at least one shutdown layer. In **Nakura et al. US '631**, the heat-resistant porous film contains a heat-resistant resin with a heat deformation temperature of 200°C or more, and preferably contains an inorganic oxide filler.

However, **Nakura et al. US '631** merely discloses the mean particle size of the inorganic oxide filler, and does not suggest what kind of particle size distribution is better.

On the other hand, as indicated by the USPTO Examiner, Example 1 of **Katayama et al. US '577** discloses a separator in which alumina fine particles having a particle size distribution of 0.3 to 0.7 μm and polyethylene powder are present in pores of a nonwoven fabric (*reproduced below*).

EXAMPLE 1

> **[0118]** 2 kg of an aqueous dispersion of a polyethylene powder (resin A) ("CHEMIPEARL W-700" (trade name) manufactured by Mitsui Chemicals, Inc.) and 800 g of ethanol were introduced into a container and dispersed by stirring with a disperser on the condition of 2800 rpm for one hour. 300 g of alumina (Al_2O_3) fine particles as filler particles ("SUMICORUNDUM AA04" (trade name) manufactured by Sumitomo Chemical; heat-resistant temperature: 180° C. or higher; average particle diameter: 0.4 μm; particle size distribution: 0.3 to 0.7 μm) were added to the dispersion, and the dispersion was further stirred for three hours to

> provide homogeneous slurry. In this slurry, a nonwoven fabric of PBT (manufactured by TAPYRUS CO., LTD.) 28 μm in thickness for making a porous base was introduced, pulled out for applying the slurry, and dried. The thus obtained separator was 35 μm in thickness, and it had the resin A and the filler particles both being contained in the pores of the nonwoven fabric.

Moreover, Example 4 of **Katayama et al. US '577** discloses a separator in which the alumina fine particles, cross-linked PMMA fine particles, and PVB (binder) are present in pores of a nonwoven fabric (*reproduced below*). Further, Comparative Example 2 of **Katayama et al. US '577** discloses a separator in which the alumina fine particles and PVB (binder) are present in pores of a nonwoven fabric (*reproduced below*).

EXAMPLE 4

> **[0121]** 1 kg of crosslinked PMMA fine particles as resin B ("GANZPEARL 0104" (trade name) manufactured by GANZ CHEMICAL CO., LTD.; average particle diameter: 1 μm; Tg=about 120° C.; B_R=0.5; B_T=2.3), 800 g of water, 200 g of isopropyl alcohol (IPA), and also 375 g of PVB as a binder as in Example 3 were introduced into a container, and dispersed by stirring with a disperser on the condition of 2800 rpm for one hour. To this, 3 kg of alumina fine particles as filler particles as in Example 1 and 750 g of the above-described binder (PVB) were added and stirred for three hours to provide a homogenous slurry. A nonwoven fabric of PBT (manufactured by TAPYRUS CO., LTD.) 28 μm in thickness was introduced into this slurry and pulled out for applying the slurry, and dried to obtain a separator 35 μm in thickness.

COMPARATIVE EXAMPLE 2

> **[0136]** 3 kg of alumina fine particles as the filler particles as in Example 1, 800 g of water, 200 g of isopropyl alcohol (IPA) and 375 g of PVB as the binder as in Example 3 were introduced into a container and dispersed by stirring with a disperser on the condition of 2800 rpm for one hour so as to obtain a homogeneous slurry. In this slurry, a nonwoven fabric of PP 15 μm in thickness (manufactured by NIPPON KODOSHI CORPORATION) was introduced and pulled out for applying the slurry, and dried to obtain a separator 20 μm in thickness.

The aqueous dispersion containing the polyethylene powder, *i.e.*, "CHEMIPEARL W-700" used in Example 1 of **Katayama et al. US '577** is a dispersion containing 40% of polyethylene with a specific gravity of 0.97. Therefore, the volume of the polyethylene powder present in the pores of the nonwoven fabric in Example 1 is calculated by $2000 \times 0.4 / 0.97 = 825\ cm^3$. On the other hand, the volume of the alumina fine particles is calculated by $300 / 4 = 75\ cm^3$, where the specific gravity of alumina is 4. Thus, the ratio (volume ratio) of the alumina fine particles to the total amount of the alumina fine particles and the polyethylene powder is calculated by $75 / (75 + 825) = 0.083$ (**8.3%**), which is much smaller than 50%.

The "S-LEC KX-5" containing PVB used in Example 4 of **Katayama et al. US '577** is a composition with a solid content of 8%. Therefore, the volume of the PVB present in the pores of the nonwoven fabric in Example 4 is calculated by $(375 + 750) \times 0.08 / 1.1 = 81.8\ cm^3$, where the specific gravity of PVB is 1.1. The volume of the cross-linked PMMA fine particles is calculated by $1000 / 1.2 = 833.3\ cm^3$, where the specific gravity of cross-linked PMMA is 1.2. Thus, the ratio (volume ratio) of the alumina fine particles to the total amount of the alumina fine particles, the cross-linked PMMA fine particles, and the PVB is calculated by $(3000 / 4) / (3000 / 4 + 81.8 + 833.3) = 0.45$ (**45%**), which is smaller than 50%.

When the volume of the nonwoven fabric is taken into account, the ratios of the alumina fine particles contained in the separators in Examples 1 and 4 would be smaller than the calculated values (8.3% and 45%).

On the other hand, the volume of the PVB present in the pores of the nonwoven fabric in Comparative Example 2 of **Katayama et al. US '577** is calculated by $375 \times 0.08 / 1.1 = 27.3\ cm^3$. Thus, the ratio (volume ratio) of the alumina fine particles to the

total amount of the alumina fine particles and the PVB is calculated by (3000 / 4) / (3000 / 4 + 27.3) = 0.965 (96.5%). Consequently, the ratio of the alumina fine particles is larger than those of the alumina fine particles contained in the separators in Examples 1 and 4. However, when the volume of the nonwoven fabric is taken into account, as in the case of Examples 1 and 4, the ratio of the alumina fine particles contained in the separator in Comparative Example 2 would be smaller than the calculated value.

Assuming that the porosity of the nonwoven fabric of the separator in Comparative Example 2 of **Katayama et al. US '577** is 70 vol%, *i.e.*, the ratio of the resin of the nonwoven fabric is 30 vol%, and the porosity of the whole separator is 20 vol% (which is the lower limit described in paragraph [**0088**] of **Katayama et al. US '577**; *reproduced below*), the total amount of the alumina fine particles and the PVB present in the pores of the nonwoven fabric is calculated by 70 – 20 = 50 vol%. Thus, the ratio (volume ratio) of the alumina fine particles to the total volume of the components constituting the separator in Comparative Example 2 is calculated by (50 × 0.965) / (50 + 30) = 0.60 (60%).

> [**0088**] It is preferable that the porosity of the separator is 20% or more in a dry state for securing the liquid capacity for the electrolyte and improving the ionic permeability, and more preferably 30% or more. It is preferable from the viewpoint of securing the separator strength and preventing the internal short-circuit that the porosity of the separator is 70% or less, and more preferably, 60% or less. The porosity P (%) of the separator can be calculated on the basis of the total for the respective ingredients 'i' through the equation below, from the separator thickness, the mass per area, and density of the ingredient.
>
> $$P=100-(\Sigma a_i/\rho_i)\times(m/t)$$
>
> In the above equation, a_i: rate of the ingredient 'i' expressed with mass %; ρ_i: density of ingredient 'i' (g/cm^3); m: mass per unit area of the separator (g/cm^2); and t: separator thickness (cm).

Table 6 of **Katayama et al. US '577** (*reproduced below*) shows the charging efficiency of the batteries (Example 4A and Comparative Example 2A) using the separators in Example 4 and Comparative Example 2, respectively.

TABLE 6

Battery	Charging efficiency (capacity rate) (%)
Example 4A	99.5
Example 5A	99.9
Example 6A	99.6
Example 7A	99.3
Example 9A	99.5
Comparative Example 1A	99.5
Comparative Example 2A	56

In the battery of Example 4A, the charting efficiency is substantially 100%, and the formation of lithium dendrite is suppressed. In the battery of Comparative Example 2A, the battery efficiency is 56%, and an internal short circuit occurs due to the formation of lithium dendrite (*see* paragraph **[0157]**; *reproduced below*).

> **[0157]** The batteries in Examples 4A-7A and 9A had charging efficiencies of substantially 100% similarly to the case of Comparative Example 1A, and formation of lithium dendrite at the time of charging was suppressed. In contrast, for the battery in Comparative Example 2A including only the filler particles in the pores of the porous base, the charging efficiency was poor and internal short-circuit due to the formation of lithium dendrite at the time of charging was found. It was considered that since the alumina fine particles used as the filler particles were shaped differently from the plate shape that provides excellent effect in suppressing formation of lithium dendrite, formation of the lithium dendrite might not be suppressed in a case where shutdown resin particles do not coexist.

The above results demonstrate that when the alumina fine particles contained in the separator (heat-resistant layer) is less than 50 vol% of the total volume of the components of the separator, and the alumina fine particles include 10 vol% or less of particles with a particle size of 0.2 μm or less and 10 vol% or less of particles with a particle size of 2 μm or more, the battery using this separator can effectively reduce an internal short circuit. On the other hand, when the alumina fine particles contained in the separator is 50 vol% or more of the total volume of the components of the separator, the battery using this separator causes an internal short circuit.

It is obvious to a person skilled in the art that the battery separator is designed so as not to cause an internal short circuit during the normal operation of the battery. If **Nakura et al. US '631** is combined with **Katayama et al. US '577** to adjust the particle size distribution of the inorganic oxide filler, a person skilled in the art would obviously set the ratio of the inorganic oxide filler to 50 vol% or less.

In the first place, **Nakura et al. US '631** intends to control the battery temperature not to excess 140°C during the overcharge, as is evident from paragraph [**0089**] (*reproduced below*).

> [**0089**] In Examples 1 to 13 with the porous membranes and the shut-down layer, the heat generation of the batteries upon overcharge is significantly suppressed in comparison with Comparative Examples 1, 5, and 9 having neither porous membrane nor shut-down layer. Generally, when the battery temperature exceeds 140° C. upon overcharge, the overcharged positive electrode starts to generate heat, but this phenomenon can be avoided in Examples.

Comparative Example 4 shows the battery using a single separator in which a heat-resistant porous film and a shutdown layer are formed. This battery has a problem in safety when the temperature has reached 165°C during the overcharge (*see* **Table 4**; *reproduced below*).

TABLE 4

	Porous membrane			Battery					
					Charge/discharge characteristics			Internal short-circuit safety	Overcharge safety
		Flexibility	Negative	Design		Discharge		Nail speed 180 mm/sec.	4 C. mA
	Adhesion	(Number of defects/10)	electrode appearance	capacity (mAh)	Charge (mAh)	400 mA (mAh)	4000 mA (mAh)	Highest temperature (° C.)	Highest temperature (° C.)
Comp. example 1	—	—	Not changed	2000	1980	1975	1900	71	180
Comp. example 2	OK	0	Not changed	2000	1985	1980	1900	70	150
Comp. example 3	OK	0	Not changed	2000	1988	1985	1900	75	149
Comp. example 4	—	—	Not changed	2000	1992	1989	1900	70	165
Comp. example 5	—	—	Not changed	2000	1988	1980	1900	68	180
Comp. example 6	OK	0	Not changed	2000	1998	1990	1910	65	149
Comp. example 7	OK	0	Not changed	2000	1995	1990	1910	65	150
Comp. example 8	—	—	Not changed	2000	1994	1990	1899	72	164
Comp. example 9	—	—	Not changed	2000	1987	1980	1905	70	181
Comp. example 10	OK	0	Not changed	2000	1994	1990	1925	71	149
Comp. example 11	OK	0	Not changed	2000	1997	1995	1920	65	149
Comp. example 12	—	—	Not changed	2000	1992	1987	1890	75	167
Comp. example 13	OK	0	Not changed	2000	1990	1985	1890	75	170

Therefore, the present invention narrows the particle size distribution of the heat-resistant fine particles used in the heat-resistant layer, and thus can sufficiently suppress a short circuit due to shrinkage of the separator when the battery temperature becomes high, and also can improve the safety of the battery in a high temperature environment. For this reason, the present invention cannot be obvious from **Nakura et al. US '631** and **Katayama et al. US '577**.

Apart from the above considerations, the cited art being applied by the USPTO fails to either teach or disclose each of the limitations found in the pending claims, and also fails to provide any motivation, or reasoning or rationale that would allow one having ordinary skill in the art to arrive at the instant invention as claimed. As such, the cited art of record is incapable of either anticipating or rendering the instant invention as claimed obvious. Any contentions of the USPTO to the contrary are respectfully requested to be reconsidered at once.

CONCLUSION

All of the stated grounds of rejection have been properly traversed, accommodated, or rendered moot. It is believed that a full and complete response has been made to the outstanding Office Action, and as such, the present application is in condition for allowance.

Based upon the amendments and remarks presented herein, the USPTO Examiner is respectfully requested to issue a Notice of Allowance clearly indicating that each of the pending claims 1-23, 25, 27-29, 31, and 33-41 is allowable under the provisions of Title 35 of the United States Code.

Should there be any outstanding matters that need to be resolved in the present application, the USPTO Examiner is respectfully requested to contact John W. Bailey, Registration No. 32,881, at the telephone number of the undersigned below to conduct an interview in an effort to expedite prosecution in connection with the present application.

If necessary, the Director is hereby authorized in this, concurrent, and future replies to charge any fees required during the pendency of the above-identified application or credit any overpayment to Deposit Account No. 02-2448.

Dated: MAY 12 2015

Respectfully submitted,

By _____

John W. Bailey
Registration No.: 32,881
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Falls Church, VA 22040-0747
703-205-8000

Electronic Acknowledgement Receipt

EFS ID:	22325881
Application Number:	12673961
International Application Number:	
Confirmation Number:	2754
Title of Invention:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY
First Named Inventor/Applicant Name:	Hideaki Katayama
Customer Number:	127226
Filer:	John Wayne Bailey/Thien Hoang
Filer Authorized By:	John Wayne Bailey
Attorney Docket Number:	5271-0195PUS1
Receipt Date:	12-MAY-2015
Filing Date:	17-FEB-2010
Time Stamp:	16:49:26
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		2015-5-12_PTO-OFFICE_ACTION_RESPONSE_5271-0195PUS1.pdf	580859 e8e214e559fa905191b7037865c67048c247a1c6	yes	13

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Transmittal Letter	1	1
	Response After Final Action	2	2
	Applicant Arguments/Remarks Made in an Amendment	3	13
Warnings:			
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	Total Files Size (in bytes):	580859	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

AMENDMENT TRANSMITTAL LETTER

Docket No. 5271-0195PUS1			
Application No. 12/673,961 - Conf. # 2754	Filing Date February 17, 2010	Examiner Olatunji A. Godo	Art Unit 1721

Applicant(s): Hideaki KATAYAMA et al.

Invention: BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY

MS AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Transmitted herewith is an amendment in the above-identified application.

The fee has been calculated and is transmitted as shown below.

CLAIMS AS AMENDED						
	Claims Remaining After Amendment	Highest Number Previously Paid		Number Extra Claims Present	Rate	
Total Claims	37	- 37	=	0	x 80.00	0.00
Independent Claims	1	- 3	=	0	x 420.00	0.00
Multiple Dependent Claims (check if applicable)	☐				780.00	0.00
Other fee (please specify):						0.00
TOTAL ADDITIONAL FEE FOR THIS AMENDMENT:						0.00

☒ Large Entity ☐ Small Entity ☐ Micro Entity

☒ No additional fee is required for this amendment.

☐ Please charge Deposit Account No. 02-2448 in the amount of $ 0.00.

☐ A check in the amount of $ 0.00 is enclosed.

☐ Payment by credit card. Form PTO-2038 is attached.

☒ The Director is hereby authorized to charge and credit Deposit Account No. 02-2448 as described below.

☒ Credit any overpayment.

☒ Charge any additional filing or application processing fees required under 37 C.F.R. §§ 1.16 and 1.17.

Dated: MAY 12 2015

John W. Bailey
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NOTICE OF ALLOWANCE AND FEE(S) DUE

127226 7590 06/05/2015

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EXAMINER
GODO, OLATUNJI A

ART UNIT	PAPER NUMBER
1721	

DATE MAILED: 06/05/2015

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/673,961	02/17/2010	Hideaki Katayama	5271-0195PUS1	2754

TITLE OF INVENTION: BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	09/08/2015

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

127226 7590 06/05/2015
Birch, Stewart, Kolasch & Birch, LLP
P.O. Box 747
Falls Church, VA 22040-0747

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/673,961	02/17/2010	Hideaki Katayama	5271-0195PUS1	2754

TITLE OF INVENTION: BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	09/08/2015

EXAMINER	ART UNIT	CLASS-SUBCLASS
GODO, OLATUNJI A	1721	429-145000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ Applicant certifying micro entity status. See 37 CFR 1.29 — NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
- ❑ Applicant asserting small entity status. See 37 CFR 1.27 — NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
- ❑ Applicant changing to regular undiscounted fee status. — NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/673,961	02/17/2010	Hideaki Katayama	5271-0195PUS1	2754

127226 7590 06/05/2015

Birch, Stewart, Kolasch & Birch, LLP
P.O. Box 747
Falls Church, VA 22040-0747

EXAMINER	
GODO, OLATUNJI A	
ART UNIT	PAPER NUMBER
1721	

DATE MAILED: 06/05/2015

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 12/673,961	Applicant(s) KATAYAMA ET AL.	
	Examiner OLATUNJI GODO	Art Unit 1721	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *3/27/14*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *1-23,25,27-29,31 and 33-41*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov .
4. ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☒ All b) ☐ Some *c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☒ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
5. ☐ Examiner's Amendment/Comment
6. ☒ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/OLATUNJI GODO/
Examiner, Art Unit 1721

The present application is being examined under the pre-AIA first to invent provisions.

EXAMINER'S COMMENT/REASONS FOR ALLOWANCE

Allowable Claims

Claims 1-23,25,27-29,31 and 33-41 are allowed over the prior art of record.

Reasons for Allowance

The following is an examiner's statement of reasons for allowance:

The prior art of record fails to disclose or reasonably suggest alone or in combination, the specified composition of the battery separator recited in claim 1.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statements of Reasons for Allowance."

Any inquiry concerning this communication or earlier communications from the examiner should be directed to OLATUNJI GODO whose telephone number is (571)272-3104. The examiner can normally be reached on Monday-Friday (8:30-5 pm).

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Cynthia Kelly can be reached on 571 272 1526. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/OLATUNJI GODO/
Examiner, Art Unit 1721

/STEWART FRASER/
Primary Examiner, Art Unit 1721

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12673961	KATAYAMA ET AL.
	Examiner	**Art Unit**
	OLATUNJI GODO	1721

CPC						
Symbol					**Type**	**Version**
H01M		10	/	0525	F	2013-01-01
H01M		2	/	1646	I	2013-01-01
H01M		2	/	1653	I	2013-01-01
H01M		2	/	166	I	2013-01-01
H01M		10	/	4235	I	2013-01-01
Y02E		60	/	122	A	2013-01-01
			/			
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			/			
			/			
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			/			
			/			

CPC Combination Sets							
Symbol					**Type**	**Set**	**Ranking**	**Version**
			/					
			/					

/OLATUNJI GODO/ Examiner.Art Unit 1721	05/30/2015	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	37	
/STEWART FRASER/ Primary Examiner.Art Unit 1721	05/31/2015	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12673961	KATAYAMA ET AL.
	Examiner	**Art Unit**
	OLATUNJI GODO	1721

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION										
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED					
429	145	H	0	1	M	2 / 14 (2006.01.01)						

CROSS REFERENCE(S)					
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
429	144				

/OLATUNJI GODO/ Examiner.Art Unit 1721	05/30/2015	**Total Claims Allowed:** 37	
(Assistant Examiner)	(Date)		
/STEWART FRASER/ Primary Examiner.Art Unit 1721	05/31/2015	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12673961	KATAYAMA ET AL.
	Examiner	**Art Unit**
	OLATUNJI GODO	1721

☒ **Claims renumbered in the same order as presented by applicant** ☐ **CPA** ☐ **T.D.** ☐ **R.1.47**

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original

/OLATUNJI GODO/ Examiner.Art Unit 1721	05/30/2015	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	37	
/STEWART FRASER/ Primary Examiner.Art Unit 1721	05/31/2015	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12673961	KATAYAMA ET AL.
	Examiner	Art Unit
	OLATUNJI GODO	1721

CPC- SEARCHED		
Symbol	Date	Examiner
H01M2/1686, H01M2/1673, H01M2/14	5/30/2015	OG

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner
429	144, 145	5/30/2015	OG

SEARCH NOTES		
Search Notes	Date	Examiner
Inventor search performed in EAST	5/30/2015	OG
EAST search history is attached	5/30/2015	OG

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
Interference search performed in EAST		5/30/2015	OG

UNITED STATES PATENT AND TRADEMARK OFFICE

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www.uspto.gov

BIB DATA SHEET

CONFIRMATION NO. 2754

SERIAL NUMBER	FILING or 371(c) DATE RULE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
12/673,961	02/17/2010	429	1721	5271-0195PUS1

APPLICANTS

INVENTORS

Hideaki Katayama, Osaka, JAPAN;
Mitsuhiro Kishimi, Osaka, JAPAN;
Yoshinori Sato, Osaka, JAPAN;
Yasutaka Kuroki, Osaka, JAPAN;
Toshiyuki Edamoto, Osaka, JAPAN;

**** CONTINUING DATA ***************************

This application is a 371 of PCT/JP2008/067757 09/30/2008

**** FOREIGN APPLICATIONS ***************************

JAPAN 2007-259575 10/03/2007
JAPAN 2008-039527 02/21/2008

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED ****

11/19/2010

Foreign Priority claimed ☑ Yes ☐ No 35 USC 119(a-d) conditions met ☑ Yes ☐ No Verified and Acknowledged /OLATUNJI A GODO/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		JAPAN	2	20	2

ADDRESS

Birch, Stewart, Kolasch & Birch, LLP
P.O. Box 747
Falls Church, VA 22040-0747
UNITED STATES

TITLE

BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY

FILING FEE RECEIVED	FEES: Authority has been given in Paper	☐ All Fees
2060	No._____ to charge/credit DEPOSIT ACCOUNT	☐ 1.16 Fees (Filing)
	No._____ for following:	☐ 1.17 Fees (Processing Ext. of time)
		☐ 1.18 Fees (Issue)
		☐ Other _____
		☐ Credit

EAST Search History

EAST Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L21	0	(battery separator comprising heat resistant fine particles thermoplastic resin proportion particles size shutdown binder multilayer and thickness and microporous volume film sum).clm.	USPAT; UPAD	AND	ON	2015/05/30 16:23

5/ 30/ 2015 4:24:00 PM
C:\ Users\ ogodo\ Documents\ EAST\ Workspaces\ 12673961.wsp

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
L1	1162	separator and batter$3 and shutdown and binder	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2015/05/30 15:40
L2	734661	heat with layer	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2015/05/30 15:43
L3	561	1 and 2	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2015/05/30 15:44
L4	10972	layer and shutdown and thickness	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2015/05/30 15:44
L5	537	3 and 4	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2015/05/30 15:44
L6	210	layer with shutdown with thickness	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2015/05/30 15:45
L7	87	1 and 6	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2015/05/30 15:45
L8	315542	heat with resistant	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2015/05/30 15:50
L9	60	1 and 6 and 8	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2015/05/30 15:50
L10	1990	H01M2/1686.cpc.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2015/05/30 15:51
L11	1560	H01M2/1673.cpc.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2015/05/30 15:51
L12	891	H01M2/14.cpc.	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2015/05/30 15:51
L13	108	6 and 10	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2015/05/30 15:52
L14	6	6 and 11	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2015/05/30 15:52
L15	1	6 and 12	US-PGPUB; USPAT; USOCR; EPO; JPO; DERWENT	OR	ON	2015/05/30 15:53
L16	49	((Hideaki) near2 (Katayama)).INV.	US-PGPUB; USPAT	OR	OFF	2015/05/30 16:03

L17	22	((Mitsuhiro) near2 (Kishimi)).INV.	US-PGPUB; USPAT	OR	OFF	2015/05/30 16:03
L18	281	((Yoshinori) near2 (Sato)).INV.	US-PGPUB; USPAT	OR	OFF	2015/05/30 16:07
L19	2	((Yasutaka) near2 (Kuroki)).INV.	US-PGPUB; USPAT	OR	OFF	2015/05/30 16:07
L20	7	((Toshiyuki) near2 (Edamoto)).INV.	US-PGPUB; USPAT	OR	OFF	2015/05/30 16:07

5/ 30/ 2015 4:23:32 PM
C:\ Users\ ogodo\ Documents\ EAST\ Workspaces\ 12673961.wsp

OK TO ENTER: /O.G./ (05/30/2015)

Docket No.: 5271-0195PUS1
(Patent)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:
Hideaki KATAYAMA et al.

Application No.:	12/673,961	Confirmation No.:	2754
Filed:	February 17, 2010	Art Unit:	1721
For:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY	Examiner:	Olatunji A. Godo

REPLY UNDER 37 C.F.R. § 1.116

MS AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Commissioner:

INTRODUCTORY COMMENTS

In reply to the Office Action dated February 12, 2015, the following remarks are respectfully submitted in connection with the above-identified application.

Remarks begin on page 2.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/673,961	02/17/2010	Hideaki Katayama	5271-0195PUS1	2754

127226 7590 09/04/2015

Birch, Stewart, Kolasch & Birch, LLP
P.O. Box 747
Falls Church, VA 22040-0747

EXAMINER	
GODO, OLATUNJI A	

ART UNIT	PAPER NUMBER
1721	

NOTIFICATION DATE	DELIVERY MODE
09/04/2015	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

mailroom@bskb.com

Supplemental Notice of Allowability	Application No. 12/673,961	Applicant(s) KATAYAMA ET AL.	
	Examiner OLATUNJI GODO	Art Unit 1721	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *5/12/15*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *1-23,25,27-29,31 and 33-41*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov .
4. ☒ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☒ All b) ☐ Some *c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☒ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
5. ☐ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/STEWART FRASER/ Primary Examiner, Art Unit 1721	/OLATUNJI GODO/ Examiner, Art Unit 1721

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12673961	KATAYAMA ET AL.
	Examiner	**Art Unit**
	OLATUNJI GODO	1721

CPC						
Symbol					**Type**	**Version**
H01M		10	/	0525	F	2013-01-01
H01M		2	/	1646	I	2013-01-01
H01M		2	/	1653	I	2013-01-01
H01M		2	/	166	I	2013-01-01
H01M		10	/	4235	I	2013-01-01
Y02E		60	/	122	A	2013-01-01
			/			
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			/			

CPC Combination Sets							
Symbol					**Type**	**Set**	**Ranking**	**Version**
			/					
			/					

/OLATUNJI GODO/ Examiner.Art Unit 1721	09/02/2015	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	37	
/STEWART FRASER/ Primary Examiner.Art Unit 1721	09/02/2015	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12673961	KATAYAMA ET AL.
	Examiner	**Art Unit**
	OLATUNJI GODO	1721

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION										
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED					
429	145	H	0	1	M	2 / 14 (2006.01.01)						

CROSS REFERENCE(S)					
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)				
429	144				

/OLATUNJI GODO/ Examiner.Art Unit 1721	09/02/2015	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	37	
/STEWART FRASER/ Primary Examiner.Art Unit 1721	09/02/2015	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	12673961	KATAYAMA ET AL.
	Examiner	**Art Unit**
	OLATUNJI GODO	1721

☒ **Claims renumbered in the same order as presented by applicant** ☐ **CPA** ☐ **T.D.** ☐ **R.1.47**

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original

/OLATUNJI GODO/ Examiner.Art Unit 1721	09/02/2015	**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	37	
/STEWART FRASER/ Primary Examiner.Art Unit 1721	09/02/2015	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	2

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

127226 7590 06/05/2015
Birch, Stewart, Kolasch & Birch, LLP
P.O. Box 747
Falls Church, VA 22040-0747

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/673,961	02/17/2010	Hideaki Katayama	5271-0195PUS1	2754

TITLE OF INVENTION: BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	UNDISCOUNTED	$960	$0	$0	$960	09/08/2015

EXAMINER	ART UNIT	CLASS-SUBCLASS
GODO, OLATUNJI A	1721	429-145000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 **Birch, Stewart, Kolasch & Birch, LLP**
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: **HITACHI MAXELL, LTD.**

(B) RESIDENCE: (CITY and STATE OR COUNTRY): **IBARAKI-SHI, OSAKA, JAPAN**

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
- ☒ Issue Fee
- ☐ Publication Fee (No small entity discount permitted)
- ☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ☐ A check is enclosed.
- ☒ Payment by credit card. Form PTO-2038 is attached.
- ☒ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number **02-2448** (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ☐ Applicant certifying micro entity status. See 37 CFR 1.29 — NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
- ☐ Applicant asserting small entity status. See 37 CFR 1.27 — NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
- ☐ Applicant changing to regular undiscounted fee status. — NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature John W. Bailey Date SEP 4 2015

Typed or printed name **John W. Bailey** Registration No. **32,881**

Electronic Patent Application Fee Transmittal

Application Number:	12673961
Filing Date:	17-Feb-2010
Title of Invention:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY
First Named Inventor/Applicant Name:	Hideaki Katayama
Filer:	John Wayne Bailey/Thien Hoang
Attorney Docket Number:	5271-0195PUS1

Filed as Large Entity

Filing Fees for U.S. National Stage under 35 USC 371

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Utility Appl Issue Fee	1501	1	960	960

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**960**

Electronic Acknowledgement Receipt

EFS ID:	23407566
Application Number:	12673961
International Application Number:	
Confirmation Number:	2754
Title of Invention:	BATTERY SEPARATOR AND NONAQUEOUS ELECTROLYTE BATTERY
First Named Inventor/Applicant Name:	Hideaki Katayama
Customer Number:	127226
Filer:	John Wayne Bailey/Thien Hoang
Filer Authorized By:	John Wayne Bailey
Attorney Docket Number:	5271-0195PUS1
Receipt Date:	04-SEP-2015
Filing Date:	17-FEB-2010
Time Stamp:	12:29:32
Application Type:	U.S. National Stage under 35 USC 371

Payment information:

Submitted with Payment	yes
Payment Type	Credit Card
Payment was successfully received in RAM	$960
RAM confirmation Number	12470
Deposit Account	022448
Authorized User	BAILEY, JOHN

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. 1.492 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.19 (Document supply fees)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	2015-9-4_PTO-ISSUE_FEE_TRANSMITTAL_5271-0195PUS1.pdf	93108 8eaf01a6bf990fd1d24c513339d8f3187e36adef	no	1
Warnings:					
Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30749 9105a199f86b9bf8da265abf783f8782d61021a5	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	123857		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
12/673,961	10/20/2015	9166251	5271-0195PUS1	2754

127226 7590 09/30/2015

Birch, Stewart, Kolasch & Birch, LLP
P.O. Box 747
Falls Church, VA 22040-0747

ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 846 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

Hideaki Katayama, Osaka, JAPAN;
Mitsuhiro Kishimi, Osaka, JAPAN;
Yoshinori Sato, Osaka, JAPAN;
Yasutaka Kuroki, Osaka, JAPAN;
Toshiyuki Edamoto, Osaka, JAPAN;

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit SelectUSA.gov.

AO 120 (Rev. 08/10)

TO:	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court for the Western District of Texas on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
6:21-cv-347	4/8/2021	for the Western District of Texas

PLAINTIFF	DEFENDANT
Maxell Holdings, Ltd.	Amperex Technology Limited

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	8,691,446 B2	4/8/2014	Maxell Holdings, Ltd.
2	9,077,035 B2	7/7/2015	Maxell Holdings, Ltd.
3	9,166,251 B2	10/20/2015	Maxell Holdings, Ltd.
4	9,350,019 B2	5/24/2016	Maxell Holdings, Ltd.
5			

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director **Copy 3—Upon termination of action, mail this copy to Director**
Copy 2—Upon filing document adding patent(s), mail this copy to Director **Copy 4—Case file copy**

AO 120 (Rev. 08/10)

TO:	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court for the Western District of Texas on the following

☐ Trademarks or ☑ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
6:21-cv-845	8/13/2021	for the Western District of Texas

PLAINTIFF	DEFENDANT
Maxell Holdings, Ltd.	Zhuhai CosMx Battery Co., Ltd.

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1	8,691,446	4/8/2014	Maxell Holdings, Ltd.
2	9,350,019	5/24/2016	Maxell Holdings, Ltd.
3	9,077,035	7/7/2015	Maxell Holdings, Ltd.
4	9,166,251	10/20/2015	Maxell Holdings, Ltd.
5			

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ☐ Amendment ☐ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

AO 120 (Rev. 08/10)

TO:	**Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313–1450**	**REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK**

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the **U.S. District Court for the District of New Jersey** on the following:
____ Trademarks or **X** Patents. (____ the patent action involves 35 U.S.C. § 292.)

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
2:21–cv–08461–KM–MF	4/9/2021	NEWARK, NJ

PLAINTIFF	DEFENDANT
AMPEREX TECHNOLOGY LIMITED	MAXELL, LTD.

PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 ~~See attached~~		
2 8691446		
3 9350019		
4 9077035		
5 9166251		

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED	INCLUDED BY ___ Amendment ___ Answer ___ Cross Bill ___ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1		
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE
William T. Walsh	s/ Briana Townsend	4/9/2021

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
Copy 2—Upon filing document adding patent(s), mail this copy to Director Copy 4—Case file copy

AO 120 (Rev. 08/10)

TO:	REPORT ON THE FILING OR DETERMINATION OF AN ACTION REGARDING A PATENT OR TRADEMARK
Mail Stop 8 Director of the U.S. Patent and Trademark Office P.O. Box 1450 Alexandria, VA 22313-1450	

In Compliance with 35 U.S.C. § 290 and/or 15 U.S.C. § 1116 you are hereby advised that a court action has been filed in the U.S. District Court of Arizona on the following

☑ Trademarks or ☐ Patents. (☐ the patent action involves 35 U.S.C. § 292.):

DOCKET NO.	DATE FILED	U.S. DISTRICT COURT
2:20-cv-01622-SMB	6/25/2018	of Arizona

PLAINTIFF	DEFENDANT
Green Aire for Air Conditioning, W.L.L.	Mohamed Farouk Salem, Does 1 though 50

	PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1			
2			
3			
4			
5			

In the above—entitled case, the following patent(s)/ trademark(s) have been included:

DATE INCLUDED 9/4/2018	INCLUDED BY ☐ Amendment ☑ Answer ☐ Cross Bill ☐ Other Pleading	
PATENT OR TRADEMARK NO.	DATE OF PATENT OR TRADEMARK	HOLDER OF PATENT OR TRADEMARK
1 5368899	1/2/2018	Salem, Mohamed
2		
3		
4		
5		

In the above—entitled case, the following decision has been rendered or judgement issued:

DECISION/JUDGEMENT

CLERK	(BY) DEPUTY CLERK	DATE
DEBRA LUCAS		12/29/20

Copy 1—Upon initiation of action, mail this copy to Director Copy 3—Upon termination of action, mail this copy to Director
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Trials@uspto.gov
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Paper 16
Entered: April 12, 2022

UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

AMPEREX TECHNOLOGY LIMITED,
Petitioner,

v.

MAXELL, LTD.,
Patent Owner.

IPR2021-01442
Patent 9,166,251 B2

Before KRISTINA M. KALAN, WESLEY B. DERRICK, and ELIZABETH M. ROESEL, *Administrative Patent Judges*.

KALAN, *Administrative Patent Judge*.

DECISION
Granting Institution of *Inter Partes* Review
35 U.S.C. § 314

I. INTRODUCTION

Amperex Technology Limited ("Petitioner") filed a Petition (Paper 2, "Pet.") requesting *inter partes* review of claims 1–37 of U.S. Patent No. 9,166,251 B2 (Ex. 1001, "the '251 patent"). Maxell, Ltd. ("Patent Owner") filed a Preliminary Response (Paper 9, "Prelim. Resp."). Pursuant to Board authorization, Petitioner filed a Reply (Paper 10, "Reply") and Patent Owner filed a Sur-Reply (Paper 13, "Sur-Reply").

To institute *inter partes* review, we must determine that the information presented in the Petition shows "there is a reasonable likelihood that the petitioner would prevail with respect to at least 1 of the claims challenged in the petition." 35 U.S.C. § 314(a). For the reasons discussed below, after considering the parties' submissions and the evidence of record, we determine that Petitioner has demonstrated a reasonable likelihood of prevailing with respect to at least one claim of the '251 patent. Thus, we institute *inter partes* review of all claims and all grounds asserted in the Petition.[1]

A. Related Proceedings

The parties identify the following district court litigation as a related matter: *Maxell, Ltd. v. Amperex Tech. Ltd.*, No. 6:21-cv-00347-ADA (W.D. Tex.). Pet. 69; Paper 8, 2 (Patent Owner's updated mandatory notices). The other federal court proceedings identified by the parties are no longer pending. *See* Sur-Reply 1.

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[1] *Guidance on the Impact of SAS on AIA Trial Proceedings* (Apr. 26, 2018), https://www.uspto.gov/patents-application-process/patent-trial-and-appeal-board/trials/guidance-impact-sas-aia-trial; *see also SAS Inst., Inc. v. Iancu*, 138 S. Ct. 1348, 1359–60 (2018).

B. Real Parties In Interest

Petitioner identifies itself as the real party-in-interest. Pet. 2. Patent Owner identifies itself as the real party-in-interest, but clarifies: "On October 1, 2021, following a corporate restructuring, Maxell Holdings, Ltd. changed its name to Maxell, Ltd. Maxell, Ltd. is working to update assignment records to reflect Patent Owner's new name." Paper 4, 2.

C. The '251 Patent

The '251 patent is titled "Battery Separator and Nonaqueous Electrolyte Battery," and is directed to a battery including "a positive electrode having a positive active material capable of intercalating and deintercalating a lithium ion, a negative electrode having a negative active material capable of intercalating and deintercalating a lithium ion, a separator interposed between the positive electrode and the negative electrode, and a nonaqueous electrolyte." Ex. 1001, codes (54), (57). The "heat generation starting temperature of the positive electrode is 180° C. or higher," and the separator "includes heat-resistant fine particles and a thermoplastic resin" where the "proportion of particles with a particle size of 0.2 μm or less in the heat-resistant fine particles is10 vol% or less and the proportion of particles with a particle size of 2 μm or more in the heat-resistant fine particles is 10 vol% or less," and the "separator effects a shutdown in the range of 100° C. to 150° C." *Id.* at code (57). Figure 1B of the '251 patent is reproduced below.

FIG. 1B

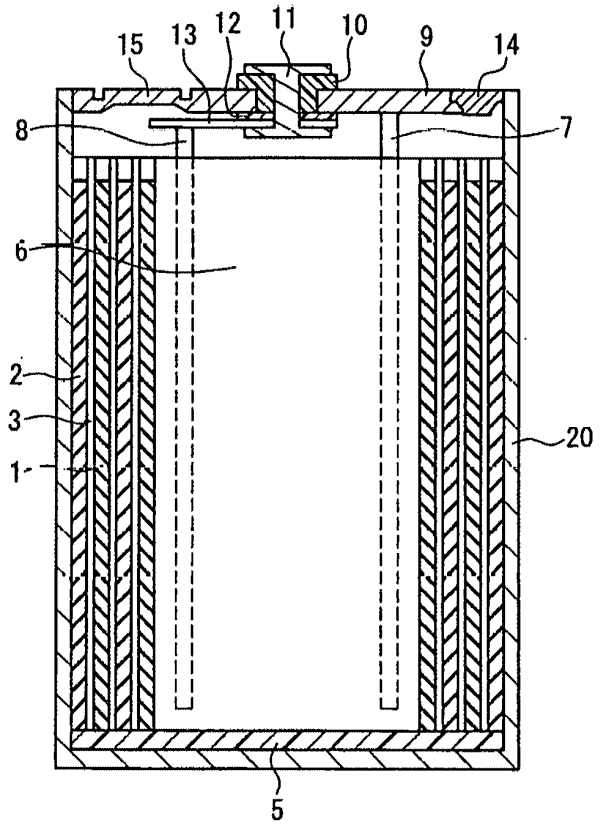


Figure 1B of the '251 patent is a schematic cross-sectional view of a nonaqueous electrolyte battery, having negative electrode 1 and positive electrode 2 wound via separator 3 in a spiral fashion, and then pressed into a flat shape, thereby providing wound electrode body 6, housed in rectangular cylindrical outer can 20. *Id.* at 2:63–65, 13:34–40. The '251 patent provides examples illustrating production of a separator (*see, e.g.*, *id.* at 14:56–15:10, 16:35–42) and results of the measurement of thermal shrinkage ratio and measurement of shutdown temperature using these separators (*id.* at 17:39–18:42; Table 1).

D. Illustrative Claim

Claim 1 is representative of the challenged claims, and is reproduced below:

1[Prc]. A battery separator comprising:
[1.A] heat-resistant fine particles; and
[1.B] a thermoplastic resin,
[1.C] wherein the heat-resistant fine particles along with a binder constitute a heat-resistant layer,
[1.D] the thermoplastic resin constitutes a shutdown layer formed of a heat-shrinkable microporous film,
[1.E] the heat-resistant layer and the shutdown layer are integrated into a multilayer structure,
[1.F] the shutdown layer has a thickness A (μm) of 5 to 30, the heat-resistant layer has a thickness B (μm) of 1 to 10, a sum of A and B is 6 to 23, and a ratio A/B is 1/2 to 4,
[1.G] a content of the heat-resistant fine particles in the heat-resistant layer is 50 vol % or more of a total volume of components in the heat-resistant layer,
[1.H] a proportion of particles with a particle size of 0.2 μm or less in the heat-resistant fine particles is 10 vol% or less and a proportion of particles with a particle size of 2 μm or more in the heat-resistant fine particles is 10 vol% or less, and
[1.I] a shutdown is effected in a range of 135° C. to 150° C.

Ex. 1001, 19:51–20:4 (bracketed designations added).

E. The Asserted Grounds of Unpatentability

Petitioner asserts the following grounds of unpatentability.

Ground	References	Basis[2]	Claims Challenged
1A	Kasamatsu,[3] Katayama[4]	§ 103	1, 3–10, 13–30, 32–37
1B	Kasamatsu, Katayama, Miyatake[5]	§ 103	2, 11, 12
2A	Yoshida,[6] Nagayama,[7] Takezawa,[8] Amagi[9]	§ 103	1, 4–10, 13, 15–23, 26–27, 30–35
2B	Yoshida, Nagayama, Takezawa, Amagi, Miyatake	§ 103	2, 11, 12
2C	Yoshida, Nagayama, Takezawa, Amagi, Katayama	§ 103	3, 14, 24–25, 28–29, 36–37

[2] The Leahy-Smith America Invents Act, Pub. L. No. 112-29, 125 Stat. 284 (2011) ("AIA"), amended 35 U.S.C. § 103. Because the '251 patent has an effective filing date prior to the effective date of the applicable AIA amendments, we refer to the pre-AIA versions of § 103.

[3] WO 2006/061936, published on June 15, 2006 (Ex. 1005). Exhibit 1005 includes a copy of the original document and a certified translation. Pet. 5 n.1.

[4] WO 2007/066768, published on June 14, 2007 (Ex. 1006). Exhibit 1006 includes a copy of the original document and a certified translation. Pet. 5 n.1.

[5] JP 2007-335294, published on December 27, 2007 (Ex. 1007). Exhibit 1007 includes a copy of the original document and a certified translation. Pet. 5 n.1.

[6] EP 1115166, published on July 11, 2001 (Ex. 1008).

[7] WO 2006/134833, published on December 21, 2006 (Ex. 1009). Exhibit 1009 includes a copy of the original document and a certified translation. Pet. 5 n.1.

[8] US 2007/0015058, published on January 18, 2007 (Ex. 1010).

[9] JP 2003-306594, published October 31, 2003 (Ex. 1022). Exhibit 1022 includes a copy of the original document and a certified translation. Pet. 5 n.1.

In support of its unpatentability arguments, Petitioner relies on the declaration of Dr. Walter van Schalkwijk. Ex. 1003. Patent Owner submits the declaration of Dr. Brett Lucht to support its opposition. Ex. 2008.

II. ANALYSIS

A. Claim Construction

We apply the claim construction standard articulated in *Phillips v. AWH Corp.*, 415 F.3d 1303 (Fed. Cir. 2005). 37 C.F.R. § 42.100(b) (2020). Under *Phillips*, claim terms are afforded "their ordinary and customary meaning." *Phillips*, 415 F.3d at 1312. The "ordinary and customary meaning of a claim term is the meaning that the term would have to a person of ordinary skill in the art in question at the time of the invention." *Id.* at 1313. Only terms that are in controversy need to be construed, and then only to the extent necessary to resolve the controversy. *Vivid Techs., Inc. v. Am. Sci. & Eng'g, Inc.*, 200 F.3d 795, 803 (Fed. Cir. 1999).

Petitioner states that "each of the challenged claims includes terms that POSITA would understand according to their plain and ordinary meaning." Pet. 5. Patent Owner does not appear to propose any express claim constructions. *See generally* Prelim. Resp. On this record, we determine that no claim terms require express construction.

B. Level of Ordinary Skill in the Art

Petitioner asserts that a person of ordinary skill in the art "would have had at least a bachelor's degree in chemistry, chemical engineering, or materials science and five or more years of experience in the field of batteries and battery materials." Pet. 7 (citing Ex. 1003 ¶ 11). Patent Owner does not propose a definition of one of ordinary skill in the art. *See generally* Prelim. Resp. In light of the record before us, we adopt

Petitioner's proposal regarding the level of one of ordinary skill in the art, with the caveat that the phrases "at least" and "or more" should not be construed as requiring a significantly greater level of education or experience than is explicitly set forth in Petitioner's definition. The level of ordinary skill in the art is also reflected by the prior art of record. *See Okajima v. Bourdeau*, 261 F.3d 1350, 1355 (Fed. Cir. 2001).

C. Discretion under 35 U.S.C. § 314(a)

Patent Owner argues the Board should exercise its discretion under 35 U.S.C. § 314(a) and deny institution in light of the district court litigation involving the '251 Patent. Prelim. Resp. 1–14; Sur-Reply 1–4. Petitioner argues the opposite. Pet. 64–67; Reply 1–4.

In assessing whether to exercise such discretion, the Board weighs six non-exclusive factors, known as the *Fintiv* factors. *Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, Paper 11 at 6 (PTAB Mar. 20, 2020) (precedential) ("*Fintiv I*"). Recognizing that "there is some overlap among these factors" and that "[s]ome facts may be relevant to more than one factor," the Board "takes a holistic view of whether efficiency and integrity of the system are best served by denying or instituting review." *Id.* We have considered Patent Owner's arguments in light of the *Fintiv* factors, together with Petitioner's opposition, and we decline to exercise our discretion to deny the Petition as explained further below.

1. Factor 1: Whether a Stay Exists or Is Likely to Be Granted if a Proceeding Is Instituted

The district court litigation has not been stayed, but Petitioner argues that it will likely move for a stay. Pet. 65. Patent Owner argues that the district court is unlikely to grant a stay. Prelim. Resp. 4–6; Sur-Reply 1–2.

There is no evidence that a stay has been requested in the district court litigation. We decline to speculate on how the district court would rule on a stay, if one were requested. *Apple Inc. v. Fintiv, Inc.*, IPR2020-00019, Paper 15 at 12 (PTAB May 13, 2020) (informative) ("*Fintiv II*") (explaining that factor 1 generally "does not weigh for or against discretionary denial" when neither party has requested a stay). Accordingly, this factor is neutral.

2. Factor 2: Proximity of the Court's Trial Date to the Board's Projected Statutory Deadline

The projected statutory deadline for this proceeding would be, at the latest, April 18, 2023. According to the parties, a jury trial in the district court litigation is scheduled to begin on February 7, 2023. Prelim. Resp. 6; Reply 2–3; Sur-Reply 1 (citing Ex. 2013, 1–2). Citing a recent instance where the district court moved a trial date by more than five months, Petitioner characterizes the trial date in this case as "speculative." Reply 3 (citing docket entries in *Fintiv, Inc. v. Apple Inc.*, No. 1:21-cv-00896 (W.D. Tex. 2022)). Patent Owner argues that the postponement in the cited district court case stemmed from circumstances not present here, and there is "no uncertainty" about the trial date in this case. Sur-Reply 2–3.

We typically take a district court's trial schedule at "face value." *Fintiv II* at 13. Accordingly, we assume that trial will begin in the district court litigation on February 7, 2023.

Given that trial is currently set to begin in the district court litigation about two months before the projected statutory deadline for a final written decision, we determine that this factor weighs marginally in favor of exercising our discretion to deny institution.

3. Factor 3: Investment in the Parallel Proceeding by the Court and Parties

In the district court litigation, we understand that a *Markman* hearing was held on February 14, 2022, and fact discovery related to infringement and invalidity issues began on February 15, 2022. Ex. 2003 (district court's amended scheduling order entered November 8, 2021); *see also* Pet. 66–67; Prelim. Resp. 8–9 (discussing status of district court litigation). The parties have exchanged preliminary infringement and invalidity contentions (*see* Prelim. Resp. 9), and final contentions are due April 11, 2022. Ex. 2003. Fact discovery closes September 2, 2022, and expert discovery closes October 21, 2022. *Id.* Although Patent Owner asserts that "extensive jurisdictional discovery" took place before the *Markman* hearing (Prelim. Resp. 8), Petitioner argues that "resources expended on jurisdictional discovery . . . are not pertinent." Reply 3.

The district court issued a claim construction order on the same day as the *Markman* hearing. Ex. 1036. The order includes a table showing the disputed claim terms, the parties' proposed constructions, and the district court's preliminary constructions. *Id.* For all disputed claim terms of the '251 Patent, the district court's "preliminary construction" is "[p]lain-and-ordinary meaning." *Id.* at 2–4.

We agree with Petitioner that discovery related to the district court's jurisdiction is an "ancillary matter[] untethered to the validity issue itself." Reply 3 (quoting *Sand Revolution II, LLC v. Continental Intermodal Group-Trucking LLC*, IPR2019-01393, Paper 24 at 10 (PTAB June 16, 2020) (informative)). We recognize that much work remains to be done in the district court litigation as it relates to invalidity: fact discovery is still

ongoing, expert reports are not yet due, there have been no fact or expert depositions, and substantive motion practice is yet to come. *See* Ex. 2003. Thus, although the parties and the district court have invested some effort in the district court litigation, the bulk of the work to prepare the invalidity case for trial is yet to be done.

As in *Sand Revolution*, the district court's claim construction order (Ex. 1036) does not, on its face, demonstrate a high level of investment of time and resources. *Sand Revolution*, Paper 24 at 10–11 (contrasting two-page *Markman* order giving each disputed claim term its "plain and ordinary meaning" with the detailed 34-page *Markman* order construing seven claim terms in *Fintiv II*).

We also acknowledge Petitioner's diligence in filing the Petition two months after receiving Patent Owner's infringement contentions. Reply 3.

Under these circumstances, we determine that this factor weighs slightly against exercising our discretion to deny institution.

4. Factor 4: Overlap Between Issues Raised in the Petition and in the Parallel Proceeding

Petitioner has agreed to a *Sotera*-style stipulation. Reply 1; *see Sotera Wireless, Inc. v. Masimo Corp.*, IPR2020-01019, Paper 12 (PTAB Dec. 1, 2020) (precedential) ("*Sotera*"). Specifically, Petitioner stipulates that, if an *inter partes* review ("IPR") is instituted, "Petitioner will not pursue invalidity of the asserted claims of the '251 Patent in [the district court litigation] based on the grounds raised in this IPR or on any other ground that was raised or could have been reasonably raised in this IPR." Reply 1. Petitioner states that its stipulation should not be construed as limiting its ability to assert invalidity "based in whole or in part on prior art not

consisting of patents or printed publications (e.g., system prior art) or invalidity grounds under Section 112." *Id.* at 1–2.

Patent Owner argues that Petitioner's stipulation "does not completely remove possible duplicative efforts" because it leaves Petitioner "wiggle room" to assert prior art that "could have been brought in this IPR." Sur-Reply 3–4.

We find that Petitioner's stipulation is substantially the same as the stipulation in *Sotera*. *Sotera* at 18 (the petitioner stipulating that, "if IPR is instituted, they will not pursue in the District Court Litigation any ground raised or that could have been reasonably raised in an IPR."). Petitioner's stipulation invokes our *Sotera* precedent, "mitigates any concerns of duplicative efforts between the district court and the Board, as well as concerns of potentially conflicting decisions," and "ensures that an *inter partes* review is a 'true alternative' to the district court proceeding." *Id.* at 19.

Accordingly, we find that this factor weighs strongly against exercising discretion to deny institution under 35 U.S.C. § 314(a).

5. Factor 5: Whether the Petitioner and the Defendant in the Parallel Proceeding Are the Same Party

The Petitioner here is a defendant in the district court litigation and, thus, this factor weighs in favor of exercising our discretion to deny institution under § 314(a). *Fintiv II* at 15.

6. Factor 6: Other Circumstances that Impact the Board's Exercise of Discretion, Including the Merits

Petitioner contends that "the grounds provide a strong showing of obviousness." Pet. 67. Petitioner asserts that Patent Owner's Preliminary

Response "illustrates the strength of the Petition in that it repeatedly ignored evidence." Reply 4.

Patent Owner contends that Petitioner's "arguments on the merits are not strong." Prelim. Resp. 13–14. According to Patent Owner, the Preliminary Response provides "detailed examples of how the merits of the Petition are weak." Sur-Reply 4.

As the Board explained in *Fintiv I*, we consider this factor as "part of a balanced assessment of all the relevant circumstances in the case." *Fintiv I* at 14. The assessment requires consideration of the "strengths or weaknesses regarding the merits," but this "is not to suggest that a full merits analysis is necessary to evaluate this factor." *Id.* at 15–16.

We discuss the merits of this case below, finding Petitioner's evidence and arguments are sufficient to meet our standard for instituting *inter partes* review, and, thus, we determine that this factor is neutral.

7. Balancing the Fintiv Factors

We have considered the circumstances and facts before us in view of the *Fintiv* factors. We take "a holistic view of whether efficiency and integrity of the system are best served by denying or instituting review." *Fintiv I* at 6. Having evaluated all of the factors, we determine that the circumstances presented here do not support exercising our discretion under § 314(a) to deny institution.

D. Discretion under 35 U.S.C. § 325(d)

Patent Owner argues that we should exercise our discretion to deny institution under 35 U.S.C. § 325(d). Prelim. Resp. 14–19; Sur-Reply 5. Petitioner argues the opposite. Pet. 63–64; Reply 4–5.

The statute provides that, in determining whether to institute an *inter partes* review, "the Director may take into account whether, and reject the petition or request because, the same or substantially the same prior art or arguments previously were presented to the Office." 35 U.S.C. § 325(d).

The Board's most recent precedential decision addressing § 325(d) provides the following two-part framework:

> (1) whether the same or substantially the same art previously was presented to the Office or whether the same or substantially the same arguments previously were presented to the Office; and (2) if either condition of first part of the framework is satisfied, whether the petitioner has demonstrated that the Office erred in a manner material to the patentability of challenged claims.

Advanced Bionics, LLC v. MED-EL Elektromedizinische Geräte GmbH, IPR2019-01469, Paper 6 at 8 (PTAB Feb. 13, 2020) (precedential). *Advanced Bionics* explains that the *Becton, Dickinson* factors[10] provide "useful insight" into how to apply the statutory framework and address "challenging factual questions, such as when a ground of unpatentability

[10] *Becton, Dickinson* identifies the following non-exclusive factors: (a) the similarities and material differences between the asserted art and the prior art involved during examination; (b) the cumulative nature of the asserted art and the prior art evaluated during examination; (c) the extent to which the asserted art was evaluated during examination, including whether the prior art was the basis for rejection; (d) the extent of the overlap between the arguments made during examination and the manner in which petitioner relies on the prior art; (e) whether petitioner has pointed out sufficiently how the examiner erred in its evaluation of the asserted prior art; and (f) the extent to which additional evidence and facts presented in the petition warrant reconsideration of the prior art or arguments. *Becton, Dickinson & Co. v. B. Braun Melsungen AG*, IPR2017-01586, Paper 8 at 17–18 (PTAB Dec. 15, 2017) (precedential as to § III.C.5, first paragraph).

presents 'substantially the same prior art or arguments' previously presented to the Office." *Id.* at 9.

Under the first part of the *Advanced Bionics* framework, we consider whether the art presented in the Petition is the same or substantially the same as the art previously presented to the Office during examination (evaluating, if appropriate, *Becton, Dickinson* factors (a), (b), and (d)). Patent Owner argues that Miyatake, Katayama, and Yoshida were disclosed on an Information Disclosure Statement, and that Yoshida was cited by the Examiner during prosecution of the '251 patent. Prelim. Resp. 16; Sur-Reply 5. Petitioner argues that "none of the references or combination of references were relied upon by the Examiner in an Office Action, which favors institution." Pet. 63.

The Petition presents two grounds with Kasamatsu as the primary reference (Grounds 1A and 1B) and three with Yoshida as the primary reference (Grounds 2A, 2B, and 2C). Pet. 1–2. The Kasamatsu-led grounds additionally rely on Katayama and Miyatake, and the Yoshida-led grounds additionally rely on Nagayama, Takezawa, Amagi, Miyatake, and Katayama. *Id.* There is no suggestion that Kasamatsu was presented to the Office during examination. There is no suggestion that any newly-asserted reference is cumulative of the art presented to the Office during examination (*Becton, Dickinson* factor (b)). *See generally* Prelim. Resp. Further, in view of the importance of Kasamatsu and additional, unconsidered prior art to Petitioner's grounds of unpatentability, we determine that, although Miyatake, Katayama, and Yoshida were disclosed on an Information Disclosure Statement, and Yoshida was cited by the Examiner during prosecution of the '251 patent, overall, the combinations of art presented in

the Petition are not the same or substantially the same as the art previously presented to the Office during examination (*Becton, Dickinson* factor (a)).

We also consider whether the arguments presented in the Petition are the same or substantially the same as the arguments previously presented to the Office during examination ((*Becton, Dickinson* factor (d)). Patent Owner concedes that "the file history does not feature arguments concerning the examination of the *Miyatake* or *Yoshida* references." Prelim. Resp. 18. Patent Owner does not direct us to any file history argument concerning the subject matter of Miyatake, Katayama, and Yoshida that Patent Owner asserts is cumulative of the prior art cited during examination. *See generally* Prelim. Resp.

The Examiner's reasons for allowance make no mention of claim element [1.F], which was added to claim 1 just before allowance, and for which Petitioner relies on the previously unpresented combination of Kasamatsu and Katayama and the previously uncited Nagayama reference. Pet. 16–17, 47; Ex. 1002, 890–891; Reply 5. Patent Owner does not assert any similarity between Petitioner's arguments based on Miyatake, Katayama, and Yoshida and the arguments previously presented to the Office during examination. *See generally* Prelim. Resp. On this record, we determine that the arguments presented in the Petition are not the same or substantially the same as the arguments previously presented to the Office during examination.

Because neither condition of the first part of the *Advanced Bionics* framework is satisfied, we need not consider the second part of the framework, i.e., whether Petitioner has demonstrated that the Office erred in a manner material to the patentability of challenged claims.

For these reasons, we do not exercise our discretion to deny institution under § 325(d).

E. Reasonable Likelihood under 35 U.S.C. § 314(a)

"In an [*inter partes* review], the petitioner has the burden from the onset to show with particularity why the patent it challenges is unpatentable." *Harmonic Inc. v. Avid Tech., Inc.*, 815 F.3d 1356, 1363 (Fed. Cir. 2016) (citing 35 U.S.C. § 312(a)(3) (requiring *inter partes* review petitions to identify "with particularity . . . the evidence that supports the grounds for the challenge to each claim")); *see also* 37 C.F.R. § 42.104(b) (requiring a petition for *inter partes* review to identify how the challenged claim is to be construed and where each element of the claim is found in the prior art patents or printed publications relied upon).

A patent claim is unpatentable under 35 U.S.C. § 103 if the differences between the claimed subject matter and the prior art are such that the subject matter, as a whole, would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. *KSR Int'l Co. v. Teleflex Inc.*, 550 U.S. 398, 406 (2007). The question of obviousness is resolved based on underlying factual determinations including: (1) the scope and content of the prior art; (2) any differences between the claimed subject matter and the prior art; (3) the level of ordinary skill in the art; and (4) when presented, objective evidence of nonobviousness, i.e., secondary considerations. *Graham v. John Deere Co.*, 383 U.S. 1, 17–18 (1966).

Additionally, the obviousness inquiry typically requires an analysis of "whether there was an apparent reason to combine the known elements in the fashion claimed by the patent at issue." *KSR*, 550 U.S. at 418 (citing

In re Kahn, 441 F.3d 977, 988 (Fed. Cir. 2006) (requiring "articulated reasoning with some rational underpinning to support the legal conclusion of obviousness")). Petitioner cannot satisfy its burden of proving obviousness by employing "mere conclusory statements," but "must instead articulate specific reasoning, based on evidence of record, to support the legal conclusion of obviousness." *In re Magnum Oil Tools Int'l, Ltd.*, 829 F.3d 1364, 1380 (Fed. Cir. 2016).

F. Asserted Obviousness – Grounds 1A and 1B

Petitioner argues that Kasamatsu and Katayama would have rendered obvious claims 1, 3–10, 13–30, and 32–37. Pet. 8–34 (Ground 1A). Petitioner also argues that Kasamatsu, Katayama, and Miyatake would have rendered obvious claims 2, 11, and 12. *Id.* at 34–38 (Ground 1B).

1. Kasamatsu

Kasamatsu is a patent publication titled "Separator and Non-Aqueous Electrolyte Secondary Battery Using Same" and is directed to "a separator comprising at least a fine particulate filler-containing layer and a shutdown layer" including "a joined-particle filler wherein a plurality of primary particles are joined and bonded with one another." Ex. 1005, codes (54) (57).

2. Katayama

Katayama is a patent publication titled "Separator for Electrochemical Device and Method for Producing the Same, and Electrochemical Device and Method for Producing the Same," and is directed to an "electrochemical device having excellent safety at a high temperature" because it uses "a separator for an electrochemical device, which is made of a porous film

including a first separator layer and a second separator layer." Ex. 1006, codes (54), (57).

3. Miyatake

Miyatake is a Japanese unexamined patent application publication titled "Laminated Battery." Ex. 1007, codes (12), (54). Miyatake is directed to a laminated rechargeable lithium ion battery having excellent durability and heat resistance, due to its ability to "sufficiently suppress heat generation and temperature increases due to short circuits and the like." *Id.* at code (57).

4. Petitioner's Arguments

Petitioner asserts that every element of claim 1 is found in the combination of Kasamatsu and Katayama, as follows:

[1.Pre] *A battery separator comprising*: (Pet. 13 (relying on Ex. 1005 ¶ 1; Ex. 1006 ¶ 14; Ex. 1003 ¶¶ 157–159));[11]

[1.A] *heat-resistant fine particles*; (Pet. 13 (relying on Ex. 1005 ¶¶ 14, 15, 23, 26, 45, 65; Ex. 1006 ¶¶ 53–54; Ex. 1003 ¶¶ 160–164));

[1.B] *and a thermoplastic resin,* (Pet. 14 (relying on Ex. 1005 ¶¶ 20, 36; Ex. 1006 ¶¶ 14, 27; Ex. 1003 ¶¶ 166–169));

[1.C] *wherein the heat-resistant fine particles along with a binder constitute a heat-resistant layer,* (Pet. 14 (relying on Ex. 1005 ¶¶ 15–16; Ex. 1006 ¶¶ 14, 68, 23; Ex. 1003 ¶¶ 170–171));

[1.D] *the thermoplastic resin constitutes a shutdown layer formed of a heat-shrinkable microporous film,* (Pet. 14–15 (relying on Ex. 1005 ¶¶ 20, 36; Ex. 1006 ¶¶ 22, 14, 27, 3; Ex. 1003 ¶¶ 174–177));

[11] We express no opinion on whether the preamble is limiting.

[1.E] *the heat-resistant layer and the shutdown layer are integrated into a multilayer structure,* (Pet. 15–16 (relying on Ex. 1005 ¶¶ 56, 78, 84, 86, 17, Fig. 1; Ex. 1006 ¶ 76; Ex. 1003 ¶¶ 180–183));

[1.F] *the shutdown layer has a thickness A (μm) of 5 to 30, the heat-resistant layer has a thickness B (μm) of 1 to 10, a sum of A and B is 6 to 23, and a ratio A/B is 1/2 to 4,* (Pet. 16–17 (relying on Ex. 1005 ¶¶ 36, 56, 78, 84, 81, 82; Ex. 1006 ¶ 82; Ex. 1003 ¶¶ 186–190));

[1.G] *a content of the heat-resistant fine particles in the heat-resistant layer is 50 vol % or more of a total volume of components in the heat-resistant layer,* (Pet. 17 (relying on Ex. 1005 ¶¶ 10, 17; Ex. 1006 ¶¶ 59, 125; Ex. 1003 ¶¶ 192–196));

[1.H] *a proportion of particles with a particle size of 0.2 μm or less in the heat-resistant fine particles is 10 vol % or less and a proportion of particles with a particle size of 2 μm or more in the heat-resistant fine particles is 10 vol % or less, and* (Pet. 18–19 (relying on Ex. 1006 ¶¶ 124, 150–159; Ex. 1003 ¶¶ 199–201));

[1.I] *a shutdown is effected in a range of 135° C. to 150° C.* Pet. 19–20 (relying on Ex. 1005 ¶¶ 36, 20; Ex. 1006 ¶ 185, Table 3; Ex. 1003 ¶¶ 203–206).

Petitioner argues that Kasamatsu teaches the limitations of claim 1, apart from the "particle size distribution of heat-resistant fine particles in the heat-resistant layer" and "a concentration of heat-resistant particles in terms of volume-percent." Pet. 10 (citing Ex. 1003 ¶ 148). Petitioner also argues that one of ordinary skill in the art "would have looked to Katayama to optimize the concentration and size distribution of the heat-resistant particles" to "maximize the heat-resistant properties of the heat-resistant

layer without negatively impacting ion movement between the electrodes, thereby avoiding short-circuit at high temperatures." *Id.* at 10–11 (citing Ex. 1003 ¶ 154). This combination, according to Petitioner, is an example of "combining prior art methods of making a separator according to known methods to yield predictable results." *Id.* (citing *KSR*, 550 U.S. at 416). One of ordinary skill in the art "would have had a reasonable expectation of success" because "Kasamatsu teaches that a high concentration and lower average particle size will work in a similar battery, and because lithium-ion chemistry was predictable at the time of Kasamatsu and Katayama." *Id.* at 12 (citing Ex. 1003 ¶¶ 40, 155–156).

The remaining challenged claims in Ground 1 all depend from claim 1, and Petitioner presents additional arguments that the combination of Katayama and Kasamatsu disclose all the limitations of those dependent challenged claims. Pet. 20–34. For Ground 1B (additionally relying on Miyatake), Petitioner argues that the proposed combinations disclose all of the challenged dependent claim limitations. Pet. 34–38.

5. Patent Owner's Arguments

Patent Owner argues Petitioner has failed to show a reasonable likelihood of prevailing in proving the obviousness of the claims challenged under Grounds 1A and 1B. Prelim. Resp. 20–25

First, Patent Owner argues that neither Kasamatsu nor Katayama discloses the "shutdown layer" as claimed. *Id.* at 20. Instead, Patent Owner argues, Katayama's disclosure at ¶ 82 is "the opposite of the '251 Patent, and it is not obvious to do the opposite of what *Katayama* teaches." *Id.* at 21.

Second, Patent Owner argues that neither Kasamatsu nor Katayama discloses a "proportion of particles" with the claimed particle sizes. *Id.* More particularly, Patent Owner argues, Kasamatsu "discloses a fine particulate filler that includes a joined-particle filler which includes both joined and primary particles." *Id.* Kasamatsu's teachings of joined particles and a "need to control particle size so to avoid short circuit," Patent Owner argues, suggest "much larger particles than the 'particle size of 0.2 μm' used in the '251 Patent." *Id.* at 22 (citing Ex. 2008 ¶ 33). Additionally, Patent Owner argues, Katayama's "average particle diameter of 0.4 μm with a particle size distribution of 0.3 to 0.7 μm for fine particles used" does not render the claimed particles sizes obvious, because prior art teaching of a broad genus does not disclose every species within that genus. *Id.* at 23 (citing *Atofina v. Great Lakes Chem. Corp.*, 441 F.3d 991 (Fed. Cir. 2006)).

Third, Patent Owner argues that Petitioner has failed to demonstrate a motivation to combine Kasamatsu and Katayama. *Id.* at 23. Kasamatsu "is directed to a battery intended for use at low temperatures," whereas Katayama "is not concerned with low-temperature batteries," and, Patent Owner argues, one of ordinary skill in the art "would not look to *Katayama* and its techniques intended to make batteries resilient to cold temperatures to arrive at the invention of the '251 Patent." *Id.* at 23–25.

6. Analysis

Regarding Patent Owner's first argument, Patent Owner appears to argue that neither Kasamatsu nor Katayama discloses claim element [1.F]. Based on our review of the record and Petitioner's arguments (Pet. 16–17), Petitioner appears to demonstrate sufficiently that Kasamatsu and Katayama disclose the thicknesses, sum, and ratio in claim element [1.F]. To the extent

Patent Owner is challenging the references individually, nonobviousness cannot be shown by attacking references individually when the argument is based on a combination of references. *In re Keller,* 642 F.2d 413, 426 (CCPA 1981). Petitioner references both Kasamatsu and Katayama to disclose values for thickness A and thickness B within or overlapping the claimed ranges. Pet. 16–17. Petitioner also relies on its declarant's supporting testimony regarding these references with respect to claim element [1.F] and regarding the combination of the references, which we find sufficient at this stage in the proceeding. *Id.* (citing Ex. 1003 ¶¶ 125–156, 186–190).

Regarding Patent Owner's second argument, we find sufficient, on this record, Petitioner's arguments regarding claim element [1.H] and the proportion of particles with particular particle sizes disclosed by Kasamatsu in combination with Katayama. Although Kasamatsu may disclose a joined-particle filler, as Patent Owner indicates, we do not understand Kasamatsu's teachings of joined-particle filler and a "need to control particle size so to avoid short circuit" (Prelim. Resp. 22) to somehow negate Kasamatsu's disclosure that "the maximum particle size of the primary particles is preferably 3 μm or less." Ex. 1005 ¶ 28. Nor do we understand this disclosure of Katayama to suggest "much larger particles than the 'particle size of 0.2 μm' used in the '251 Patent," as argued by Patent Owner (Prelim. Resp. 22), when claim element [1.H] is directed to a variety of particle sizes that range from "0.2 μm or less" to "2 μm or more." Regarding Patent Owner's argument that Katayama's "average particle diameter of 0.4 μm with a particle size distribution of 0.3 to 0.7 μm for fine particles" does not render the claimed particles sizes obvious (Prelim. Resp. 22–23), a "*prima*

facie case of obviousness typically exists when the ranges of a claimed composition overlap the ranges disclosed in the prior art." *In re Peterson*, 315 F.3d 1325, 1329 (Fed. Cir. 2003) (citing *In re Geisler*, 116 F.3d 1465, 1469 (Fed. Cir. 1997)). Petitioner demonstrates sufficiently on this record that Katayama's particle size distribution range overlaps with the ranges in claim element [1.H]. Pet. 18–19.

Patent Owner's third argument appears to assert that Kasamatsu's battery intended for low temperatures teaches away from a combination with Katayama's disclosure, which is "not concerned with low-temperature batteries." Prelim. Resp. 23–25. We do not perceive a teaching away in Kasamatsu that would lead one of ordinary skill in the art away from combining Kasamatsu's teachings with Katayama's. *See In re Fulton*, 391 F.3d 1195, 1201 (Fed. Cir. 2004) (disclosing a different solution to a similar problem in a prior art reference does not teach away from the claimed subject matter unless the prior art reference also criticizes, discredits or otherwise discourages the solution claimed). Rather, we determine that, for purposes of institution, Petitioner presents a sufficient rationale for combining the teachings of Kasamatsu and Katayama, and sufficient evidentiary support for that rationale. Pet. 8–12; Ex. 1003 ¶¶ 120–156.

On this record, Petitioner demonstrates a reasonable likelihood of prevailing on its argument that the challenged claims would have been obvious over the Grounds 1A and 1B combinations of prior art.

G. Asserted Obviousness – Grounds 2A, 2B, and 2C

Petitioner argues that Yoshida, Nagayama, Takezawa, and Amagi would have rendered obvious claims 1, 4–10, 13, 15–23, 26–27, and 30–35. Pet. 38–58 (Ground 2A). Petitioner also argues that Yoshida, Nagayama,

Takezawa, Amagi, and Miyatake would have rendered obvious claims 2, 11, and 12 (*id.* at 59–60 (Ground 2B)) and that Yoshida, Nagayama, Takezawa, Amagi, and Katayama would have rendered obvious claims 3, 14, 24–25, 28–29, and 36–37 (*id.* at 60–62 (Ground 2C)).

1. Yoshida

Yoshida is a patent application titled "Separator for Cell, Cell, and Method for Producing Separator" and is directed to a separator comprising a first porous layer mainly containing thermoplastic resin and a second porous layer formed over the first porous layer and having a heat resistance higher than that of the first porous layer. Ex. 1008, codes (54) (57).

2. Nagayama

Nagayama is a patent publication titled "Non-Aqueous Electrolyte Secondary Battery," and is directed to a "non-aqueous electrolyte secondary battery comprising a positive electrode, a negative electrode, and a non-aqueous electrolyte" wherein the "porous heat-resistant layer is arranged between the positive electrode and the negative electrode." Ex. 1009, codes (54), (57).

3. Takezawa

Takezawa is a patent application publication titled "Positive Electrode for Lithium Secondary Battery, and Lithium Secondary Battery Using the Same," and is directed in part to a positive electrode film containing, "as a positive electrode active material, two or more kinds of lithium-containing compounds having exothermic initiation temperatures different from each other," wherein at least "one kind of the two or more kinds of lithium-containing compounds has the exothermic initiation temperature of 300° C. or higher." Ex. 1010, codes (54), (57).

4. Amagi

Amagi is a Japanese unexamined patent application titled "Epoxy Resin Composition and Rotating Machine Using the Same," and is directed to an epoxy resin composition having an inorganic filler. Ex. 1022, codes (54), (57). Amagi discloses using inorganic filler in various particle sizes and distributions. *Id.* ¶ 6.

5. Petitioner's Arguments

Petitioner asserts that every element of claim 1 is found in the combination of Yoshida, Nagayama, Takezawa, and Amagi, as follows:

[1.Pre] *A battery separator comprising*: (Pet. 44 (relying on Ex. 1008 ¶ 1; Ex. 1009 ¶¶ 7–8, 44; Ex. 1010 ¶ 139; Ex. 1003 ¶¶ 358–360));[12]

[1.A] *heat-resistant fine particles*; (Pet. 44–45 (relying on Ex. 1008 ¶¶ 11, 25–26; Ex. 1009 ¶¶ 21, 9, 28, 4; Ex. 1022, Fig. 1; Ex. 1003 ¶¶ 361–366));

[1.B] *and a thermoplastic resin,* (Pet. 45 (relying on 1008 ¶ 22; Ex. 1009 ¶ 44; Ex. 1010 ¶ 58; Ex. 1003 ¶¶ 368–372));

[1.C] *wherein the heat-resistant fine particles along with a binder constitute a heat-resistant layer,* (Pet. 45 (relying on Ex. 1008 ¶ 25; Ex. 1009 ¶¶ 21, 9; Ex. 1003 ¶¶ 373–374));

[1.D] *the thermoplastic resin constitutes a shutdown layer formed of a heat-shrinkable microporous film,* (Pet. 46 (relying on Ex. 1008 ¶¶ 36, 22; Ex. 1009 ¶ 44; Ex. 1010 ¶ 58; Ex. 1003 ¶¶ 376–380));

[12] We express no opinion on whether the preamble is limiting.

[1.E] *the heat-resistant layer and the shutdown layer are integrated into a multilayer structure,* (Pet. 46–47 (relying on Ex. 1008 ¶ 21, Fig. 1; Ex. 1003 ¶¶ 382));

[1.F] *the shutdown layer has a thickness A (μm) of 5 to 30, the heat-resistant layer has a thickness B (μm) of 1 to 10, a sum of A and B is 6 to 23, and a ratio A/B is 1/2 to 4,* (Pet. 47 (relying on Ex. 1009 ¶¶ 44, 25; Ex. 1003 ¶¶ 385–387));

[1.G] *a content of the heat-resistant fine particles in the heat-resistant layer is 50 vol % or more of a total volume of components in the heat-resistant layer,* (Pet. 47–48 (relying on Ex. 1008 ¶¶ 31, 42; Ex. 1003 ¶¶ 391–394));

[1.H] *a proportion of particles with a particle size of 0.2 μm or less in the heat-resistant fine particles is 10 vol % or less and a proportion of particles with a particle size of 2 μm or more in the heat-resistant fine particles is 10 vol % or less, and* (Pet. 48–49 (relying on Ex. 1008 ¶ 26; Ex. 1022, Fig. 1; Ex. 1003 ¶¶ 395–402));

[1.I] *a shutdown is effected in a range of 135° C. to 150° C.* Pet. 49 (relying on Ex. 1008 ¶¶ 22; Ex. 1003 ¶ 404).

Petitioner argues that "each of the references are directed to non-aqueous secondary batteries and/or heat-resistant materials for use in non-aqueous secondary batteries." Pet. 39 (citing Ex. 1003 ¶ 337). Petitioner also argues that to the extent Yoshida does not teach or suggest the claimed particle size distribution, one of ordinary skill in the art "would have looked to identify a particular particle that satisfies its specified particle size distribution," such as the alumina particles (AA-03) disclosed in Amagi, which "met the requirements of Yoshida and would have further improved

the Yoshida system." *Id.* at 40 (citing Ex. 1022 ¶¶ 23,48, 11, Fig. 1; Ex. 1003 ¶ 342). Petitioner further argues that, although Yoshida "does not provide specific implementation details for its separator," one of ordinary skill in the art "would have been motivated to turn to" Nagayama's specific separator properties, with a reasonable expectation of success, because using Nagayama's separator thickness instead of Yoshida's "is just a simple substitution." *Id.* at 41–42 (citing Ex. 1009 ¶¶ 44, 25; Ex. 1003 ¶¶ 345–346). Similarly, although Yoshida does not specifically recite its electrode materials, Petitioner argues that one of ordinary skill in the art would have looked to Nagayama's disclosed examples of positive electrode materials, and used those disclosed with a reasonable expectation of success as a matter of simple substitution. *Id.* at 42–43 (citing Ex. 1009 ¶¶ 2, 5, 11–12, 34–35, Table 4; Ex. 1003 ¶¶ 347–349, 444–449). Finally, Petitioner argues that one of ordinary skill in the art would have used the cathode materials of Takczawa, which discloses "high-capacity positive electrode active materials having heat generation temperatures ranging from 202 to over 400°C," in the combination with a reasonable expectation of success. *Id.* at 43–44 (citing Ex. 1010 ¶¶ 21, 44, 87; Ex. 1003 ¶¶ 350–352).

The remaining challenged claims in Ground 2A all depend from claim 1, and Petitioner presents additional arguments that the combination of Yoshida, Nagayama, Takezawa, and Amagi discloses all the limitations of those dependent challenged claims. Pet. 50–58. For Ground 2B (additionally relying on Miyatake), Petitioner argues that the proposed combinations disclose all of the challenged dependent claim limitations. Pet. 59–60. For Ground 2C (additionally relying on Katayama), Petitioner

argues that the proposed combinations disclose all of the challenged dependent claim limitations. Pet. 60–62.

6. Patent Owner's Arguments

Patent Owner argues Petitioner has failed to show a reasonable likelihood of prevailing in proving the obviousness of the claims challenged under Grounds 2A, 2B, or 2C. Prelim. Resp. 25–27. Patent Owner faults Petitioner for employing a "prohibited hindsight analysis" and "using the claims of the '251 Patent as a blueprint" to "arrive at the claimed invention." *Id.* at 25. Patent Owner specifically faults Petitioner for failing to identify why the combination of Yoshida and Amagi would occur, and for providing no motivation to combine Nagayama or Takezawa with those references. *Id.* at 26–27.

7. Analysis

Regarding Patent Owner's hindsight reconstruction argument, we have reviewed the record before us and do not perceive that Petitioner's arguments are impermissibly based in hindsight. Petitioner provides sufficient reasoning, on this record, why one of ordinary skill in the art would have been motivated to combine the references with a reasonable expectation of success, supported by expert testimony. *See, e.g.*, Pet. 39–44 (citing Ex. 1003 ¶¶ 337–357). Accordingly, Petitioner has provided "some articulated reasoning with some rational underpinning to support the legal conclusion of obviousness," without impermissibly resorting to hindsight. *In re Kahn*, 441 F.3d at 988. The portions of Yoshida, Nagayama, Takezawa, Amagi, Miyatake, and Katayama on which Petitioner relies appear on this record to teach the limitations of the challenged claims. When supported by the declarant's testimony regarding the combinability of

the cited references, and regarding the motivation of one of ordinary skill in the art to make the combination (*see, e.g.*, Ex. 1003 ¶¶ 337–357), Petitioner's arguments and evidence are sufficient at this stage in the proceeding.

On this record, Petitioner demonstrates a reasonable likelihood of prevailing on its argument that the challenged claims would have been obvious over the Grounds 2A, 2B, and 2C combinations of prior art.

III. CONCLUSION

For the reasons set forth above, we determine that Petitioner has demonstrated a reasonable likelihood of prevailing with respect to at least one challenged claim of the '251 patent. Thus, we institute *inter partes* review on all challenged claims and on all grounds presented.

At this preliminary stage of the proceeding, we have not made a final determination as to the patentability of any challenged claim or any factual or legal issue underlying the patentability inquiry. Any final determination will be based on the record developed during trial. We place Patent Owner on express notice that any argument not asserted in a timely-filed Response to the Petition, or in another manner permitted during trial, shall be deemed waived, even if that argument was presented in the Preliminary Response.

IV. ORDER

In consideration of the foregoing, it is hereby:

ORDERED that *inter partes* review is instituted on each of the grounds asserted in the Petition; and

FURTHER ORDERED that, pursuant to 35 U.S.C. § 314(c) and 37 C.F.R. § 42.4, notice is hereby given of the institution of a trial, which shall commence on the entry date of this decision.

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