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Alex Martinez

Applicant : Do-Hyung Park, et al. Confirmation No.: 1031
Application No. : 61/285,785
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Title : POSITIVE ELECTRODE ACTIVE MATERIAL FOR LITHIUM
BATTERY AND LITHIUM BATTERY USING THE SAME

Grp./Div. : TBD
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VERIFIED ENGLISH LANGUAGE TRANSLATION

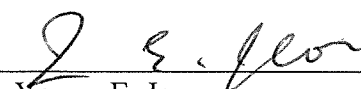
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Attached please find the Verified English language translation of the subject provisional application.

Respectfully submitted,
CHRISTIE, PARKER & HALE, LLP

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IN THE MATTER OF

U.S. Provisional Application No. 61/285,785

By Samsung SDI Co., Ltd.

I, Yeonsook Yun, an employee of Y.P. LEE, MOCK & PARTNERS of Koryo Bldg., 1575-1 Seocho-dong, Seocho-gu, Seoul, Republic of Korea, hereby declare that I am familiar with the Korean and English language and that I am the translator of U.S. Provisional Application and certify that the following is to the best of my knowledge and belief a true and correct translation.

Signed this 18 day of January 2010

Yeonsook Yun

【Abstract】

A positive electrode active material for lithium batteries, a method of manufacturing the positive electrode active material, and a positive electrode including the positive electrode active material, wherein the positive electrode active material includes secondary particles having primary particles and an amorphous material.

【Representative Drawing】

FIG. 1

【Specification】

【Title of Invention】

Positive electrode active material for lithium batteries, method of manufacturing positive electrode active material, and lithium battery including the same

【Detailed Description】

【Technical Field】

One or more embodiments of the present invention relate to a positive electrode active material for lithium batteries, method of manufacturing the positive electrode active material, and a lithium battery including the positive electrode active material.

【Background】

Lithium secondary batteries are recently used as a power source for portable compact electronic devices. Lithium secondary batteries have high energy density because they use an organic electrolyte and thus a discharge voltage thereof is twice greater than that of batteries using a conventional alkali aqueous solution.

In lithium secondary batteries, a material capable of absorbing and desorbing lithium ions is used in a negative electrode and a positive electrode, and an organic electrolytic solution or a polymer electrolytic solution fills a space between the positive electrode and negative electrode. When lithium ions are absorbed or desorbed, an oxidation reaction and a reduction reaction occur, respectively, and due to the oxidation reaction and the reduction reaction, electric energy is generated.

Meanwhile, LiCoO_2 is widely used as a positive electrode active material for lithium secondary batteries.

However, LiCoO_2 is expensive and its supply is unstable. Thus, alternatives such as a composite including nickel or manganese, are being developed as a positive electrode active material.

However, residual capacity, recovery capacity, and thermal stability of conventional positive electrode active materials are unsatisfactory.

【Disclosure of the Invention】

【Technical Goals of the Invention】

One or more embodiments of the present invention include a positive electrode active material for lithium batteries, capable of improving capacity and thermal stability, and a method of manufacturing the same.

One or more embodiments of the present invention include a lithium battery including the positive electrode active material.

【Means for Achieving Technical Goals】

According to one or more embodiments of the present invention, a positive electrode active material for lithium batteries includes secondary particles including primary particles and an amorphous material, wherein the primary particles are a lithium composite oxide.

According to one or more embodiments of the present invention, a method of manufacturing a positive electrode active material for lithium batteries includes: mixing and stirring a lithium composite oxide and a lithium salt; and heat treating the resultant at a temperature of about 700 to about 950°C, wherein the positive electrode active material includes a secondary particle including primary particles and an amorphous material, wherein the primary particles are a lithium composite oxide.

According to one or more embodiments of the present invention, a lithium battery includes a positive electrode, a negative electrode, and a separator interposed between the positive electrode and the negative electrode, wherein the positive electrode includes the positive electrode active material.

【Effect of the Invention】

A positive electrode active material for lithium batteries according to an embodiment of the present invention includes primary particles having an average diameter that is controlled in such a way that a specific surface between the positive electrode active material and an electrolyte is reduced. Thus, the positive electrode active material obtains high thermal stability, high residual capacity at a high temperature, and a preservation capacity at a high temperature.

【Description of Embodiment】

A positive electrode active material for lithium batteries includes secondary particles including primary particles and an amorphous material, wherein the primary particles are a lithium composite oxide.

The amorphous material may exist along a grain boundary of adjacent primary particles and in the form of an amorphous material layer. The grain boundary of adjacent primary particles may exist inside the secondary particles.

The term “primary particles” refer to particles that agglomerate and form a secondary particle, and have various shapes such as a rod shape or a square.

The term “secondary particles” refer to particles that do not agglomerate and are spherical.

The amorphous material may be a lithium salt, but is not limited thereto.

The lithium salt may be lithium sulfate, lithium nitrate, or lithium hydroxide.

The amount of the amorphous material may be in the range of about 0.01 to about 10 parts by weight, for example, about 0.1 to about 2 parts by weight, based on 100 parts by weight of the lithium composite oxide. If the amount of the amorphous material is in the range of about 0.01 to about 10 parts by weight, the positive electrode active material has a high capacity.

The average diameter of the primary particles may be in the range of about 1 to about 3 μm , and the average diameter of the secondary particles may be in the range of about 10 to about 15 μm . In this regard, the average diameters are measured using a laser diffraction-type particle distribution evaluator.

If the average diameter of the primary particles is within the range described above, a specific surface between the positive electrode active material and an electrolyte is reduced and thus the positive electrode active material has a high thermal stability and a high capacity.

If the average diameter of the secondary particles is within the range described above, the positive electrode active material has a high thermal stability and a high capacity.

The lithium composite oxide may be, for example, a compound represented by Formula 1:

Formula 1



where $0.85 \leq x \leq 1.25$, $0 \leq y \leq 0.5$, $0 < z \leq 0.5$, and $0 < y+z \leq 1$, and Me is selected from the group consisting of aluminum(Al), manganese(Mn), titanium (Ti), and calcium (Ca).

For example, $0.9 \leq x \leq 1.1$, $0.1 \leq y \leq 0.5$, $0.1 \leq z \leq 0.5$, and $0.2 < y+z \leq 0.75$. However, values of x, y, z, and y+z are not limited thereto.

The lithium composite oxide may be $\text{Li}_{0.6}\text{Co}_{0.2}\text{Mn}_{0.2}\text{O}_2$, $\text{LiNi}_{0.5}\text{Co}_{0.2}\text{Mn}_{0.3}\text{O}_2$, or $\text{LiNi}_{0.6}\text{Co}_{0.2}\text{Mn}_{0.2}\text{O}_2$.

FIG. 1 is a schematic fine structure of a secondary particle 12 included in a positive electrode active material for lithium batteries, according to an embodiment of the present invention.

Referring to FIG. 1, primary particles 11 agglomerate and form the secondary particle 12, and an amorphous material 13 (for example, lithium sulfate) is present along a grain boundary of the primary particles 11 at the surface of the secondary particle 12.

Hereinafter, a method of manufacturing the positive electrode active material, according to an embodiment of the present invention will be described in detail.

First, a lithium composite oxide and a lithium salt are mixed and then heat treated.

The heat treatment may be performed under an air atmosphere or an oxygen atmosphere.

The lithium composite oxide may be the compound represented by Formula 1. If an amount of nickel (1-x-y) in Formula 1 is equal to or greater than 0.7 and equal to or less than 1.25, the heat treatment is performed under an oxygen atmosphere. If the heat treatment is performed under an oxygen atmosphere, the positive electrode active material obtains a high capacity.

The lithium salt may be a lithium carbonate (Li_2CO_3), a lithium sulfate (Li_2SO_4), a lithium nitrate (LiNO_3), or a lithium hydroxide (LiOH).

The amount of the lithium salt may be controlled such that the amount of the lithium salt in the positive electrode active material is in the range of about 0.01 to about 10 parts by weight based on 100 parts by weight of the lithium composite oxide. For example, the amount of the lithium salt may be in the range of about 1 to about 1.1 mole, for example, about 1 to about 1.05 mole, based on 1 mole of the lithium composite oxide 1 mole.

If the amount of the lithium salt is in the range of about 0.01 to about 10 parts by weight based on 100 parts by weight of the lithium composite oxide, the positive electrode active material has a high thermal stability and a high capacity.

The heat treatment temperature may be in the range of about 700 to about 950°C, for example, about 850 to about 900°C. If the heat treatment temperature is in the range of about 700 to about 950°C, a positive electrode active material including the amorphous material may be obtained.

The amorphous material included in the positive electrode active material prepared as described above is identified by using a transmission electron microscope (TEM).

(The inventors are preparing analysis data with which presence of the amorphous material can be directly and/or indirectly identified)

In the positive electrode active material, the amorphous material increases diameters of primary particles by acting as a flux while maintaining capacity characteristics of the lithium composite oxide that is a primary particle during a heat treatment. When the diameters of primary particles are increased, a specific surface between the positive electrode active material and an electrolyte is reduced. Thus, the positive electrode active material has high thermal stability, a high residual capacity at a high temperature, and a high recovery capacity at a high temperature.

The capacity of the positive electrode active material may be 180 mAh/g or more.

The positive electrode oxide may further include a lithium transition metal oxide which is generally used in lithium batteries.

The lithium transition metal active material may include at least one material selected from the group consisting of LiCoO_2 , LiNiO_2 , LiMnO_2 , LiMn_2O_4 , $\text{Li}(\text{Ni}_a\text{Co}_b\text{Mn}_c)\text{O}_2$ where $0 < a < 1$, $0 < b < 1$, $0 < c < 1$, and $a+b+c=1$, $\text{LiNi}_{1-y}\text{Co}_y\text{O}_2$, $\text{LiCo}_{1-y}\text{Mn}_y\text{O}_2$, $\text{LiNi}_{1-y}\text{Mn}_y\text{O}_2$ where $0 \leq y < 1$, $\text{LiMn}_{2-z}\text{Ni}_z\text{O}_4$, $\text{LiMn}_{2-z}\text{Co}_z\text{O}_4$ where $0 < z < 2$, LiCoPO_4 , and LiFePO_4 .

According to an embodiment of the present invention, the lithium transition metal active material may be, for example, LiCoO_2 .

The amount of the lithium transition metal oxide may be in the range of about 0.1 to about 90 parts by weight based on 100 parts by weight of the positive electrode

active material including the secondary particles including the primary particles and the amorphous material.

If the amount of the lithium transition metal oxide is within the range described above, the positive electrode active material has a high capacity.

Hereinafter, a method of manufacturing a lithium battery including the positive electrode active material will be described, in particular, a lithium secondary battery including a positive electrode according to an embodiment of the present invention, a negative electrode, a lithium salt-containing non-aqueous electrolyte, and a separator will be described in detail.

The positive electrode is manufactured by coating and drying a composition for forming a positive electrode active material layer on a collector, and the negative electrode is manufactured by coating and drying a composition for forming a negative electrode active material layer on a collector.

The composition for forming a positive electrode active material layer may be prepared by mixing the positive electrode active material described above, a conducting agent, a binder, and a solvent.

The positive electrode active material may be used together with lithium transition metal oxides which are generally used as a positive electrode active material for lithium batteries as described above.

The binder is a component that enhances binding of the positive electrode active material to the conducting agent or to the collector. The amount of the binder may be in the range of about 1 to about 50 parts by weight based on 100 parts by weight of the total weight of the positive electrode active material. Examples of the binder include polyvinylidene fluoride, polyvinylalcohol, carboxymethylcellulose(CMC), starch, hydroxypropylcellulose, regenerated cellulose, polyvinylpyrrolidone, tetrafluoroethylene, polyethylene, polypropylene, ethylene-propylene-diene ter polymer(EPDM), sulfonated EPDM, styrene butylene rubber, fluoro rubber, and various copolymers. The amount of the binder may be in the range of about 2 to about 5 parts by weight based on 100 parts by weight of the positive electrode active material. If the amount of the binder is within the range described above, the positive active material layer is more strongly attached to the collector.

The conducting agent may be any conducting material that does not cause chemical changes in batteries. Examples of the conducting agent include graphite such as natural graphite or artificial graphite; a carbonaceous material such as carbon black, acetylene black, ketchen black, channel black, furnace black, lamp black, or summer black; a conducting fiber such as carbonaceous fiber or metal fiber; metal powder such as carbon fluoride powder, aluminum powder, or nickel powder; conducting whiskey such as zinc oxide or potassium titanate; and a conducting metal oxide such as a titanium oxide; and a conducting material such as a polyphenylene derivative.

The amount of the conducting agent may be in the range of about 2 to about 5 parts by weight based on 100 parts by weight of the total weight of the positive electrode active material. If the amount of the conducting agent is inside the range described above, the resultant electrode has high conductivity.

The solvent may be N-methylpyrrolidone.

The amount of the solvent may be in the range of about 1 to about 10 parts by weight based on 100 parts by weight of the total weight of the positive electrode active material. If the amount of the solvent is within the range described above, the positive active material layer may be easily formed.

The collector that is used to form the positive electrode may have a thickness of about 3 to about 500 μm , and may be formed using any material that does not cause chemical changes in batteries and has high conductivity. The collector may be formed using stainless steel, aluminum, nickel, titanium, heat treated carbon, or aluminum, or may be a stainless steel support that is surface-treated with carbon, nickel, titanium, or silver. The collector may have a corrugated surface and thus the positive electrode active material is more strongly attached thereto. The collector may have various forms, such as a film, a sheet, a foil, a net, a porous product, a foam, or a nonwoven fabric.

Separately, the composition for forming a negative electrode active material layer is prepared by mixing a negative electrode active material, a binder, a conducting agent, and a solvent.

The negative electrode active material may be a material capable of absorbing or desorbing lithium ions. Examples of the negative electrode active material include carbonaceous material such as graphite or carbon, lithium metal, alloys, and silicon oxides. According to an embodiment of the present invention, the negative electrode active material may be silicon oxide.

The amount of the binder may be in the range of about 1 to about 50 parts by weight based on 100 parts by weight of the total weight of the negative electrode active material. Examples of the binder may be the same as the examples described with the positive electrode.

The amount of the conducting agent may be in the range of about 1 to about 5 parts by weight based on 100 parts by weight of the total weight of the negative electrode active material. If the amount of the conducting agent is inside the range described above, the resultant electrode has high conductivity.

The amount of the solvent may be in the range of about 1 to about 10 parts by weight based on 100 parts by weight of the total weight of the negative electrode active material. If the amount of the solvent is within the range described above, the negative active material layer may be easily formed.

Examples of the conducting agent and the solvent may be the same as the examples described with the positive electrode.

The collector that is used to form the negative electrode may have a thickness of about 3 to about 500 μm . The negative electrode may be formed using any material that does not cause chemical changes in batteries and has high conductivity. The collector may be formed using copper, stainless steel, aluminum, nickel, titanium, heat treated carbon, or aluminum, or may be a stainless steel support that is surface-treated with carbon, nickel, titanium, or silver. The collector may have a corrugated surface and thus the negative electrode active material is more strongly attached thereto. The collector may have various forms, such as a film, a sheet, a foil, a net, a porous product, a foam, or a nonwoven fabric.

The separator is interposed between the positive electrode and the negative electrode.

The separator may have a porous diameter of about 0.01 to about 10 μm , and a thickness of about 5 to about 300 μm . The separator may be a sheet or a nonwoven fabric formed of an olefin-based polymer such as polypropylene or polyethylene, or glass fiber. If an electrolyte used is a solid electrolyte such as a polymer, the solid electrolyte may also act as the separator.

The lithium salt-containing non-aqueous electrolyte may include a non-aqueous electrolyte and lithium. The non-aqueous electrolyte may be a non-aqueous electrolytic solution, an organic solid electrolyte, or an inorganic solid electrolyte.

The non-aqueous electrolytic solution may be an aprotic organic solvent such as N-methyl-2-pyrrolidinone, propylene carbonate, ethylene carbonate, butylene carbonate, dimethyl carbonate, diethyl carbonate, gamma-butyrolactone, 1,2-dimethoxy ethane, 2-methyl tetrahydrofuran, dimethylsulfoxide, 1,3-dioxolane, formamide, dimethyl formamide, dioxolane, acetonitrile, nitromethane, methyl formate, methyl acetate, trimethyl phosphate, trimethoxy methane, dioxolane derivatives, sulfolane, methyl sulfolane, 1,3-dimethyl-2-imidazolidinone, propylene carbonate derivatives, tetrahydrofuran derivatives, ether, methyl propionate, or ethyl propionate.

Examples of the organic solid electrolyte include polyethylene derivatives, polyethylene oxide derivatives, polypropylene oxide derivatives, a phosphate ester polymer, polyester sulfide, polyvinyl alcohol, and polyvinylidene fluoride.

The inorganic solid electrolyte may be a nitrate, halide, or sulfate of lithium, such as Li_3N , LiI , Li_5NI_2 , $\text{Li}_3\text{N-LiI-LiOH}$, LiSiO_4 , $\text{LiSiO}_4\text{-LiI-LiOH}$, Li_2SiS_3 , Li_4SiO_4 , $\text{Li}_4\text{SiO}_4\text{-LiI-LiOH}$, or $\text{Li}_3\text{PO}_4\text{-Li}_2\text{S-SiS}_2$.

The lithium salt is a material that is easily dissolved in the non-aqueous electrolyte, and may be, for example, LiCl , LiBr , LiI , LiClO_4 , LiBF_4 , $\text{LiB}_{10}\text{Cl}_{10}$, LiPF_6 , LiCF_3SO_3 , LiCF_3CO_2 , LiAsF_6 , LiSbF_6 , LiAlCl_4 , $\text{CH}_3\text{SO}_3\text{Li}$, $\text{CF}_3\text{SO}_3\text{Li}$, $(\text{CF}_3\text{SO}_2)_2\text{NLi}$, lithiumchloroborate, lower aliphatic carbonic acid lithium, phenyl lithium tetraborate, or imide.

FIG. 2 is a schematic view of a lithium battery 30 according to an embodiment of the present invention.

Referring to FIG. 2, the lithium battery 30 includes a positive electrode 23, a negative electrode 22, a separator 24 interposed between the positive electrode 23 and

the negative electrode 22, a battery container 25, and an encapsulating member 26 for sealing the battery container 25, wherein the positive electrode 23, the negative electrode 22, and the separator 24 are impregnated with an electrolyte (not shown). The lithium battery 30 is formed by sequentially stacking the positive electrode 23, the separator 24, and the negative electrode 22 and then the stack structure is wound and placed in the battery container 25.

Hereinafter, one or more embodiments of the present invention will be described in detail with reference to the following examples. However, these examples are not intended to limit the purpose and scope of the one or more embodiments of the present invention.

Preparation Example 1: Preparation of positive electrode active material

() g of lithium sulfate Li_2SO_4 was added to () g of $\text{Li}_{0.6}\text{Co}_{0.2}\text{Mn}_{0.2}\text{O}_2$ that is a lithium composite oxide and the mixture was stirred.

The resultant was heat treated at a temperature of 800°C under an oxygen atmosphere, thereby forming a positive electrode active material including a secondary particle that includes a Li_2SO_4 non-aqueous layer formed along a grain boundary of adjacent primary particles.

Preparation Example 2: Preparation of positive electrode active material

A positive electrode active material was prepared in the same manner as in Preparation Example 1, except that the heat treatment temperature was 900°C instead of 800°C .

Preparation Example 3: Preparation of positive electrode active material

A positive electrode active material was prepared in the same manner as in Preparation Example 1, except that the heat treatment temperature was 700°C instead of 800°C .

Preparation Example 4: Preparation of positive electrode active material

A positive electrode active material was prepared in the same manner as in Preparation Example 1, except that the heat treatment temperature was 950°C instead

of 800□.

Preparation Example 5: Preparation of positive electrode active material

A positive electrode active material was prepared in the same manner as in Preparation Example 1, except that () g of Li_2SO_4 was used.

(The inventors are preparing data for Preparation Examples and Examples in which the amount of lithium sulfide is different from that in Preparation Example 1)

Comparative Preparation Example 1: Preparation of positive electrode active material

A positive electrode active material was prepared in the same manner as in Preparation Example 1, except that the heat treatment temperature was 1000□ instead of 800□.

Comparative Preparation Example 2: Preparation of positive electrode active material

A positive electrode active material was prepared in the same manner as in Preparation Example 1, except that the heat treatment temperature was 650□ instead of 800□

(The inventors are preparing data for Comparative Preparation Example)

The positive electrode active materials prepared according to Preparation Examples 1 and 2 and Comparative Preparation Example 1 were analyzed using a scanning electron microscope (SEM) (about 40,000 magnifications), and the enlarged images are shown in FIGS. 3 through 5.

(A SEM image corresponding to Comparative Preparation Example 2 will be provided.)

FIGS. 3 and 4 are SEM images of the positive electrode active materials prepared according to Preparation Example 1 and Preparation Example 2, and FIG. 5 is a SEM image of the positive electrode active material prepared according to Comparative Preparation Example 1.

Referring to FIGS. 3 through 5, it can be seen that the positive electrode active materials prepared according to Preparation Example 1 and Preparation Example 2 include a non-amorphous layer formed of lithium sulfate between adjacent primary particles, and the positive electrode active material prepared according to Comparative Preparation Example 1 does not include a non-amorphous layer between adjacent primary particles.

With regard to the positive electrode active materials prepared according to Preparation Examples 1 through 5 and Comparative Preparation Example 1, an average diameter of primary particles and an average diameter of secondary particles were measured. The results are shown in Table 1. The average diameters of the primary particles and secondary particles were measured by referring to the SEM images of the positive electrode active materials.

(The inventors are preparing data for Table 1 below)

[Table 1]

	Average diameter of primary particles (nm)	Average diameter of secondary particles (nm)
Preparation Example 1		12
Preparation Example 2		13
Preparation Example 3		
Preparation Example 4		
Preparation Example 5		
Comparative Preparation Example 1		

Referring to Table 1, it can be seen that the average diameter of primary particles of each of the positive electrode active materials prepared according to Preparation Examples 1 through 5 is greater than that of primary particles of the positive electrode

active material prepared according to Comparative Preparation Example 1. When an average diameter of primary particles is increased as described above, a specific surface of the positive electrode active material with respect to an electrolyte is reduced. Thus, excellent thermal stability, a residual capacity at a high temperature, and a recovery capacity at a high temperature may be obtained.

Thermal stability of the positive electrode active materials prepared according to Preparation Example 1 and Comparative Preparation Example 1 was evaluated using a differential scanning calorimeter.

The evaluation results are shown in FIG. 6.

Referring to FIG. 6, the positive electrode active material of Preparation Example 1 emits heat less than the positive electrode active material of Comparative Preparation Example 1. Thus, it can be seen that the thermal stability of the positive electrode active material of Preparation Example 1 is improved.

Example 1: Manufacturing of positive electrode and lithium secondary battery including the same

4.75 g of the positive electrode active material prepared according to Preparation Example 1, 0.15 g of polyvinylidene fluoride, and 0.15 g of a carbon black were dispersed in 2.5 g of N-methylpyrrolidone, thereby preparing a composition for forming a positive electrode active material layer.

The composition was coated on an aluminum foil, thereby forming a thin polar plate having a thickness of 60 μm , and then dried at a temperature of 135 $^{\circ}\text{C}$ for 3 hours or more, and then the dried polar plate was pressed, thereby manufacturing a positive electrode.

Separately, a negative electrode was manufactured as follows.

SiO and a polyvinylidene fluoride were mixed in a weight ratio of 96:4 in an N-methylpyrrolidone, thereby preparing a composition for forming a negative electrode active material layer. The composition was coated on a copper foil, thereby forming a thin polar plate having a thickness of 14 μm and then the formed thin polar plate was dried at a temperature of 135 $^{\circ}\text{C}$ for 3 hours or more and then pressed, thereby manufacturing a negative electrode.

In order to prepare an electrolyte, 1.3M LiPF_6 was added to a solvent including ethylenecarbonate(EC), ethylmethyl carbonate(EMC), and dimethylcarbonate(DMC) in a volume ratio of 1:1:1.

A porous polyethylene(PE) film that is a separator was disposed between the positive electrode and the negative electrode, thereby forming a battery assembly. The battery assembly was wound and compressed and the resultant structure was placed in a battery case and then the electrolyte was injected thereto, thereby manufacturing a lithium secondary battery having a capacity of 2600 mAh.

Examples 2-5: Manufacturing of positive electrodes and lithium secondary batteries including the same

Lithium secondary batteries were manufactured in the same manner as in Example 1, except that positive electrodes were manufactured using the positive electrode active materials prepared according to Preparation Examples 2 through 5 instead of the primary particle prepared according to Preparation Example 1.

Comparative Example 1: Manufacturing of positive electrode and lithium secondary battery including the same

A lithium secondary battery was manufactured in the same manner as in Example 1, except that $\text{Li}_{0.6}\text{Co}_2\text{Mn}_{0.2}\text{O}_2$ that is a lithium composite oxide was used instead of the positive electrode active material prepared according to Preparation Example 1.

Comparative Example 2: Manufacturing of positive electrode and lithium secondary battery including the same

A lithium secondary battery was manufactured in the same manner as in Example 1, except that the positive electrode active material according to Comparative Preparation Example 1 was used instead of the positive electrode active material prepared according to Preparation Example 1.

Comparative Example 3: Manufacturing of positive electrode and lithium secondary battery including the same

A lithium secondary battery was manufactured in the same manner as in Example

1, except that the positive electrode active material according to Comparative Preparation Example 2 was used instead of the positive electrode active material prepared according to Preparation Example 1.

The residual capacity at a high temperature and recovery capacity at a high temperature of the lithium secondary batteries manufactured according to Examples 1 through 5 and Comparative Examples 1 through 3 were evaluated. The result is shown in Table 1.

The residual capacity at a high temperature and the recovery capacity at a high temperature were evaluated as follows.

1) Residual capacity at a high temperature

(An evaluation method will be added)

2) Recovery capacity at a high temperature

The lithium secondary batteries were left to sit at a temperature of 60□ for 25 days and then an initial capacity of the lithium secondary batteries at 0.5 C was measured.

(An evaluation method will be added)

[Table 2]

	Residual capacity (%)	Recovery capacity(%)
Example 1	113	103
Example 2		
Example 3		
Example 4		
Example 5		
Comparative Example 1	100	100

Comparative Example 2		
Comparative Example 3		

(The residual capacity and recovery capacity data of the lithium secondary batteries manufactured according to Examples 2 through 5 and Comparative Examples 2 through 3 are being prepared)

Referring to Table 2, it can be seen that the lithium secondary battery manufactured according to Example 1 has higher residual capacity and recovery capacity than that of Comparative Example 1.

(The inventors are preparing data that supports an improvement of battery efficiency)

It should be understood that the exemplary embodiments described therein should be considered in a descriptive sense only and not for purposes of limitation. Descriptions of features or aspects within each embodiment should typically be considered as available for other similar features or aspects in other embodiments.

【BRIEF DESCRIPTION OF THE DRAWINGS】

FIG. 1 is a schematic fine structure of a secondary particle included in a positive electrode active material for lithium batteries, according to an embodiment of the present invention.

FIG. 2 is a schematic view of a lithium battery according to an embodiment of the present invention.

FIG. 3 is a scanning electron microscope (SEM) image of a positive electrode active material prepared according to Preparation Example 1.

FIG. 4 is a SEM image of a positive electrode active material prepared according to Preparation Example 2.

FIG. 5 is a SEM image of a positive electrode active material prepared according to Comparative Preparation Example 1.

FIG. 6 is a graph of analysis results of positive electrode active materials material prepared according to Preparation Example 1 and Comparative Preparation Example 1

evaluated using a differential scanning calorimeter.

FIG. 1

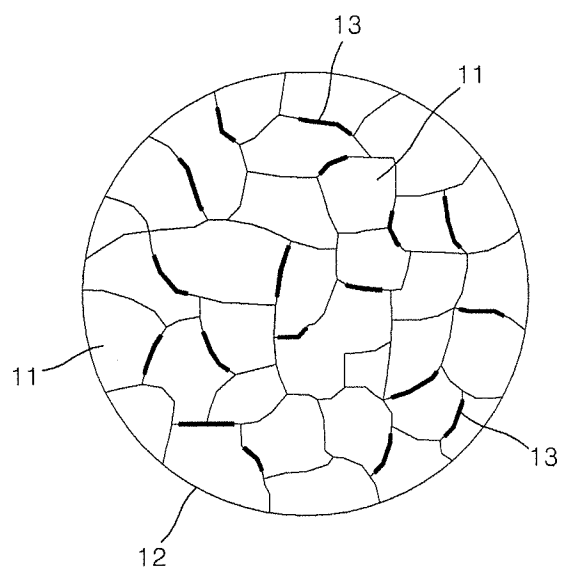


FIG. 2

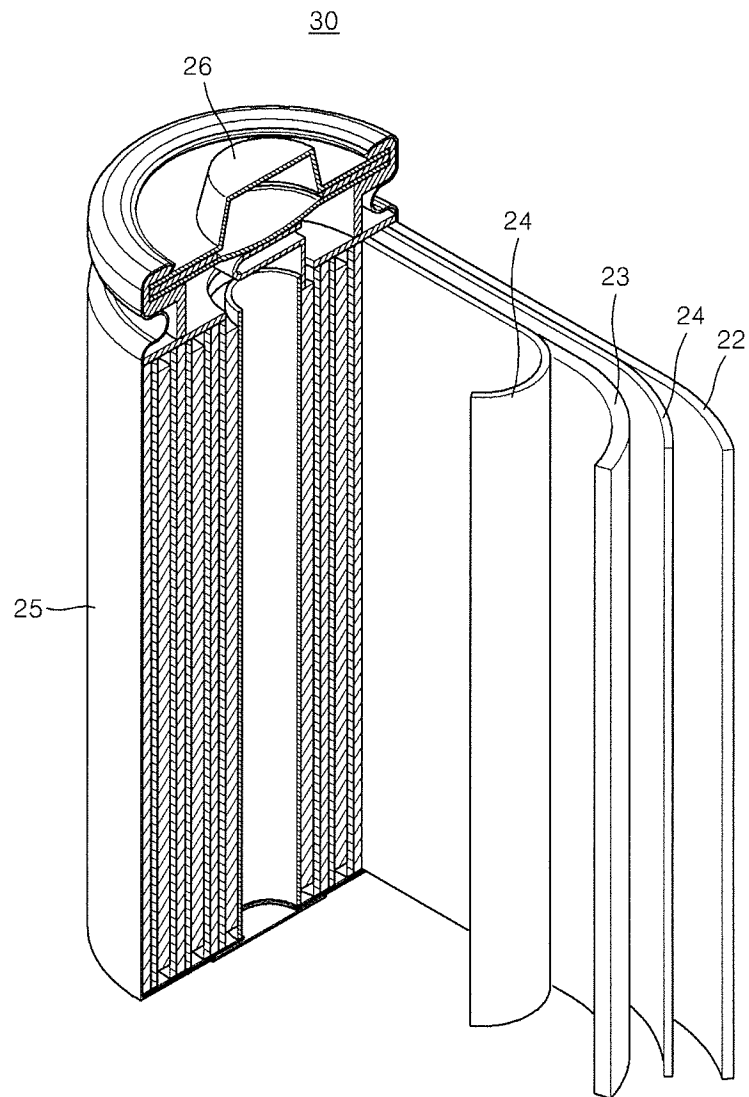


FIG. 3

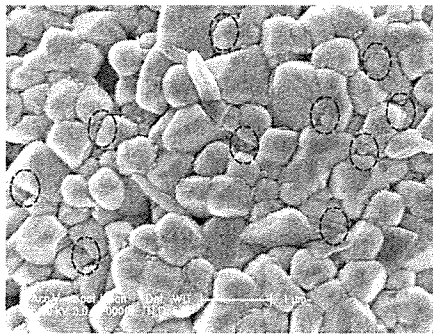


FIG. 4

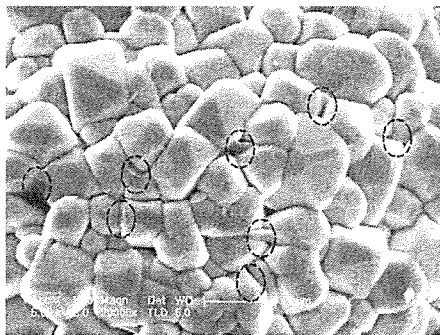


FIG. 5

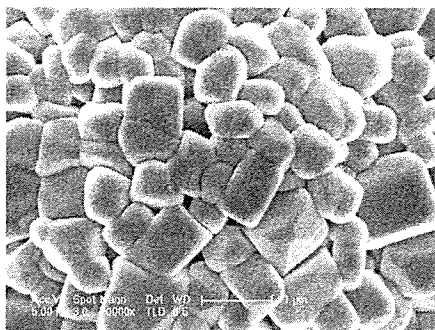
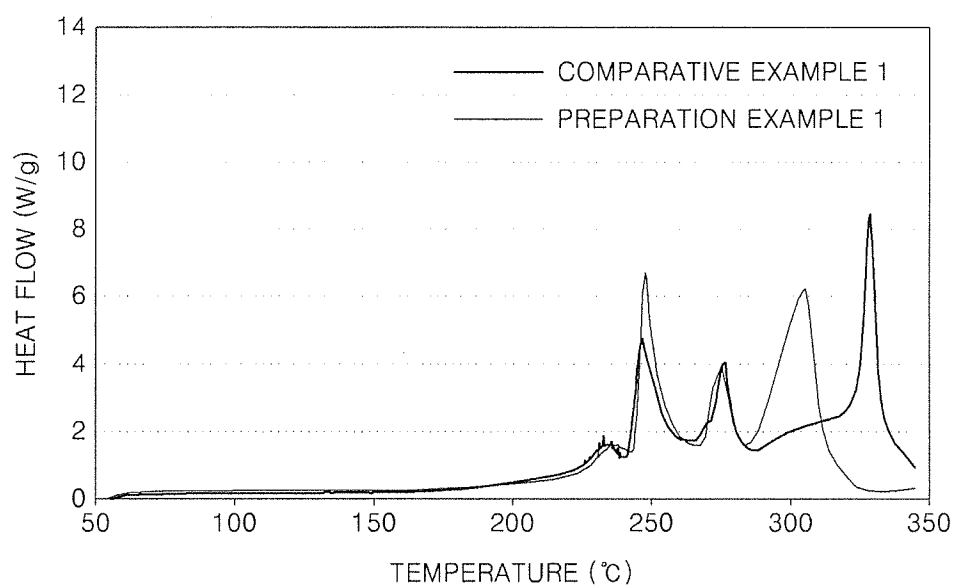


FIG. 6



Electronic Acknowledgement Receipt

EFS ID:	6886371
Application Number:	61285785
International Application Number:	
Confirmation Number:	1031
Title of Invention:	POSITIVE ELECTRODE ACTIVE MATERIAL FOR LITHIUM BATTERY AND LITHIUM BATTERY USING THE SAME
First Named Inventor/Applicant Name:	Do-Hyung Park
Customer Number:	23363
Filer:	Jun-Young E. Jeon/Alex Martinez
Filer Authorized By:	Jun-Young E. Jeon
Attorney Docket Number:	64781/L550
Receipt Date:	26-JAN-2010
Filing Date:	11-DEC-2009
Time Stamp:	19:27:18
Application Type:	Provisional

Payment information:

Submitted with Payment	no
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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Miscellaneous Incoming Letter	64781_English_Trans.pdf	14933 c7a46efe0bf0475500d2ebbb5e10670ca59dcd9a	no	1

Warnings:

Information:

POSCO Future M v. TIAX LLC

POSCO Future M EX1025

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2		64781_English.pdf	316189 eab8c7143bd30bc407244c165b640739017733ec	yes	24
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Appendix to the Specification		1	1	
	Abstract		2	2	
	Specification		3	19	
	Drawings-only black and white line drawings		20	24	
Warnings:					
Information:					
Total Files Size (in bytes):			331122		
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. <u>New Applications Under 35 U.S.C. 111</u> 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. <u>National Stage of an International Application under 35 U.S.C. 371</u> 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. <u>New International Application Filed with the USPTO as a Receiving Office</u> 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

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
61/285,785	12/11/2009		220	64781/L550		

CONFIRMATION NO. 1031

23363
CHRISTIE, PARKER & HALE, LLP
PO BOX 7068
PASADENA, CA 91109-7068

FILING RECEIPT



Date Mailed: 01/07/2010

Receipt is acknowledged of this provisional patent application. It will not be examined for patentability and will become abandoned not later than twelve months after its filing date. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Applicant(s)

Do-Hyung Park, Suwon-si, KOREA, REPUBLIC OF;
Seon-Young Kwon, Suwon-si, KOREA, REPUBLIC OF;
Min-Han Kim, Suwon-si, KOREA, REPUBLIC OF;
Ji-Hyun Kim, Suwon-si, KOREA, REPUBLIC OF;
Chang-Hyuk Kim, Suwon-si, KOREA, REPUBLIC OF;
Yoon-Chang Kim, Suwon-si, KOREA, REPUBLIC OF;
Jeong-Seop Lee, Suwon-si, KOREA, REPUBLIC OF;

Power of Attorney:

Jun-Young Jeon--43693

Permission to Access - A proper **Authorization to Permit Access to Application by Participating Offices** (PTO/SB/39 or its equivalent) has been received by the USPTO.

If Required, Foreign Filing License Granted: 01/06/2010

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 61/285,785**

Projected Publication Date: None, application is not eligible for pre-grant publication

Non-Publication Request: No

Early Publication Request: No

Title

POSITIVE ELECTRODE ACTIVE MATERIAL FOR LITHIUM BATTERY AND LITHIUM BATTERY
USING THE SAME

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4158).

LICENSE FOR FOREIGN FILING UNDER**Title 35, United States Code, Section 184****Title 37, Code of Federal Regulations, 5.11 & 5.15****GRANTED**

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The

date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

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UNITED STATES PATENT AND TRADEMARK OFFICE

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www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
61/285,785	12/11/2009	Do-Hyung Park	64781/L550

23363
CHRISTIE, PARKER & HALE, LLP
PO BOX 7068
PASADENA, CA 91109-7068

CONFIRMATION NO. 1031
IMPROPER PROVISIONAL LETTER



Date Mailed: 01/07/2010

Letter re Non-English Language Application Papers in a Provisional Application

The above-identified provisional application was filed in a language other than English. An English-language translation of a non-English provisional application and a statement that the translation is accurate must be filed in the provisional application. See 37 CFR 1.78(a)(5)(iv). Applicants are strongly encouraged to file the English-language translation of the provisional application and the statement that the translation is accurate in the provisional application before a nonprovisional application claiming the benefit of the provisional application is filed, or, alternatively, when making a claim for the benefit of the provisional application in a nonprovisional application. If, however, an English translation and a statement that the translation is accurate have not been filed in the above-identified provisional application when a nonprovisional application is filed claiming the benefit of the filing date of the provisional application, the Office should mail a Notice requiring an English translation and the statement to be filed in the provisional application and a confirmation to be filed in the nonprovisional application.

In the event that the Office schedules a nonprovisional application that claims the benefit of a provisional application filed in a language other than English for publication without issuing a Notice requiring the applicant to file an English translation of the non-English provisional application, the applicant should file the English translation of the non-English provisional application and a statement that the translation is accurate as soon as possible in the provisional application.

/nprasadouk/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

PROVISIONAL APPLICATION COVER SHEET [37 CFR 1.53(c)]

This is a request for filing a PROVISIONAL APPLICATION under 35 U.S.C. §111(b) and 37 CFR 1.51(a)(2)

I hereby certify that this correspondence is being electronically filed with the United States Patent and Trademark Office on December 11, 2009 at or before 11:59 p.m. Eastern Standard Time under the Rules of 37 CFR § 1.10.

Carol L. Burchfield
Carol L. Burchfield

Date : December 11, 2009

Docket No. : 64781/L550

INVENTOR(S)/APPLICANT(S) (LAST NAME, FIRST NAME, MIDDLE INITIAL, RESIDENCE (CITY AND EITHER STATE OR FOREIGN COUNTRY))

PARK, DO-HYUNG; Suwon-si, Republic of Korea
KWON, SEON-YOUNG; Suwon-si, Republic of Korea
KIM, MIN-HAN; Suwon-si, Republic of Korea
KIM, JI-HYUN; Suwon-si, Republic of Korea
KIM, CHANG-HYUK; Suwon-si, Republic of Korea

 X Additional inventors are being named on separately numbered sheets attached hereto.

TITLE OF THE INVENTION (500 characters max)

POSITIVE ELECTRODE ACTIVE MATERIAL FOR LITHIUM BATTERY AND LITHIUM BATTERY
USING THE SAME

ENCLOSED APPLICATION PARTS

 28 Specification (number of pages)
 5 Drawings (number of sheets)
 Assignment
 X Other (specify): SB39

FEE AND METHOD OF PAYMENT

 X Please deduct the filing fee of \$220.00 from our Deposit Account No. 03-1728. No application size fee payment.

 X The Commissioner is hereby authorized to charge any fees under 37 CFR 1.16 and 1.17 which may be required during the **entire pendency** of the application to Deposit Account No. 03-1728. Please show our docket number with any charge or credit to our Deposit Account.

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

 X No
 Yes, the name of the U.S. Government agency and the Government contract number are:
—

CORRESPONDENCE ADDRESS

Please address all correspondence to the address corresponding to **CUSTOMER NUMBER 23363**, the

PROVISIONAL APPLICATION COVER SHEET [37 CFR 1.53(c)]

This is a request for filing a PROVISIONAL APPLICATION under 35 U.S.C. §111(b) and 37 CFR 1.51(a)(2)

Docket No. 64781/L550

practitioners associated with the law firm of Christie, Parker & Hale, LLP, who are authorized to transact all business in the U.S. Patent and Trademark Office connected with this application.

Respectfully submitted,

CHRISTIE, PARKER & HALE, LLP

By 
Jun-Young E. Jeon
Reg. No. 43,693
626/795-9900

PROVISIONAL APPLICATION FILING ONLY

JEJ/clb

PROVISIONAL APPLICATION COVER SHEET [37 CFR 1.53(c)]

This is a request for filing a PROVISIONAL APPLICATION under 35 U.S.C. §111(b) and 37 CFR 1.51(a)(2)

Docket No. 64781/L550

ADDITIONAL INVENTORS

(LAST NAME, FIRST NAME, MIDDLE INITIAL, RESIDENCE (CITY AND EITHER STATE OR FOREIGN COUNTRY))

KIM, YOON-CHANG, Suwon-si, Republic of Korea

LEE, JEONG-SEOP, Suwon-si, Republic of Korea

AUTHORIZATION TO PERMIT ACCESS TO APPLICATION BY PARTICIPATING OFFICES

COMPLETE IF KNOWN

Send completed form to: Commissioner for Patents
P.O. Box 1450, Alexandria, VA 22313-1450

Application Number	TBA
Filing Date	December 11, 2009
First Named Inventor	Do-Hyung Park, et al.
Attorney Docket Number	64781
Title (Required)	POSITIVE ELECTRODE ACTIVE MATERIAL FOR LITHIUM...

The undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the above-identified patent application is filed access to the above-identified patent application. See 37 CFR 1.14(c) and (h).

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the above-identified application with respect to: 1) the above-identified patent application-as-filed; 2) any foreign application to which the above-identified patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the above-identified patent application; and 3) any U.S. application-as-filed from which benefit is sought in the above-identified patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date of filing the Authorization to Permit Access to Application by Participating Offices.

This written authorization should be submitted prior to the filing of a subsequent foreign application, in which priority is claimed to the above-identified patent application, with any intellectual property office (e.g., the EPO, JPO, KIPO, or DAS Accessing Office). However, if applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the above-identified patent application is filed to have access to the above-identified patent application, this written authorization should not be filed.

No fee will be charged under 37 CFR 1.19(b)(1) for providing a participating intellectual property office with an electronic copy of the above-identified patent application.

This form must be signed by an authorized party in accordance with 37 CFR 1.14(c).

Jun-Young E. Jeon

Signature

December 11, 2009

Date

Jun-Young E. Jeon

Printed or Typed Name

(626)795-9900

Telephone Number

Attorney of Record

Title

43693

Registration Number, if applicable

This collection of information is required by 37 CFR 1.14(h). 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: 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.

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 the Freedom of Information Act requires disclosure of these records.
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 inspections 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.

【요약】

1 차 입자와 비정질 물질을 포함하는 2 차 입자를 갖는 리튬 전지용 양극 활물질, 그 제조방법과 상기 리튬 전지용 양극 활물질을 포함하는 양극을 채용한 리튬전지가 제시된다.

【대표도】

도 1

【명세서】

【발명의 명칭】

리튬 전지용 양극 활물질, 그 제조방법 및 이를 이용한 리튬 전지

【발명의 상세한 설명】

【기술분야】

리튬 전지용 양극 활물질, 그 제조방법 및 이를 이용한 리튬 전지에 관한 것이다.

【배경기술】

최근의 휴대용 소형 전자기기의 전원으로서 각광받고 있는 리튬 이차 전지는 유기 전해액을 사용하여 기존의 알칼리 수용액을 사용한 전지보다 2 배 이상의 높은 방전 전압을 보임으로써 높은 에너지 밀도를 나타내는 전지이다.

리튬 이차 전지는 리튬 이온의 삽입 및 탈리가 가능한 물질을 음극 및 양극으로 사용하고, 상기 양극 및 음극 사이에 유기 전해액 또는 폴리머 전해액을 충전시켜 제조하며, 리튬 이온이 양극 및 음극에서 삽입 및 탈리될 때의 산화반응, 환원반응에 의하여 전기적 에너지를 생성한다.

리튬 이차 전지의 양극 활물질로는 LiCoO_2 가 널리 사용된다.

그런데 LiCoO_2 는 제조비용이 많이 들고, 안정적 공급이 어렵다. 따라서 이를 대체할 수 있는 물질로서 니켈 또는 망간을 복합적으로 사용된 양극 활물질이 개발되고 있다.

그런데 현재까지 개발된 양극 활물질은 잔존용량, 회복용량 및 열적 안정성이 만족할만한 수준에 도달하여 개선의 여지가 많다.

【발명의 내용】

【해결하고자 하는 과제】

본 발명의 한 측면은 용량 및 열적 안정성을 동시에 향상시킬 수 있는 리튬 전지용 양극 활물질 및 그 제조방법을 제공하는 것이다.

본 발명의 다른 측면은 상기 양극 활물질을 채운 리튬 전지를 제공하는 것이다.

【과제 해결 수단】

본 발명의 한 측면에 따라 1 차 입자와 비정질 물질을 포함하는 2 차 입자를 포함하며,

상기 1 차 입자가 리튬 복합 산화물인 리튬 전지용 양극 활물질이 제공된다.

본 발명의 다른 측면에 따라, 리튬 복합 산화물에 리튬염을 혼합 및 교반하는 단계; 및

상기 결과물을 700 내지 950°C에서 열처리하는 단계;를 포함하여

1 차 입자와 비정질 물질을 포함하는 2 차 입자를 함유하며, 상기 1 차 입자가 리튬 복합 산화물인 리튬 전지용 양극 활물질을 제조하는 리튬전지용 양극 활물질의 제조방법이 제공된다.

본 발명의 또 다른 측면에 따라 양극, 음극 및 이들 사이에 개재된

세퍼레이타를 포함하는 리튬 전지에 있어서,

상기 양극이,

상술한 양극 활물질을 포함하는 리튬 전지가 제공된다.

【효과】

본 발명의 일구현예에 따른 리튬 전지용 양극 활물질은 양극 활물질과 전해액간의 비표면적이 감소되도록 1 차 입자의 평균 입경이 제어되어 열적 안정성과, 고온에서의 잔존용량 및 보존용량이 모두 우수하다.

【발명의 실시를 위한 구체적인 내용】

본 발명의 일구현예에 따른 리튬 전지용 양극 활물질은 1 차 입자와 비정질 물질을 포함하는 2 차 입자를 포함하며, 상기 1 차 입자가 리튬 복합 산화물이다.

상기 비정질 물질은 인접하는 1 차 입자간의 계면(grain boundary)사이에 존재할 수 있고, 비정질 물질층 형태로 존재가능하다. 이 때 상기 1 차 입자간의 계면은 2 차 입자의 내부에 존재한다.

용어 “1차 입자”는 서로 응집되어 2차 입자를 형성하며, 1차 입자는 로드(rod)형에서 사각형까지 다양한 형태를 가질 수 있다.

용어 “2차 입자”는 더 이상 응집되지 않은 입자를 말하며, 구형 특성을 갖고 있다.

상기 비정질 물질의 비제한적인 예로서, 리튬염을 들 수 있다.

상기 리튬염으로는, 황산리튬, 질산리튬 또는 수산화리튬이 있다.

상기 비정질 물질의 함량은 리튬 복합 산화물 100 중량부를 기준으로 하여 0.01 내지 10 중량부, 예를 들어 0.1 내지 2 중량부이다. 비정질 물질의 함량이 상기 범위인 경우, 양극 활물질의 용량 특성이 우수하다.

상기 1 차 입자의 평균 입경은 1 내지 3 μm 이고, 2 차 입자의 평균 입경은 10 내지 15 μm 이다. 여기에서 평균 입경은 레이저 회절식의 입자 분포 측정 장치를 이용한다.

상기 1 차 입자의 평균 입경이 상기 범위인 경우, 양극 활물질과 전해액과의 비표면적이 감소되어 열적 안정성 및 용량 특성이 우수하다.

상기 2 차 입자의 평균 입경이 상기 범위인 경우, 양극 활물질의 열적 안정성 및 용량 특성이 우수하다.

상기 리튬 복합 산화물은 예를 들어 하기 화학식 1 로 표시되는 화합물로 표시된다.

<화학식 1>



상기식중, $0.85 \leq x \leq 1.25$, $0 \leq y \leq 0.5$, $0 < z \leq 0.5$, $0 < y+z \leq 1$,

Me는 알루미늄(Al), 망간(Mn), 티타늄(Ti) 및 칼슘(Ca)으로 이루어진 군으로부터 선택된다.

예를 들어, $0.9 \leq x \leq 1.1$, $0.1 \leq y \leq 0.5$, $0.1 \leq z \leq 0.5$, $0.2 < y+z \leq 0.75$ 일 수 있으나, 이에 한정되는 것은 아니다.

상기 리튬 복합 산화물은 $\text{Li}_{0.6}\text{Co}_{0.2}\text{Mn}_{0.2}\text{O}_2$, $\text{LiNi}_{0.5}\text{Co}_{0.2}\text{Mn}_{0.3}\text{O}_2$, 또는 $\text{LiNi}_{0.6}\text{Co}_{0.2}\text{Mn}_{0.2}\text{O}_2$ 일 수 있다.

도 1 은 본 발명의 일구현예에 따른 리튬 전지용 양극 활물질에 있어서, 2 차 입자의 미세 구조를 개념적으로 나타낸 도면이다.

이를 참조하면, 1 차 입자 11 이 응집되어 2 차 입자 12 를 형성하고, 1 차 입자 11 간의 계면에 비정질 물질 13(예를 들어, 황산리튬)이 형성되어 있다.

이하, 본 발명의 일구현예에 따른 리튬 전지용 양극 활물질의 제조방법을 설명하기로 한다.

먼저, 리튬 복합 산화물과 리튬염을 혼합하고, 이를 열처리한다.

상기 열처리는 공기 분위기 또는 산소 분위기 하에서 실시할 수 있다.

상기 리튬 복합 산화물은 상술한 바와 같이 화학식 1로 표시되는 화합물을 사용할 수 있다. 화학식 1에서 니켈의 함량(1-x-y)이 0.7 이상인 화합물을 사용하는 경우에는 상기 열처리시 산소 분위기하에서 실시한다. 이와 같이 산소 분위기하에서 실시한 경우, 양극 활물질의 용량 특성이 우수하다.

상기 리튬염으로는 탄산리튬(Li_2CO_3), 황산리튬(Li_2SO_4), 질산리튬(LiNO_3), 수산화리튬(LiOH) 등을 사용한다.

상기 리튬염의 함량은 최종적으로 얻은 양극 활물질에서 리튬 복합 산화물 100 중량부를 기준으로 하여 0.01 내지 10 중량부의 리튬염이 포함되도록 사용한다. 예를 들어 상기 리튬염의 함량은, 리튬 복합 산화물 1몰을 기준으로 하여 1 내지 1.1몰, 예를 들어 1 내지 1.05몰을 사용한다.

상기 리튬염의 함량이 상기 범위일 때, 최종적으로 얻은 양극 활물질의 열적

안정성 및 용량 특성이 우수하다.

상기 열처리시 온도는 700 내지 950°C, 예를 들어 850 내지 900°C이다.

열처리 온도가 상기 범위일 때 비정질 물질을 갖는 양극 활물질을 얻을 수 있다.

상기 과정에 따라 제조된 양극 활물질에서 비정질

물질은, 투과전자현미경(Transmission Electron Microscope TEM:), () 등을 통하여

확인가능하다.

(발명자가 최종적으로 얻은 양극 활물질의 분석 데이터중 비정질 물질의 존재를 직접적으로 및/또는 간접적으로 확인할 수 있는 분석 데이터를 보충하고 있는 중입니다.)

상기 양극 활물질에서 비정질물질은 1 차 입자인 리튬 복합 산화물의 용량 특성을 그대로 유지하면서 열처리시 용제로서 작용하여 1 차 입자의 입경을 증가하는 방향으로 제어한다. 이와 같이 1차 입자의 입경이 증가되면 양극 활물질과 전해액과의 비표면적이 감소되어 열적 안정성이 확보되고 고온에서의 잔존용량 및 회복용량이 우수하다.

상기 양극 활물질은 용량이 180mAh/g 이상으로 우수하다.

상기 리튬 전지용 양극 활물질은 리튬 전지에서 통상적으로 사용하는 리튬 전이 금속 산화물을 더 포함할 수 있다.

상기 리튬 전이금속 활물질로는 LiCoO_2 , LiNiO_2 , LiMnO_2 , LiMn_2O_4 , $\text{Li}(\text{Ni}_a\text{Co}_b\text{Mn}_c)\text{O}_2$ ($0 < a < 1$, $0 < b < 1$, $0 < c < 1$, $a+b+c=1$), $\text{LiNi}_{1-Y}\text{Co}_Y\text{O}_2$, $\text{LiCo}_{1-Y}\text{Mn}_Y\text{O}_2$, $\text{LiNi}_{1-Y}\text{Mn}_Y\text{O}_2$ (여기에서, $0 \leq Y < 1$), $\text{LiMn}_{2-Z}\text{Ni}_Z\text{O}_4$, $\text{LiMn}_{2-Z}\text{Co}_Z\text{O}_4$ (여기에서, $0 < Z < 2$), LiCoPO_4 , 및 LiFePO_4 로 이루어진 군으로부터 1종 이상 선택되는 것을 사용할 수 있다.

본 발명의 일구현예에 따르면, 상기 리튬 전이금속 산화물은 예를 들어 LiCoO_2 를 사용한다.

상기 리튬 전이금속 산화물의 함량은 상기 1차 입자와 비정질 물질을 포함하는 2차 입자를 갖는 양극 활물질 100 중량부를 기준으로 하여 0.1 내지 90 중량부이다.

상기 리튬 전이금속 산화물의 함량이 상기 범위일 때, 양극 활물질의 용량 특성이 우수하다.

이하, 상기 리튬 전지용 양극 활물질을 이용한 리튬 전지를 제조하는 과정을

살펴 보기로 하되, 본 발명의 일구현예에 따른 양극, 음극, 리튬염 함유 비수전해질, 및 세퍼레이터를 갖는 리튬 이차 전지의 제조방법을 기술하기로 한다.

양극 및 음극은 집전체상에 양극 활물질층 형성용 조성물 및 음극 활물질층 형성용 조성물을 각각 도포 및 건조하여 제작된다.

상기 양극 활물질 형성용 조성물은 상술한 양극 활물질, 도전제, 바인더 및 용매를 혼합하여 제조된다.

상기 양극 활물질로는 상술한 바와 같이 리튬 전지에서 양극 활물질로서 통상적으로 사용되는 리튬 전이금속 산화물을 함께 사용할 수 있다.

상기 바인더는, 활물질과 도전제 등의 결합과 집전체에 대한 결합에 조력하는 성분으로서, 양극 활물질의 총중량 100 중량부를 기준으로 1 내지 50 중량부로 첨가된다. 이러한 바인더의 예로는, 폴리불화비닐리덴, 폴리비닐알코올, 카르복시메틸셀룰로우즈(CMC), 전분, 히드록시프로필셀룰로우즈, 재생 셀룰로우즈, 폴리비닐피롤리돈, 테트라플루오로에틸렌, 폴리에틸렌, 폴리프로필렌, 에틸렌-프로필렌-디엔 테르 폴리머(EPDM), 술폰화 EPDM, 스티렌 브티렌 고무, 불소 고무, 다양한 공중합체 등을 들 수 있다. 그 함량은 양극 활물질의 총중량 100

중량부를 기준으로 하여 2 내지 5 중량부를 사용한다. 바인더의 함량이 상기 범위일 때 집전체에 대한 활물질층의 결합력이 양호하다.

상기 도전제로는 당해 전지에 화학적 변화를 유발하지 않으면서 도전성을 가진 것이라면 특별히 제한되는 것은 아니며, 예를 들어, 천연 흑연이나 인조 흑연 등의 흑연; 카본블랙, 아세틸렌 블랙, 케첸 블랙, 채널 블랙, 퍼네이스 블랙, 램프 블랙, 서머 블랙 등의 카본계 물질; 탄소 섬유나 금속 섬유 등의 도전성 섬유; 불화 카본, 알루미늄, 니켈 분말 등의 금속 분말; 산화아연, 티탄산 칼륨 등의 도전성 위스키; 산화 티탄 등의 도전성 금속 산화물; 폴리페닐렌 유도체 등의 도전성 소재 등이 사용될 수 있다.

상기 도전제의 함량은 양극 활물질의 총중량 100 중량부를 기준으로 하여 2 내지 5 중량부를 사용한다. 도전제의 함량이 상기 범위일 때 최종적으로 얻어진 전극의 전도도 특성이 우수하다.

상기 용매로는 N-메틸피롤리돈 등을 사용한다.

상기 용매의 함량은 양극 활물질 100 중량부를 기준으로 하여 1 내지 10 중량부를 사용한다. 용매의 함량이 상기 범위일 때 활물질층을 형성하기 위한 작업이 용이하다.

상기 양극 집전체는 3 내지 500 μm 의 두께로서, 당해 전지에 화학적 변화를 유발하지 않으면서 높은 도전성을 가지는 것이라면 특별히 제한되는 것은 아니며, 예를 들어, 스테인레스 스틸, 알루미늄, 니켈, 티탄, 열처리 탄소, 또는 알루미늄이나 스테리인레스 스틸의 표면에 카본, 니켈, 티탄, 은 등으로 표면처리한 것 등이 사용될 수 있다. 집전체는 그것의 표면에 미세한 요철을 형성하여 양극 활물질의 접착력을 높일 수도 있으며, 필름, 시트, 호일, 네트, 다공질체, 발포체, 부직포체 등 다양한 형태가 가능하다.

이와 별도로 음극 활물질, 바인더, 도전제, 용매를 혼합하여 음극 활물질층 형성용 조성물을 준비한다.

상기 음극 활물질은 리튬 이온을 흡장 및 방출할 수 있는 흑연, 탄소와 같은 탄소계 재료, 리튬 금속, 그 합금, 실리콘 옥사이드계 물질 등을 사용할 수 있다. 본 발명의 일구현예에 따르면 실리콘 옥사이드를 사용한다.

상기 바인더는 음극 활물질의 총중량 100 중량부를 기준으로 1 내지 50 중량부로 첨가된다. 이러한 바인더는 양극과 동일한 종류를 사용할 수 있다.

도전제는 음극 활물질의 총중량 100 중량부를 기준으로 하여 1 내지 5 중량부를 사용한다. 도전제의 함량이 상기 범위일 때 최종적으로 얻어진 전극의 전도도 특성이 우수하다.

상기 용매의 함량은 음극 활물질의 총중량 100 중량부를 기준으로 하여 1 내지 10 중량부를 사용한다. 용매의 함량이 상기 범위일 때 음극 활물질층을 형성하기 위한 작업이 용이하다.

상기 도전제 및 용매는 양극 제조시와 동일한 종류의 물질을 사용할 수 있다.

상기 음극 집전체로는, 일반적으로 3 내지 500 μm 의 두께로 만들어진다. 이러한 음극 집전체는, 당해 전지에 화학적 변화를 유발하지 않으면서 도전성을 가진 것이라면 특별히 제한되는 것은 아니며, 예를 들어, 구리, 스테인레스 스틸, 알루미늄, 니켈, 티탄, 열처리 탄소, 구리나 스테인레스 스틸의 표면에 카본, 니켈, 티탄, 은 등으로 표면처리한 것, 알루미늄-카드뮴 합금 등이 사용될 수 있다. 또한, 양극 집전체와 마찬가지로, 표면에 미세한 요철을 형성하여 음극 활물질의 결합력을

강화시킬 수도 있으며, 필름, 시트, 호일, 네트, 다공질체, 발포체, 부직포체 등 다양한 형태로 사용될 수 있다.

상기 과정에 따라 제작된 양극과 음극 사이에 세퍼레이터를 개재한다.

상기 세퍼레이타는 기공 직경이 0.01 ~ 10 μm 이고, 두께는 일반적으로 5 ~ 300 μm 인 것을 사용한다. 구체적인 예로서, 폴리프로필렌, 폴리에틸렌 등의 올레핀계 폴리머; 또는 유리섬유로 만들어진 시트나 부직포 등이 사용된다. 전해질로서 폴리머 등의 고체 전해질이 사용되는 경우에는 고체 전해질이 세퍼레이터를 겸할 수도 있다.

리튬염 함유 비수계 전해질은, 비수 전해액과 리튬으로 이루어져 있다. 비수 전해질로는 비수 전해액, 유기 고체 전해질, 무기 고체 전해질 등이 사용된다.

상기 비수 전해액으로는, 예를 들어, N-메틸-2-피롤리디논, 프로필렌 카보네이트, 에틸렌 카보네이트, 부틸렌 카보네이트, 디메틸 카보네이트, 디에틸 카르보네이트, 감마-부티로 락톤, 1,2-디메톡시 에탄, 2-메틸 테트라하이드로푸란, 디메틸술폭시드, 1,3-디옥소란, 포름아미드, 디메틸포름아미드, 디옥소란, 아세토니트릴, 니트로메탄, 포름산 메틸, 초산메틸, 인산 트리에스테르, 트리메톡시

메탄, 디옥소란 유도체, 설펜, 메틸 설펜, 1,3-디메틸-2-이미다졸리디논, 프로필렌 카르보네이트 유도체, 테트라하이드로푸란 유도체, 에테르, 피로피온산 메틸, 프로피온산 에틸 등의 비양자성 유기용매가 사용될 수 있다.

상기 유기 고체 전해질로는, 예를 들어, 폴리에틸렌 유도체, 폴리에틸렌 옥사이드 유도체, 폴리프로필렌 옥사이드 유도체, 인산 에스테르 폴리머, 폴리에스테르 술파이드, 폴리비닐 알코올, 폴리 불화 비닐리덴 등이 사용될 수 있다.

상기 무기 고체 전해질로는, 예를 들어, Li_3N , LiI , Li_5NI_2 , $\text{Li}_3\text{N-LiI-LiOH}$, LiSiO_4 , $\text{LiSiO}_4\text{-LiI-LiOH}$, Li_2SiS_3 , Li_4SiO_4 , $\text{Li}_4\text{SiO}_4\text{-LiI-LiOH}$, $\text{Li}_3\text{PO}_4\text{-Li}_2\text{S-SiS}_2$ 등의 Li 의 질화물, 할로겐화물, 황산염 등이 사용될 수 있다.

상기 리튬염은 상기 비수계 전해질에 용해되기 좋은 물질로서, 예를 들어, LiCl , LiBr , LiI , LiClO_4 , LiBF_4 , $\text{LiB}_{10}\text{Cl}_{10}$, LiPF_6 , LiCF_3SO_3 , LiCF_3CO_2 , LiAsF_6 , LiSbF_6 , LiAlCl_4 , $\text{CH}_3\text{SO}_3\text{Li}$, $\text{CF}_3\text{SO}_3\text{Li}$, $(\text{CF}_3\text{SO}_2)_2\text{NLi}$, 리튬클로로보레이트, 저급 지방족 카르본산 리튬, 테트라페닐 붕산 리튬, 이미드 등이 사용될 수 있다.

도 2에 본 발명의 일구현예에 따른 리튬 전지의 대표적인 구조를 개략적으로 도시한 것이다.

도 2를 참조하여, 상기 리튬 전지(30)는 양극(23), 음극(22) 및 상기 양극(23)과 음극(22) 사이에 배치된 세퍼레이터(24), 상기 양극(23), 음극(22) 및 세퍼레이터(24)에 함침된 전해질(미도시), 전지 용기(25), 및 상기 전지 용기(25)를 봉입하는 봉입 부재(26)를 주된 부분으로 하여 구성되어 있다. 이러한 리튬 전지(30)는, 양극(23), 음극(22) 및 세퍼레이터(24)를 차례로 적층한 다음 스피럴 상으로 권취된 상태로 전지 용기(25)에 수납하여 구성될 수 있다.

이하, 하기 실시예를 들어 보다 상세하게 설명하기로 하되, 하기 실시예로만 한정되는 것은 아니다.

제조예 1: 양극 활물질의 제조

리튬 복합 산화물인 $\text{Li}_{0.6}\text{Co}_{0.2}\text{Mn}_{0.2}\text{O}_2$ ()g에 황산리튬 (Li_2SO_4)()g을 부가 및 혼합하여 이를 교반하였다.

상기 결과물을 800°C에서 산소 분위기하에서 열처리하여 1차 입자간의 계면에 Li_2SO_4 비정질층이 존재하는 2차 입자를 갖는 양극 활물질을 제조하였다.

제조예 2: 양극 활물질의 제조

열처리 온도가 800°C 대신 900°C로 변경된 것을 제외하고는, 제조예 1과 동일한 방법에 따라 실시하여 양극 활물질을 제조하였다.

제조예 3: 양극 활물질의 제조

열처리 온도가 800°C 대신 700°C로 변경된 것을 제외하고는, 제조예 1과 동일한 방법에 따라 실시하여 양극 활물질을 제조하였다.

제조예 4: 양극 활물질의 제조

열처리 온도가 800°C 대신 950°C로 변경된 것을 제외하고는, 제조예 1과 동일한 방법에 따라 실시하여 양극 활물질을 제조하였다.

제조예 5: 양극 활물질의 제조

Li_2SO_4 의 함량이 ()g으로 변화된 것을 제외하고는, 제조예 1과 동일한 방법에 따라 실시하여 양극 활물질을 제조하였다.

(발명자가 황산리튬의 함량을 변화시킨 제조예 및 실시예 및 그 데이터를 준비중입니다.)

비교제조예 1: 양극 활물질의 제조

열처리 온도가 800°C 대신 1000°C로 변경된 것을 제외하고는, 제조에 1과 동일한 방법에 따라 실시하여 양극 활물질을 제조하였다.

비교제조예 2: 양극 활물질의 제조

열처리 온도가 800°C 대신 650°C로 변경된 것을 제외하고는, 제조에 1과 동일한 방법에 따라 실시하여 양극 활물질을 제조하였다.

(발명자가 비교제조예 2의 데이터 준비중입니다)

상기 제조예 1-2 및 비교제조예 1에 따라 제조된 양극 활물질을 전자주사현미경(Scanning Electron Microscope: SEM)을 이용하여 약 40,000배까지 확대하여 분석하였고, 이를 도 3 내지 도 5에 나타내었다.

(비교제조예 2 데이터 보충될 예정입니다)

도 3 및 도 4는 각각 제조예 1 및 제조예 2의 양극 활물질의 전자주사현미경 사진이고, 도 5는 비교제조예 1의 양극 활물질의 전자주사현미경 사진이다.

이를 참조하면, 제조예 1-2의 양극 활물질은 1차 입자 사이에 황산리튬으로 된 비정질층이 형성된 것을 확인할 수 있었지만, 비교제조예 1의 경우는 1차 입자

사이에 비정질층이 형성되지 않았음을 알 수 있었다.

상기 제조예 1-5 및 비교제조예 1에 따라 제조된 양극 활물질의 1차 입자의 평균 입경 및 2차 입자의 평균 입경을 측정하였고 그 결과를 하기 표 1에 나타내었다. 상기 1차 입자 및 2차 입자의 평균 입경은 전자주사현미경(SEM) 사진을 통하여 측정하였다.

(발명자가 하기 표 1의 데이터 준비중입니다.)

[표 1]

구분	1차 입자의 평균 입경(nm)	2차 입자의 평균 입경(nm)
제조예 1		12
제조예 2		13
제조예 3		
제조예 4		
제조예 5		

비교제조예 1		
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상기 표 1로부터, 제조예 1-5의 양극 활물질의 1차 입자는 비교제조예 1의 경우와 비교하여 평균 입경이 증가하는 것으로 나타났다. 이와 같이 1차 입자의 입경이 증가되면 양극 활물질과 전해액의 비표면적이 감소되어 우수한 열안정성 및 고온에서의 잔존 용량 및 회복 용량을 확보할 수 있다.

상기 제조예 1 및 비교제조예 1에 따라 제조된 양극 활물질의 시차주사열량계를 이용하여 열적 안정성을 평가하였다.

상기 평가 결과는 도 6에 나타난 바와 같다.

도 6을 참조하여, 제조예 1의 양극 활물질은 비교제조예 1의 경우와 비교하여 전체적인 발열량이 감소하여 열적 안정성이 개선됨을 알 수 있었다.

실시에 1: 양극 및 이를 이용한 리튬 2차 전지의 제조

제조예 1에 따라 양극 활물질 4.75g에 폴리비닐리덴플루오라이드 0.15g, 및 카본블랙 0.15g를 N-메틸피롤리돈 2.5g에서 분산시켜 양극 활물질층 형성용 조성물을 제조하였다.

상기 양극 활물질층 형성용 조성물을 60 μ m의 두께로 알루미늄 박위에 코팅하여 얇은 극판 형태로 만든 후, 135°C에서 3시간 이상 건조시킨 후, 압연(pressing)하여 양극을 제조하였다.

이와 별도로, 음극을 하기 과정에 따라 제조하였다.

SiO₂ 및 폴리비닐리덴 플루오라이드를 96:4의 중량비로 N-메틸피롤리돈 용매에서 혼합하여 음극 활물질층 형성용 조성물을 제조하였다. 상기 음극 활물질층 형성용 조성물을 14 μ m의 두께로 구리박(Cu-foil) 위에 코팅하여 얇은 극판의 형태로 만든 후, 135°C에서 3시간 이상 건조시킨 다음, 압연(pressing)하여 음극을 제조하였다.

전해액으로는, 에틸렌카보네이트(EC), 에틸메틸 카보네이트(EMC), 및 디메틸카보네이트(DMC)를 1:1:1의 부피비로 혼합한 용매에 1.3M LiPF₆를 첨가하여 제조하였다.

상기 과정에 따라 얻은 양극 및 음극 사이에 다공질 폴리에틸렌(PE) 필름으로 이루어진 세퍼레이터를 개재하여 전지 조립체를 형성하고, 이를 권취 및 압축하여 전지 케이스에 넣은 다음, 상기 전해액을 주입하여 2600mAh 용량의 리튬 이차 전지를 제조하였다.

실시에 2-5: 양극 및 이를 이용한 리튬 2차 전지의 제조

양극 제조시, 제조에 1에 따라 제조된 양극 활물질 대신 제조에 2-5에 따라 제조된 양극 활물질을 사용한 것을 제외하고는, 실시예 1과 동일한 방법에 따라 실시하여 리튬 이차 전지를 제조하였다.

비교예 1: 양극 및 이를 이용한 리튬 2차 전지의 제조

양극 활물질로서, 제조에 1의 양극 활물질 대신 리튬 복합 산화물인 $\text{Li}_{0.6}\text{Co}_{0.2}\text{Mn}_{0.2}\text{O}_2$ 을 사용한 것을 제외하고는, 실시예 1과 동일한 방법에 따라 실시하여 리튬 이차 전지를 제조하였다.

비교예 2: 양극 및 이를 이용한 리튬 2차 전지의 제조

양극 활물질로서, 제조에 1의 양극 활물질 대신 비교제조에 1의 양극 활물질을 사용한 것을 제외하고는, 실시예 1과 동일한 방법에 따라 실시하여 리튬 이차 전지를 제조하였다.

비교예 3: 양극 및 이를 이용한 리튬 2차 전지의 제조

양극 활물질로서, 제조예 1의 양극 활물질 대신 비교제조예 2의 양극 활물질을 사용한 것을 제외하고는, 실시예 1과 동일한 방법에 따라 실시하여 리튬 이차 전지를 제조하였다.

상기 실시예 1-5 및 비교예 1-3에 따라 제조된 리튬 2차 전지에 있어서, 고온에서의 잔존 용량 및 회복 용량을 조사하여 하기 표 1에 나타내었다.

상기 고온에서의 잔존용량 및 회복 용량의 평가방법은 다음과 같다.

1) 고온에서의 잔존용량

평가 방법이 보충될 예정입니다.

2) 고온에서의 회복 용량

60°C에서 25일간 방치한 다음, 0.5C에서의 초기용량을 평가한다.

구체적인 평가 방법이 보충될 예정입니다.

[표 2]

구분	잔존용량(%)	회복용량(%)
실시에 1	113	103
실시에 2		
실시에 3		
실시에 4		
실시에 5		
비교예 1	100	100
비교예 2		
비교예 3		

상기 표 2의 실시에 2-5 및 비교예 2-3의 잔존용량 및 회복 용량 데이터는 준비중입니다.

상기 표 2로부터 알 수 있듯이, 실시에 1의 리튬 전지는 비교예 1의 경우와

비교하여 잔존용량 및 회복용량이 증가함을 알 수 있었다.

(발명자는 전지의 효율 관련 자료를 준비중입니다)

상기에서 본 발명의 바람직한 제조예를 참조하여 설명하였지만, 해당 기술 분야의 숙련된 당업자는 하기의 특허청구범위에 기재된 본 발명의 사상 및 영역으로부터 벗어나지 않는 범위내에서 본 발명을 다양하게 수정 및 변경시킬 수 있음을 이해할 수 있을 것이다.

【도면의 간단한 설명】

도 1 은 본 발명의 일구현예에 따른 리튬 전지용 양극 활물질에 있어서, 2 차 입자의 미세 구조를 개념적으로 나타낸 도면이고,

도 2는 본 발명의 일구현예에 따른 리튬 전지의 개략적인 구조를 나타낸 개략도이고,

도 3은 제조예 1에 따른 양극 활물질의 주사전자현미경 사진이고,

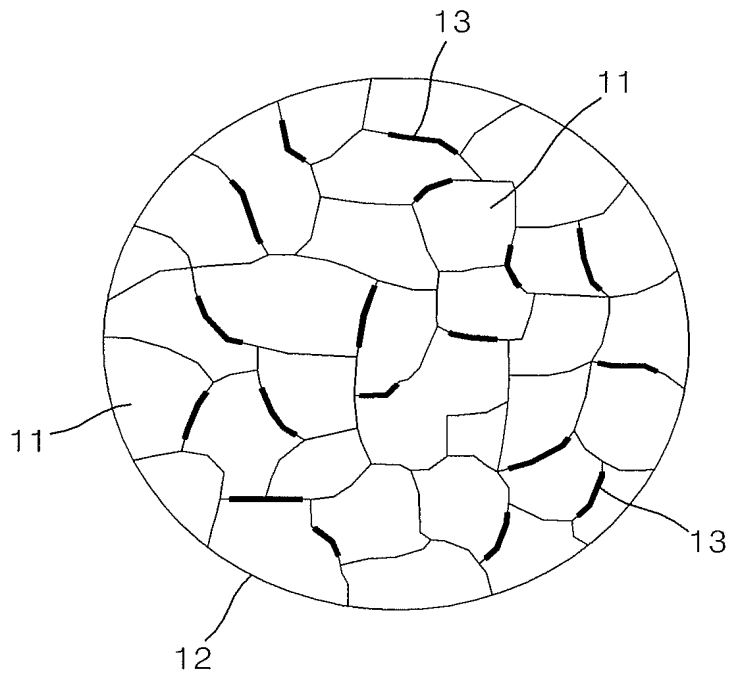
도 4는 제조예 2에 따른 양극 활물질의 주사전자현미경 사진이고,

도 5는 비교제조예 1에 따른 양극 활물질의 주사전자현미경 사진이고,

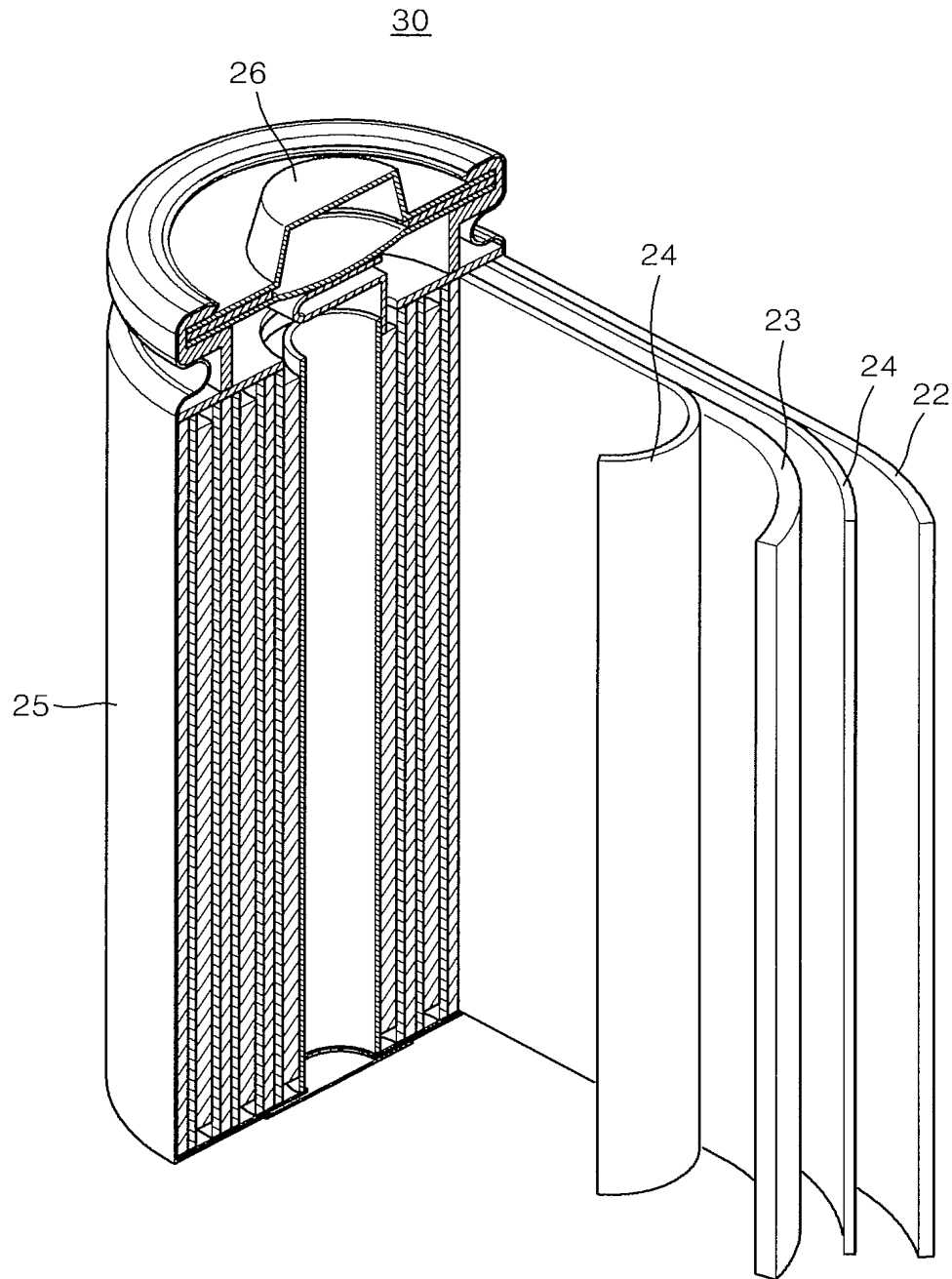
도 6은 제조예 1 및 비교제조예 1에 따른 양극 활물질의 시차주사열량계 분석 사진이다.

【도면】

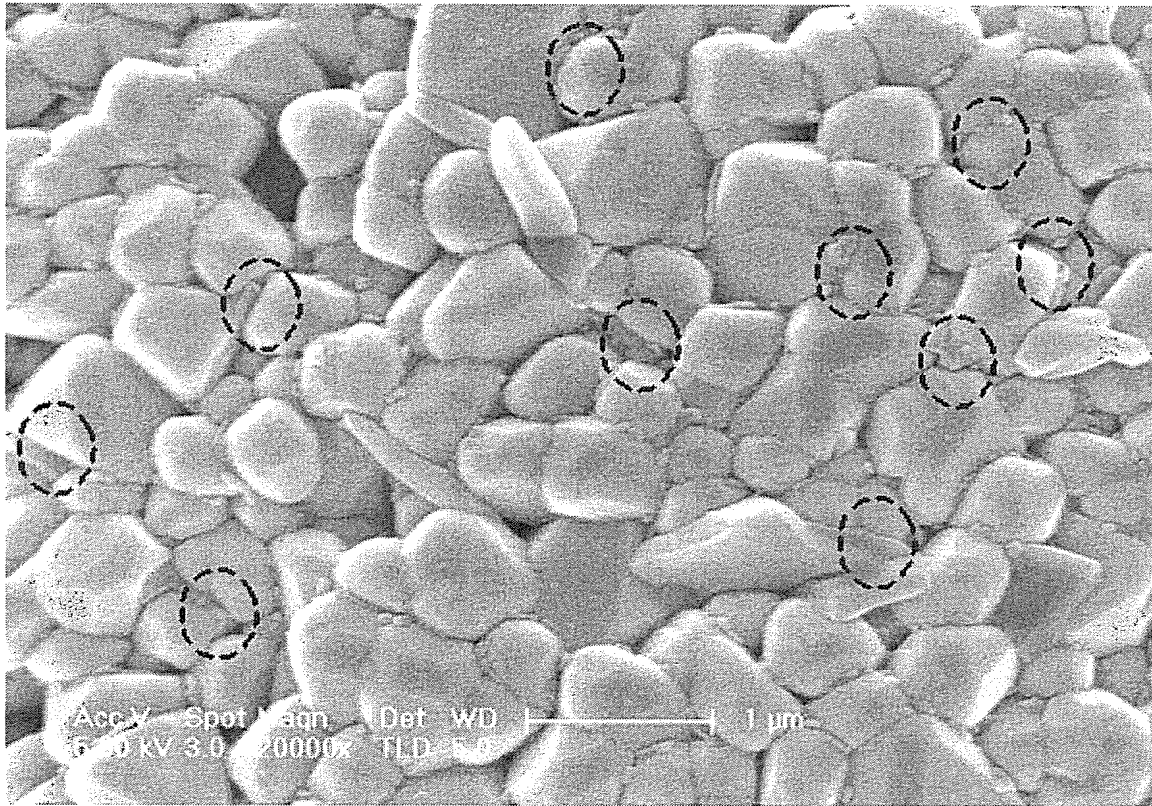
【도 1】



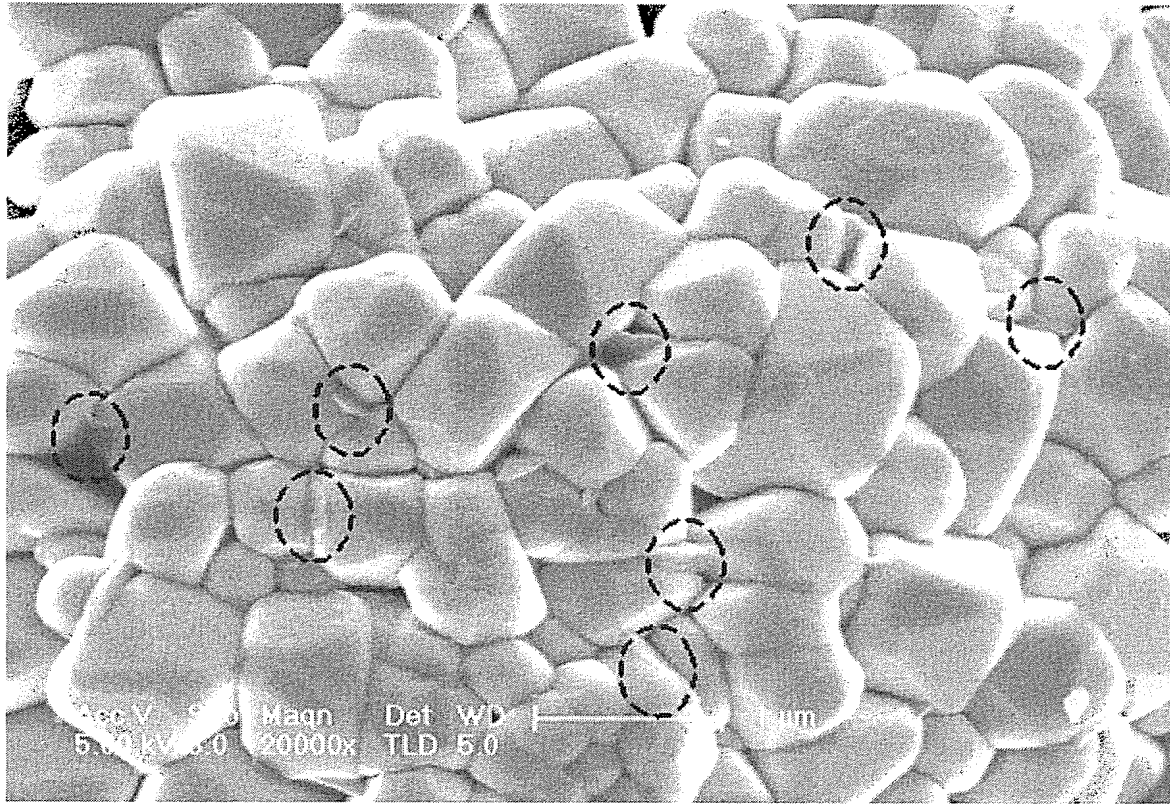
【도 2】



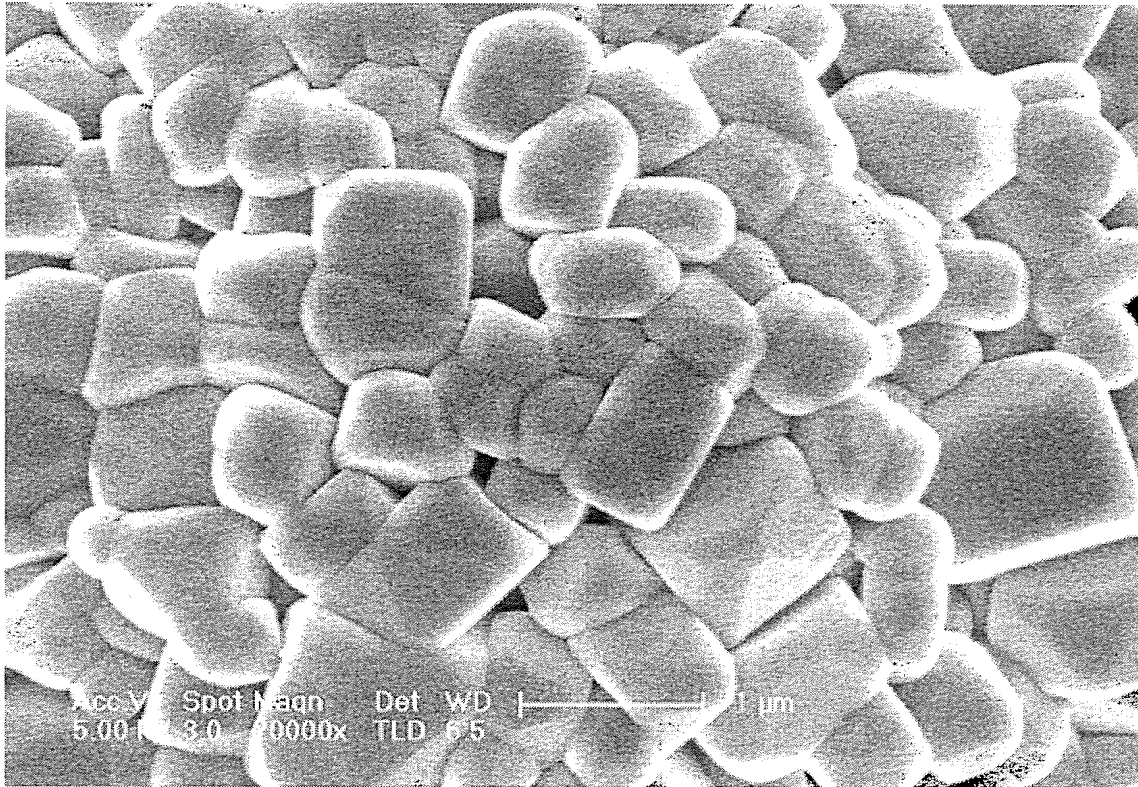
【도 3】



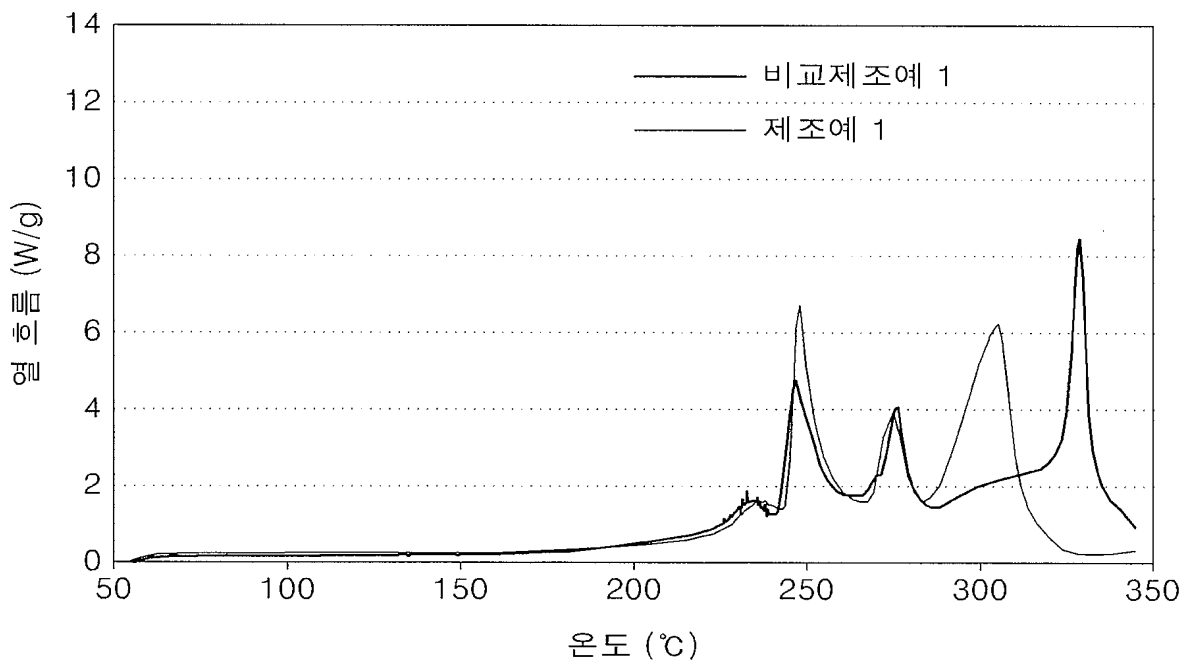
【도 4】



【도 5】



【도 6】



Electronic Patent Application Fee Transmittal

Application Number:

Filing Date:

Title of Invention:

POSITIVE ELECTRODE ACTIVE MATERIAL FOR LITHIUM BATTERY AND LITHIUM BATTERY USING THE SAME

First Named Inventor/Applicant Name:

Do-Hyung Park

Filer:

Jun-Young E. Jeon/Carol Burchfield

Attorney Docket Number:

64781/L550

Filed as Large Entity

Provisional Filing Fees

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Basic Filing:				
Provisional application filing	1005	1	220	220

Pages:

Claims:

Miscellaneous-Filing:

Petition:

Patent-Appeals-and-Interference:

Post-Allowance-and-Post-Issuance:

Extension-of-Time:

POSCO Future M v. TIAX LLC
POSCO Future M EX1025

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Miscellaneous:				
Total in USD (\$)				220

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Application Number:	61285785
International Application Number:	
Confirmation Number:	1031
Title of Invention:	POSITIVE ELECTRODE ACTIVE MATERIAL FOR LITHIUM BATTERY AND LITHIUM BATTERY USING THE SAME
First Named Inventor/Applicant Name:	Do-Hyung Park
Customer Number:	23363
Filer:	Jun-Young E. Jeon/Carol Burchfield
Filer Authorized By:	Jun-Young E. Jeon
Attorney Docket Number:	64781/L550
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RAM confirmation Number	2539
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File Listing:					
Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Transmittal of New Application	64781_TRANS.pdf	59684	no	3
			46ccc990961fd47e505427c9d20619ffbd292a44		
Warnings:					
Information:					
2	Authorization to access Appl. by Trilateral Office	64781_SB39.pdf	134989	no	2
			24b3f49f445b433aaf9d0478248594588de777cd		
Warnings:					
Information:					
3		64781_APP.pdf	1043566	yes	33
			dtbbcbce919e3d1bb2df5925668b8bfadad0e18a45		
	Multipart Description/PDF files in .zip description				
	Document Description		Start	End	
	Specification - Not in English		1	28	
	Drawings-only black and white line drawings		29	33	
Warnings:					
Information:					
4	Fee Worksheet (PTO-875)	fee-info.pdf	29834	no	2
			316bd2a6f2cc84d4da0ee7eaad6dcd36b9f7886d		
Warnings:					
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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.

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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.