

のP E Tの一方のn型半導体領域21が形成される。

【0050】次に、半導体基板12上に酸化シリコン膜23をCVD法によって堆積する。次いで、図示はしないが、レジストパターンをマスクにして酸化シリコン膜23、第1のBPSG膜20、酸化シリコン膜19およびゲート絶縁膜15を同一層の絶縁膜を順次エッチングすることにより、メモリアル選択用MISFETの他方の後に形成されるn型半導体領域上に第2のコンタクトホールを形成する。この際、後に形成されるビット線を周辺回路部に存在し、周辺回路部の半導体基板12に接続するための第2のコンタクトホール（周辺回路部）25を形成してもよい。

【0051】次いで、半導体基板12上にPが導入された多結晶シリコン膜26およびWS1、膜27をCVD法によって順次堆積した後、レジストパターンをマスクにしてWS1、膜27および多結晶シリコン膜26を順次エッチングすることにより、WS1、膜27および多結晶シリコン膜26からなるビット線を形成する。

【0052】また、多結晶シリコン膜26に導入されたPの拡散によってメモリアル選択用MISFETの他方のn型半導体領域（図示せず）は形成され、ビット線は第2のコンタクトホールを通して、このメモリアル選択用MISFETの他方のn型半導体領域に移接される。この際、多結晶シリコン膜26に導入されたPの拡散によって周辺回路部のp型ウェル13にもn型半導体領域（周辺回路部）28が形成され、第2のコンタクトホール（周辺回路部）25を通して、ビット線が上記n型半導体領域（周辺回路部）28に接続される。

【0053】次に、半導体基板12上に酸化シリコン膜29、酸化シリコン膜30および第2のBPSG膜（図示せず）をCVD法によって順次堆積した後、900〜950℃のリフロー処理により上記第2のBPSG膜の表面を平坦化する。

【0054】次に、半導体基板12上にPが導入された多結晶シリコン膜31をCVD法によって堆積した後、レジストパターンをマスクにして多結晶シリコン膜31をエッチングする。次いで、半導体基板12上にCVD法によって堆積されたPが導入された多結晶シリコン膜32をRIE法などの異方性エッチングによって加工し、上記多結晶シリコン膜31の側壁に多結晶シリコン膜32からなるサイドウォールスペーサを形成する。

【0055】次いで、レジストパターンをマスクにしてメモリアルの第2のBPSG膜、酸化シリコン膜30、酸化シリコン膜29および酸化シリコン膜24を順次エッチングすることにより、第1のコンタクトホール22内に設けられた第1フラップ電極上に第3のコンタクトホール33を形成した後、半導体基板12上にPが導入された多結晶シリコン膜34および第3のBPSG膜（図示せず）をCVD法によって順次堆積する。

【0056】次に、レジストパターンをマスクにして上

記第3のBPSG膜および多結晶シリコン膜34、31を順次エッチングした後、半導体基板12上にPが導入された多結晶シリコン膜35をCVD法によって堆積する。次いで、この多結晶シリコン膜35をRIE法などの異方性エッチングによって加工し、メモリアルの第3のBPSG膜および多結晶シリコン膜34、31の側壁に多結晶シリコン膜35を残す。

【0057】次に、例えば、フッ酸溶液を用いたウェットエッチングによって、第3のBPSG膜および第2のBPSG膜を除去し、メモリアルに多結晶シリコン膜31、32、34、35からなる円筒型の蓄積電極を形成する。

【0058】次に、半導体基板12上に厚さ約2nmの酸化シリコン膜（図示せず）をCVD法によって堆積し、続いて、厚さ約30nmの非晶質の酸化タングステル（ Ta_2O_5 ）膜（図示せず）をCVD法によって堆積した後、半導体基板12に熱酸化処理を施すことによって、上記 Ta_2O_5 膜を結晶化する。その後、半導体基板12上にTIN膜36をCVD法によって堆積し、次いで、フォトリソストをマスクにしてこのTIN膜36をエッチングすることにより、TIN膜36からなるプレート電極を形成する。

【0059】なお、蓄積電極に Ta_2O_5 膜を用いたが、その他の酸化タングステル膜（例えば、 $(Ba, Sr)TiO_3$ 膜または $Pb(2r, Ti)O_3$ 膜）などを用いてもよく、また、上記プレート電極にTIN膜を用いたが、その他のメタルナイトライド膜（例えば、WN膜）またはメタル膜（例えば、W膜）などを用いてもよい。

【0060】次に、半導体基板12上に酸化シリコン膜37および第4のBPSG膜38をCVD法によって順次堆積した後、900〜950℃でのリフロー処理により上記第4のBPSG膜38の表面を平坦化する。

【0061】次いで、レジストパターンをマスクにして第4のBPSG膜38および酸化シリコン膜37を順次エッチングすることにより、TIN膜36からなるプレート電極上に第4のコンタクトホール39aを形成し、同時に、第4のBPSG膜38、酸化シリコン膜37および酸化シリコン膜29を順次エッチングすることにより、WS1、膜27および多結晶シリコン膜26からなるビット線上に第4のコンタクトホール39bを形成する。

【0062】さらに、同時に、第4のBPSG膜38、酸化シリコン膜37、酸化シリコン膜29、酸化シリコン膜24、第1のBPSG膜20、酸化シリコン膜19およびゲート絶縁膜15を同一層の絶縁膜を順次エッチングすることにより、nチャネル型MISFETQ₂のn型半導体領域17上に第4のコンタクトホール39cを形成する。

【0063】次に、半導体基板12上に金属膜（図示せず）を堆積した後、レジストパターンをマスクにして上

金属層膜をエッチングすることにより、第1層目のメタル配線M₁が形成される。次いで、半導体基板12上にECR(Electron Cyclotron Resonance: 電子サイクロトロン共振)プラズマCVD法によって酸化シリコン膜を堆積した後、この酸化シリコン膜の表面を本実施の形態である前記CMP装置P₁を用いて研磨することによって、その表面が平坦化された酸化シリコン膜によって構成される第1の層間絶縁膜40を設ける。

【0064】次に、レジストパターンをマスクにして上記第1の層間絶縁膜40をエッチングすることにより、第1層目のメタル配線M₁に接するスルーホール41を形成した後、半導体基板12上に金属膜(図示せず)を堆積し、次いで、この金属膜をレジストパターンをマスクにしてエッチングすることにより、第2層目のメタル配線M₂を形成する。

【0065】ここで、第1の層間絶縁膜40の表面が平坦化されているので、第2層目のメタル配線M₂を形成する際のフォトリソグラフィ工程において、マスクパターン転写における焦点深度に余裕が生じ、高解像度のレジストパターンが形成される。これによって、レジストパターンをマスクとして加工、形成される第2層目のメタル配線M₂の対照または隣接する第2層目のメタル配線M₂間の接触を防ぐことができる。

【0066】さらに、上記第1の層間絶縁膜40と同様に、半導体基板12上にECRプラズマCVD法によって酸化シリコン膜を堆積した後、この酸化シリコン膜の表面を本実施の形態である前記CMP装置P₁を用いて研磨することによって、その表面が平坦化された酸化シリコン膜によって構成される第2の層間絶縁膜42を設ける。

【0067】次に、レジストパターンをマスクにして上記第2の層間絶縁膜42をエッチングすることにより、第2層目のメタル配線M₂に接するスルーホール42を形成した後、半導体基板12上に金属膜(図示せず)を堆積し、次いで、この金属膜をレジストパターンをマスクにしてエッチングすることにより、第3層目のメタル配線M₃を形成する。

【0068】最後に、半導体基板12の表面をパッシベーション(図示せず)で被覆することにより、本実施の形態のCMP装置P₁を用いて加工された第1の層間絶縁膜40および第2の層間絶縁膜42を有するDRAMが完成する。

【0069】このように、本実施の形態では、研磨パッド4の寿命が、従来の同時ドレッシングを採用した研磨パッドの寿命の約40倍以上、また、従来の間欠ドレッシングを採用した研磨パッドの寿命の約1.6倍以上長くなり、例えば、従来の同時ドレッシングでは4〜5時間毎に必要な研磨パッドの交換を週に1度の頻度とすることができる。さらに、第2のドレッシング6のブラシ7を研磨パッド4の表面の逆めを立たせる方向に磨削さ

せることによって、研磨パッド4の表面の倒れた基めを立てさせて、比較的容易に元の磨き磨きに復元することができるので、研磨速度を安定化することができる。さらに、研磨パッド4に対する第1のドレッシングの押圧力を低下させる必要がないので、研磨パッド4の表面の平坦度が確保できて、半導体ウエハ1上の被研磨膜の全面を均一に研磨することができる。

【0070】以上、本発明者によって企及された発明を発明の実施の形態に基づき具体的に説明したが、本発明は前記実施の形態に限定されるものではなく、その要旨を逸脱しない範囲で種々変更可能であることはいふまでもない。

【0071】

【発明の効果】本願によって開示される発明のうち、代表的なものによって得られる効果を簡単に説明すれば、以下のとおりである。

【0072】本発明によれば、ブラシによって構成された第2のドレッシングによるドレッシングによって、研磨パッドの表面を切磨することなく、比較的容易に研磨パッドの表面の逆めを荒い磨きに復元することができるので、研磨パッドの寿命を大幅に長くできると同時に、半導体ウエハ1上の被研磨膜の表面の研磨速度を安定化することができる。さらに、ダイヤモンド磨粒を埋め込んだ第1のドレッシングの研磨パッドに対する押圧力を低下させる必要がないので、研磨パッドの表面の平坦度が確保できて、半導体ウエハ1上の被研磨膜の全面を均一に研磨することができる。

【0073】また、本発明によれば、研磨パッドの寿命が長くなるので、半導体製造装置としての生産能力、稼働率が大幅に向上し、また、高価な研磨パッドの消費量が減少する。

【図面の簡単な説明】

【図1】本発明の一実施の形態であるCMP装置の概略図であり、(a)は上面図、(b)は側面断面図である。

【図2】本発明の一実施の形態であるドレッシング、従来の同時ドレッシングまたは従来の間欠ドレッシングをそれぞれ採用した研磨パッドを有するCMP装置を用いて、半導体ウエハ1上の酸化シリコン膜の表面を研磨した際の酸化シリコン膜の研磨速度の経時変化を示すグラフ図である。

【図3】本発明の一実施の形態であるドレッシング、従来の同時ドレッシングまたは従来の間欠ドレッシングをそれぞれ採用した研磨パッドを有するCMP装置を用いて、半導体ウエハ1上の酸化シリコン膜の表面を研磨した際の研磨パッドの厚さの経時変化を示すグラフ図である。

【図4】本発明の一実施の形態であるドレッシングを採用した研磨パッドを有するCMP装置を用いて平坦化される層間絶縁膜を有するDRAMを示す半導体基板の要

部断面図である。

【図5】従来のCMP装置の要部断面の模式図である。

【図6】(a)～(f)はそれぞれ従来のドレッシングを採用した研磨パッドを有するCMP装置を用いて平坦化される絶縁膜または金属膜を有する半導体基板の要部断面図である。

【図7】従来のドレッシングを採用した研磨パッドを有するCMP装置を用いて研磨された半導体ウエハ上の被研磨膜の研磨速度と研磨パッドの磨耗の経時変化を示すグラフ図である。

【図8】従来の研磨パッドのドレッシング方法を説明するための概略図である。

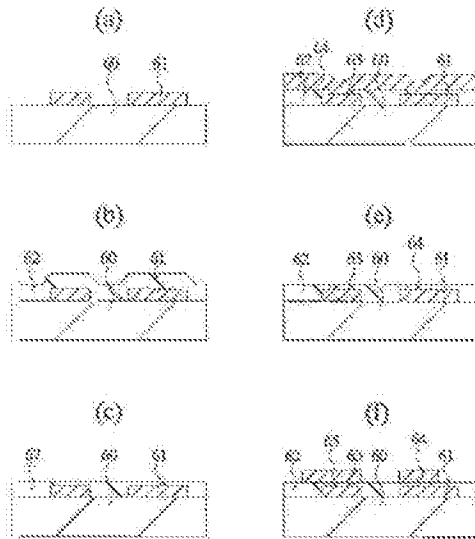
【図9】従来の研磨パッドのドレッシング方法を説明するための概略図である。

【符号の説明】

- | | |
|--------------------------|--------------------------------|
| 1 半導体ウエハ | 27 クラウドゲートシリサイド膜 |
| 2a 加圧ヘッド | 28 n型半導体領域（周辺回路部） |
| 2b 加圧ヘッド | 29 酸化シリコン膜 |
| 3 研磨定盤 | 30 酸化シリコン膜 |
| 4 研磨パッド | 31 多結晶シリコン膜 |
| 5 第1のドレッサ | 32 多結晶シリコン膜 |
| 6 第2のドレッサ | 33 第3のコンタクトホール |
| 7 ブラシ | 34 多結晶シリコン膜 |
| 8a 歯車 | 35 多結晶シリコン膜 |
| 8b 歯車 | 36 酸化イタン膜 |
| 8c 歯車 | 37 酸化シリコン膜 |
| 9 ギア | 38 第4のEPSG膜 |
| 10 供給ノズル | 39a 第4のコンタクトホール |
| 11 研磨微粒溶液 | 39b 第4のコンタクトホール |
| 12 半導体基板 | 39c 第4のコンタクトホール |
| 13 p型ウエハ | 40 第1の層間絶縁膜 |
| 14 フィールド絶縁膜 | 41 スルーホール |
| 15 ゲート絶縁膜 | 42 第2の層間絶縁膜 |
| 16 ゲート電極 | 43 スルーホール |
| 17 n型半導体領域（ソース領域、ドレイン領域） | 51 半導体ウエハ |
| 18 絶縁膜 | 52 剛性板 |
| 19 酸化シリコン膜 | 53 加圧用パッド |
| 20 第1のEPSG膜 | 54 通気孔 |
| 21 n型半導体領域 | 55 通気孔 |
| 22 第1のコンタクトホール | 56 加圧ヘッド |
| 23 多結晶シリコン膜 | 57 研磨パッド |
| 24 酸化シリコン膜 | 58 研磨定盤 |
| 25 第2のコンタクトホール（周辺回路部） | 59 ストップ |
| 26 多結晶シリコン膜 | 60 半導体基板 |
| | 61 第1層目の配線 |
| | 62 層間絶縁膜 |
| | 63 スルーホール |
| | 64 金属膜 |
| | 65 第2層目の配線 |
| | 66 大型のドレッサ |
| | 67 アーム機構 |
| | 68 小型のドレッサ |
| | P ₁ 本発明の実施の形態のCMP装置 |
| | P ₂ 従来のCMP装置 |
| | Q ₁ nチャネル型MISFET |
| | M ₁ 第1層目のメタル配線 |
| | M ₂ 第2層目のメタル配線 |
| | M ₃ 第3層目のメタル配線 |

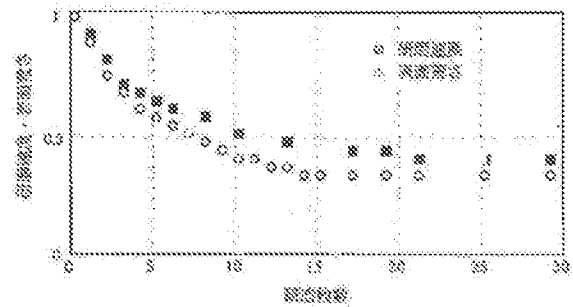
【図6】

図 6



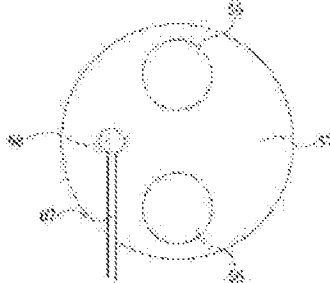
【図7】

図 7



【図9】

図 9



フロントページの続き

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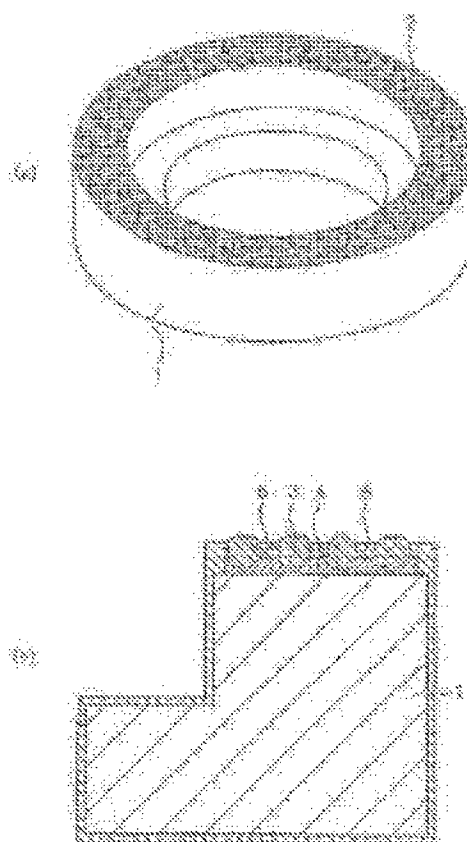
Bibliographic data: JP11077536 (A) — 1999-03-23

CONDITIONER FOR CMP AND ITS MANUFACTURE

Inventor(s): HARA TOMOYOSHI ±
Applicant(s): ASAHI DIAMOND IND ±
Classification: • International: B24B53/12; (IPC 1-7): B24B53/12
 • European:
Application number: JP19970255987 19970904
Priority number(s): JP19970255987 19970904
Also published as: JP3895840 (B2)

Abstract of JP11077536 (A)

PROBLEM TO BE SOLVED: To prevent a plated layer fixing diamond abrasive grains from being corroded even by highly acidic polishing liquid and to prevent contamination caused by metallic elution, and falling off of diamond abrasive grains.
SOLUTION: This CPM conditioner has diamond abrasive grains 3 fixed by a plated layer 4, and is applied with nitric acid resistant plating to the plated layer 4; coated its surface with a synthetic resin, and having action tip parts of the diamond abrasive grains projected out of the synthetic resin layer 6. The CPM conditioner is manufactured by fixing the diamond abrasive grains 3 to an action surface by an electrodeposition or a reversible electroforming followed by nitric acid resistant plating 5 and covering with synthetic resin its action surface.



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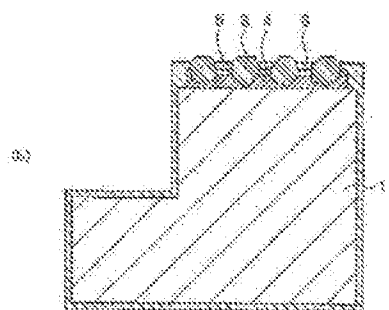
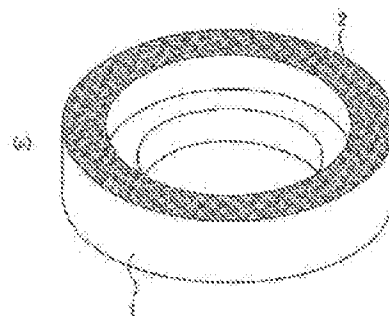
(74) 代理人 弁理士 内山 亮

(54) 【発明の名称】 CMP用コンディショナ及びその製造方法

(57) 【要約】

【課題】 半導体ウェーハ研磨用のポリッシングワットのコンディショニングにおいて、酸性の高い研磨液によってもダイヤモンド砥粒を固着するメッキ層が侵されるおそれがなく、金属の溶出によるコンタミネーションやダイヤモンド砥粒の脱落を生じないCMP用コンディショナ及びその製造方法を提供する。

【解決手段】 ダイヤモンド砥粒がメッキ層により固着されたコンディショナにおいて、メッキ層上に耐腐蝕性のメッキが施され、その表面がさらに合成樹脂により被覆され、ダイヤモンド砥粒の先端作用部が合成樹脂層より突出してなることを特徴とするCMP用コンディショナ、及び、作用面にダイヤモンド砥粒を電着法又は反電電鍍法によって固着したのも、さらに耐腐蝕性のメッキを施し、その表面を合成樹脂により被覆することを特徴とする該CMP用コンディショナの製造方法。



【特許請求の範囲】

【請求項1】ダイヤモンド砥粒がメッキ層により固着されたコンディショナにおいて、メッキ層上に耐腐蝕性のメッキが施され、その表面がさらに合成樹脂により被覆され、ダイヤモンド砥粒の先端作用部が合成樹脂層より突出してなることを特徴とするCMP用コンディショナ。

【請求項2】耐腐蝕性のメッキが、アルミニウム、クロム、金、ロジウム、銀又はこれらの合金のメッキである請求項1記載のCMP用コンディショナ。

【請求項3】作用面にダイヤモンド砥粒を電着法又は反転電着法によって固着したのち、さらに耐腐蝕性のメッキを施し、その表面を合成樹脂により被覆することを特徴とする請求項1又は請求項2記載のCMP用コンディショナの製造方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、CMP用コンディショナ及びその製造方法に関する。さらに詳しくは、本発明は、半導体ウェーハ研磨用のポリッシングマットのコンディショニングにおいて、酸性の高い研磨液によってもダイヤモンド砥粒を固着するメッキ層が侵され、ダイヤモンド砥粒が脱落するおそれのないCMP用コンディショナ及びその製造方法に関する。

【0002】

【従来の技術】一般に半導体ウェーハの表面を研磨するウェーハ加工装置では、円盤状の定盤の上に研磨用ポリッシングマットを貼り付け、定盤上面に1枚又は複数枚のウェーハを配置し、これらウェーハをポリッシングマット上でキャリアにより強制回転させつつポリッシングマットとウェーハの間に微細な研磨粒子と研磨液を供給して、界面の化学的機械的作用によりケミカルメカニカルポリッシング(CMP)を行っている。ポリッシングマットとしては、ポリエステル不織布にポリウレタン樹脂を含浸させたペロアタイプマット、ポリエステル不織布を基材としてその上に発泡ポリウレタン層を形成したスエードタイプマット、あるいは中空気泡を有する発泡ポリウレタンのマットなどを、さらにこれらの多層構造体などが使用されている。また、研磨粒子としては、酸化鉄、アルミナ、炭酸バリウム、酸化セリウム、コロイダルシリカなどが用いられ、研磨液には水酸化カリウム溶液、希硫酸、過酸化水素水、硝酸脱水溶液など、それぞれの場合に応じて使い分けられる。このようなウェーハの研磨を繰り返すうちに、研磨粒子や研磨液などがポリッシングマットの微細な孔に入り込んで目詰まりを起こしたり、研磨粒子と研磨液の化学反応熱によってポリッシングマットの表面が酸化して、研磨速度が低下してしまう。このため、ポリッシングマットの表面を再生して研磨速度を回復させる、いわゆるコンディショニングと呼ばれる操作を常時又は定期的に行う必要がある。

このような操作にはCMP用コンディショナと呼ばれる工具が使用される。ダイヤモンド砥粒は溶れたコンディショニング材料であり、ダイヤモンド砥粒を利用した半導体ウェーハ研磨用のポリッシングマットのコンディショニングが検討されている。例えば、特開昭64-71661号公報には、ダイヤモンド砥粒と合金粉末を混合し、加熱焼結したダイヤモンドペレットを端面に貼り付けるが、あるいは、端面にダイヤモンド砥粒を均一に分布するように嵌めて電着した修正リングを用い、ポリッシングマットと修正リングを相対移動させることによりポリッシングマットの表面を研磨して平坦度を高める方法が提案されている。しかし、合金粉末を用いて焼結したダイヤモンドペレットからは、コンディショニングの際に合金が溶出してウェーハの研磨時にウェーハを汚染するおそれがある。また、特開平4-364730号公報には、ウェーハ研磨装置の定盤に貼り付けられたポリッシングマットのコンディショニングに、ダイヤモンド砥粒をエポキシ樹脂に電着したペレットを用いる方法が提案されている。しかし、ペレットがメタルボンドの場合、合金が研磨液によって溶解され、半導体ウェーハに残存して微細傷を及ぼすおそれがある。特に、一般にメタルボンドの主成分として使用される銅は腐蝕性が著しい。本発明者らは、先に半導体デバイスの層間絶縁膜及び金属配線などのCMP用のポリッシングマットのコンディショニングに際して、金属分による汚染を主としないコンディショナとして、合金作表面にメッキにより固着されたダイヤモンド砥粒層を有し、メッキされた合金が合成樹脂層により被覆され、ダイヤモンド砥粒の先端作用部が合成樹脂層より突出してなるコンディショナを提案した。このコンディショナは、CMP用ポリッシングマットのコンディショニングに好適に使用されているが、さらに強い酸性条件下でのCMP加工においても、金属の溶出やダイヤモンド砥粒の脱落のおそれのないCMP用コンディショナが求められるようになった。

【0003】

【発明が解決しようとする課題】本発明は、半導体ウェーハ研磨用のポリッシングマットのコンディショニングにおいて、酸性の高い研磨液によってもダイヤモンド砥粒を固着するメッキ層が侵されるおそれがなく、金属の溶出によるコンタミネーションやダイヤモンド砥粒の脱落を生じないCMP用コンディショナ及びその製造方法を提供することを目的としてなされたものである。

【0004】

【課題を解決するための手段】本発明者は、上記の課題を解決すべく鋭意研究を重ねた結果、ダイヤモンド砥粒がメッキ層により固着されたコンディショナにおいて、メッキ層上に耐腐蝕性のメッキを施し、さらにその表面を合成樹脂で被覆することにより、強い酸性条件下でのCMP加工の際にも、金属の溶出によるコンタミネーションやダイヤモンド砥粒の脱落を生ずることがなく、ま

た。このようなコンディショナは、作用面にダイヤモンド砥粒を電着法又は反転電着法によって固着したのち、その表面に耐腐蝕性のメッキを施し、さらに合成樹脂で被覆することにより、容易に製造し得ることを見いだし、この知見に基づいて本発明を完成するに至った。すなわち、本発明は、(1)ダイヤモンド砥粒がメッキ層により固着されたコンディショナにおいて、メッキ層上に耐腐蝕性のメッキが施され、その表面がさらに合成樹脂により被覆され、ダイヤモンド砥粒の先端作用部が合成樹脂層より突出してなることを特徴とするCMP用コンディショナ、(2)耐腐蝕性のメッキが、アルミニウム、クロム、金、ロジウム、銅又はこれらの合金のメッキである第(1)項記載のCMP用コンディショナ、及び、(3)作用面にダイヤモンド砥粒を電着法又は反転電着法によって固着したのち、さらに耐腐蝕性のメッキを施し、その表面を合成樹脂により被覆することを特徴とする第(1)項又は第(2)項記載のCMP用コンディショナの製造方法、を提供するものである。さらに、本発明の好ましい態様として、(4)耐腐蝕性のメッキが、金メッキである第(2)項記載のCMP用コンディショナ、(5)金メッキの厚さが2~10 μm である第(4)項記載のCMP用コンディショナ、を挙げることができる。

【0005】

【発明の実施の形態】本発明のCMP用コンディショナは、合金作用面にダイヤモンド砥粒がメッキ層により固着され、メッキ層上に耐腐蝕性のメッキが施され、その表面がさらに合成樹脂層により被覆され、ダイヤモンド砥粒の先端作用部が合成樹脂層より突出してなるものである。図1(a)は、本発明のCMP用コンディショナの一態様の斜視図であり、図1(b)は、図1(a)のコンディショナを中心軸を通る平面で切断したときの切断部断面図である。図1に示すCMP用コンディショナは、カップ型の合金1の作用面にダイヤモンド砥粒がメッキにより固着されて、ダイヤモンド砥粒2を形成している。ダイヤモンド砥粒3は、メッキ層4により合金1に固着され、メッキ層上に耐腐蝕性のメッキ5が施され、その表面が合成樹脂層6により被覆され、ダイヤモンド砥粒の先端作用部が合成樹脂層より突出している。本発明において、耐腐蝕性のメッキとは、2.0mm $\times$ 2.0mm $\times$ 0.2~2mmの金属試験片を重量百分率5.0mlに24時間浸漬したのち、JIS K 0121にしたがって腐蝕をフレイム原子吸光分析して、金属の溶出量が5 μg /ml以下である金属のメッキをいう。このような金属としては、例えば、アルミニウム、クロム、金、ロジウム、銅などや、これらの金属の合金を挙げることができる。本発明のコンディショナは、ダイヤモンド砥粒がすべてメッキにより合金に強固に固着され、メッキ層上に耐腐蝕性のメッキが施され、その表面がさらに合成樹脂層により被覆されているので、pHが2以下であるような

強い酸性的研磨液を用いた場合でも、研磨液が合成樹脂層に浸透してダイヤモンド砥粒を固着しているメッキ層と直接接触することがなく、金属分の溶出やダイヤモンド砥粒の脱落を生ずるおそれがない。そのため、本発明のCMP用コンディショナは、半導体デバイスの層間絶縁膜及び金属配線などのCMP用のポリッシングマットのコンディショニングに使用したとき、磨耗したダイヤモンド砥粒によるウェーハの損傷を生ずることがなく、CMP加工後のウェーハの洗浄工程を簡略化することができる。

【0006】図2及び図3は、本発明のCMP用コンディショナの製造方法の一態様の説明図である。本態様においては、合金作用面にダイヤモンド砥粒をメッキにより仮固定し、次いでダイヤモンド砥粒をメッキ層により固着してダイヤモンド砥粒層を形成し、メッキ層上に耐腐蝕性のメッキを施し、その表面をさらに合成樹脂により被覆し、ダイヤモンド砥粒の先端作用部を突出させる。ダイヤモンド砥粒をメッキにより仮固定する場合、図2(a)に示すように、合金1のダイヤモンド砥粒固定面7を覆って、絶縁性のマスキング材8で被覆する。合金をメッキ液に浸漬し、ダイヤモンド砥粒固定面にダイヤモンド砥粒9を沈着し、合金に研磨を施す。メッキ液に陽極を接続して、電気メッキを行う。使用するダイヤモンド砥粒に粗に制限はないが、JIS B 4130に規定する粒度100/120~30/40の粒度を有する砥粒であることが好ましく、粒度60/80程度の粒度を有する砥粒であることがより好ましい。ダイヤモンド砥粒の粒度が、粒度100/120に相当する粒度未満であると、研磨する合成樹脂層の厚さが薄くなって、耐腐蝕性のメッキの表面を完全に被覆しきれなくなるおそれがある。ダイヤモンド砥粒の粒度が、粒度30/40に相当する粒度を超えると、ダイヤモンド砥粒が高価になって経済的に不利であるばかりでなく、コンディショニングの際にポリッシングマットが短命化するおそれがある。メッキする金属は、ダイヤモンド砥粒を仮固定することができるものであれば特に制限はなく、例えば、ニッケル、クロムなどを好適に使用することができる。ダイヤモンド砥粒が仮固定され、ダイヤモンド砥粒固定面から脱落しない状態になれば、余剰のダイヤモンド砥粒を除去する。図2(b)は、ダイヤモンド砥粒が、ダイヤモンド砥粒固定面に仮固定された状態を示す断面図である。ダイヤモンド砥粒を仮固定したとき、大部分のダイヤモンド砥粒はその一部が合金のダイヤモンド砥粒固定面に接した状態で仮固定されるが、合金のダイヤモンド砥粒固定面に接しない状態で付着し、浮き石9となっているダイヤモンド砥粒が存在する場合もあるので、研磨を終了したのち、ダイヤモンド砥粒層の表面をアルミナ砥石、シリコンカーバイド砥石などを用いて軽く研磨することにより、浮き石を除去することが好ましい。図2(c)は、浮き石を除去した状態を

示す断面図である。

【0007】浮き石を除去したのち、白金をふたたびメッキ浴に浸漬し、白金に腐蝕を抑制し、メッキ浴に腐蝕を抑制して、ダイヤモンド砥粒固定面のメッキを行い、ダイヤモンド砥粒をメッキ層4により固定してダイヤモンド砥粒層を形成し、図2(d)に示す状態とする。メッキする金属は、ダイヤモンド砥粒を固定することができるものであれば特に制限はなく、例えば、ニッケル、クロムなどを使用することができるが、特にニッケルが好ましい。ニッケルメッキによりダイヤモンド砥粒を固定する場合、添加剤を加えたスルファミン酸ニッケル浴を使用すると、ニッケルの硬度はHV400〜600、伸び率は1〜5%となり、ニッケル固着層は十分な靱性を有する。ダイヤモンド砥粒を固定するメッキ層の厚さは、ダイヤモンド砥粒の粒径の40%以上であることが好ましく、50%以上であることがより好ましい。メッキ層の厚さがダイヤモンド砥粒の粒径の40%未満であると、ダイヤモンド砥粒を保持する力が不足するおそれがある。ダイヤモンド砥粒をメッキ層により固定してダイヤモンド砥粒層を形成したのち、さらにメッキ層上に耐腐蝕性のメッキを施す。耐腐蝕性のメッキを施す方法には特に制限はなく、メッキする金属に応じてそれぞれ公知の方法を適宜選択することができる。例えば、耐腐蝕性のメッキが金メッキである場合は、金シアン化カリウムを用いるシアン化物メッキ浴法や塩化金を用いるリン酸塩浴法などを挙げることができる。金は最も貴な金属であるので、白金をメッキ浴に浸漬するだけで腐蝕によって表面に金が析出する。このような析出物は薬性金属との密着力が弱く剥離しやすいので、白金に腐蝕を空气中で抑制し、通電を始めてから手早くメッキ浴に浸漬することが好ましい。使用する陽極の材質には特に制限はなく、例えば、純質炭素、ステンレス鋼、ニクロム鋼などを使用することができる。金のメッキを続けると、時間の経過にしたがって析出物が粗粒になるので、時々白金をメッキ浴から取り出して刷毛で摩擦し、ふたたびメッキを繰り返すことにより、平滑なメッキ面を得ることができる。金メッキの厚さは、2〜10 μm であることが好ましく、3〜6 μm であることがより好ましい。金メッキの厚さが2 μm 未満であると、強い酸性条件下でダイヤモンド砥粒を固定するメッキ層が侵食されるおそれがある。金メッキの厚さは10 μm で十分であり、10 μm を超える金メッキは通常は必要はない。図3(a)は、メッキ層上に耐腐蝕性のメッキが施された状態を示す断面図である。メッキ層上に耐腐蝕性のメッキを施したのち、白金よりマスキング材を外して洗浄、乾燥し、合成樹脂層により耐腐蝕性のメッキの表面を被覆する。使用する合成樹脂には特に制限はなく、熱硬化性樹脂及び熱可塑性樹脂のいずれをも使用することができる。熱硬化性樹脂としては、例えば、エポキシ樹脂、ポリウレタン樹脂、不飽和ポリエステル樹脂、フッ素樹

脂などを挙げるることができる。熱可塑性樹脂としては、例えば、フッ素樹脂、ポリアミド樹脂、ポリイミド樹脂などを挙げることができる。また、本発明においては、樹脂の機械的強度を向上させるために、非導電性の無機化合物粒子やファイバーを加えることもできる。熱硬化性樹脂としては、加熱硬化型のほかに常温硬化型の樹脂も使用することができ、さらに、熱硬化性樹脂に代えて光硬化性樹脂も使用することができる。

【0008】図3(b)は、耐腐蝕性のメッキの表面を、さらに合成樹脂層で被覆した状態を示す断面図である。合成樹脂層6で被覆したのち合成樹脂層の表面部分を除去することにより、ダイヤモンド砥粒3の先端作用部を突出させる。ダイヤモンド砥粒の先端作用部を突出させる方法に特に制限はなく、例えば、ダイヤモンド砥粒の最突出部が見えるまで研削盤などを用いて合成樹脂層を除去したのち、一級砥石などによるドレーシング、鏡鉄などの定盤上でのシリコンカーバイトやアルミサなどの微細砥粒を用いたドレーシング、ショットブラストなどにより、ダイヤモンド砥粒の突出量を容易に所定の値とすることができる。ダイヤモンド砥粒は、メッキによって強固に白金に固定されているので、ダイヤモンド砥粒に強い力がかかっても、コンディショナからダイヤモンド砥粒が脱落するおそれがない。図3(c)は、合成樹脂層の表面部分を除去してダイヤモンド砥粒の先端作用部が合成樹脂層6より突出し、かつ耐腐蝕性のメッキの表面が合成樹脂層に被覆されて露出しない状態を示す断面図である。

【0009】図4及び図5は、本発明のCMP用コンディショナの製造方法の他の態様の説明図である。本態様においては、反転型のダイヤモンド砥粒固定面にダイヤモンド砥粒をメッキにより固定し、さらにダイヤモンド砥粒をメッキ層により粗め込んだのち、必要に応じてメッキ層を平坦化し白金の作用面に接合する。その後、反転型を除去し、メッキ層の表面部分を除去してダイヤモンド砥粒を露出させ、メッキ層上に耐腐蝕性のメッキを施し、その表面をさらに合成樹脂により被覆し、ダイヤモンド砥粒の先端作用部を突出させる。ダイヤモンド砥粒をメッキにより固定する場合は、図4(a)に示すように、反転型10のダイヤモンド砥粒固定面7を埋めて、絶縁性のマスキング材8で被覆する。反転型をメッキ浴に浸漬し、ダイヤモンド砥粒固定面にダイヤモンド砥粒3を被覆し、反転型に腐蝕を抑制し、メッキ浴に腐蝕を抑制して、電気メッキを行う。使用するダイヤモンド砥粒に特に制限はないが、JIS B 4130に規定する粒度100/120〜30/40の粒度を有する砥粒であることが好ましく、粒度60/80程度の粒度を有する砥粒であることがより好ましい。ダイヤモンド砥粒の粒径が、粒度100/120に相当する粒径より小さいと、被覆する合成樹脂層の厚さが薄くなって、耐腐蝕性のメッキの表面を完全に被覆しきれなくなるおそれ

がある。ダイヤモンド砥粒の粒径が、粒度30/40に相当する粒径より大きいと、ダイヤモンド砥粒が露出になって経済的に不利であるばかりでなく、コンディショニングの際にポリッシングワットが粗面化するおそれがある。メッキする金属は、ダイヤモンド砥粒を仮固定することができるものであれば特に制限はなく、例えば、ニッケル、クロムなどを好適に使用することができる。ダイヤモンド砥粒が仮固定され、ダイヤモンド砥粒固定面から脱落しない状態になれば、余剰のダイヤモンド砥粒を除去する。図4(b)は、ダイヤモンド砥粒が、ダイヤモンド砥粒固定面に仮固定された状態を示す断面図である。

【0010】余剰のダイヤモンド砥粒を除去したのち、反転型をふたたびメッキ浴に浸漬し、反転型に砥粒を被着し、メッキ浴に砥粒を被着して、ダイヤモンド砥粒固定面のメッキを行い、ダイヤモンド砥粒をメッキ層4により埋め込んでダイヤモンド砥粒層を形成し、図4(c)に示す状態とする。メッキする金属は、ダイヤモンド砥粒を埋め込んで固着することができるものであれば特に制限はなく、例えば、ニッケル、クロムなどを使用することができるが、特にニッケルが好ましい。ニッケルメッキによりダイヤモンド砥粒を埋め込む場合、添加剤を加えたスルファミン酸ニッケル浴を使用すると、ニッケルの膜厚は10~600nm、伸び率は1~5%となり、ニッケル固着層は十分な靱性を有する。ダイヤモンド砥粒をメッキにより埋め込んでダイヤモンド砥粒層を形成した反転型は、マスキング材を外して洗浄、乾燥し、必要に応じて、反転型上のメッキ層の表面を平坦に加工する。例えば、図4(d)に示すように、反転型10上のメッキ層4を合金1に接合する。反転型上のメッキ層4若しくは合金1のダイヤモンド砥粒層接合面又はその双方に接着剤を塗付し、メッキ層とダイヤモンド砥粒層接合面を合わせて固定し、メッキ層を合金1に接合する。使用する接着剤は、コンディショナーの使用に十分な強度を有するものであれば特に制限はなく、例えば、エポキシ接着剤などを好適に使用することができる。必要に応じて、接着剤に無塵充填材、例えば、アルミニウム粉末などを配合することができる。メッキ層4を合金1に接合したのち、反転型10を除去する。反転型を除去する方法には特に制限はなく、例えば、旋盤加工、フライス盤加工などを挙げることができるが、旋盤加工を特に好適に使用することができる。図5(a)は、メッキ層4を合金1に接合し、反転型を除去した状態を示す。

【0011】合金に接合したメッキ層は、金属の表面部分を除去してダイヤモンド砥粒を露出させる。ダイヤモンド砥粒を露出させる方法には特に制限はなく、例えば、一般砥石などによるドレッシング、銼削などの定数上でのシリコンカーバイドやアルミナなどの砥粒砥石によるドレッシング、ショットブラスト、金属剥離材による化学エッチング、電解エッチングなどにより行うこと

ができる。化学エッチング処理は、白金及びダイヤモンド砥粒層を形成する材料のうち、メッキされた金属のみを溶解する薬剤に浸漬することにより行うものである。このような薬剤としては、金属がニッケルである場合はエンストリップNP〔メルテックス(株)製〕、金属がクロムである場合はエンストリップCローテ〔メルテックス(株)製〕などの市販されている薬剤を使用することができる。図5(b)は、メッキ層4の表面部分を除去して、ダイヤモンド砥粒3を露出させた状態を示す。ダイヤモンド砥粒を露出させたメッキ層は、次いでその上に耐腐蝕性のメッキを施す。耐腐蝕性のメッキを必要としない合金の部分は、あらかじめマスキング材により保護することができる。耐腐蝕性のメッキを施す方法には特に制限はなく、メッキする金属に応じてそれぞれ公知の方法を適宜選択することができる。例えば、耐腐蝕性のメッキが金メッキである場合は、金シアン化カリウムを用いるシアン化物メッキ浴法や塩化金を用いるリン酸塩浴法などを挙げることができる。金は最も貴な金属であるので、合金をメッキ浴に浸漬するだけで露出によって表面に金が析出する。このような析出物は希地金属との密着力が弱く剥離しやすいので、合金に砥粒を空気中で被着し、通電を始めてから手早くメッキ浴に浸漬することが好ましい。使用する砥粒の材質には特に制限はなく、例えば、硬質炭素、ステンレス鋼、ニクロム鋼などを使用することができる。金のメッキを続けると、時間の経過にしたがって析出結晶が粗大になるので、時々合金をメッキ浴から取り出して刷毛で擦擦し、ふたたびメッキを繰り返すことにより、平滑なメッキ面を得ることができる。金メッキの厚さは、2~10μmであることが好ましく、3~6μmであることがより好ましい。金メッキの厚さが2μm未満であると、強い酸性条件下でダイヤモンド砥粒を固着するメッキ層が侵されるおそれがある。金メッキの厚さは10μmで十分であり、10μmを超える金メッキは通常は必要はない。図5(c)は、メッキ層4上に耐腐蝕性のメッキ5が施された状態を示す断面図である。メッキ層4上に耐腐蝕性のメッキを施したのち、洗浄、乾燥し、合成樹脂層により耐腐蝕性のメッキの表面を被覆する。使用する合成樹脂には特に制限はなく、熱硬化性樹脂及び熱可塑性樹脂のいずれをも使用することができる。熱硬化性樹脂としては、例えば、エポキシ樹脂、ポリウレタン樹脂、不飽和ポリエステル樹脂、フッ素樹脂などを挙げることができる。熱可塑性樹脂としては、例えば、フッ素樹脂、ポリアミド樹脂、ポリイミド樹脂などを挙げることができる。また、本発明においては、樹脂の機械的強度を向上させるために、非導電性の無機化合物粒子やファイバーを加えることもできる。熱硬化性樹脂としては、加熱硬化型の樹脂が常温硬化型の樹脂も使用することができる。さらに、熱硬化性樹脂に代えて光硬化性樹脂も使用することができる。

【0012】図5(d)は、前腐蝕性のメッキの表面を、さらに合成樹脂層で被覆した状態を示す断面図である。合成樹脂層6で被覆したのも合成樹脂層の表面部分を除去することにより、ダイヤモンド砥粒の先端作用部を突出させる。ダイヤモンド砥粒の先端作用部を突出させる方法に特に制限はなく、例えば、ダイヤモンド砥粒の最突出部が見えるまで研削盤などを用いて合成樹脂層を除去したのち、一般砥石などによるドレッシング、鏡面などの定盤上でのシリコンカーバイドやアルミナなどの微細砥粒を用いたドレッシング、ショットブラストなどにより、ダイヤモンド砥粒の突出量を容易に所定の値とすることができる。ダイヤモンド砥粒は、メッキによって強固に固着されているので、ダイヤモンド砥粒に強い力がかかっても、コンディショナからダイヤモンド砥粒が脱落するおそれがない。図5(c)は、合成樹脂層の表面部分を除去してダイヤモンド砥粒の先端作用部が合成樹脂層より突出し、かつ前腐蝕性のメッキの表面が合成樹脂層に覆われて突出しない状態を示す断面図である。本発明により製造されたコンディショナは、ダイヤモンド砥粒の仮固定の際に、ダイヤモンド砥粒が反転型のダイヤモンド砥粒固定面に接して固定され、ダイヤモンド砥粒層を台金に接合したとき、ダイヤモンド砥粒の最突出部は反転型のダイヤモンド砥粒固定面に接した部分であるので、コンディショナにおいて、各ダイヤモンド砥粒の最突出部が完全に同一平面上に存在する構造となる。また、ダイヤモンド砥粒層と台金の接合後の高表面転写により、ダイヤモンド砥粒層面の粗れ精度は数 μm である。ニッケルの電鍍によりダイヤモンド砥粒を固着する場合、添加剤を加えたスルファミン酸ニッケル浴を使用すると、ニッケルの硬度はHV400～600、伸び率は1～5%となり、ニッケル固着層は十分な靱性を有する。このために、ポリッシングマットのコンディショニングを精度よく効率よく行うことができ、ダイヤモンド砥粒の脱落が長期にわたって生じない。

【0013】合成樹脂によりダイヤモンド砥粒層を覆う方法によれば、数ミリの厚さの合成樹脂層も短時間で形成することができ、前腐蝕性微細砥粒による合成樹脂の除去も短時間で精度よく行うことができる。本発明のCMP用コンディショナにおいて、ダイヤモンド砥粒の突出量は、ダイヤモンド砥粒の平均粒径の5～50%であることが好ましい。平均粒径の20～30%であることがより好ましい。ダイヤモンド砥粒の突出量が平均粒径の5%未満であると、コンディショナのコンディショニング作用が微弱になるおそれがある。ダイヤモンド砥粒の突出量が平均粒径の50%を超えると、コンディショニング作用が強すぎてポリッシングマットを損傷し、ダイヤモンド砥粒が脱落するおそれがある。本発明方法においては、必要に応じてさらにラップ加工を行うことができる。ラップ加工は、ダイヤモンド砥石を用いて突出したダイヤモンド砥粒の先端部をカットするもの

であり、ラップ加工を行うことにより、コンディショナに、使用当初から安定した優れた性能を発揮させることができる。本発明のCMP用コンディショナによれば、前腐蝕性のメッキがバリアとなって、pHの低い酸性の強い研磨液を用いても、メッキ層の金属と研磨液が接触することがないので、ダイヤモンド砥粒が脱落してウェーハを傷つけたり、金属分が溶出してウェーハを汚染することがない。さらに、本発明のコンディショナはダイヤモンド砥粒の最突出部の粗粗さに優れるので、ポリッシングマットの平坦度が向上し、ポリッシングマットの切れ味が向上する。

【0014】

【実施例】以下に、実施例を挙げて本発明をさらに詳細に説明するが、本発明はこれらの実施例によりなんら限定されるものではない。

実施例1

寸法が127D×5W×20T×30Hの台金を、ステンレス鋼(SUS304)を旋盤加工することにより作製した。次に、ダイヤモンド砥粒固定面を残して、表面を絶縁テープ及び塗料によりマスキングした。台金のアルカリ脱脂処理を行い、塩化ニッケル240g/リットル及び塩酸100g/リットルを含有する前処理液に浸漬し、電流密度10A/dm²で常温にて陽極側に台金をセットし2分間電解エッチングしたのち、陰極側に台金をセットしてストライクメッキを3分間行った。次いで、スルファミン酸ニッケルメッキ浴で電流密度1A/dm²で15分間メッキを行い、下地メッキ層を3 μm 形成した。次に、ダイヤモンド砥粒固定面に粗度番号80/80、平均粒径250 μm のダイヤモンド砥粒を載置し、メッキ圧力と硬度調整のための添加剤を加えたスルファミン酸ニッケルメッキ浴を用い、電流密度0.5A/dm²で3時間メッキを行い、ダイヤモンド砥粒一層分を仮固定した。余剰のダイヤモンド砥粒を払い落とし、電流密度1A/dm²で1時間粗めの込みメッキを行ったのち、#100アルミナ砥石を当て、研き石となっているダイヤモンド砥粒を除去した。次いで、塩化ニッケル240g/リットル及び塩酸100g/リットルを含有する前処理液に浸漬して陽極側に台金をセットし、電流密度10A/dm²で常温にて30秒電解エッチングしたのち、陰極側に台金をセットしてストライクメッキを2分間行った。次に、スルファミン酸ニッケルメッキ浴で電流密度1A/dm²で15分間メッキを行い、さらに同じスルファミン酸ニッケルメッキ浴で、電流密度1A/dm²で5時間メッキを行い、ダイヤモンド砥粒を固着するよう厚さ約125 μm のメッキを施した。ダイヤモンド砥粒固定面及び台金を洗浄したのち、シアン化金2.5g/リットル、シアン化カリウム30.0g/リットル、炭素リソ酸ナトリウム15.0g/リットル及びシアン化コバルト10.0g/リットルを含むメッキ浴に浸漬し、ステンレス鋼を陽極とし、浴温50℃、電流密

度0.2A/dm²、電圧2Vの条件で30時間メッキを行い、厚さ4μmの合金金層を形成した。合金金の組成は、金99.7重量%、コバルト0.3重量%であった。マスキングをすべて外し、ダイヤモンド砥粒層が形成された台金を洗浄、乾燥したのち、フッ素樹脂塗料〔日産塗料工業(株)、PFA〕を、塗膜厚さが100μmとなるように塗付して、330℃で30分間焼き付けた。その後、アルミナ砥粒#800を用いてスエードタイプの研磨マットで、ダイヤモンド砥粒先端部が50μm露出するまでラップ加工を行った。得られたCMP用コンディショナを5重量%硝酸に24時間浸漬したが、金属分の溶出は全く認められなかった。また、このCMP用コンディショナを研磨マット(1C1000)を用い、スラリー(硝酸・水・硝酸・アルミナ)でCMP加工を行ったところ、金属露出率の研磨レート1.870μm/分という良好な結果が得られた。

実施例2

寸法が280D-6W-20T-140Hの反転型(S45C)を、旋盤加工により作製した。ダイヤモンド砥粒固定面をマスキングテープで覆い、さらにその他のダイヤモンド砥粒層非形成部分のマスキング処理を行った。アルカリ脱脂処理したのち、反転型を、メッキ浴力と硬度調節のため添加剤を加えたスルファミン酸ニッケル溶に浸め、密度が60/80のダイヤモンド砥粒をダイヤモンド砥粒固定面に載置した。電流密度1A/dm²で2時間メッキを行い、ダイヤモンド砥粒の仮固定を行ったのち、余剰のダイヤモンド砥粒を除去し、さらに電流密度2A/dm²で96時間メッキを行い、3mmの厚みのニッケル固着層を形成してダイヤモンド砥粒を完全に埋め込んだ。次いで、反転型上のニッケル固着層面を、旋盤加工により半粗に加工した。寸法286D-12W-35T-160Hの召金(SUS304)を、旋盤加工により作製した。2液型エポキシ接着剤10重量部にアルミニウム粉末5重量部を混合し、反転型上のニッケル固着層面と召金のダイヤモンド砥粒層接着部分に塗布し接合した。接合層が十分に硬化したのち、旋盤で反転型を正にして召金の裏面を切削して基準面転写した。さらに、召金を旋盤にくわえ、反転型を切削した。その後、ニッケル剥離剤エンストリアMP〔メルテックス(株)〕を用いて、ダイヤモンド砥粒層面のニッケルを約125μm溶解除去した。ダイヤモンド砥粒層が形成された台金を洗浄、乾燥したのち、ダイヤモンド砥粒層以外の部分をマスキング処理し、シアン化金2.5g/リットル、シアン化カリウム30.0g/リットル、薬二リン酸ナトリウム15.0g/リットル及びシアン化コ

バルト10.0g/リットルを含むメッキ浴に浸漬し、ステンレス鋼を陽極とし、浴温50℃、電流密度0.2A/dm²、電圧2Vの条件で35時間メッキを行い、厚さ5μmの合金金層を形成した。合金金の組成は、金99.7重量%、コバルト0.3重量%であった。次いで、エポキシ塗料を塗膜厚さが110μmとなるように塗付し、焼き付けた。その後、シリコンカーバイド#800を用いてエポキシ樹脂層約50μmを削り出し、ダイヤモンド砥粒の光照射用部をエポキシ樹脂層から露出させて、CMP用コンディショナを得た。得られたCMP用コンディショナを5重量%硝酸に24時間浸漬したが、金属分の溶出は全く認められなかった。また、このCMP用コンディショナを用いて、ポリエステル不織布を基剤とし、その上に発泡ポリウレタン層を形成したスエードタイプのポリッシングマットのコンデショニングを行った。平坦性に優れたコンデショニングを、効率よく行うことができた。

【0015】

【発明の効果】本発明のCMP用コンディショナは、pH2以下のような強い酸性条件下でのCMP加工に使用しても、メッキ層から金属が溶出したり、ダイヤモンド砥粒が脱落するおそれがなく、安定してコンデショニングを行うことができる。

【図面の簡単な説明】

【図1】図1は、本発明のCMP用コンディショナの一態様の斜視図及び切断部断面図である。

【図2】図2は、本発明のCMP用コンディショナの製造方法の一態様の説明図である。

【図3】図3は、本発明のCMP用コンディショナの製造方法の一態様の説明図である。

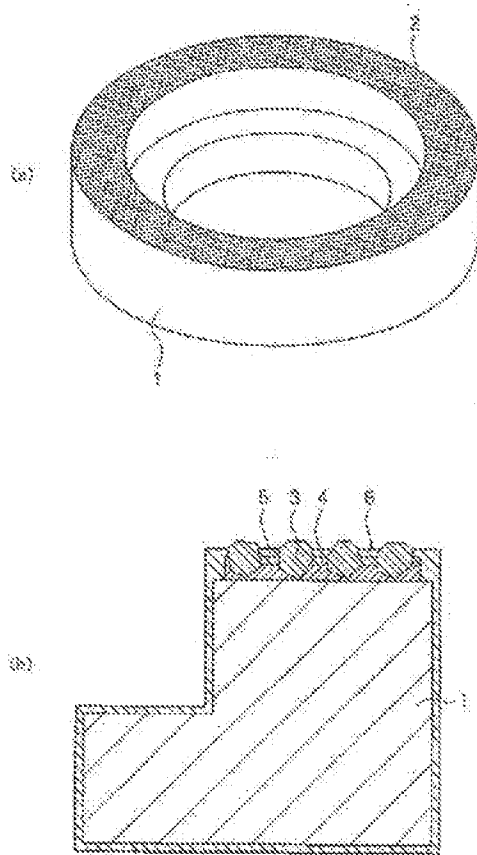
【図4】図4は、本発明のCMP用コンディショナの製造方法の他の態様の説明図である。

【図5】図5は、本発明のCMP用コンディショナの製造方法の他の態様の説明図である。

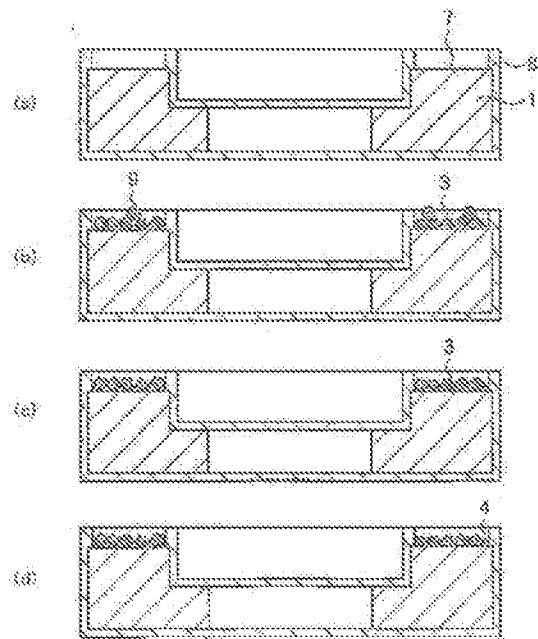
【符号の説明】

- 1 台金
- 2 ダイヤモンド砥粒層
- 3 ダイヤモンド砥粒
- 4 メッキ層
- 5 耐腐蝕性のメッキ
- 6 合成樹脂層
- 7 ダイヤモンド砥粒固定面
- 8 マスキング材
- 9 研磨石
- 10 反転型

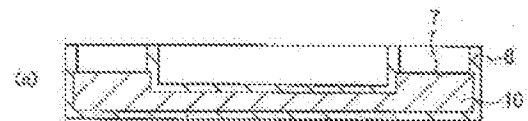
【図1】



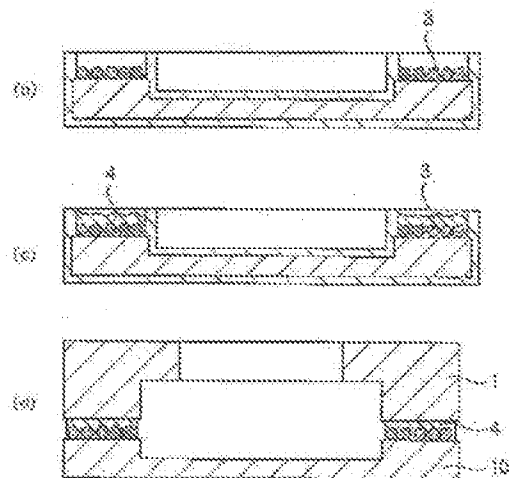
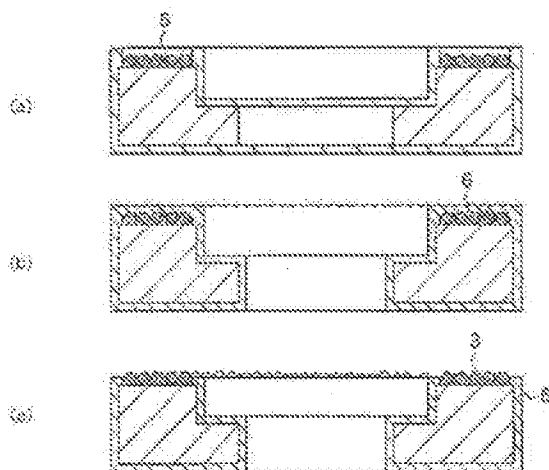
【図2】



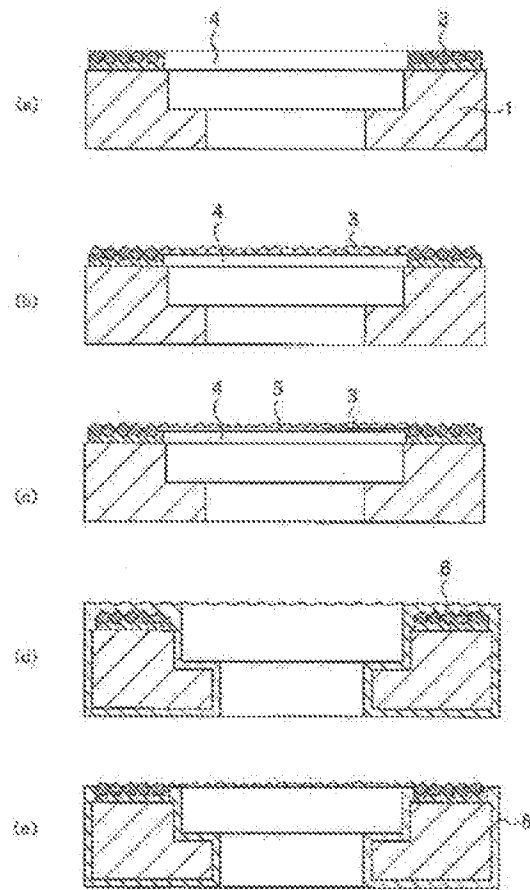
【図3】



【図5】



【図5】





Espacenet

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CMP CONDITIONER, METHOD FOR ARRANGING HARD ABRASIVE GRAIN USED
IN CMP CONDITIONER AND METHOD FOR MANUFACTURING CMP CONDITIONER

Inventor(s): HASHINO HIDEJI; KINOSHITA TOSHIYA; SATO SETSUO;
ARAKI RYUICHI ±

Applicant(s): NIPPON STEEL CORP ±

Classification: - *B24B37/00; B24B53/12; B24D3/00;*
- *B24D7/18; H01L21/304; (IPC1-*
International: 7); *B24B37/00; B24B53/12; B24D3/00;*
B24D7/18; H01L21/304

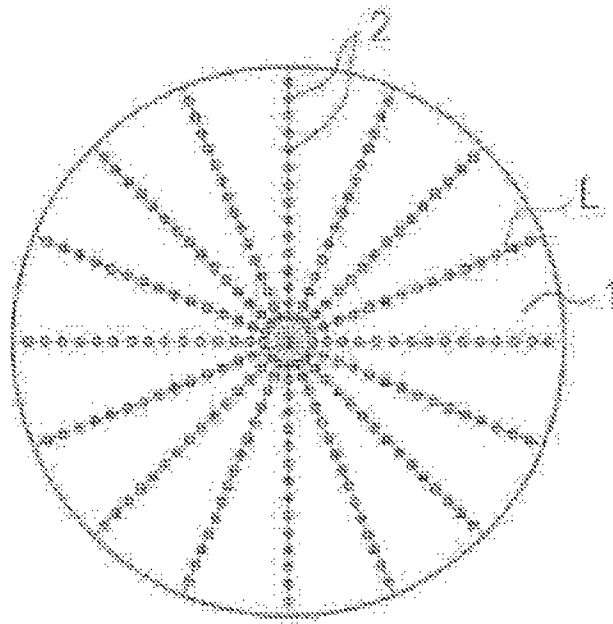
- **European:**

Application
number: JP20010262167 20010830

Priority number
(s): JP20010262167 20010830

Abstract of JP2003071718 (A)

PROBLEM TO BE SOLVED: To provide stable CMP conditioner characteristics and to relieve slurry or the like in polishing without forming relief groove or the like on a support member. **SOLUTION:** This CMP conditioner of polishing cloth for a semiconductor substrate is composed of the support member 1 and plural diamond grains 2 brazed on a surface of the supporting member 1. Plural straight lines or curved lines radially extending from a center of the support member 1 are laid out on the surface of the disk-shaped support member 1 and the diamond grains 2 are arranged on the straight lines or the curved lines. The diamond grains 2 are arranged in such a manner that density of the diamond grains 2 at edge parts is smaller than that at a center part of the support member 1. Since area where no diamond grain 2 exists is secured in radial shape on the surface of the support member 1, slurry can be relieved outward from the support member 1 in polishing.



(10) 日本特許庁長 (J P)

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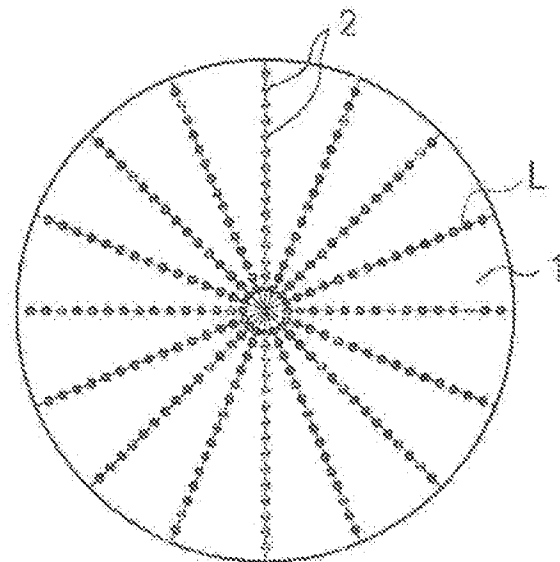
図表頁に続く

(54) 【発明の名称】 CMPコンディショナー、CMPコンディショナーに使用する磨粒砥粒の配列方法、及びCMP
コンディショナー製造方法

(57) 【要約】

【課題】 安定したCMPコンディショナー特性が得られるとともに、支持部材に過剰磨耗を形成しなくとも研磨時にスラリー等を逃すことができるようにする。

【解決手段】 半導体基板上用研磨布のCMPコンディショナーは、支持部材1と、支持部材1の面上にろう付けされた複数のダイヤモンド粒2とからなり、円板状の支持部材1の表面において、支持部材1の中心から放射状に伸びる複数の直線状の溝1を考へ、それら直線状の溝1にダイヤモンド粒2を配置するようにしている。このようにしたCMPコンディショナーでは、ダイヤモンド粒2が支持部材1の中央部分に比べて縁部分における密度が小さくなるよう配列されており、支持部材1の表面上には、ダイヤモンド粒2が存在しない領域が放射状に確保されることになるので、研磨時にスラリーを支持部材1の外側に向けて逃すことができる。



【特許請求の範囲】

【請求項1】 支持部材と、前記支持部材の面上に設けられた複数の硬質砥粒とを備えたCMPコンディショナーであって、

前記支持部材の面上に、前記複数の硬質砥粒を規則的に、かつ、前記支持部材の内側から外側にかけて密度が減少するように配列させたことを特徴とするCMPコンディショナー。

【請求項2】 前記硬質砥粒を、前記支持部材の中心から放射状に配列させていることを特徴とする請求項1に記載のCMPコンディショナー。

【請求項3】 支持部材と、前記支持部材の面上に設けられた複数の硬質砥粒とを備えたCMPコンディショナーであって、前記支持部材の面上に、前記複数の硬質砥粒が存在しない領域を放射状に確保していることを特徴とするCMPコンディショナー。

【請求項4】 前記硬質砥粒はダイヤモンド粒であることを特徴とする請求項1～3のいずれか1項に記載のCMPコンディショナー。

【請求項5】 モタン、クロム、又はジルコニウムより選ばれた1種以上を0.5～20wt%含む融点500℃～1200℃の合金を用いて、前記ダイヤモンド粒を金属及び/又は合金からなる前記支持部材に、単層、ろう付けし、前記ダイヤモンド粒と前記合金との界面にナクン、クロム、又はジルコニウムより選ばれた金属の炭化物層が形成されていることを特徴とする請求項4に記載のCMPコンディショナー。

【請求項6】 前記融点500℃～1200℃の合金がニッケル基合金であることを特徴とする請求項5に記載のCMPコンディショナー。

【請求項7】 規則的に、かつ、内側から外側にかけて密度が減少するように配列させた複数の貫通穴が形成された薄板状の配列部材を被配列面上に位置させる手順と、

前記配列部材の各貫通穴に硬質砥粒を入込む手順とを有することを特徴とするCMPコンディショナーに使用する硬質砥粒の配列方法。

【請求項8】 複数の貫通穴の存在しない領域が放射状に確保された薄板状の配列部材を被配列面上に位置させる手順と、

前記配列部材の各貫通穴に硬質砥粒を入込む手順とを有することを特徴とするCMPコンディショナーに使用する硬質砥粒の配列方法。

【請求項9】 前記被配列面は、CMPコンディショナーを構成する支持部材の表面であることを特徴とする請求項7又は8に記載のCMPコンディショナーに使用する硬質砥粒の配列方法。

【請求項10】 複数の硬質砥粒を規則的に、かつ、内側から外側にかけて密度が減少するように配列させた

態で保持部材に保持する手順と、

前記保持部材により保持された硬質砥粒を、CMPコンディショナーを構成する支持部材の表面に転写する手順とを有することを特徴とするCMPコンディショナーに使用する硬質砥粒の配列方法。

【請求項11】 複数の硬質砥粒の存在しない領域が放射状に確保された状態で前記複数の硬質砥粒を保持部材に保持する手順と、

前記保持部材により保持された硬質砥粒を、CMPコンディショナーを構成する支持部材の表面に転写する手順とを有することを特徴とするCMPコンディショナーに使用する硬質砥粒の配列方法。

【請求項12】 前記保持部材には前記硬質砥粒を保持するための第1の接着手段を設け、前記支持部材の表面には第2の接着手段を設け、これら第1、2の接着手段の性質に差を持たせたことを特徴とする請求項10又は11に記載のCMPコンディショナーに使用する硬質砥粒の配列方法。

【請求項13】 請求項7～12のいずれか1項に記載のCMPコンディショナーに使用する硬質砥粒の配列方法を利用して前記硬質砥粒を前記支持部材の表面上に配列させた後、前記硬質砥粒を前記支持部材の表面に固着することを特徴とするCMPコンディショナー製造方法。

【発明の詳細な説明】

【0601】

【発明の属する技術分野】本発明は、半導体基板用の研磨布の目詰まりを解消し、異物を除去するのに使用されるCMPコンディショナー、CMPコンディショナーに使用する硬質砥粒の配列方法、及びCMPコンディショナー製造方法に関する。

【0602】

【従来の技術】ウェハのポリッシングにおいては、CMP (Chemical Mechanical Polishing) と呼ばれる研磨方法が提案されている。CMPは、機械的研磨作用に化学的研磨作用を重ねて行なわれることにより、研磨速度の確保と被研磨材が無欠陥であることの両立を可能としたものであり、シリコンウェハの仕上げポリッシング工程で広く使用されている。

【0603】また、近年ではデバイスの高集積化に伴い、集積回路を製造する所定の段階で、ウェハ表面やウェハ表面に導電膜・誘電膜が形成された半導体基板表面を研磨することが必要になってきた。半導体基板は、研磨されて、高い突起、引っかけ傷、粗さ等の表面欠陥が除去される。通常、この工程は、ウェハ上に種々の粒子及び集積回路を形成する間に行われる。この研磨工程では、シリコンウェハの仕上げポリッシング工程と同様に、研磨速度と無欠陥であることの両立が必要である。化学スラリーを導入することにより、半導体表面により大きな研磨除去速度及び無欠陥性が与えられる化学的か

つ機械的平坦化が行われる。

【0004】CMP工程の一例としては、図8に示すように、例えば5〜300nm程度の粗度を有するシリカ粒子を含有スラリ、アンモニア及びアミン等のアルカリ溶液に懸濁させてpH9〜12程度に化学スラリー101と、ポリウレタン樹脂等からなる研磨布102とを用いられる。研磨時には、化学スラリー101を流布しながら、半導体基板103を研磨布102に適当な圧力で当接させ、同図の矢印に示すように相対回転させることにより研磨が行われる。

【0005】そして、前記研磨布102のコンディショニング法としては、研磨布102に水又は化学スラリー101を流しながら、CMPコンディショナーを用いたコンディショニングを行って、研磨布102の目詰まりを解消し、異物を除去していた。CMPコンディショナーを用いたコンディショニングは、半導体基板103の研磨が終わった後に、CMPコンディショナーを研磨布102に当接させるか、或いは、半導体基板103の研磨と同時に、半導体基板103が当接する位置とは別の位置でCMPコンディショナーを研磨布102に当接させるかして行われる。

【0006】

【発明が解決しようとする課題】従来の研磨布のコンディショニングに用いられるCMPコンディショナーでは、図9に示すように、円板状の支持部材201の表面に、研磨砥粒としてダイヤモンド粒202を手で盛く等して適当に均一に分布させた後、これらダイヤモンド粒202を回轉させていた。しかし、この場合、いかに丁寧にダイヤモンド粒202を散布したとしても、ダイヤモンド粒202は平均的に分布し、CMPコンディショナー固持間での粗達の原因となり、安定したCMPコンディショナー特性の発現が妨げられていた。

【0007】また、従来のCMPコンディショナーでは、スラリーの逃げが悪いため、マイクロクラッチが多くなった。また、スラリーの逃げを改良するためには、図10に示すように、支持部材201に化学スラリー101を逃すための逃し溝203等を形成しておき、研磨時に、この逃し溝203を介して化学スラリー101を逃すことがなされていた。しかし、支持部材201に逃し溝203を形成するのでは、CMPコンディショナー特性に悪影響を与えるおそれがあり、また、その逃し溝の加工に手間がかかり、コストアップの原因となってしまう。

【0008】本発明は前記のような点に鑑みてなされたものであり、安定したCMPコンディショナー特性が得られるとともに、逃し溝等を形成しなくとも研磨時にスラリー等を逃すことができ、マイクロクラッチを減らすようにすることを目的とする。

【0009】

【課題を解決するための手段】本発明のCMPコンディ

ショナーは、支持部材と、前記支持部材の面上に設けられた複数の硬質砥粒とを備えたCMPコンディショナーであって、前記支持部材の面上に、前記複数の硬質砥粒を規則的に、かつ、前記支持部材の内側から外側にかけて密度が減少するように配列させた点に特徴を有する。

【0010】本発明の他のCMPコンディショナーは、支持部材と、前記支持部材の面上に設けられた複数の硬質砥粒とを備えたCMPコンディショナーであって、前記支持部材の面上に、前記複数の硬質砥粒が存在しない領域が放射状に確保している点に特徴を有する。

【0011】本発明のCMPコンディショナーに使用する硬質砥粒の配列方法は、規則的に、かつ、内側から外側にかけて密度が減少するように配列させた複数の貫通穴が形成された基板状の配列部材を前記配列面上に位置させる手順と、前記配列部材の各貫通穴に硬質砥粒を入れ込む手順とを有する点に特徴を有する。

【0012】本発明の他のCMPコンディショナーに使用する硬質砥粒の配列方法は、複数の貫通穴の存在しない領域が放射状に確保された基板状の配列部材を前記配列面上に位置させる手順と、前記配列部材の各貫通穴に硬質砥粒を入れ込む手順とを有する点に特徴を有する。

【0013】本発明の他のCMPコンディショナーに使用する硬質砥粒の配列方法は、複数の硬質砥粒を規則的に、かつ、内側から外側にかけて密度が減少するように配列させた状態で保持部材に保持する手順と、前記保持部材により保持された硬質砥粒を、CMPコンディショナーを構成する支持部材の表面に転写する手順とを有する点に特徴を有する。

【0014】本発明の他のCMPコンディショナーに使用する硬質砥粒の配列方法は、複数の硬質砥粒が存在しない領域が放射状に確保された状態で前記複数の硬質砥粒を保持部材に保持する手順と、前記保持部材により保持された硬質砥粒を、CMPコンディショナーを構成する支持部材の表面に転写する手順とを有する点に特徴を有する。

【0015】本発明のCMPコンディショナー製造方法は、前記CMPコンディショナーに使用する硬質砥粒の配列方法を利用して前記硬質砥粒を前記支持部材の表面上に配列させた後、前記硬質砥粒を前記支持部材の表面に固着する点に特徴を有する。

【0016】

【発明の実施の形態】以下、図面を参照して、本発明の半導体基板用研磨布のCMPコンディショナー、半導体基板用研磨布のCMPコンディショナーに使用する硬質砥粒の配列方法、及びCMPコンディショナー製造方法の実施の形態について説明する。

【0017】図1を用いて、CMPコンディショナーについて説明する。図1に示すように、ステンレス鋼等からなる円板状の支持部材1の表面には、硬質砥粒としてダイヤモンド粒2が回轉されている。

【0018】図2、3には、支持部材1の表面におけるダイヤモンド粒2の配列の概要を示す。図2に示す例は、円板状の支持部材1の中心から放射状に伸びる複数の直線（一点鎖線）を考え、それら直線上にダイヤモンド粒2を配置したものである。このようにしたCMPコンディショナーでは、ダイヤモンド粒2が支持部材1の内側から外側にかけて密度が小さくなるように配列されており、支持部材1の表面上には、ダイヤモンド粒2の存在しない領域が放射状に確保されることになる。

【0019】また、図3に示す例は、円板状の支持部材1の中心から放射状に伸びる複数の曲線（一点鎖線）を考え、それら曲線上にダイヤモンド粒2を配置したものである。このようにしたCMPコンディショナーでは、ダイヤモンド粒2が支持部材1の内側から外側にかけて密度が小さくなるように配列されており、支持部材1の表面上には、ダイヤモンド粒2が存在しない領域が放射状に確保されることになる。本発明では、放射状とは、図2に示すように直線的に放射する場合だけでなく、図3に示すように曲線的に放射する場合も含むものとする。

【0020】なお、実際のダイヤモンド粒2は、支持部材1に比べて非常に小さなものであるが、図1や後述する図2、3では、説明を簡単にするためダイヤモンド粒2を大きく図示する。また、直線や曲線の数についても、より密な状態で放射させるようにするが、図2、3では簡単に図示する。

【0021】以下、図4～7を参照して、ダイヤモンド粒2の配列方法について説明する。本実施の形態では、次の2通りの方法により、ダイヤモンド粒2を配列させている。

【0022】第1の方法では、図4に示すように、ろう材3が設けられた支持部材1の表面に、接着剤4を塗布しておく。そして、接着剤4を塗布した支持部材1の表面上に配列板5を配置して、プレスする。

【0023】図5に示すように、配列板5には、ダイヤモンド粒2を配列させるための貫通穴6が形成されている。すなわち、配列板5には、図2や図3に示す配列と同様に貫通穴6を配列させている。貫通穴6の口径Xは、ダイヤモンド粒2のサイズDに対して、 $1, 0D < X < 2, 0D$ となっており、1つの貫通穴6に1個以上のダイヤモンド粒2が同時に入り込まないようにしている。なお、配列板5の周囲には、飛散防止用壁5aが設けられている。

【0024】図4に示すように、前記配列板5を支持部材1の表面に設置した状態で、配列板5上にダイヤモンド粒2を散布する。このとき、配列板5に適切な振動を加える等して、ダイヤモンド粒2が全ての貫通穴6に入り込むようにする。全ての貫通穴6にダイヤモンド粒2が入り込んだらば、配列板5上の余分なダイヤモンド粒2をはけ等を用いて取り除く。その後、配列板5を支

持部材1の表面から取り外せば、ダイヤモンド粒2は、図2や図3に示すように配列された状態で支持部材1の表面上に残ることになる。

【0025】以上述べたようにして支持部材1の表面にダイヤモンド粒2を配列させたならば、単層、ろう付けを行い、ダイヤモンド粒2を固定する。このろう付けの際に、支持部材1の表面に塗布された接着剤4はろう材3への加熱によって昇華し、支持部材1の表面上に残留しない。

【0026】なお、第1の方法において、配列板5の代わりに、ワイヤで編まれたメッシュを用いてもよい。すなわち、メッシュの各開口部分を配列板5でいう貫通穴6として使用し、該開口部分にダイヤモンド粒2を入れ込んで、支持部材1の表面に配列させる。

【0027】第2の方法では、前記第1の方法のようにダイヤモンド粒2を支持部材1の表面に直接的に配列するのではなく、粘着シート等の保持部材にいったん配列させてから、支持部材1の表面に転写するようにしている。

【0028】図6(a)に示すように、配列板7には、ダイヤモンド粒2を配列させるための凹部8が形成されている。すなわち、配列板7には、図2や図3に示す配列と同様に凹部8を配列させている。なお、凹部8の口径Yを、ダイヤモンド粒サイズDに対して、 $1, 0D < Y < 2, 0D$ とすることにより、前記第1の方法で述べた貫通穴6と同じである。

【0029】前記配列板7上にダイヤモンド粒2を散布する。このときも、前記第1の方法で説明したように、配列板7に適切な振動を加える等して、ダイヤモンド粒2が全ての凹部8に入り込むようにする。全ての凹部8にダイヤモンド粒2が入り込んだらば、配列板7上の余分なダイヤモンド粒2をはけ等を用いて取り除く。

【0030】次に、配列板7の凹部8が開口する面に粘着シート10を貼り付ける。そして、図6(b)に示すように、配列板7の上下を逆にする等して、粘着シート10を剥がすと、粘着シート10にダイヤモンド粒2が配列された状態で保持されることになる。

【0031】前記粘着シート10のダイヤモンド粒2を保持する粘着面を、接着剤4が塗布された支持部材1の表面に貼り合わせるようにする。したがって、図7に示すように、ダイヤモンド粒2は、一端が粘着シート10側で、他端が支持部材1の表面側で支持された状態となる。その後、支持部材1の表面側にダイヤモンド粒2を露し、粘着シート10だけを取り除けば、ダイヤモンド粒2を支持部材1の表面上に配列させることができる。

【0032】粘着シート10だけを剥離する手法としては、例えば、粘着シート10の接着材の溶解性と、支持部材1側の接着剤4の溶解性とを差を持たせておけばよい。この場合、図7に示す状態で粘着シート10の接着剤が溶けるような環境にすれば、支持部材1側の接着剤

4は保持力を維持したまま、粘着シート10の接着材4だけを溶かし、粘着シート10だけを取り除くことができる。

【0033】以上述べたようにして支持部材1の表面にダイヤモンド粒2を配列させたならば、単層、ろう付けを行い、ダイヤモンド粒2を固定する。このろう付けの際に、支持部材1の表面に塗布された接着剤4はろう材3への加熱によって昇華し、支持部材1の表面上に残留しない。

【0034】なお、第2の方法では、配列板7に凹部8を形成するようにしたが、貫通穴としてよい。この場合、図4に示す支持部材1を粘着シート10に交換すれば、粘着シート10にダイヤモンド粒を配列させることができるので、それを支持部材1の表面に転写すればよい。

【0035】以上述べたように本実施の形態によれば、ダイヤモンド粒2を規則的に配列させているので、CMPコンディショナー間での固体磨がなくなり、安定したCMPコンディショナー特性を得ることができる。また、ダイヤモンド粒2を、支持部材1の中心から放射状に配列させることにより、支持部材1の内側から外側にかけて密度が小さくなるよう配列するようにし、また、ダイヤモンド粒2が存在しない領域を放射状に確保するようにしたので、研磨時にスラリーを支持部材1の外側に向けて送すことができ、マイクロスクラッチが減少する。そして、スラリーを送すための特別な加工を支持部材1に施す必要がなくなるので、加工の手間やコストを軽減させることができる。

【0036】なお、本実施の形態では、本発明という概念範囲としてダイヤモンド粒2を用いたが、その他の材質、例えば立方晶窒化ホウ素、窒化ホウ素、窒化珪素又は酸化アルミニウム等からなるものであってもよい。

【0037】また、ダイヤモンド粒2の支持部材1への固定方法としては、ろう付け以外の方法、例えばニッケル電着等により固定させてもよい。

【0038】ここで、好適な一例として、ダイヤモンド粒をろう付けにより固定する方法について説明すると、ろう材として、チタン、クロム、又はジルコニウムより選ばれた1種以上を0.5～20wt%含む融点650℃～1200℃の合金を用いることにより、ダイヤモンド粒とろう付け合金との界面に当該金属の炭化物層が形成される。ろう材に含まれるチタン、クロム、又はジルコニウムより選ばれた1種以上を0.5～20wt%とするのは、0.3wt%より少ない含有量ではダイヤモンド-ろう付け合金の界面に当該金属の炭化物層が形成されないためであり、20wt%を超えれば十分な接合強度を示す炭化物層が形成されるためである。

【0039】ろう付け合金を融点650℃～1200℃の合金とするのは、650℃未満のろう付け温度では、接合強度が得られず、1200℃超のろう付け温度で

は、ダイヤモンドの劣化が起こるので好ましくないからである。ろう付け合金としては、例えば、上記成分を含有するニッケル(Ni)-基合金等が好適に用いることができる。

【0040】ろう付け合金の厚さは、ダイヤモンド粒の0.2～1.5倍の厚さが適当である。薄すぎると、ダイヤモンドとろう付け合金との接合強度が低くなり、厚すぎると、ろう材と支持部材との剥離が起こりやすくなるためである。

【0041】ダイヤモンド粒の径は、50μm～360μmとすることが好ましい。50μm未満の微粒ダイヤモンド粒では、十分な研磨速度が得られず、また、凝集しやすい傾向があり、脱落しやすくなるためである。また、360μm超の粗粒のダイヤモンド粒では、研磨時の圧力集中が大きくなり、脱落しやすくなるためである。

【0042】

【発明の効果】以上述べたように本発明によれば、CMPコンディショナー間での固体磨がなくなり、安定したCMPコンディショナー特性を得ることができるので、安定した量産CMPプロセスを実現することが可能となる。また、研磨時にスラリーを送すことができ、マイクロスクラッチを減らすことができ、しかも、そのための特別な加工を支持部材に施す必要がなくなるので、加工の手間やコストを軽減させることができる。

【図面の簡単な説明】

【図1】CMPコンディショナーについて説明するための図である。

【図2】ダイヤモンド粒2の配列の一例を示す図である。

【図3】ダイヤモンド粒2の配列の一例を示す図である。

【図4】第1の方法によるダイヤモンド粒2の配列方法を説明するための図である。

【図5】配列板7を説明するための図である。

【図6】第2の方法によるダイヤモンド粒2の配列方法を説明するための図である。

【図7】第2の方法によるダイヤモンド粒2の配列方法を説明するための図である。

【図8】CMP工程を説明するための図である。

【図9】従来のCMPコンディショナーについて説明するための図である。

【図10】層203を形成したCMPコンディショナーを示す模式図である。

【符号の説明】

- 1 支持部材
- 2 ダイヤモンド粒
- 3 ろう材
- 4 接着剤
- 5 配列板

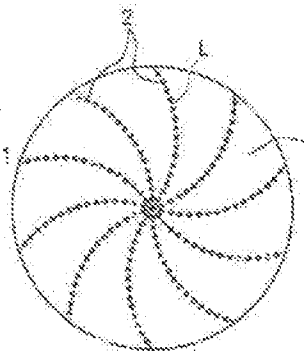
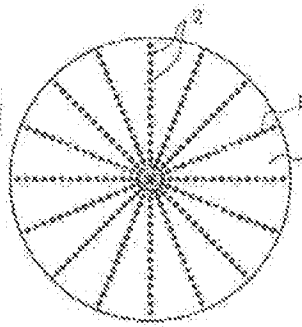
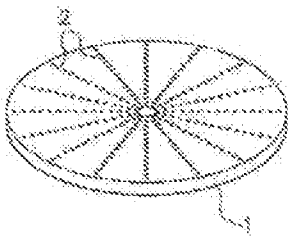
5a 飛散防止用壁
6 貫通穴
7 配列板
8 凹部
9 鉛封

10 粘着シート
101 化学スラリー
102 研磨布
103 半導体基板

【図1】

【図2】

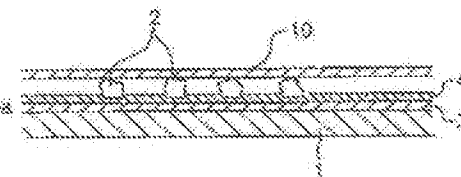
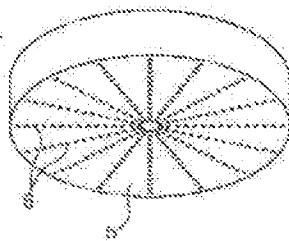
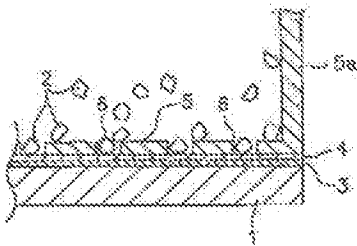
【図3】



【図4】

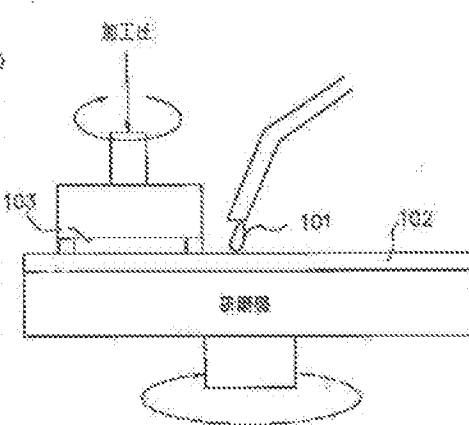
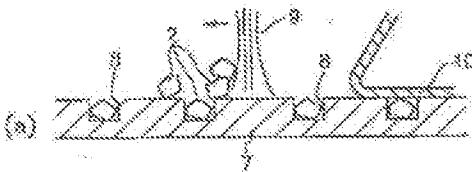
【図5】

【図7】



【図6】

【図8】



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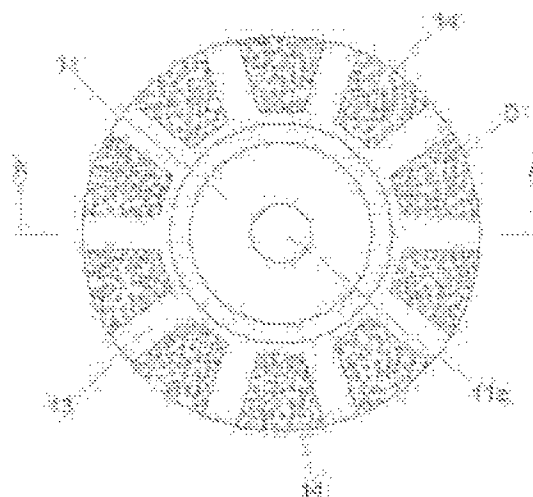
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DISC-SHAPED DIAMOND GRINDING WHEEL

Inventor(s): NAGAYA AKIHIKO; KOTANI NORIOMI ±
Applicant(s): AIRTEC JAPAN KK; GOEI SEISAKUSHO KK ±
Classification: *international:* B24D3/00; B24D3/06; B24D7/06;
 (IPC1-7): B24D3/00; B24D3/06;
 B24D7/06
- European:
Application number: JP20020188194 20020627
Priority number (s): JP20020188194 20020627

Abstract of JP2004025401 (A)

PROBLEM TO BE SOLVED: To provide a disc-shaped diamond grinding wheel hardly causing loading and having flexibility. ;
SOLUTION: A base plate 11 of the disc diamond grinding wheel is made into a cup form of 10 cm in diameter having flexibility, and a jig mounting hole 11a to mount the base plate 11 on a grinder, etc. is provided on a central part of the base plate 11. Additionally, a rubber sheet 13 is adhered on a do-nut shaped part on a flat surface of a peripheral part of the base plate 11, and a plurality of polishing chips 14 are adhered along a circumference under a deposition method coating diamond abrasive grains D on its upper layer. As they are supported by the base plate 11 excellent in flexibility, strength, etc. and the rubber sheet 13 transmits its elasticity to the polishing chips 14, the polishing chips 14 respectively and independently polish a polishing article along its surface and also polish the small area part and the curved surface. ;
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Last updated: 14.03.2012 Worldwide Database 5.7.38, 83p

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		Fターム(参考)	2C063 AA02 AB05 BA08 BB02 BC02 BF02 BG01 BH07 CC02 EE25

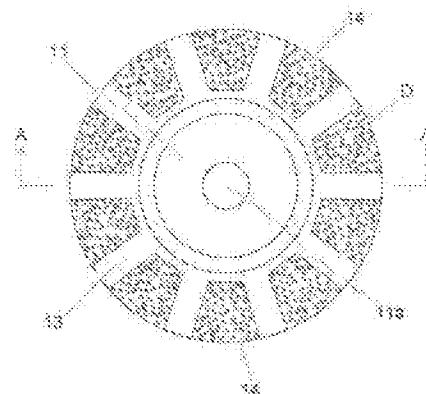
(54) 【発明の名称】 ディスク状ダイヤモンド砥石

(57) 【要約】

【課題】目詰まりの起こし難く、可塑性を有するディスク状ダイヤモンド砥石を得る。

【解決手段】ディスク状ダイヤモンド砥石の基板11は可塑性を有する直径10cmのカップ状とされ、基板11の中心部には基板11をグラインド等に取り付けるための治具取付孔11aが設けられている。また、基板11の周辺部の平面上のドーナツ状部分にはゴムシート13が接着され、更にその上層にダイヤモンド砥粒Dを塗布した溶着法による複数個の研磨チップ14が円周に沿って接着されている。可塑性、強度等に優れた基板11に支持され、ゴムシート13がその弾力性を研磨チップ14に伝えるため、研磨チップ14はそれぞれ独立に被研磨物の面に沿って研磨でき、小面積部や曲面も研磨することができる。

【図1】 図1



【特許請求の範囲】

【請求項1】

ダイヤモンド微粒を塗布した複数個の金属片から成る研磨チップを可溶性材料から成るディスク状基板上の外周平坦部表面に配列したことを特徴とするディスク状ダイヤモンド砥石。

【請求項2】

前記研磨チップは前記ディスク状基板の内周に沿って等間隔に配列したことを特徴とするディスク状ダイヤモンド砥石。

【請求項3】

前記研磨チップは前記ディスク状基板上に積層したゴム層上に接着した請求項1に記載のディスク状ダイヤモンド砥石。

【請求項4】

前記ダイヤモンド砥粒は溶着法により前記研磨チップに塗布した請求項1に記載のディスク状ダイヤモンド砥石。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】

本発明は、グラインダ等の回転工具に取り付け、硬質材料表面に塗着された表面塗膜を剝離したり、金属表面の錆を除去したり、或いは研磨をするディスク状ダイヤモンド砥石に関するものである。

【0002】

【従来の技術】

例えば、建設の橋梁や工場の大梁、タンク等の保守に際して、表面塗膜の補修をする場合において、それらの表面に塗着されている重防食塗料の剥離はなかなか困難であり、二度、三度の手間を要する難作業である。

【0003】

通常では、グラインダ等の電動工具の回転により金属片を表面塗膜に打ち付けることにより面を荒らし、その後、ディスク状サンドペーパーによって塗膜を剝離する。

【0004】

【発明が解決しようとする課題】

しかしながら上述の従来例においては、金属片を打ち付ける際に、その母材の鉄やコンクリートの打撃音や振動が激しく、母材を痛めることもある。また、ディスク状サンドペーパーも重防食塗料により無時間で目詰まりを起こしてしまい、交換頻度も多く、作業効率も極めて悪い。

【0005】

通常の建物の外壁塗膜の剥離においても、塗料の違いこそあれ、目詰まりによる交換損失を生ずる。目詰まりさえしなければ安い安い砥粒が好適であることは明白であるが、実際には砥粒は摩耗しておらず研磨性能は十分あっても、目詰まりで砥石が使用できなくなるという問題がある。

【0006】

現在、ダイヤモンド砥石を使用した研磨材としては、図4に模式的に示すような金属粉末を用いてダイヤモンド微粒を混入して固めたメタルボンドと称される研磨剤1と、図5に示すように表面にメッキによる電着法により製造された研磨剤2が知られている。

【0007】

しかしながら、前述のメタルボンド製の研磨剤1は、ダイヤモンド砥粒Dの突き出しが少なく、目詰まりするため研磨効率には不適である。後者の電着製の研磨剤2は砥粒の突き出しは多いが、ダイヤモンド砥粒Dとメッキの間に隙間Gが発生してメッキが剥離し易く、ダイヤモンド砥粒Dの脱落が多く目詰まりを生じ易い。

【0008】

また、現状のディスク状ダイヤモンド砥石としては、カップ型のものが多く用いられてい

るが、金属製の板形基盤の平坦部にメタルボンド製ダイヤモンドを下駄歯状のブロックにして取り付けたものが多く、騒音、振動共に非常に激しい。

【0009】

本発明の目的は、上述の問題点を解消し、金属片を打ち付ける作業を不要とし、目詰まりが少なく長時間の作業に耐え、作業音や振動が静かな可能性を有し、小面積部や曲面をも研磨することのできるディスク状ダイヤモンド砥石を提供することにある。

【0010】

【課題を解決するための手段】

上記目的を達成するための本発明に係るディスク状ダイヤモンド砥石は、ダイヤモンド砥粒を散布した被敷層の金属片から成る研磨チップを可溶性材料から成るディスク状基板上の外周平坦部表面に配列したことを特徴とする。

【0011】

【発明の実施の形態】

本発明を図1～図3に図示の実施の形態に基づいて詳細に説明する。

図1は本実施の形態におけるディスク状ダイヤモンド砥石の平面図、図2は図1におけるA—A線に沿った断面図を示している。基板11は例えばエポキシ樹脂材に繊維質料としてガラスファイバ材料を混合し、例えば直径100mmの可撓性を有するカップ状とされ、基板11の中心部には基板11をグラインダ等に取り付けるための治具取付孔11aが設けられている。また、基板11の周辺部の平面状のドーナツ状部分12にはゴムシート13が接着され、更にその上層にダイヤモンド砥粒を散布した例えば10mmの研磨チップ14が接着されている。

【0012】

研磨チップ14としては、特に溶着方法を用いてダイヤモンド砥粒を散布したものが好適である。溶着方法は自溶性合金タイプとブロンズタイプの2種があり、自溶性合金タイプはNi—Cr系合金粉末、ブロンズタイプはブロンズ系粉末及びTi等の活性金属粉末を、市販の真空炉バインダと混合することにより、先ずペーストを作製する。続いて、所定の形状、例えば本実施の形態では、周辺の基板11と同曲率にして原状に打ち付けた金属片上に、厚みが一定になるようにすり切り治具を使用して上述のペーストを塗布する。

【0013】

ペーストを塗布すり切りした後、塗布したペースト上に振動機等を用い、ダイヤモンド砥粒を散布する。なお、自溶性合金タイプの場合には市販の真空炉バインダを金属片上に均一に塗布し、ダイヤモンド砥粒Dを散布した後、Ni—Cr系合金粉末を振りかける方法でも同様なものが作製できる。

【0014】

次に、ダイヤモンド砥粒Dを散布した金属片を乾燥機に入れ、24時間乾燥することにより、バインダに含まれている油類成分を十分に除去する。続いて、この乾燥処理を行った金属片を真空炉にセットし、真空度が 10^{-2} 以上の高真空とした後に、自溶性合金タイプは1000～1100℃、ブロンズタイプは800～950℃の温度で焼成を行う。これらの温度で焼成を行うことによりダイヤモンド砥粒DをNi—Cr系金属、活性金属含有ブロンズ系金属でそれぞれ良好に溶着することができる。

【0015】

溶着されたダイヤモンド砥粒は、図3の模式図に示すように活性金属と反応層を形成し強固な金属結合することにより、研磨チップ14上からのダイヤモンド砥粒Dの突き出しが大きい。そして、研磨チップ14は真空炉内の温度が室温に下った後に取り出す。

【0016】

なお、研磨チップ14のダイヤモンド砥粒Dの溶着や電着等の塗布方式では、被研磨物によって耐久性上問題があることもあり、基板11にダイヤモンド砥粒Dを混入したメタルボンド製のブロックを、円形や板状等に成形し貼り付けたものでし、振動や騒音を格段に解消することもできる。

【0017】

ディスク状ダイヤモンド砥石を被研物の研磨に用いる際には、基板11をブライнда等の回転工具に取り付けて回転させ、被研物側に研磨チップ14を押し当てる。この際に、基板11は柔軟性、屈曲性、強度等に優れた基板11に支持されつつ、ゴムシート13がその弾力性を研磨チップ14に伝えるため、研磨チップ14はそれぞれ独立に被研物の面に沿って研磨できるため、小凹部や曲面においても、優れた研磨を行うことができる。

【0018】

なお、本実施の形態においては研磨チップ14はゴム層13を介して取り付けだが、ゴム層13を省略して基板11に直接取り付けてもよい。また、研磨チップ14は扇状の金属片上にダイヤモンドを散布したが、研磨チップ14の形状は扇状に限らず、円形やその他の形状でも支障はない。

【0019】

【発明の効果】

以上説明したように本発明に係るディスク状ダイヤモンド砥石は、特に、金属の鋳取りや硬質樹脂、塗料等の研磨・剥離に有効であり、均一な広い面荒いは逃げ面をも容易に得ることができると共に、打撃音や振動を小さくし、作業者の労務上も、周囲への騒音問題についても、問題が発生することは少ない。

【0020】

また、可塑性を有するため研磨チップが被研磨面に良く密着し、効率良く剥離作業を行うことができる。更に、ダイヤモンド砥粒を溶着法により散布すれば、電気法のように切削塵があり、メタルボンド法に近い耐久性のあるものとなる。

【図面の簡単な説明】

【図1】 ディスク状ダイヤモンド砥石の平面図である。

【図2】 図1のA-A線に沿った断面図である。

【図3】 溶着による研磨チップの模式的断面図である。

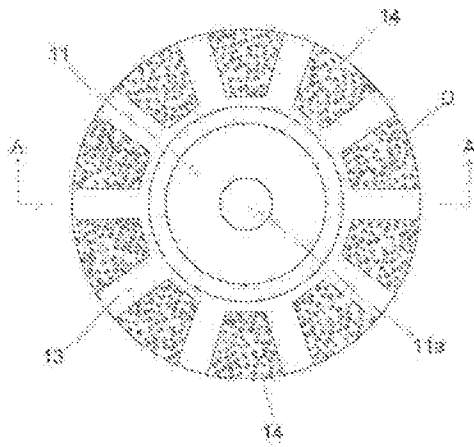
【図4】 メタルボンドによる研磨チップの模式的断面図である。

【図5】 電気法による研磨チップの模式的断面図である。

【符号の説明】

- 11 基板
- 12 ドーナツ状部分
- 13 ゴムシート
- 14 研磨チップ
- D ダイヤモンド砥粒
- R 反応層

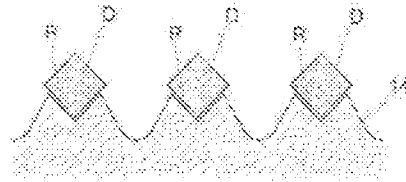
【図1】



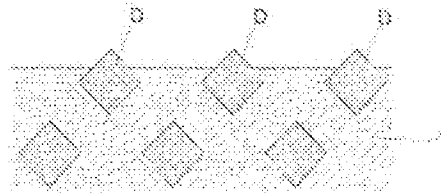
【図2】



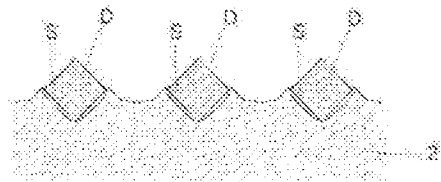
【図3】



【図4】



【図5】



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요약

본 고안은 화학적-기계적-연마(CMP)용 폴리싱 페드의 평탄화를 향상시킴과 동시에, 이 페드의 전디서너를 효과적으로 행하는 기능을 가지고, 더구나 전디서너 성능이 우수하고, 수명이 길며, 전디서너의 제조가 용이하여 제조사의 불량률을 현저히 감소시킬 수 있는 CMP 장치용 전디서너를 제공함에 그 목적이 있다.

이러한 목적을 달성하기 위한 본 고안은, 상크(3)의 표면에 구멍 형상의 비마스킹부(1)를 가지는 마스킹 시트(2)를 정착하고, 하나의 비마스킹부(1)에 하나의 다이아몬드 입자(4)만을 예비 고정한 후에 마스킹 시트(2)를 박리시키고, 이어서 도금액 안에 넣어서 다이아몬드 입자 적량의 40~60% 정도의 두께를 가지도록 NH 도금액(6)을 석출시키며, 더욱이 1개 구멍 형상의 비마스킹부(1)의 면적이 다이아몬드 입자(4)의 투영 면적의 110~160%배로 되고, 상기한 마스킹 시트(2)의 비마스킹부(1)의 면적적 비마스킹 시트(2)의 면적적의 0.04~0.2배의 범위로 하는 것이 특징으로 된 화학적-기계적-연마 페드용 다이아몬드 전착 전디서너를 제공한다.

본 고안에 의해 지수 생밀도가 임격한 제련 형상을 제련성 높게 용이하게 형성시킬 수 있고, 마스킹 시트(2)의 상크(3)에 대한 밀착력이 높으며, 또한 상크(3)에 결합되는 80~120배수의 다이아몬드 입자(4)가, 구멍형의 비마스킹부(1)에 한 개씩 분산된다. 따라서 CMP용 폴리싱 페드의 평탄화를 향상시킴과 동시에, 이 페드의 전디서너를 효과적으로 행하는 기능을 가지고, 더구나 전디서너 성능이 우수하고, 수명이 길며, 전디서너의 제조가 용이하기 때문에 제조사의 불량률을 현저히 감소시킬 수 있다.

도면도

도 1

설명어

화학적-기계적-전기, 레드, 컨디셔너, 폴리싱, 다이아몬드

영세서

도면의 간단한 설명

도 1은 마스크링 시트를 장착한 상크의 부분 평면도

도 2는 다이아몬드 입자가 예리 고정된 상크의 부분 평면도

도 3은 본 고안 컨디셔너의 작동면의 부분 단면도

도 4는 본 고안에 의한 일실시예인 컨디셔너의 작동면의 평면도

도 5는 본 고안에 의한 다른 실시예인 컨디셔너의 작동면의 평면도

〈도면의 주요부분에 대한 부호의 설명〉

1: 구멍형상의 비마스크링부 2: 마스크링 시트

3: 상크 4: 다이아몬드 입자

5: 예리 도금층 6: Ni 도금층

7: 컨디셔너 8: 비전착 영역

고안의 상세한 설명

고안의 목적

고안이 속하는 기술 및 그 분야의 종래기술

본 고안은 반도체의 웨이퍼 가공에 사용되는 CMP(Chemical mechanical planarization) 장치의 레드 컨디셔너에 관한 것이다. 보다 상세하게는, 본 고안은 CMP용 폴리싱 레드의 평탄화를 향상시킴과 동시에, 이 레드의 컨디셔닝을 효과적으로 행하는 기능을 가지고, 더구나 컨디셔닝 성능이 우수하고, 수명이 긴 CMP 장치용 컨디셔너에 관한 것이다.

반도체 웨이퍼의 면마를 반복하기 위하여, 연마 입자나 연마질 등이 폴리싱 레드의 미세한 구멍에 들어가서 누출음이 일어난다든지, 연마 입자와 웨이퍼와의 화학 반응 등에 의해 폴리싱 레드의 표면이 평면화하여 연마 속도를 저하시키게 된다. 이 때문에 폴리싱 레드의 표면을 재생시켜 연마 속도를 회복시키는 컨디셔너라고 불리는 공구가 사용된다. 다이아몬드 입자는 우수한 컨디셔닝 재료이며, 다이아몬드 입자를 이용한 컨디셔닝이 실용화되어 있다. 이와 같은 CMP용 폴리싱 레드의 컨디셔너에 대해서는, 폴리싱 레드의 마찰을 가급적 억제할 수 있으며, 더욱이 레드의 표면 상태를 항상 소정의 연마속도가 얻어지도록 일정하게 유지되는 것과, 다이아몬드 입자의 탈락이 없고, 레드면에 누출음을 일으키지 않는 것이 요구된다.

다이아몬드 입자를 컨디셔너 본체의 작용면에 금속 결합재를 사용하여 고정하는 방법에는 여러 가지가 있으나, 전착법은 비교적 용이하고 더욱이 다이아몬드 입자를 컨디셔너 본체의 작용면에 확실하게 고정시킬 수 있으므로 많이 사용되고 있다. 전착법에 의해 다이아몬드 입자를 고정하는 경우는, 컨디셔너 본체의 작용면에 다이아몬드 입자의 고정면을 남겨 두어서, 절연성의 마스크 재료로 피복한다. 컨디셔너의 본체를 도금액에 담그고 입자 고정면에 입자를 놓아서 컨디셔너의 본체에 음극을 접속하고, 도금액에 양극을 접속하여 전기 도금을 행하여 다이아몬드 입자를 예리 고정한다. 다이아몬드 입자를 예리 고정된 후에 대부분의 입자는 그 일 부가 본체의 입자 고정면에 접한 상태에서 예리 고정되지만, 본체의 입자 고정면에 접하지 않은 상태에 부착하여, 부유하는 입자가 존재하는 경우도 있다. 컨디셔너의 본체를 다시 도금액에 넣어서, 본체에 음극을 접속하고 도금액에 양극을 접속하여 다이아몬드 입자 고정면의 도금을 행한다.

그러나 종래의 전착 스텝들의 계조에 있어서, 전다셔너 본체의 폭출면에 다이아몬드 입자의 고정면을 남겨 두어서, 전 연성의 마스크 재료로 피복하는 경우에 미세한 크기의 적절한 치수 정밀도로 피복하는 것이 곤란하여 마스크 되어 있지 않은 곳에 두 개 이상의 다이아몬드 입자가 동시에 들어가는 문제가 발생하였고, 마스크 위치가 어긋나서 동일한 형상으로 재현하는 것이 곤란하였고, 피복층이 평활하게 되지않고 요철(BUMP)이 심하였으며, 피복층의 밀착력이 약하여 이후에 공정에서 벗겨지는 경우가 있었기 때문에, CMP 패드를 전다셔닝 하는데 있어서 불행함이 매우 높았다. 또한 종래의 전다셔너는, 패드의 표면 상태를 항상 소량의 연마속도가 떨어지도록 일정하게 유지시키는 것이 곤란하였 으며, 다이아몬드 입자의 탈락이 많고, 패드면에 농배율을 일으키는 경우가 많았으며, 종래의 전다셔너를 사용하여 패 드를 전다셔닝하면, 웨이퍼의 표면거칠기 값 및 스크래치 개수가 높은 것이 큰 문제로 되어왔다.

본 고안이 이루고자 하는 기술적 과제

본 고안은 CMP용 폴리싱 패드의 평탄화를 향상시킨과 동시에, 이 패드의 전다셔닝을 효과적으로 행하는 기능을 가 지고, 더구나 전다셔닝 성능이 우수하고, 수명이 길며, 전다셔너의 계조가 용이하며 제조사의 불량률을 현저히 감소시 켜 줄 수 있는 CMP 장치용 전다셔너를 제공함에 그 목적이 있다.

본 고안의 구성 및 작용

본 고안자들은, 상기와 목적을 해결하기 위하여 실험적인 연구를 거듭한 결과, 전착 전다셔너의 연성면에서 있어서, 한 다의 비마스크부에 한 개씩의 다이아몬드 입자를 분산시키는 것에 의해, 연착 저항을 감소시키고 전다셔너의 수명이 증가되며, 연마속도와 전다셔닝 속도가 높아지며, 웨이퍼의 표면거칠기 값이 낮아지며, 웨이퍼의 스크래치 개수가 감소됨을 확인하였다. 즉, 본 고안은, 상크(3)의 표면에 구멍 형상의 비마스크부(1)를 가지는 마스크 시트(2)를 제작 하고, 하나의 비마스크부(1)에 하나의 다이아몬드 입자(4)만을 예비 고정할 후에 마스크 시트(2)를 박리시키고, 이어 서 도금액 안에 넣어서 다이아몬드 입자 직경의 40~60% 정도의 두께를 가지도록 Ni 도금층을 적층시키며, 더욱이 1 개의 구멍 형상의 비마스크부(1)의 면적이 다이아몬드 입자(4)의 두께 면적의 110~160%배로 작고, 상기한 마스크 시트(2)의 비마스크부(1)의 전면적이 마스크 시트(2)의 전면적의 0.04~0.2배의 범위로 하는 것이 특징으로 된 특특 적-기계적-연마 패드 전다셔너를 제공하는 것이다.

아래에, 도면을 참고하여 본 고안을 상세히 설명한다. 그림 1은 마스크 시트(2)를 정작한 상크의 부분 평면도이다. 그 려면 1에서 알기로 표시되는 부분이 비마스크부(1)로서, 한 개의 비마스크부(1)에 1개의 다이아몬드 입자(4)가 고정된 다. 1개의 비마스크부(1)에 고정되는 다이아몬드 입자(4)가 2개를 넣으면, 패드에 의한 연마에서 웨이퍼의 표면거칠 기 값이 낮아지며, 웨이퍼의 스크래치 개수가 감소되기 쉽다. 그림 1에서 비마스크부(1)의 전면적이 다이아몬드 입자 (4)를 고정할 연성면 적의 0.04~0.2배이다. 비마스크부(1)의 전면적이 다이아몬드 입자(4)를 고정할 연성면의 전면 적의 0.04배 미만이면, 전다셔너(7)로서의 연마력이 부족한 문제가 있으며, 전다셔너(7)의 수명이 짧아지게 된다. 또 한 비마스크부(1)의 전면적이 다이아몬드 입자(4)를 고정할 연성면의 전면적의 0.3배 이상이면 패드에 의한 연마에서 웨이퍼의 표면거칠기 값이 낮아지며, 웨이퍼의 스크래치 개수가 감소되기 쉽다. 본 고안의 전다셔너의 상크(3) 재료로는, 스테인레스 강재인 STS 304를 사용하는 것이 바람직하나, 경우에 따라서는 예를 들면 알루미늄 합금 등이 사 용될 수 있다.

본 고안의 전다셔너를 제조하기 위해서는, 우선 상크(3)의 앞저를 행하는 것이 바람직하다. 앞저를 종료한 상크면에, 구멍 형상의 비마스크부(1)를 가지는 마스크 시트(2)를 접착한다. 그림 1에서, 원형의 구멍 형상의 비마스크부(1)를 가지는 마스크 시트(2)가 상크(3)에 접착되고, 상크(3)의 일부가 비마스크부(1)의 형상으로 노출되어 있다. 본 고안에 서는, 마스크 시트(2)를 정작한 상태에서, 전다셔너의 연마면으로 되는 상크면에 예비 도금층(5)을 형성시키는 것이 바람직하다. 예비 도금을 실시하는 것에 의해, 다이아몬드 입자(4)와 상크(3)가 직접 접촉하는 것이 아니고, 다이아몬 드 입자(4)의 상크(3)에 대한 고정성이 개량된다. 예비 도금하는 금속으로는 니켈 및 니켈 합금을 사용할 수가 있다. 본 고안에서는, 예비 도금을 실시한 상크를, 마스크 시트(2)를 정작한 상태에서 도금 용기에 넣고, 도금 용기 안에서 상크의 마스크 시트(2)를 정작한 면의 부분에 다이아몬드 입자(4)를 충전한다. 여기서, 상크에 용액을 침투시키고, 도금 액에 양극을 계속하여, 예비 도금층(5)의 형성을 위한 전기 도금을 실시한다. 예비 도금을 위한 금속은 다이아몬드 입 자(4)를 상크(3)에 예비 고정할 수 있는 것이라면 제한이 없으나, 니켈 및 니켈 합금을 사용할 수가 있다. 각 다이아몬 드 입자(4)의 일부분은 비마스크부(1)에서 예비 도금층(5)을 사이에 두고 예비고정되며, 상크 표면에서 탈락하지 않 는 상태로 되면, 예비 고정을 위한 도금을 종료하고, 상크를 도금 용기로부터 꺼낸다. 그림 2는, 다이아몬드 입자가 예 비 고정된 상크의 부분 단면도이다. 본 그림에서, 상크(3)에 마스크 시트(2)가 정작되고, 마스크 시트의 구멍 형상의 비마스크부(1)에 다이아몬드 입자(4)가 예비 도금층(5)에 의해 예비 고정되어 있다.

이어서 상크(3)의 표면으로부터 마스크 시트(2)를 박리시키고, 더욱이 마스크부의 앞저와 절성화 처리를 행한 후에, 다시 상크(3)를 도금 용기에 담그서 용액을 침투시키고, 도금액에 양극을 계속하여 도금을 계속하여, 다이아몬드 입자 (4)를 상크(3)에 전착하여 연성면을 형성하고, 전다셔너를 완성하게 된다. 도금에 사용하는 금속은, 예비 고정된 경우

와 마찬가지로 다이아몬드 입자(4)를 상크(3)에 고착할 수 있는 것이면 제한이 없고, 예를 들면 니켈 및 니켈 합금을 사용할 수 있다. 그림 3은 본 고안의 전디셔너의 연삭면의 부분 단면도이다. 본 그림에서 다이아몬드 입자(2)는 상크(3)에 예비 도금층(5)에 의해 예비 고정되며, 더욱이 도금층에 의해 형성된 Ni 도금층(6)에 의해 완전히 고정되어 있다. 본 고안에서 이용하는 마스크링 시트(2)는, 도금 조건에 견딜 수 있는 것이면 제한은 없으며, 예를 들면 폴리 에틸렌, 폴리 수지 시트의 일면에 아크릴계 또는 미닐 에테르계 등의 절착제를 도포한 뒤에 박리시트를 적층시키고, 또한 구멍 형성상의 비마스크링부(1)의 가공을 실시한 것을 용이하게 사용할 수가 있다. 마스크링 시트(2)의 무게란, 수지 시트 및 절착제 층의 무게의 합이 되어 이러한 마스크링 시트의 무게는 다이아몬드 입자 적정의 60%~140%의 범위로 하는 것이 바람직하다. 또한 더욱이 1개의 구멍 형성상의 비마스크링부(1)의 면적이 다이아몬드 입자의 투영 면적의 110~160%에 의 범위로 되어야 한다. 마스크링 시트의 무게를 다이아몬드 입자 적정의 60% 미만으로 한다면, 또는 한 개의 비마스크링부의 면적이 다이아몬드 입자의 투영 면적의 160%를 초과하면, 한 개의 비마스크링부에 2개 이상의 다이아몬드 입자가 고정되어서 균등한 분산이 이루어지지 않는다. 또한 비마스크링부의 면적이 다이아몬드 입자의 투영 면적의 110% 미만에서는, 다이아몬드 입자의 상크에 대한 부착이 곤란하게 된다. 따라서 마스크링의 무게를 전착할 다이아몬드 입자 적정의 60~140%의 범위로 하고, 마스크링하지 않는 구멍의 적정을 전착할 입자적정의 110~160%의 범위로 하는 것에 의해, 전디셔너 금속에 전착되는 다이아몬드 입자(4)가, 비마스크링부(1)에 한 개의 분산되도록 된다. 다이아몬드 입자의 평균 투영 면적은, 다이아몬드 입자가 분산된 상태에서 최대 시전을 촬영하는 것에 의해 구할 수 있다. 본 고안에서는, 생길 마스크링 시트의 비마스크링부의 전면적이 마스크링 시트의 전면적의 0.04~0.2배의 범위이다. 마스크링 시트의 비마스크링부의 전면적은, 본 고안의 전디셔너의 연삭면에서 다이아몬드 입자가 고정된 부분의 전면적에 대응한다. 마스크링 시트의 비마스크링부의 전면적이 마스크링 시트의 전면적의 0.04배 미만이면, 구멍 형성상의 비마스크링부의 전면적이 다이아몬드 입자를 고착한 연삭면의 전면적의 0.04배 미만으로 되어, 전디셔너로서의 연삭력이 부족할 염려가 있다. 마스크링 시트의 비마스크링부의 전면적이 마스크링 시트의 전면적의 0.2배를 초과하면, 구멍 형성상의 비마스크링부의 전면적이 다이아몬드 입자를 고착 한 연삭면의 전면적의 0.2배를 초과하여, 연삭시에 분쇄음이 발생할 염려가 있다.

[실시예]

전디셔너 상크(3)의 연삭면으로 되는 작용면을 발견하고, 마스크링 시트를 절착한 후에, 니켈에 의한 예비 도금층(5)을 형성하였다. 마스크링 시트(2)의 무게를 전착할 #120 메쉬 다이아몬드 입자적정의 80%로 하였으며, 더욱이 다이아몬드 입자(4)를 전착시키기 위해 비마스크링부(1)의 적정을 전착할 다이아몬드 입자적정의 140%로 하였다. 구멍 형성상의 비마스크링부(1)의 전면적을 마스크링 시트(2)의 전면적의 0.1배로 되도록 하였다. 그 후에 전디셔너의 본체를 도금액에 담그고 입자 고정면에 다이아몬드 입자(4)를 높고서 전디셔너의 본체에 용극을 접속하고, 도금액에 양극을 접속하여 전기 도금을 행하여 다이아몬드 입자(4)를 예비 고정하였다. 상크를 도금액으로부터 빼내고, 마스크링 시트(2)를 박리시켜, 탈지를 행한 후에 전디셔너의 본체를 다시 도금액에 담그고, 본체에 용극을 접속하고 도금액에 양극을 접속하여 다이아몬드 입자 고정면의 최종 Ni 도금을 행함에 의해 다이아몬드 입자(4)를 상크의 연삭면에 고정하였다.

전디셔너의 형상은 실시예 1에서는 도 4와 같은 다이아몬드 입자의 분포를 가지도록 하였으며, 실시예 2에서는 도 5와 같이 전착부가 스퍼터링 형상이 되도록 하였으며, 실시예 2에는 비전착 영역(8)이 형성되도록 하였다. 실시예 1 및 실시예 2는 전디셔너의 형상을 제외하고는 다른 모든 제조 조건은 동일하였다. 비교예는 실시예 1 및 실시예 2의 전디셔너의 성능과 비교를 행하기 위하여 당사에서 종래의 제조방법으로 제조되어 시장에서 판매되는 것으로, 비교예 1은 실시예 1과 동일 형상이며, 비교예 2는 실시예 2와 동일 형상의 전디셔너를 사용하였다. 실시예 1, 실시예 2, 비교예 1 및 비교예 2의 전디셔너를 사용하여, 반도체의 웨이퍼 가공에 사용되는 화학-기계-연마 장치의 제2 전디셔너를 행한 결과를 표 1에 나타낸다.

[표 1]

	실시예 1	실시예 2	비교예 1	비교예 2
연마속도(m/min)	1.38	1.35	1	0.9
전디셔너속도(μm/hr)	35	34	12	11
전디셔너수명(hr)	600	590	160	155
웨이퍼표면거칠기(nm)	0.33	0.34	0.43	0.44
웨이퍼의 스크래치 개수	1	1	7	8
웨이퍼의 표면상태	연삭흔 거의 없음	연삭흔 거의 없음	연삭흔 많음	연삭흔 많음

실시예 1 및 실시예 2의 제2 연마속도, 전디셔너 속도 및 전디셔너 수명이 비교예에 비해 현저히 높으며, 웨이퍼의 표면거칠기 및 스크래치 개수의 경우에서도 실시예 1과 실시예 2가 비교예에 비해 현저히 낮은 값을 보이며, 실시예 1 및 실시예 2의 전디셔너를 사용한 경우 웨이퍼의 연삭흔이 거의 나타나지 않았으나, 비교예의 전디셔너를 사용한 경

우선 패턴의 표면의 결함률이 많이 나타났다.

도면의 효과

이상에서 서술한 바와 같이 본 고안은, 마스크 시트(2)의 경각에 의해 마스크를 평하므로 거수 정밀도가 떨어진 패턴 형상을 제원상 높게 용이하게 형성시킬 수 있으며, 마스크 시트(2)의 컨디셔너 글속에 대한 밀착력이 높으며, 또한 컨디셔너 글속에 견착되는 80~120배위의 다이아몬드 입자(4)가, 비마스크부(1)에 한 개씩 분산된다. 따라서 CMP용 폴리싱 패드의 평면화를 향상시킴과 동시에, 이 패드의 컨디셔닝을 효과적으로 행하는 기능을 가지고, 더구나 컨디셔닝 성능이 우수하고, 수명이 길며, 컨디셔너의 제조가 용이하기 때문에 제조사의 불량률을 현저히 감소시킬 수 있다.

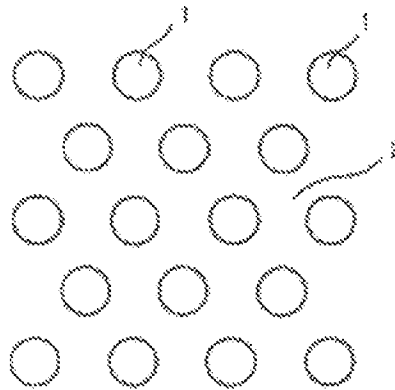
(67) 청구의 범위

청구항 1.

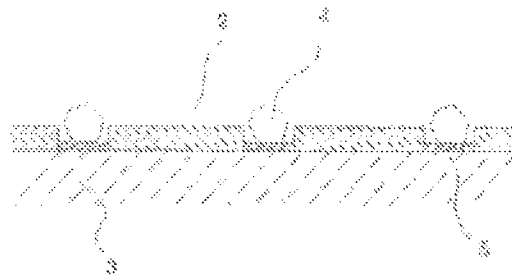
NI 도금층이 다이아몬드 입자 직경의 40~60% 정도의 두께를 가지며, 상표의 표면에 있어서, 1개의 구멍 형상의 비마스크부의 면적이 다이아몬드 입자의 부열 면적의 110~160%정도 되고, 마스크 시트의 비마스크부의 견연력이 마스크 시트의 견연력의 0.04~0.2배의 범위로 하는 것이 특징으로 된 화학적-기계적-연마 패드 컨디셔너.

도면

도면1



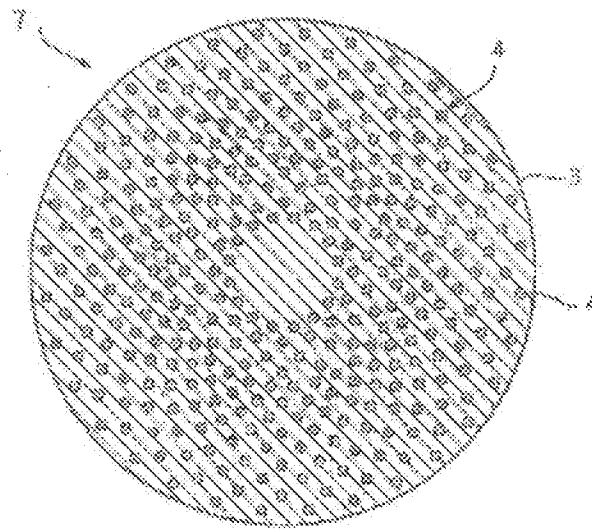
도면2



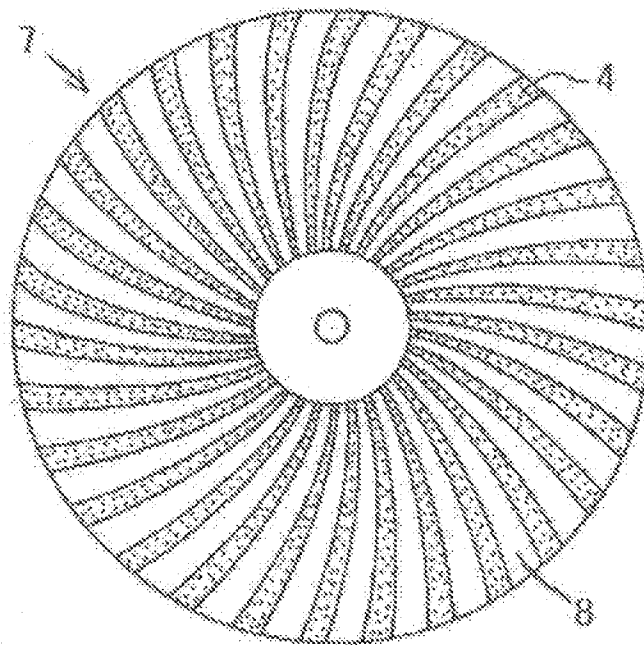
도면3



도면4



도면도



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(54) Title: POLYCRYSTALLINE ABRASIVE GRIT

(57) Abstract: A method is provided for producing a plurality of polycrystalline ultra-hard abrasive grit. The method includes the steps of providing a mass of ultra-hard abrasive particles or a mass of a combination of a precursor for such particles and a suitable solvent/catalyst, forming the mass into a plurality of green state granules, placing the granules with a separating medium between adjacent granules in the reaction zone of a high pressure/high temperature apparatus, subjecting the contents of the reaction zone to elevated temperature and pressure conditions which the ultra-hard abrasive particle is crystallographically stable, recovering the thus sintered material from the reaction zone and removing the separating medium in the sintered material to produce a plurality of crystalline abrasive grit. The ultra-hard abrasive is generally diamond or cubic boron nitride.

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POLYCRYSTALLINE ABRASIVE GRITBACKGROUND OF THE INVENTION

This invention relates to polycrystalline abrasive grit.

Ultra-hard abrasive bodies in the form of either abrasive compacts or individual crystals are well known in the art. The abrasive compact will generally be a diamond compact, also known as polycrystalline diamond or PCD, or a cubic boron nitride compact, also known as polycrystalline cubic boron nitride or PCBN. These abrasive compacts have wide application in cutting, drilling, boring, milling and other abrasive applications.

Such ultra-hard abrasive bodies are produced under conditions of elevated temperature and pressure at which the ultra-hard abrasive is crystallographically stable. Polycrystalline diamond or polycrystalline boron nitride can be produced with or without a second phase or bonding matrix. The second phase, when provided, may be in the case of diamond a solvent/catalyst such as cobalt, or it may be a carbide-forming element such as silicon. Similar sintering mechanisms are utilised in PCBN synthesis with various carbides, nitrides and borides being common second phases.

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Abrasive compacts are generally produced in the form of a disc, either free-standing or bonded to a support, which may be cut into smaller segments for use.

Single crystal ultra-hard abrasives in the form of either diamond or cubic boron nitride crystals, also referred to as "grit", are used in loose or bonded form for a variety of abrasive applications such as lapping, drilling, grinding and sawing.

Examples of abrasive tools which utilise single crystal ultra-hard abrasives are grinding wheels and saw segments. Bond types for such abrasives can be a metal, resin or a ceramic.

Diamond or CBN grits are typically produced through a high pressure/high temperature process where graphite or hexagonal boron nitride is converted in the presence of a suitable catalyst to, respectively, diamond or cubic boron nitride. In some cases natural diamond crystals are also employed.

The concepts of abrasive compacts and grits have been combined and have led to the development of polycrystalline grit. For instance United States Patent 4,776,881 describes a process for generating polycrystalline grit containing ultra-hard material. This is achieved by leaching non-diamond material from polycrystalline diamond or cubic boron nitride compacts obtained through a high pressure/high temperature process and subsequently crushing the leached product.

The process of high pressure/high temperature sintering followed by subsequent crushing is not ideal as a high amount of energy is consumed in crushing sintered PCD and control over the shape and size of the final product is limited. Hence yield and quality tend to be low.

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SUMMARY OF THE INVENTION

According to the present invention, a method of producing a plurality of polycrystalline ultra-hard abrasive grit includes the steps of providing a mass of ultra-hard abrasive particles or a mass of a combination of a precursor for such particles and a suitable solvent/catalyst, forming the mass into a plurality of green state granules, placing the granules with a separating medium between adjacent granules in the reaction zone of a high pressure/high temperature apparatus, subjecting the contents of the reaction zone to elevated temperature and pressure conditions at which the ultra-hard abrasive particle is crystallographically stable, recovering the thus sintered material from the reaction zone and removing the separating medium in the sintered material to produce a plurality of polycrystalline abrasive grit.

The method of the invention involves, as a first step, the forming of the mass of ultra-hard abrasive particles or of combination of a precursor for such particles and solvent/catalyst into a plurality of green state granules. The term "green state granules" means a coherent mass of any suitable shape or size and which is produced, for example, by known granulation or pelletising techniques.

The green state granules will generally be produced in the presence of a second (or binder) phase. The second phase may be provided by a material which participates in or contributes to the formation of the polycrystalline ultra-hard abrasive grit, e.g. a solvent/catalyst for the ultra-hard abrasive. The second phase may also be a binder, organic or inorganic, which may be removed prior to subjecting the granules to the high temperature/high pressure sintering conditions. The second phase can also consist of a combination of these two second phases.

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If a precursor for the ultra-hard abrasive is used, then a solvent/catalyst for that ultra-hard abrasive must also be present. Examples of suitable solvent/catalysts for such particles, particularly when the particles are diamond or cubic boron nitride, are well known in the art. The solvent/catalysts may be precursors which can be converted to the solvent/catalyst, e.g. metal oxides which on heating are converted to the metal. Such precursors are included in the term "solvent/catalyst".

Examples of combinations, generally in the form of mixtures, of ultra-hard abrasive particles or precursor particles and second phases which are useful in the practice of the invention are:

1. Diamond and a diamond solvent/catalyst which may be a transition metal such as cobalt, nickel, iron or manganese or non-metallic solvent/catalyst such as a carbonate or sulphate to produce a sintered, intergrown polycrystalline diamond grit material.
2. Graphite and a diamond solvent/catalyst which may be a transition metal such as cobalt, nickel, iron or manganese or a non-metallic solvent/catalyst such as a carbonate or sulphate to produce a sintered, intergrown polycrystalline diamond grit. In producing the grit, the graphite is converted to diamond.
3. A combination of 1 and 2.
4. Diamond and a carbide forming metal such as silicon or titanium to produce a grit which is a sintered polycrystalline diamond/ SiC or TiC composite.
5. A combination of 1 and 4 or 2 and 4.

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6. Cubic boron nitride together with a boride or nitride forming metal such as aluminium, titanium, zirconium, hafnium, tantalum, molybdenum, niobium, chromium or tungsten or mixtures thereof introduced either in metallic form or as a substoichiometric or stoichiometric carbide, boride or nitride. The polycrystalline cubic boron nitride grit produced consists of cubic boron nitride and metal nitrides or borides.
7. A combination of 6 and cobalt, nickel, iron or manganese.
8. A combination of cubic boron nitride and alumina or a combination of diamond and alumina.
9. Hexagonal boron nitride and a suitable solvent/catalyst for cubic boron nitride such as magnesium, lithium or calcium in either metallic form, as a nitride or in the form of a boronitride to produce a sintered, intergrown polycrystalline cubic boron nitride grit. In producing the grit, the hexagonal boron nitride is converted to cubic boron nitride.

The green state granules are placed in the reaction zone of a standard high pressure/high temperature apparatus for the high pressure/high temperature sintering. Generally, the granules will be placed in a capsule which itself is placed in the reaction zone.

A separating medium separates individual granules in the reaction zone. The separating medium is preferably provided as a coating on individual granules. A particularly suitable method of coating individual granules is spray coating in a fluidised medium.

The separating medium, in one form of the invention, may be a metal or alloy which does not interfere with the high pressure/high temperature sintering of the green state granules. For example, molybdenum is a suitable coating

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where the ultra-hard abrasive is diamond or a precursor for diamond, e.g. graphite.

The separating medium may also be an inert medium which adequately transmits pressure, e.g. a salt such as a chloride or a carbonate, graphite, hexagonal boron nitride or an oxide.

A chemical barrier layer may be applied to the green state granules, generally to coat the granules completely, prior to the separation medium being interposed between adjacent granules. Examples of suitable chemical barrier layers are niobium, molybdenum, tantalum, titanium or other transition metal. The chemical barrier layer may be left on the polycrystalline abrasive grit produced from the green state granules.

The separating medium and chemical barrier layers may be applied to the green state granules by spraying in the form of an aqueous or non-aqueous suspension. The granules will generally be in a fluidised state during spraying. Alternatively, the granules may be dipped into a suspension of the separation medium and/or chemical barrier layer, or these layers may be coated mechanically on to the granules.

In one particular form of the invention, the green state granules are placed in a container, the separating medium in powdered or liquid form poured into the container and the granules and the separating medium mixed. If necessary, good dispersion and mixing can be assisted by some mechanical agitation or vibration to ensure that there are no gaps and the green state granules are all embedded in or enclosed by the separating medium.

Before subjecting the green state granules to the elevated temperature and pressure sintering, any removable binder, e.g. an organic binder which is present is preferably removed, for example, by a pressureless heat treatment.

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The heat treatment conditions will vary according to the nature of the granules and its content. Typical heat treatment or outgassing conditions are 500°C in an argon atmosphere or 400°C in air or 1100°C in a vacuum. A slow heating cycle is preferred.

The green state granules may optionally be densified. Densification can be achieved by uniaxial compaction or cold isostatic pressing. Some deformation of the granules will take place during this compaction. When the green state granules contain a binder which is removed, the densification may take place before or after the binder is removed.

The elevated temperature and pressure sintering conditions to which the green state granules are subjected are known in the art. Typical pressures are 3 to 9 GPa and typical temperatures are 1000 to 2500°C.

The sintered material is removed from the reaction zone of the high temperature/high pressure apparatus using known techniques. The material which is recovered is sintered and coherent and consists of a plurality of sintered granules separated by the separating medium and a chemical barrier layer, when provided. The individual sintered granules or polycrystalline ultra-hard abrasive grit can be released by removing the separating medium. For example, if the separating medium is a metal such as molybdenum, the material may be placed in a hot boiling acid such as 3 parts of boiling hydrofluoric acid and one part nitric acid. This will dissolve the molybdenum leaving a plurality of polycrystalline diamond grit. When the separating medium is hexagonal boron nitride, removal of the separating medium may be achieved by placing the sintered material in an ultrasonic bath filled with water. Hexagonal boron nitride is hydrolysed by the water and the sonification breaks up or disintegrates the hexagonal boron nitride.

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The polycrystalline ultra-hard abrasive grit produced by the method of the invention will typically have a particle size less than 5 mm and typically less than 2 mm. This grit may be used in a variety of abrasive applications, depending on the content and composition of the grit. The polycrystalline nature of the grit provides for a better bond retention in the bonding matrix of an abrasive tool when compared with single crystal grit. Further, controlled fracture of the grit can occur resulting in sharp edges or points being continuously produced, in use. The invention provides a particularly effective and economic method of producing polycrystalline abrasive grit. Further, the method is versatile in that polycrystalline abrasive grit may be produced with or without a second (binder) phase and contain more than one type of ultra-abrasive. The method allows for the production of polycrystalline abrasive grit of controlled shape and size.

EXAMPLE 1

A solvent based suspension with a 80 weight percent diamond (average particle diameter approximately 10 microns) and 20 weight percent of submicron cobalt powder was prepared and approximately 1 volume percent of organic binder added. The suspension was processed using a combination of spray drying and fluidised bed technology to produce strong green state spherical granules of approximately 1mm diameter and a porosity of approximately 42%. A solvent based suspension was formulated using submicron molybdenum powder. The diamond/cobalt granules were fluidised and a thin layer of molybdenum of approximately 100 microns thickness was spray dried on to the granules, using the molybdenum suspension.

The coated green state granules were placed into a die set and uniaxially compacted to yield a green compact of approximately 60% density. Binder removal from the green state granules was achieved by heat treatment at 1100°C for 2 hours in vacuum. The outgassed green state granules were then

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loaded into a metal canister. The canister was loaded into the reaction capsule of a standard high pressure/high temperature apparatus and the loaded capsule placed into the reaction centre of this apparatus. The contents of the canister were exposed to a temperature of approximately 1450°C and a pressure of 5 GPa. These conditions were maintained for 10 minutes. After completion of the treatment a densely sintered compact was recovered from the canister. A polished cross-section showed sintered polycrystalline diamond grit separated by a honeycomb structure of thin molybdenum veins. The compact was placed into a beaker with 3 parts of boiling hydrofluoric acid and 1 part nitric acid. After a few minutes of treatment the compact separated into a plurality of roundish particles of approximately 0.5 to 0.7 mm diameter. Closer examination showed these particles to consist of hard sintered polycrystalline diamond with the cobalt leached out of the surface region of the particles.

EXAMPLE 2

An organic suspension of hexagonal boron nitride containing a small amount of dissolved organic binder was prepared. The molybdenum clad green state granules described in Example 1 were fluidised and spray coated with a second approximately 100 micron thick coating of hexagonal boron nitride, using the hexagonal boron nitride suspension. Repeating the same compaction, outgassing and high temperature/high pressure treatment as described in Example 1 resulted in a coherent sintered compact recovered from the canister. The compact was placed into an ultrasonic bath filled with water. After a few minutes of sonification the compact separated into a plurality of roundish particles of approximately 0.6 to 0.8 mm diameter. Closer examination revealed the particles to consist of sintered polycrystalline diamond grit clad with a thin sintered molybdenum metal coating.

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EXAMPLE 3

The procedure in Example 2 was repeated replacing the hexagonal boron nitride layer with a spray deposited sodium chloride layer. The binder removal temperature was lowered to 500°C in argon so as to prevent volatilisation of the chloride. Repeating the same compaction, outgassing and high temperature/high pressure treatment as described in Example 1 resulted in a coherent sintered compact recovered from the canister. The compact was placed into an ultrasonic bath filled with water. After a few minutes of sonification the compact separated into a plurality of roundish particles of approximately 0.6 to 0.8 mm diameter. Closer examination revealed the particles to consist of sintered polycrystalline diamond grit clad with a thin sintered molybdenum metal coating.

- II -

CLAIMS

- 1 A method of producing a plurality of polycrystalline ultra-hard abrasive grit includes the steps of providing a mass of ultra-hard abrasive particles or a mass of a combination of a precursor for such particles and a suitable solvent/catalyst, forming the mass into a plurality of green state granules, placing the granules with a separating medium between adjacent granules in the reaction zone of a high pressure/high temperature apparatus, subjecting the contents of the reaction zone to elevated temperature and pressure conditions at which the ultra-hard abrasive particle is crystallographically stable, recovering the thus sintered material from the reaction zone and removing the separating medium in the sintered material to produce a plurality of polycrystalline abrasive grit.
- 2 A method according to claim 1 wherein the green state granules are produced by granulation or pelletising.
- 3 A method according to claim 1 or claim 2 wherein the green state granules contain a second phase which is an organic or inorganic binder, such binder being removed prior to subjecting the granules to the high temperature/high pressure conditions.
- 4 A method according to claim 1 or claim 2 wherein the green state granules contain a second phase which participates in or contributes to the formation of the polycrystalline ultra-hard abrasive grit.
- 5 A method according to claim 4 wherein the second phase is a solvent/catalyst for the ultra-hard abrasive.

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- 6 A method according to any one of the preceding claims wherein the green state granules contain diamond and a metal solvent/catalyst.
- 7 A method according to any one of claims 1 to 5 wherein the green state granules contain graphite and a diamond solvent/catalyst.
- 8 A method according to any one of claims 1 to 5 wherein the green state granules contain diamond, graphite and a diamond solvent/catalyst.
- 9 A method according to any one of claims 1 to 5 wherein the green state granules contain diamond and a carbide forming metal.
- 10 A method according to any one of claims 1 to 5 wherein the green state granules contain diamond, a diamond solvent/catalyst and a carbide forming metal.
- 11 A method according to any one of claims 1 to 5 wherein the green state granules contain cubic boron nitride and a boride or nitride forming metal.
- 12 A method according to any one of claims 1 to 5 wherein the green state granules contain a combination of cubic boron nitride, a boride or nitride forming metal, and a metal selected from cobalt, nickel, iron and manganese.
- 13 A method according to any one of claims 1 to 5 wherein the green state granules contain cubic boron nitride and alumina.
- 14 A method according to any one of claims 1 to 5 wherein the green state granules contain diamond and alumina.

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- 15 A method according to any one of claims 1 to 5 wherein the green state granules contain hexagonal boron nitride and a solvent/catalyst for cubic boron nitride.
- 16 A method according to any one of the preceding claims wherein the separating medium is provided as a coating on individual granules.
- 17 A method according to any one of the preceding claims wherein the ultra-hard abrasive for the green state granules is diamond or a precursor for diamond, and the separating medium is molybdenum.
- 18 A method according to any one of the preceding claims wherein the separating medium is selected from a salt, graphite, hexagonal boron nitride and an oxide.
- 19 A method according to any one of the claims 1 to 16 wherein a chemical barrier layer is applied to the green state granules prior to the separation medium being interposed between adjacent granules.
- 20 A method according to claim 19 wherein the chemical barrier layer coats the granules completely.
- 21 A method according to 19 or claim 20 wherein the chemical barrier layer is selected from niobium, molybdenum, tantalum, titanium or other transition metal.
- 22 A method according to any one of claims 19 to 21 wherein the chemical barrier layer is left on the polycrystalline abrasive grit produced from the green state granules.

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- 23 A method according to any one of the preceding claims wherein the elevated temperature conditions are a pressure in the range 3 to 9 GPa and a temperature in the range 1000 to 2500°C.
- 24 A method according to claim 1 substantially as herein described with reference to any one of the examples.



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CLOSURE

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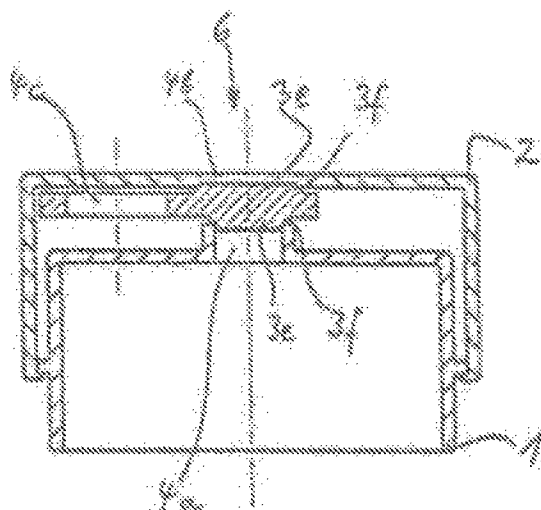
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A closure may be easily moved into an open and into a closed position and reliably seals an opening, for example of a container. To open and close the closure, a middle part (3) may be linearly moved or rotated between a top and a bottom part (2, 1). Pre-stressing the middle part (3) between top and bottom parts (2, 1) allows an opening to be sealed.




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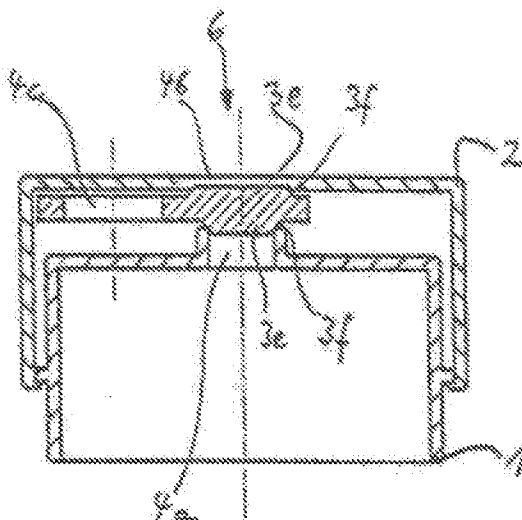
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(57) Abstract

A closure may be easily moved into an open and into a closed position and reliably seals an opening, for example of a container. To open and close the closure, a middle part (3) may be linearly moved or rotated between a top and a bottom part (2, 1). Pre-stressing the middle part (3) between top and bottom parts (2, 1) allows an opening to be sealed.

(57) Zusammenfassung

Es wird ein Verschluss zur Verfügung gestellt, der leicht in eine geschlossene und eine geöffnete Stellung bewegbar ist und zuverlässig eine Öffnung, z.B. eines Behälters, abdichten kann. Das Öffnen und Schließen kann durch eine lineare Verschiebung oder Drehung eines Mittelteils (3) zwischen einem Ober- und einem Unterteil (2, 1) erfolgen, wobei eine Vorspannung zwischen dem Ober- und dem Unterteil (2, 1) das Mittelteil (3) auf einer Öffnung abdichten kann.



LEDIGLICH ZUR INFORMATION

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Verschluß

Die Erfindung betrifft einen Verschluß, insbesondere für einen Behälter mit pastösen bis flüssigen Füllgütern. Flüssigkeit. Der Verschluß läßt sich jedoch auch als Abschluß für Leitungen von insbesondere Flüssigkeiten einsetzen.

Der Erfindung liegt die Aufgabe zugrunde, einen Verschluß zur Verfügung zu stellen, der leicht zwischen einer geöffneten und einer geschlossenen Stellung bewegbar ist und zuverlässig eine Öffnung z.B. für Flüssigkeiten abdichten kann.

Die Aufgabe wird mit den Merkmalen der Patentansprüche gelöst.

Bei der Lösung geht die Erfindung von dem Grundgedanken aus, ein Mittelteil zwischen einem Unterteil mit einer Öffnung und einem auf dem Unterteil drehbar angeordneten Oberteil anzuordnen, wobei das Mittelteil mit dem Oberteil in kraftschlüssiger Verbindung steht und die Öffnung durch lineare

1 Verschiebung, Verschwenken oder durch eine über eine Zahn-
radartige Verbindung übertragene Drehbewegung verschließt,
und wobei alternativ oder zusätzlich das Oberteil gegen das
5 Unterteil elastisch Vorspannbar sein kann und diese Vorspan-
nung das Mittelteil gegen die Öffnung abdichtend drückt.

Im folgenden wird die Erfindung anhand der Zeichnungen näher
erläutert. Es zeigen:

- 10 Fig. 1 einen Querschnitt einer erfindungsgemäßen Aus-
führungsform im geöffneten Zustand,
Fig. 2 die erfindungsgemäße Ausführungsform gemäß Fig.
1 im geschlossenen Zustand,
15 Fig. 3 und 4 die erfindungsgemäßen Ausführungsformen gemäß
Figuren 1 und 2 mit einem zusätzlich eingebautem
Ventil,
Fig. 5 einen Querschnitt längs der Linie A-A' in Fig. 4
mit einem Pendelschieber,
20 Fig. 6 einen Querschnitt längs der Linie A-A' in Fig. 4
mit einem Drehschieber,
Fig. 7 eine erfindungsgemäße Ausführungsform des Pen-
delschiebers bzw. Drehschiebers gemäß Figuren 5
und 6 im Querschnitt längs der Linie B-B',
25 Fig. 8 eine weitere erfindungsgemäße Ausführungsform
eines Drehschiebers,
Fig. 9 einen Querschnitt durch eine weitere erfindungs-
gemäße Ausführungsform,
Fig. 10 einen Querschnitt längs der Linie C-C' in Fig.
9,
30 Fig. 11 einen Querschnitt längs der Linie D-D' in Fig.
9,
Fig. 12 einen Querschnitt durch eine weitere erfindungs-
gemäße Ausführungsform,
Fig. 13 einen Querschnitt längs der Linie E-E' in Fig.
35 12,
Fig. 14 einen Querschnitt längs der Linie F-F' in Fig.
12.

- 1 Fig. 15 einen vergrößerten Teilquerschnitt längs der Li-
 nie G-G' in Fig. 12,
 Fig. 16 eine vergrößerte Darstellung einer Originali-
 tätssicherung gemäß Fig. 12,
5 Fig. 17a einen Querschnitt durch eine weitere erfindungs-
 gemäße Ausführungsform,
 Fig. 17b einen Querschnitt längs der Linie H-H' in Fig.
 17a, und
10 Fig. 18 einen Teilquerschnitt durch eine weitere Ausfüh-
 rungsform.

Fig. 1 zeigt eine erfindungsgemäße Ausführungsform eines
Verschlusses in geöffneter Stellung. Der Verschluss besteht
aus einem Unterteil bzw. Grundkörper 1, einem Oberteil bzw.
15 einer Drehkappe 2 und einem zwischen den beiden angeordneten
verschiebbaren Mittelteil 3. Der Grundkörper 1 und die Dreh-
kappe 2 sind als gegeneinander gewölbte elastisch verform-
bare Membranen ausgebildet, die miteinander durch eine Öff-
nung 4c im Mittelteil 3 hindurch ausgerichtete Öffnungen 4a
20 und 4b aufweisen. Die Drehkappe 2 ist drehbar am Grundkörper
1 gehalten. Die Öffnungen 4a und 4b sind vorzugsweise wie
in den vorstehend beschriebenen Ausführungsformen mittig in
bezug zur Drehachse angeordnet, so daß beim Verdrehen des
einen Verschlussteils gegenüber dem anderen die Öffnungen zu-
25 einander ausgerichtet bleiben.

Beim Schließen des Verschlusses wird das Mittelteil 3 durch
Drehen der Drehkappe 2 über eine kraftschlüssige Verbindung,
z.B. einen Mitnehmer 14 oder eine zahnradartige Verbindung 9
30 (Figuren 5 und 6) in den von den Öffnungen 4a und 4b ausge-
bildeten Durchlaß 6 gebracht. Dabei werden wobei der mem-
branartig ausgebildete Grundkörper 1 und die Drehkappe 2
auseinandergebogen, so daß sie durch Vorspannung fest auf
das Mittelstück 3 drücken und dieses den Durchlaß 6 abdich-
tet. Das Mittelteil 3 kann wahlweise als Fendelschieber 3a
35 (Fig. 5) oder als Drehschieber 3b (Fig. 6) ausgebildet sein.

1 Wie in der Figur deutlich erkennbar, weist das Mittelteil
einen dickeren Abschnitt auf, der aus einander gegenüberlie-
genden Erhabenheiten 3e an der Unterseite und der Oberseite
gebildet wird. Diese Erhabenheiten 3e sind in Größe und Form
5 den zugehörigen Öffnungen 4a, 4b, derart angepaßt, daß diese
den Durchlaß dichtend verschließen, wenn das Mittelteil 3 in
die Schließstellung gebracht wird. Die Erhabenheiten 3e ge-
hen mit einer umlaufenden schrägen Fläche 3f in die umgeben-
den Flächenteile des Mittelteils 3 über. Diese Schrägflächen
10 bilden in vorteilhafter Weise die Dichtflächen mit den an-
liegenden Kanten der zugehörigen Öffnungen 4a, 4b im Unter-
teil 1 bzw. Oberteil 2. Die Schrägflächen 3f bewirken eine
Ausrichtung der jeweiligen Erhabenheit 3e in den zugehörigen
Öffnungen 4a, 4b, die durch die zwischen dem Oberteil 2 und
15 dem Unterteil 1 vorhandene Vorspannung selbsttätig beim Ein-
rasten des Mittelteils 3 in der Schließlage erfolgt. Die
entsprechende seitliche Beweglichkeit der Teile zueinander
wird durch ein vorgesehene Spiel erreicht. Die Schrägflä-
chen 3f haben außerdem den Vorteil, daß beim Öffnen des Ver-
20 schlusses die Erhabenheiten 3e die Öffnungen 4a, 4b bzw. die
umlaufenden Kanten im Unterteil 1 und Oberteil 2 voneinander
wagdrücken.

25 Die Figuren 3 und 4 zeigen die erfindungsgemäße Ausführungs-
form gemäß Figuren 1 und 2 in ihrer geöffneten Stellung mit
einem Ventileinsatz 13 im Bereich der Öffnung 4a des Grund-
körpers 1. Der Ventileinsatz 13 besteht aus elastischem Ma-
terial. Dieser ist in Fig. 3 in ausgestülpter Position und
in Fig. 4 in eingasetzter Position gezeigt, wobei das Mit-
30 telteil 3 die Öffnung des Ventileinsatzes 13 abdichtet. Vor-
zugsweise wird als Ventileinsatz das in der US-PS-4.991.745
oder der EP-A-395 380 beschriebene Ventil verwendet.

35 Fig. 5 zeigt eine erfindungsgemäße Ausführungsform des Mit-
telteils 3 als Pendelschieber 3a. Der Pendelschieber 3a wird
bei einer Drehbewegung α der Drehkappe 2 durch einen an der
Drehkappe 2 befestigten Nithahmestift 14, der in einen

1 Schlitz 5 im Pendelschieber 3a eingreift, um die Strecke H
linear waagrecht verschieben, wobei die Ventilöffnung 13
entweder geöffnet oder geschlossen wird. In den beiden End-
stellungen wird der Pendelschieber 3a durch zwei Federnasen
6 7 jeweils mit einer Aussparung 8 gehalten.

Fig. 6 zeigt den Querschnitt A-A' gemäß Fig. 4 mit einer er-
findungsgemäßen Ausführungsform des Mittelstückes 3 als
Drehschieber 3b. Der Drehschieber 3b wird durch einen Dreh-
bewegung 9 der Drehkappe 2 über eine radartartige Verbin-
10 dung 9 um 180° in die geöffnete oder geschlossene Stellung
gedreht.

Fig. 7 zeigt einen Querschnitt durch den Pendelschieber 3a
15 oder den Drehschieber 3b längs der Linie B-B' in den Figuren
5 und 6. Die Schieber weisen seitlich eine keilförmige Ver-
dickung 10 an der Ober- und Unterseite auf, die die Membra-
nen des Grundkörpers 1 und der Drehkappe 2 beim Übergang in
die geschlossene Stellung des Schiebers auseinanderpressen.

Fig. 8 zeigt eine Draufsicht auf eine weitere erfindungege-
mäßige Ausführungsform eines Drehschiebers 3b im geschlossenen
Zustand. Der Drehschieber weist ein nierenförmiges Langloch
20 11 und eine am Kreisumfang angeordnete keilförmige Ver-
dickung 10 auf. Das Langloch 11 ermöglicht es z.B. einem
vorstehenden Ventil 13 sich zurückzuziehen, bevor der Dreh-
schieber 3b in die geschlossene Stellung gleitet.

Fig. 9 zeigt eine weitere erfindungsgemäße Ausführungsform
30 mit einem Pendelschieber 3c. Der Mitnehmer 14 ragt durch
einen Schlitz 23 im Pendelschieber 3c in eine Aussparung 24
in einer Führungsplatte (nicht dargestellt). Dadurch wird
eine bessere Sicherung gegen ein Herausrutschen des Mitneh-
mers 14 bei einer gegebenenfalls vorhandenen unbeabsichtig-
ten Vertikalbewegung des Oberteils 2 erreicht, die bei-
35 spielsweise bei einem vorhandenen Spiel, Stößen oder Verbie-
gungen des Oberteils auftreten kann. Der Pendelschieber 3c

ist im Querschnitt U-förmig ausgebildet und weist auf jeder Seite zwei Schenkel 25 auf, die unter der Zeichenebene liegen und gestrichelt dargestellt sind. Außerdem weist der Pendelschieber 3c seitlich eine federnde Nase 7 auf, die in zwei Aussparungen 8 in einer der Führungsschienen 15 einrastbar ist. Die Nachgiebigkeit der Nase 7 wird durch einen benachbarten, im Pendelschieber 3c angeordneten Schlitz 26 erreicht. Außerdem weist das Unterteil 1 vier dem Oberteil 2 zugewandte Ansätze 27 auf, an die zwei am Oberteil 2 angeordnete Vorsprünge 28 anschlagen und so die Drehbewegung des Oberteils 2 stoppen, wenn der Pendelschieber die geöffnete bzw. die geschlossene Stellung des Verschlusses erreicht hat, und als Anschlag zum Auf- und Abschrauben des Verschlusses auf einen Behälter dienen können.

In Fig. 10 ist ein Querschnitt längs der Linie C-C' in Fig. 9 dargestellt. Der Verschluss befindet sich in geschlossenem Zustand, und der Pendelschieber 3c verschließt die Entnahmeöffnung 4a mit dem Ventileinsatz 13. Zwischen dem Unterteil 1 und dem Pendelschieber 3c ist eine Führungsplatte 20 angeordnet, auf der der Pendelschieber 3c gleitet und die mit Stiften 22 in dem Unterteil 1 arretiert ist. Die Führungsplatte 20 hält im Klemmsitz den Ventileinsatz 13. Der Verschluss ist über eine Verschraubung 18 an seinem Unterteil mit einem Behälter 19 verbunden, wobei eine umlaufende Dichtlippe 34 das Unterteil 1 gegen das Innere des Behälters 19 abdichtet. Das Unterteil 1 liegt seitlich mit einer umlaufenden Fläche 29 an dem Behälter 19 an, wobei der Innenraum zwischen dem Unterteil 1 und dem Behälter 19 abgedichtet wird. Das Oberteil 2 ist auf dem Unterteil 1 drehbar mittels zweier umlaufender, ineinander eingepasster elastischer Lippen 30 gehalten.

Fig. 11 zeigt einen Querschnitt längs der Linie D-D' in Fig. 9. Es ist der U-förmige Querschnitt des Pendelschiebers 3c mit den Schenkeln 25 in den Führungsschienen 15 der Führungsplatte 20 zu erkennen.

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Fig. 12 stellt den Querschnitt einer weiteren erfindungsge-
mäßen Ausführungsform dar. In dieser Ausführungsform ist das
Mittelteil 3 als Schwenkteil 3d ausgebildet, das am Rande
des Verschlusses um einen Zapfen 15 schwenkbar ist. Das
Schwenkteil 3d wird durch einen am Oberteil 2 befestigten
Mitnehmer 14, der durch einen Schlitz 23 in dem Schwenkteil
3d in eine Aussparung 24 in einem Führungerring 21 ragt,
durch Drehen des Oberteils 2 in eine geöffnete oder ge-
schlossene Stellung des Verschlusses geschwenkt. Das
Schwenkteil 3d hat im wesentlichen die gleiche Funktion wie
das Mittelteil 3 bei den anderen Ausführungsformen und hat
eine Öffnung 4c, die mit den Öffnungen 4a und 4b ausgerich-
tet werden kann.

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Das Unterteil 1 weist zwei Ausschnitte 1a auf, in die das
Schwenkteil 3d in der offenen bzw. geschlossenen Stellung
des Verschlusses hineinragt. Dadurch kann der Schwenkwinkel
des Schwenkteils weiter vergrößert werden.

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Der Verschluss weist ferner eine Originalitätssicherung 17
mit einer Sollbruchstelle 17a auf, die bei einer erstmaligen
Verwendung des Verschlusses abgesichert wird. Ferner weist
der Verschluss zwei Anschläge 27 und zwei Vorsprünge 28 am
Oberteil 2 auf. Die Anschläge 27 dienen als Raststellen für
die offene oder geschlossene Stellung des Verschlusses, wo-
bei jeweils eine federnde Nase 7, der im Schwenkteil 3d ein
Schlitz 26 benachbart ist, hinter dem Anschlag 27 einrastet.
Außerdem dienen die Anschläge 27 als Anschläge an die Vor-
sprünge 28 zum Auf- und Abschrauben des Verschlusses auf
einen Behälter.

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Fig. 13 zeigt einen Querschnitt längs der Linie E-E' in Fig.
12, wobei der Verschluss geschlossen ist. Der Führungerring 21
ist zwischen dem Schwenkteil 3d und dem Unterteil 1 angeord-
net und hält den Ventileinsatz 13 im Klemmsitz. Der Ver-
schluss ist mittels der Verschraubung 18 mit einem Behälter

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1 19 verbunden und weist eine Abschraubsicherung 31, 31a zwischen dem Behälter 19 und dem Unterteil 1 auf. Das Unterteil 1 ist gegen den Behälter 19 abgeschlossen und sitzt mittels einer umlaufenden Dichtwulst 32 auf dem Behälter 19 auf.
5 Eine radial nach außen vorspringende Stufe am Unterteil 1 erlaubt das leichte Aufdrehen des Verschlusses auf die Abschraubsicherung des Behälters. Die Abschraubsicherung wird von mehreren am Unterteil 1 im Bereich der Stufe 33 angeordneten Vorsprüngen 31 und von damit in Eingriff bringbaren Vorprüngen 31a am Behälter 19 gebildet.

Fig. 14 ist ein Querschnitt längs der Linie F-F' in Fig. 12. Unterhalb der Schnittebene sind die Anschläge 27 zu erkennen, die auf dem Grundkörper 1 stehen.

Fig. 15 zeigt einen vergrößerten Teilquerschnitt längs der Linie G-G' in Fig. 12. Dabei ist der vom Oberteil 2 herabragende Mitnehmer 14 in dem Schlitz 23 des Schwenkteils 3d und der Vorsprung 28 am Oberteil 2 zu erkennen. In der vergrößerten Darstellung von Fig. 15 ist deutlich sichtbar, daß das Schwenkteil 3d im mittleren Bereich gefertigt ist, und in einem Übergangsbereich Schrägflächen 3f aufweist, an die die innenliegende Kante der Entnahmeeöffnung 4b im Oberteil 2 bzw. 4a des Führungsrings 21 anliegt. Die Verdickung im mittleren Bereich des Schwenkteils 3d ist in Größe und Form an der zugehörigen Entnahmeeöffnung 4b bzw. 4a angepaßt. Aufgrund der Vorspannung der Deckelfläche des Oberteils 2 in Richtung des Unterteils 1 bzw. des Führungsrings 21 wird ein dichter Anschluß der Entnahmeeöffnung 4b im Oberteil 2 und der Entnahmeeöffnung 4a im Unterteil 1 bzw. des Führungsrings 21 mittels des dazwischen angeordneten Mittelteils erreicht. Durch die Schrägflächen 3f entlang des Umfangs der Verdickung bzw. der Erhabenheit können Fertigungstoleranzen ausgeglichen werden und eine Selbstzentrierung des Mittelteils gegenüber den beiden Öffnungen erreicht werden. Diese Funktion der Erhabenheiten am Mittelteil sind in gleicher

1 Welse bei den anderen hierin beschriebenen Ausführungsformen
gegeben.

5 Fig. 16 zeigt eine vergrößerte Darstellung der Originali-
tätssicherung 17 mit der Sollbruchstelle 17a gemäß Fig. 12.
Die Originalitätssicherung 17 ist über eine Dünnstelle 17a
am Außendurchmesser des Grundkörpers 1 angeordnet. Die Ori-
ginalitätssicherung 17 ragt durch eine Öffnung 2a an der
10 Drehkappe 2, vorzugsweise in Form eines an der Unterkante
beginnenden Schlitzes nach außen und ist durch einen Griff
17b nach dem Abbrechen entfernbar. Gleichzeitig verhindert
der Griff 17b, daß die Originalitätssicherung 17 bei der Re-
lativbewegung von Grundkörper 1 und Drehkappe 2 nach innen
gezogen wird. Bei der erstmaligen Drehung der Drehkappe 2
15 schlägt diese an ihrer Öffnung 2a an die Originalitätssiche-
rung 17 an und bewirkt ihr Abbrechen von dem Zapfen 16.

In den Figuren 17a und 17b wird eine weitere erfindungsge-
mäßige Ausführungsform gezeigt, wobei das Oberteil 2 einen
20 ovalen Querschnitt aufweist. Ein solcher Querschnitt paßt
z.B. gut zu einem Behälter mit ovaler Form. Fig. 17b ist ein
Querschnitt längs der Linie H-H' in Fig. 17a. Das Oberteil 2
verschiebt das als Pendelschieber ausgebildete Mittelteil 3
von der geschlossenen in die geöffnete Stellung des Ver-
schlusses durch eine Drehung um 180°. Dadurch ist das ovale
25 Oberteil 2 sowohl in der geöffneten als auch geschlossenen
Stellung mit der ovalen Form des Behälters ausgerichtet. In
Fig. 17b ist zusätzlich zu Fig. 17a der Mitnehmer 14 einge-
zeichnet. Dieser läuft beim Öffnen oder Schließen auf einem
30 Halbkreis K.

Die vorstehend beschriebenen Verschlüsse können durch eine
Schraubverbindung, ein Aufspritzsystem oder durch Aufspritzen
mit einem Behälter verbunden werden. In Fig. 18 ist so-
35 schnittsweise dargestellt, wie bei einem tübenförmigen Be-
hälter die Folie 19a des Behälters am Unterteil 1 des Ver-
schlusses angespritzt ist. Das Folienmaterial 19a überdeckt

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in einem Kantenbereich die Oberseite des Unterteils 1. Hierdurch wird in vorteilhafter Weise die Tube direkt mit dem Verschluss verbunden.

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Patentansprüche

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1. Verschuß, mit

(a) einem Unterteil (1), das eine Entnahmeöffnung (4a) aufweist,

(b) einem Oberteil (2) mit einer korrespondierenden Entnahmeöffnung (4b), wobei eines der Verschlußteile (1 oder 2) gegen das andere verdrehbar ist, und

(c) einem Mittelteil (3), das in eine erste Stellung, in der die Entnahmeöffnungen (4a, 4b) frei sind, und eine zweite Stellung, in der es die Entnahmeöffnungen (4a, 4b) verschließt, bewegbar ist,

wobei

(d) das Mittelteil (3) linear verschiebbar, verschwenkbar oder in Umfangsrichtung beweglich angeordnet ist, und

(e) ein an dem verdrehbaren Verschlußteil (1 oder 2) oder am Mittelteil (3) angeordneter Mitnehmer (14) derart kraftschlüssig mit dem jeweils anderen Teil in Verbindung steht, daß durch Drehen der Verschlußteile (1, 2) gegeneinander das Mittelteil (3) in die erste oder zweite Stellung bewegt wird.

2. Verschuß, mit

(a) einem Unterteil (1), das eine Entnahmeöffnung (4a) aufweist,

(b) einem Oberteil (2) mit einer korrespondierenden Entnahmeöffnung (4b), wobei eines der Verschlußteile (1 oder 2) gegen das andere verdrehbar ist, und

(c) einem Mittelteil (3), das in eine erste Stellung, in der die Entnahmeöffnungen (4a, 4b) frei sind, und eine zweite Stellung, in der es die Entnahmeöffnungen (4a, 4b) verschließt, bewegbar ist,

wobei

(d) das Unterteil (1) oder das Oberteil (2) eine erste Umfangsfläche aufweist,

- 1 (a) das Mittelteil (3) eine zweite Umfangsfläche auf-
weist, und
(f) die erste und zweite Umfangsfläche derart kraft-
schlüssig, vorzugsweise mit einer zahnradartigen
5 Verbindung (9), in Eingriff stehen, daß durch Drehen
der Verschlusssteile (1, 2) gegeneinander das Mittel-
teil (3) in die erste oder zweite Stellung bewegt
wird.

10 3. Verschluss, mit

- (a) einem Unterteil (1), das eine Entnahmeöffnung (4a)
aufweist,
(b) einem Oberteil (2) mit einer korrespondierenden Ent-
nahmeöffnung (4b), wobei eines der Verschlusssteile (1
15 oder 2) gegen das andere verdrehbar ist, und
(c) einem Mittelteil (3), das in eine erste Stellung, in
der die Entnahmeöffnungen (4a, 4b) frei sind, und
eine zweite Stellung, in der es die Entnahmeöffnun-
gen (4a, 4b) verschließt, bewegbar ist,

20 wobei

- (d) das Oberteil (2) drehbar an dem Unterteil (1) gehal-
tert ist und die Entnahmeöffnungen (4a, 4b) einen
Durchlaß (5) ausbilden können,
(e) das Oberteil (2) und das Unterteil (1) gegeneinander
25 elastisch verspannbar sind,
(f) das Mittelteil (3) zwischen dem Unterteil (1) und
dem Oberteil (2) angeordnet ist und durch eine Dre-
hung des Oberteils (2) in die erste oder zweite
Stellung des Verschlusses bewegbar ist, und
30 (g) das Mittelteil (3) in der zweiten Stellung zwischen
den beiden Öffnungen (4a, 4b) angeordnet ist und
durch die Verspannung zwischen der Drehkappe (2) und
dem Grundkörper (1) den Durchlaß (6) zwischen ihnen
abdichtet.

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4. Verschluss nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß das Oberteil (2) und das Unterteil (1) gegeneinander elastisch Vorspannbar sind.
5. Verschluss nach Anspruch 1, 3 oder 4, dadurch gekennzeichnet, daß das Mittelteil (3) als Pendelschieber (3a, 3c) ausgebildet ist, der in Führungsschienen (15) geführt wird.
6. Verschluss nach Anspruch 5, dadurch gekennzeichnet, daß der Pendelschieber (3a; 3c) einen U-förmigen Querschnitt aufweist und mit seinen Schenkeln (25) in den Führungsschienen (15) geführt wird.
7. Verschluss nach Anspruch 1, 3 oder 4, dadurch gekennzeichnet, daß das Mittelteil (3) als Schwenkteil (3d) ausgebildet ist, das um einen auf dem Unterteil (1) befestigten Zapfen (16) schwenkbar ist.
8. Verschluss nach einem der Ansprüche 1 bis 7, dadurch gekennzeichnet, daß das Mittelteil (3) auf seiner Unterseite und/oder Oberseite mindestens eine Erhabenheit (3f) aufweist, die in Form und Größe an die jeweils zugehörige Entnahmeöffnung (4a, 4b) angepasst ist und in der zweiten Stellung in die Entnahmeöffnungen rastend und dichtend eingreift.
9. Verschluss nach Anspruch 8, dadurch gekennzeichnet, daß zur Originalitätssicherung eine Blockierung (17) zwischen dem Oberteil (2) und dem Mittelteil (3) angeordnet ist, die eine Sollbruchstelle (17a) aufweist.
10. Verschluss nach einem der Ansprüche 1 bis 8, dadurch gekennzeichnet, daß in der Entnahmeöffnung (4a) ein Ventileinsatz (13) angeordnet ist.

- 1 11. Verschluss nach einem der Ansprüche 1 bis 10, dadurch gekennzeichnet, daß das Unterteil (1) durch eine Verschraubung (12) oder ein Freilverschlußsgestell mit einem Behälter (19) verbunden ist oder bei tubenförmigen Behältern vorzugsweise am Behälter (19a) angespritzt ist.
- 5 12. Verschluss nach einem der Ansprüche 1 bis 11, dadurch gekennzeichnet, daß das Oberteil (2) einen ovalen Querschnitt aufweist.
- 10 13. Verschluss nach einem der Ansprüche 1 bis 12, dadurch gekennzeichnet, daß zwischen dem Mittelteil (3) und dem Unterteil (2) eine Führungsplatte (20) oder ein Führungerring (21) angeordnet ist, auf dem das Mittelteil (3) gleitet.
- 15 14. Verschluss nach Anspruch 13, dadurch gekennzeichnet, daß die Führungsplatte (20) mittels Stiften (22) im Unterteil (1) gehalten ist.
- 20 15. Verschluss nach einem der Ansprüche 1 bis 14, dadurch gekennzeichnet, daß das Mittelteil (3) eine keilförmige Verdickung (16) an der Ober- und Unterseite aufweist, die das Unterteil (1) und das Oberteil (2) beim Übergang in die geschlossene Stellung des Verschlusses auseinanderpressen.
- 25 16. Verschluss nach einem der Ansprüche 1 bis 15, dadurch gekennzeichnet, daß das Mittelteil (3) kreisförmig ist und ein niarenförmiges Langloch (11) aufweist.
- 30 17. Verschluss, gekennzeichnet durch eine beliebige Kombination von einzelnen Merkmalen der Ansprüche 1 bis 16.
- 35

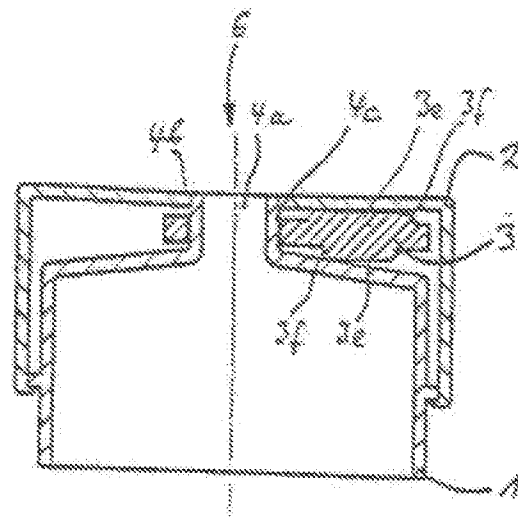


Fig. 1

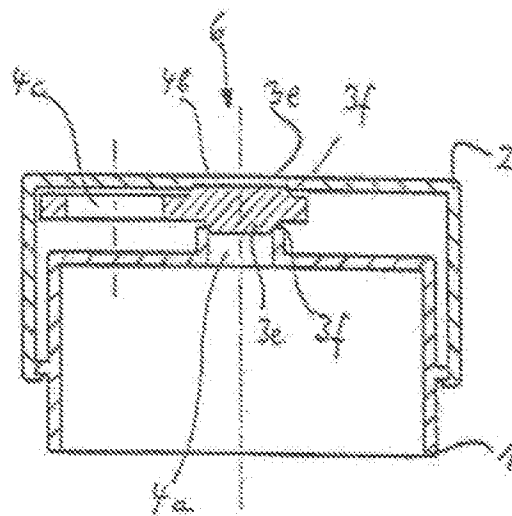


Fig. 2

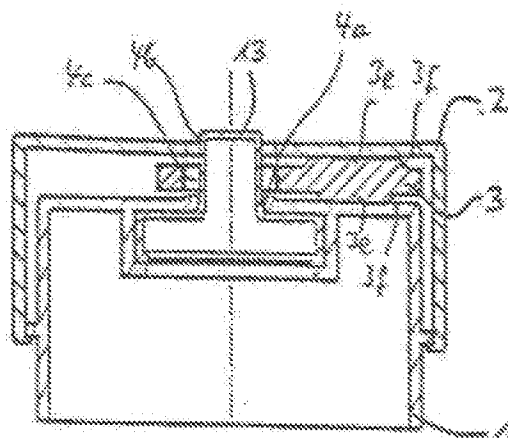


Fig. 3

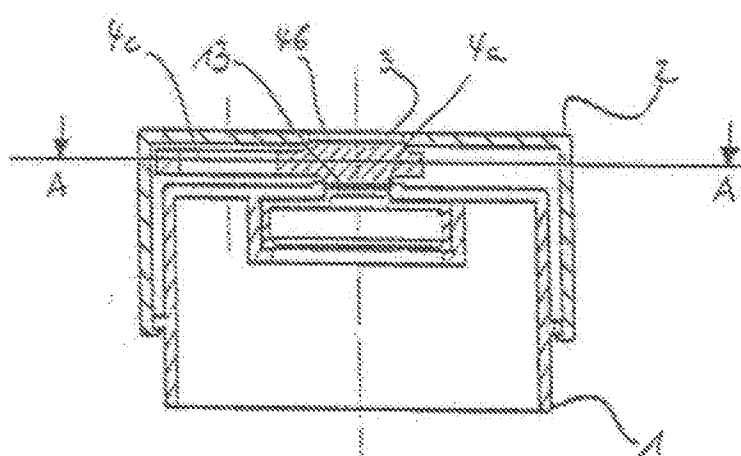


Fig. 4

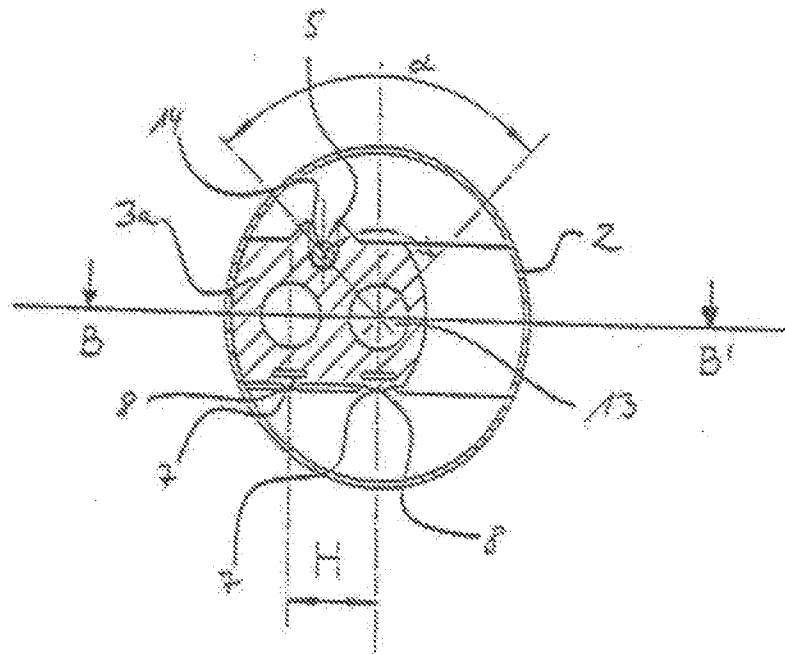


Fig. 3

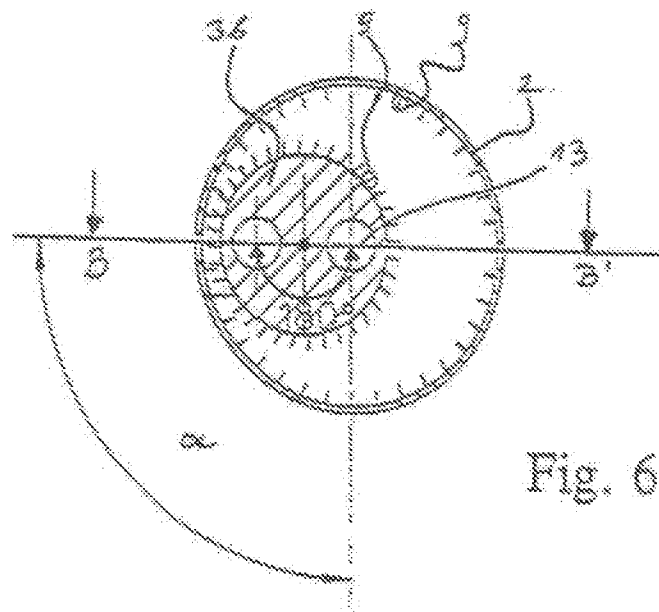


Fig. 6

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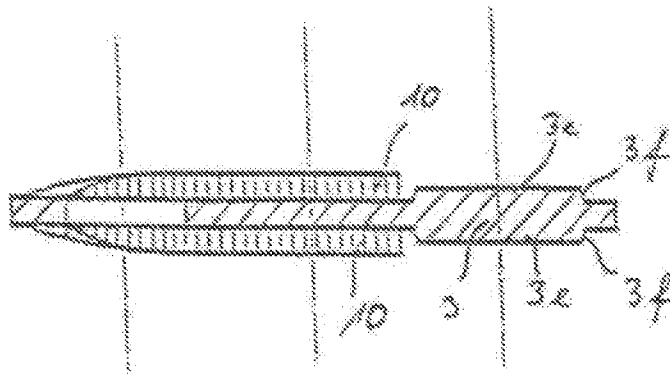


Fig. 7

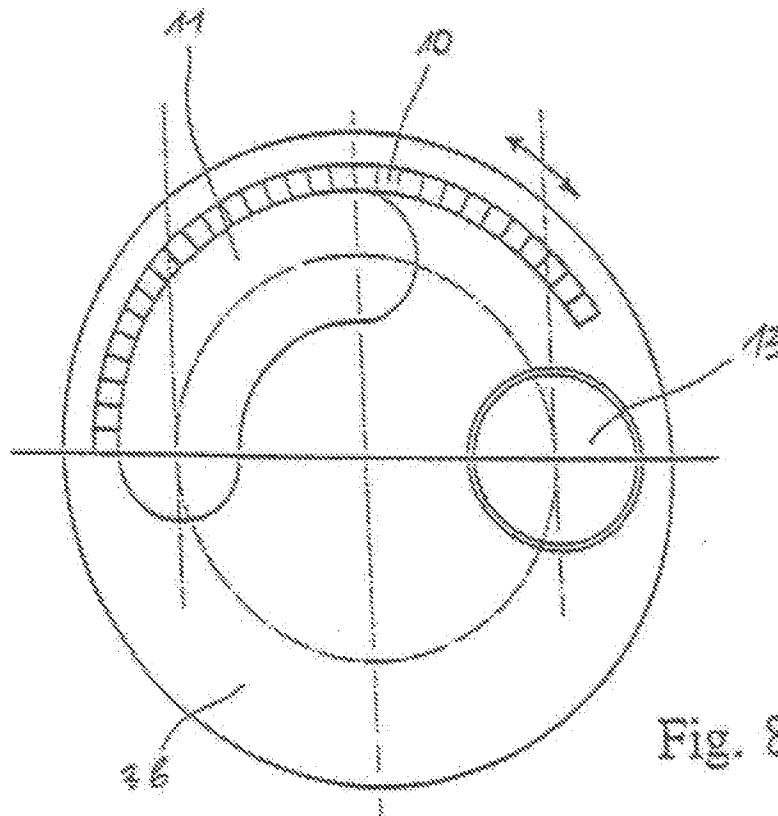


Fig. 8

ERSATZBLATT (REGEL 20)

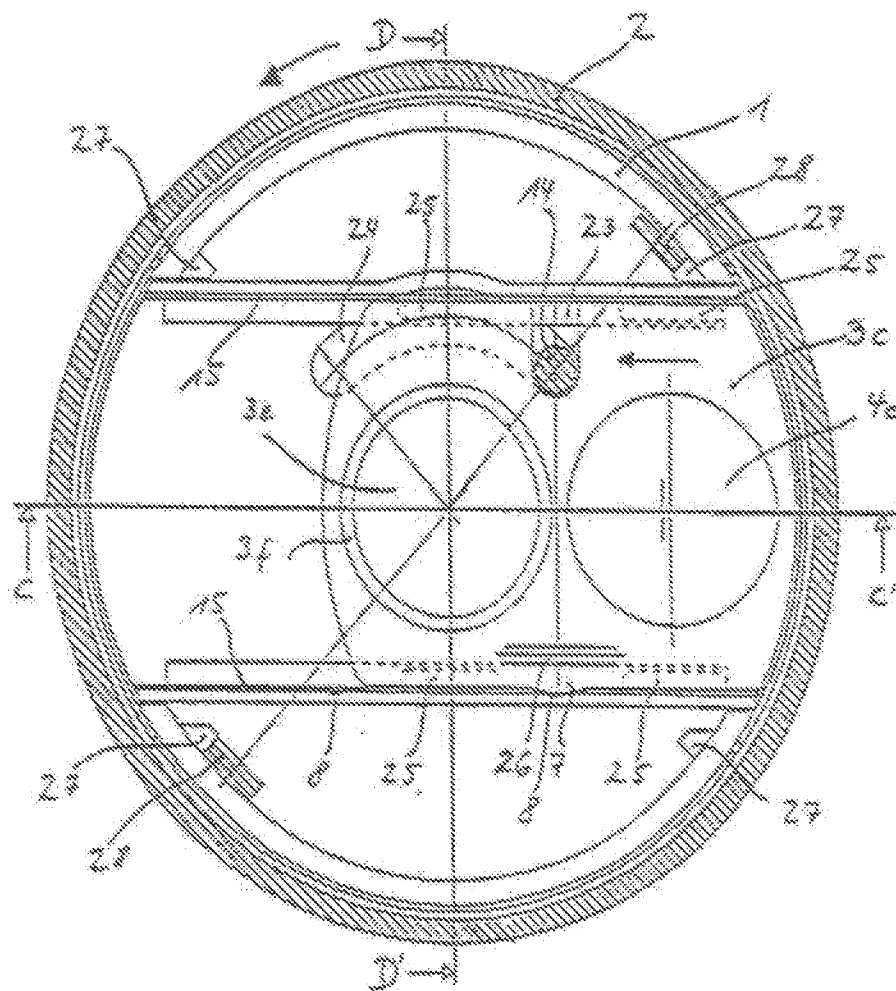


Fig. 9

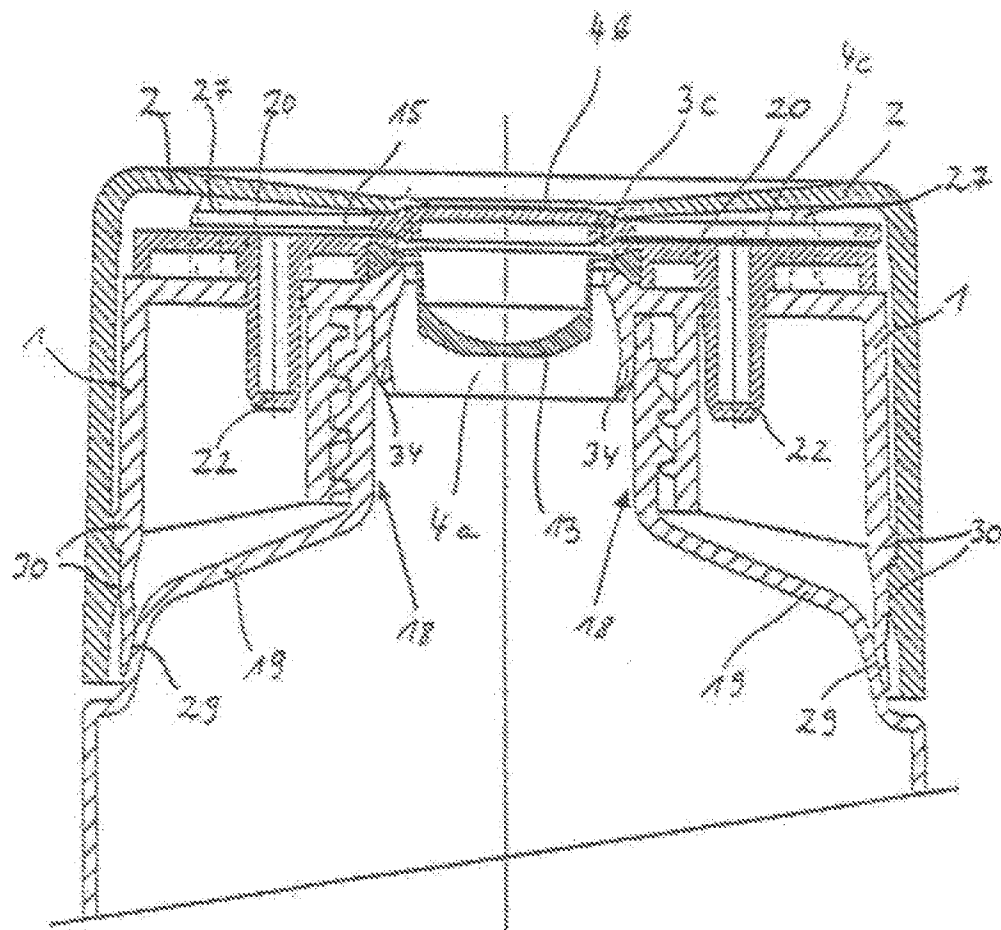


Fig. 10

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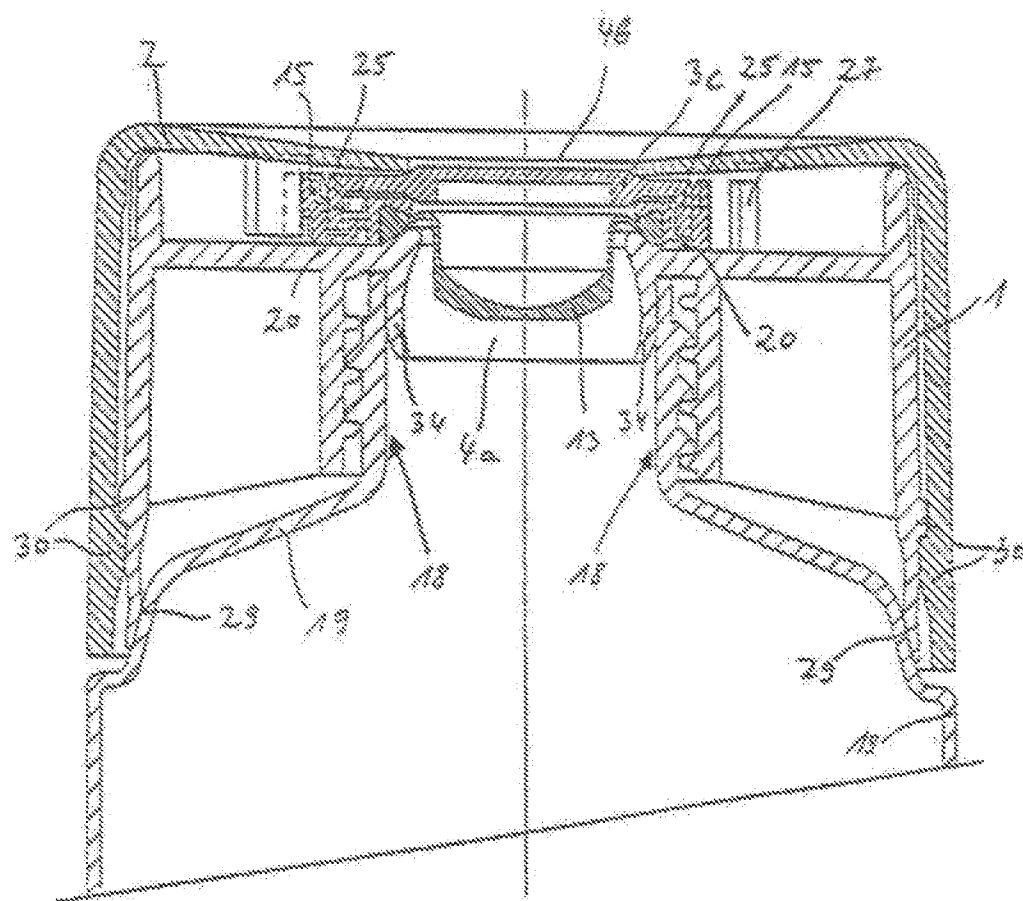


Fig. 11

ERSATZBLATT (REGEL 26)

8/14

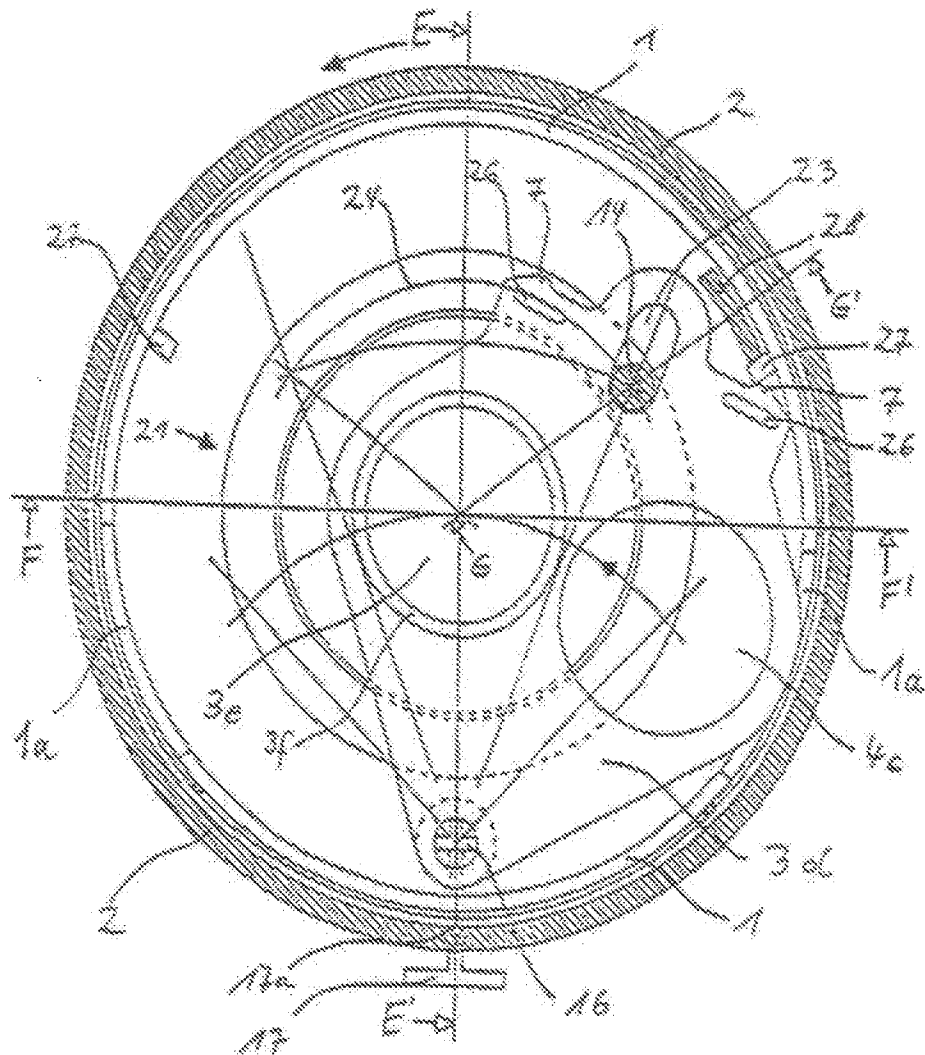


Fig. 12

ERSATZBLATT (REGEL 28)

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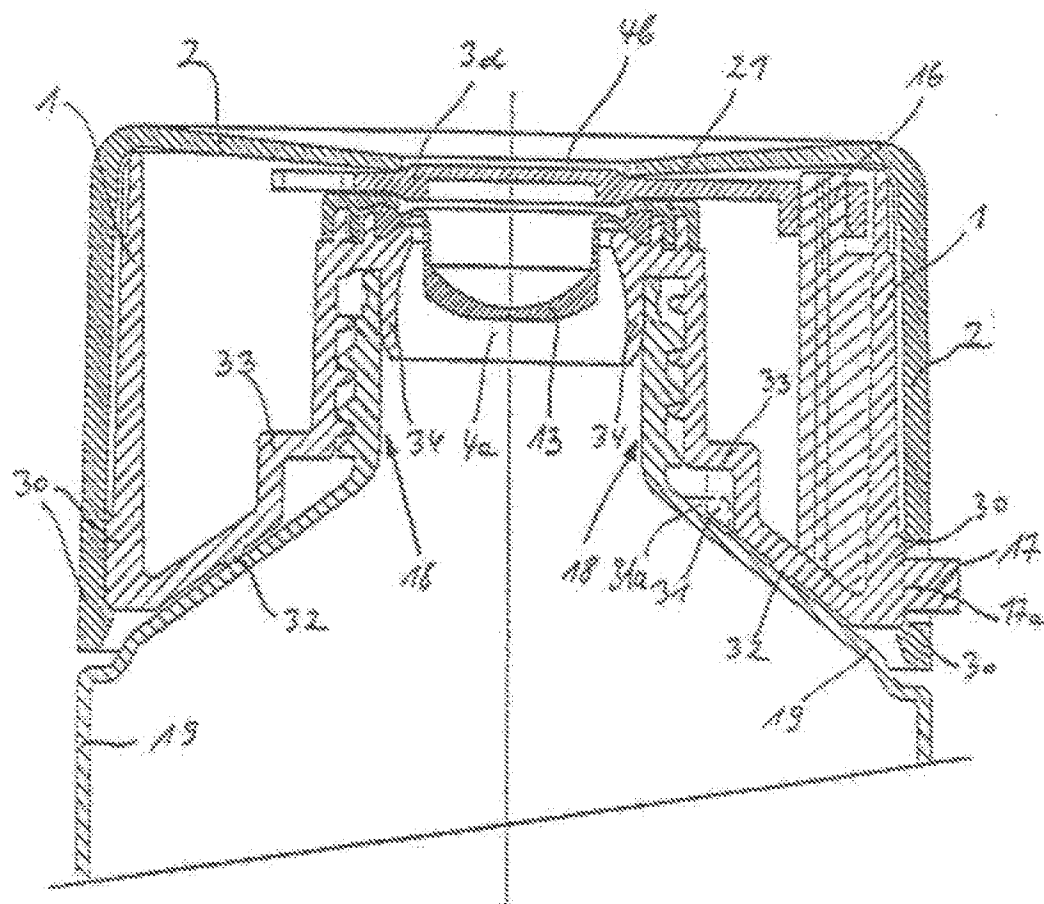


Fig. 13

ENDBLATT (REG. 20)

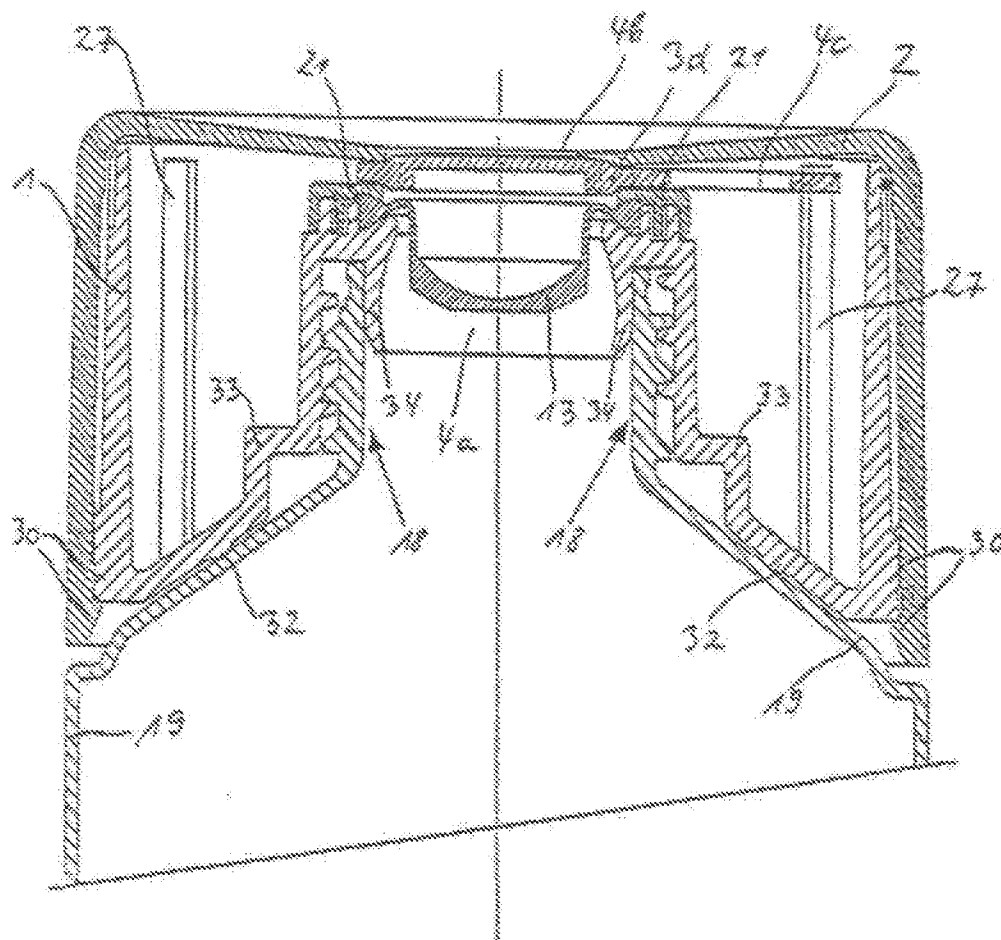


Fig. 14

11/14

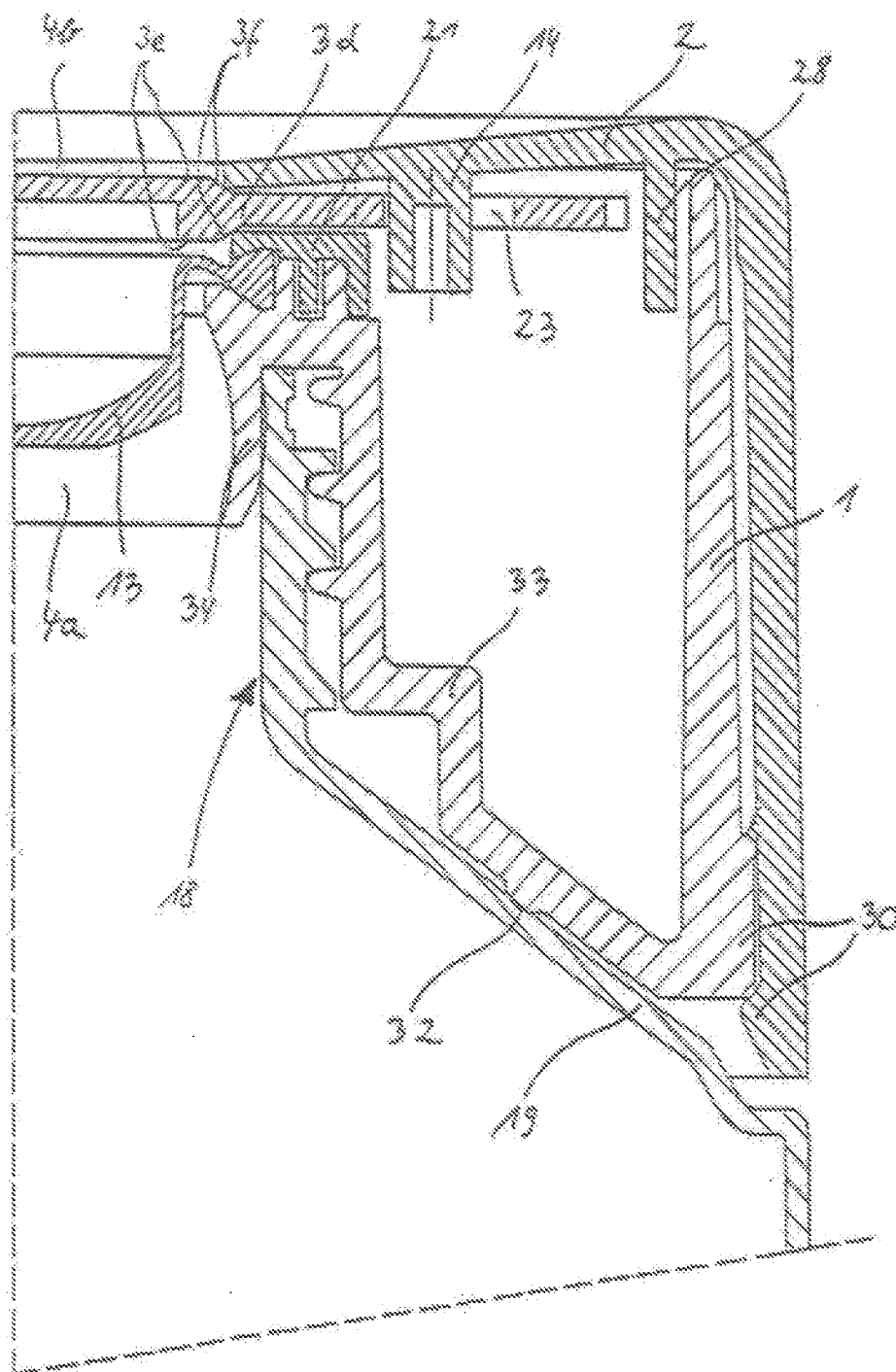


Fig. 15

ERSATZBLATT (REGEL 26)

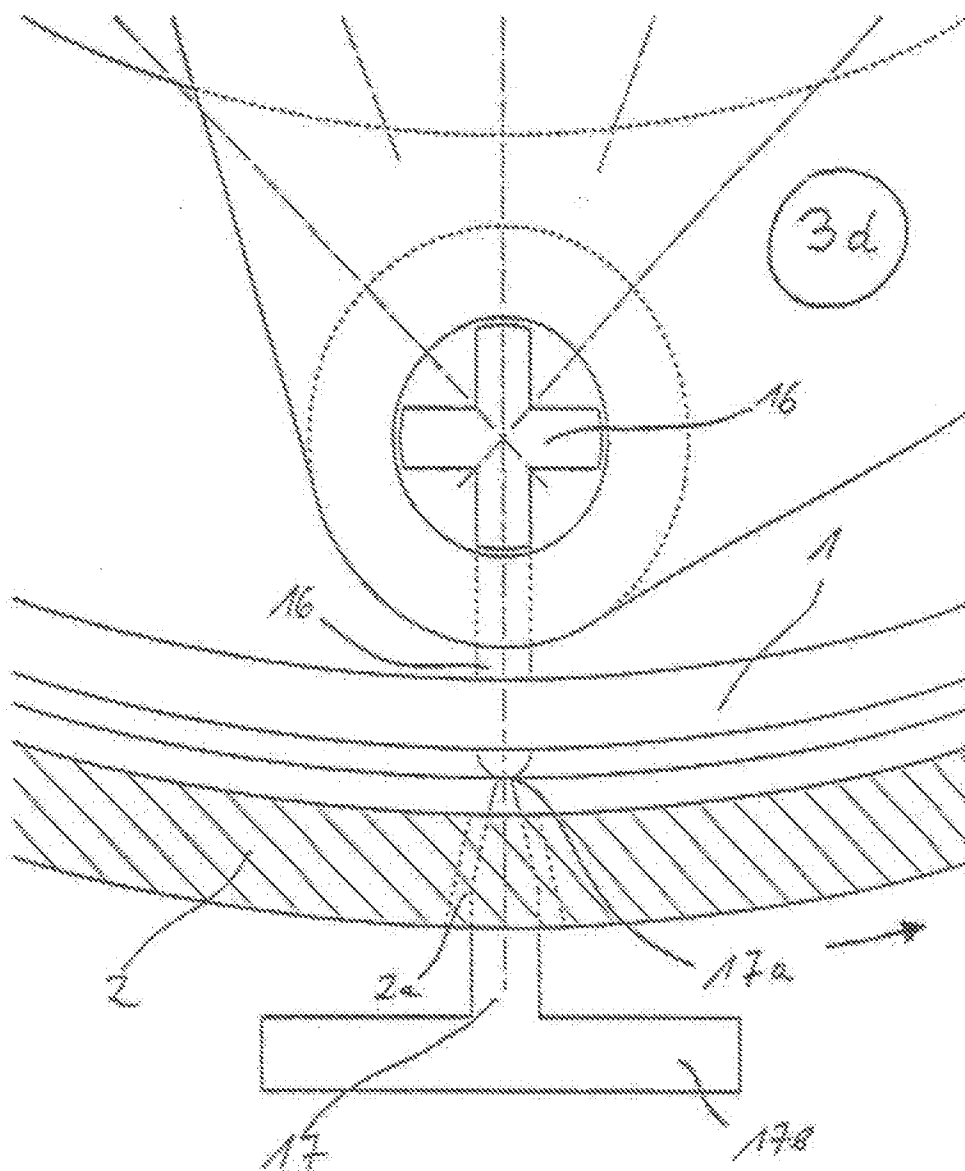


Fig. 16

ERSATZBLATT (REGEL 26)

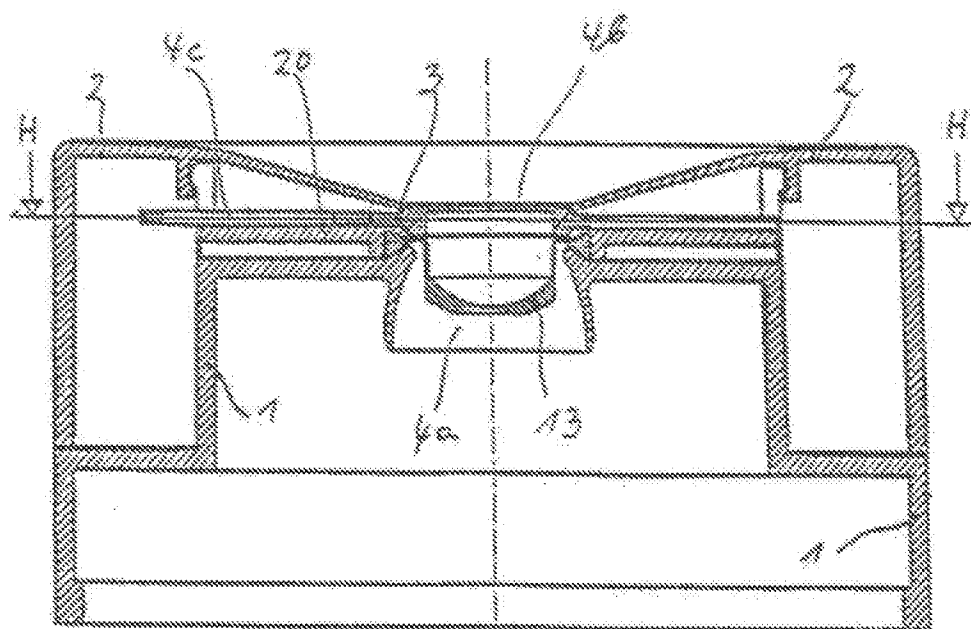


Fig. 17 a

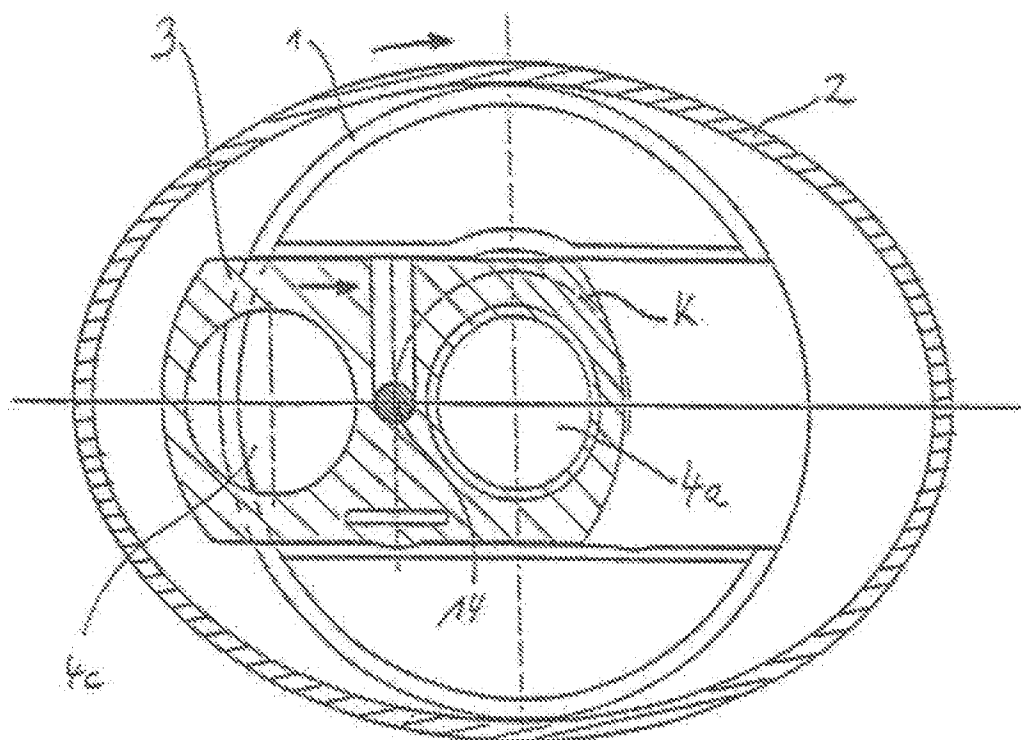


Fig. 17b

ES02047 (REG 20)

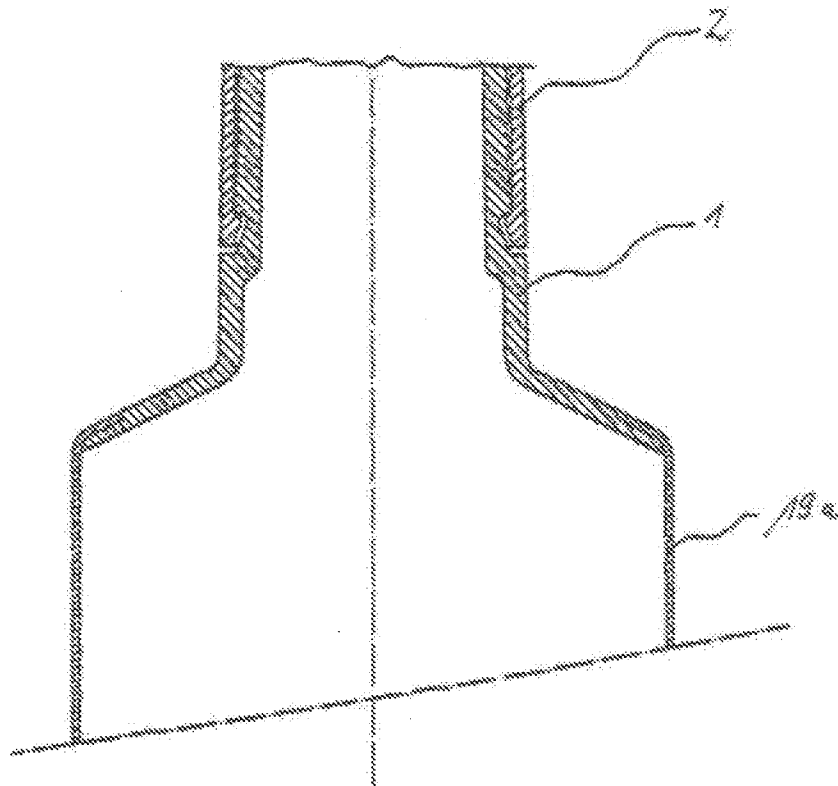


Fig. 18

INTERNATIONAL SEARCH REPORT

Letter of Application No.
PCT/EP 94/01695

A. CLASSIFICATION OF SUBJECT MATTER

IPC 5 B65D47/26 B65D47/24 B65D47/20

According to International Patent Classification (IPC) or its national equivalent and IPC.

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 5 B65D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched.

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant in claim No.
X	US,A,2 082 691 (FARRELLY) 1 June 1937	1,2,5-7, 11,13, 14,17
Y	see page 1, right column, line 38 ~ page 3, left column, line 11; figures 1-12	9,16
X	US,A,5 199 617 (BENNETT) 6 April 1993 see figures 1-8	1,2,7,8, 11,17
X	GB,A,521 672 (THORN) 28 May 1940 see figures 1-6	1,2,7, 11,17

☒ Further documents are cited in the continuation of box C.

☒ Patent family members are listed in annex.

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(C) document which may derive directly or indirectly from an invention which is cited to establish the prior art of another invention or other special reason for citation

(D) document relating to an oral disclosure, use, exhibition or other means

(E) document published prior to the international filing date but later than the priority date claimed

(F) later document published after the international filing date or priority date and not in conflict with the application but used to understand the principles or theory underlying the invention

(G) 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

(H) 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

(I) dependent member of the same patent family

Date of the actual completion of the international search

30 September 1994

Date of mailing of the international search report

11.10.94

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Fax (+49-89) 540-2016

Authorised officer

Berrington, N

INTERNATIONAL SEARCH REPORT

No. of Applicants 10

PCT/EP 94/01695

Documents Considered to be Relevant		
Category	Number of document, with indication, where appropriate, of the relevant passage	Relevant to class. No.
X	US,A,3 446 406 (TROT) 27 May 1969 see column 5, line 55 - column 7, line 35; figures 1-19 -----	1-4,7,8, 11,13, 15,17
X	DE,C,924 857 (HEUGEBAUER) 9 May 1956 see page 2, line 9 - line 91; figures 1A,8 -----	1,2,7, 10,17
X	US,A,2 106 364 (THORN) 25 January 1938 see figures 1-20 -----	1,2,7,17
Y	DE,U,92 06 097 (COMBITOOL AG) 20 August 1992 -----	9
A	see page 3, line 24 - page 4, line 19; figures 2,3 -----	3,4
Y	FR,A,2 093 327 (HILCOSAN BECHER & DOSENFABRIK) 28 January 1972 see figure 3 -----	16
A	GB,A,2 088 838 (DROLIK) 16 June 1982 -----	
A	DE,A,16 36 129 (LEITZ) 5 March 1970 -----	

INTERNATIONAL SEARCH REPORT

continuation of patent family members

Intern. Cl. Application No.

PCT/EP 94/01695

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US-A-5199617	06-04-93	NONE	
GB-A-521672		NONE	
US-A-3446406	27-05-69	NONE	
DE-C-924857		NONE	
US-A-2106364		NONE	
DE-U-9206097	20-08-92	NONE	
FR-A-2893327	28-01-72	NONE	
GB-A-2088838	16-06-82	NONE	
DE-A-1536129	05-03-70	NONE	

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X	US,A,2 082 691 (FARRELLY) 1. Juni 1937	1, 2, 6-7, 11, 13, 14, 17 9, 16
Y	siehe Seite 1, rechte Spalte, Zeile 38 - Seite 3, linke Spalte, Zeile 11; Abbildungen 1-12	
X	US,A,5 199 617 (BENNETT) 6. April 1993	1, 2, 7, 8, 11, 17
	siehe Abbildungen 1-8	
X	GB,A,521 672 (THORN) 28. Mai 1940	1, 2, 7, 11, 17
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Zusammenfassung: AUS WESSENTLICH ABGEGRIFFENE ÜBERBLÄTTER

Kategorie	Benennung der Veröffentlichung, soweit erforderlich unter Angabe der in Bericht klassierten Teile	Hier, Anspruch Nr.
X	US,A,3 446 406 (TROT) 27. Mai 1969 siehe Spalte 5, Zeile 55 - Spalte 7, Zeile 35; Abbildungen 1-15 -----	1-4,7,8, 11,13, 15,17
X	DE,C,924 857 (NEUGEBAUER) 9. Mai 1956 siehe Seite 2, Zeile 9 - Zeile 91; Abbildungen 1A,B -----	1,2,7, 10,17
X	US,A,2 106 364 (THORN) 25. Januar 1938 siehe Abbildungen 1-20 -----	1,2,7,17
Y	DE,U,92 06 097 (CONBITOOL AG) 20. August 1992 -----	9
A	siehe Seite 3, Zeile 24 - Seite 4, Zeile 19; Abbildungen 2,3 -----	3,4
Y	FR,A,2 093 327 (HILCO SAN BECHER & DOSENFABRIK) 28. Januar 1972 siehe Abbildung 3 -----	16
A	GB,A,2 088 838 (ORDLIK) 16. Juni 1982 -----	
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Im Recherchenbericht angeführtes Patentdokument	Datum der Veröffentlichung	Mitglied(er) der Patentfamilie	Datum der Veröffentlichung
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(21) International Application Number: PCT/US95/01505 (22) International Filing Date: 10 February 1994 (10.02.94) (30) Priority Data: 86/225,251 8 April 1994 (08.04.94) US (71) Applicant: ULTIMATE ABRASIVE SYSTEMS, INC. [US/US], P.O. Box 32606, Atlanta, GA 30355 (US). (72) Inventor: TSELESNI, Naum, N., 2500 Lockout Place, Atlanta, GA 30305 (US). (74) Agents: GARRETT, Arthur, S. et al., Finnegan, Henderson, Furnbow, Garrett & Dunner, 1300 I Street, N.W., Washing- ton, DC 20005-3315 (US).	(51) Designated States: AM, AT, AU, BE, BG, BR, BY, CA, CH, CN, CZ, DE, DK, EE, ES, FI, GB, GR, HU, JP, KE, KG, KP, KR, KZ, LA, LB, LT, LI, LV, MD, MG, MN, MW, MX, NL, NO, NZ, PL, PT, RO, RU, SD, SE, SI, SK, TJ, TT, UA, UG, UZ, VN, European patent (AT, BE, CH, DE, DK, EE, FR, GB, GR, IE, IT, LU), MC, NL, PT, SE), OAPI patent (BF, BI, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG), ARIPO patent (KE, MW, SD, SZ, UG). Published With international search report.	
(54) Title: METHOD FOR MAKING POWDER PREFORM AND ABRASIVE ARTICLES MADE THEREFROM		
(57) Abstract		
A method for making abrasive articles uses a soft, easily deformable and flexible preform having a high binder content. The binder gives the preform its integrity, and is present in greater quantity than the retaining powder. The preform can have superabrasive particles mixed therein, or added later. The preform allows even distribution of a small quantity of retaining powder for thin superabrasive articles. A porous layer may be added to the assembly for making an abrasive article, the porous layer ensuring the liquid binder, supporting the retaining powder and superabrasive particles to prevent lateral movement, and perhaps giving strength to the preform. The final assembly to be heated or sintered (preferably under pressure) for making the abrasive article, which may include any number of layers of superabrasive particles, porous layers and preforms.		

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Description

METHOD FOR MAKING POWDER PREFORM AND ABRASIVE ARTICLES MADE THEREFROM

Technical Field

This invention relates generally to the making of abrasive articles and the like, and is more particularly concerned with the use of soft, flexible and easily deformable powdered pieces as preforms for the manufacture of abrasive articles having superabrasive particles therein.

Background Art

Powdered preforms are widely used in the manufacture of abrasive articles that include a plurality of superabrasive particles such as diamond, cubic boron nitride and the like. Such powdered preforms are conventionally manufactured by compacting powder mixtures of retaining compositions and superabrasive particles in cold presses or roll compactors. Compacting pressure ranges from 300 to 10,000 kg/sq. cm, resulting in 20-50% relative density of the green compacts. Such green compacts are hard, stiff and brittle. The green compacts are sintered, either with or without pressure, and with or without impregnation.

There is a method of making abrasive articles wherein a non-compacted mixture of the powdered retaining composition, with the plurality of superabrasive particles therein, is placed directly into a sinter mold, then compacted and sintered in the sinter mold. This method requires a lot of adjustments in attempts to spread the powder evenly within the sinter mold. The required adjustments slow the manufacturing process, so the method does not fit well with mass production requirements.

In all the above mentioned methods, the powdered mixture can contain some binders, but the conventional green compacts are held together, not by the binder, but primarily by interaction among the particles of the powder, e.g. by mechanical interlocking of the particles. The above mentioned methods are widely used to produce traditional

cutting, drilling, and grinding abrasive tools and elements of abrasive tool, such as segments for saws and the like.

There are powdered preforms formed by spraying powder onto a substrate, and fixing the powder to itself and to the substrate by an adhesive, for example by an adhesive spray. Such preforms are flexible, but may experience loss of some powder when flexed. Also, such a method must deal with air borne particles and aerosol sprays that, because of environmental concerns, put serious limitations on the implementation of the method. This method has been used by the present inventor to make articles disclosed in U.S. Patents Nos. 4,925,457, 5,049,165, 5,092,910 and 5,190,568, as well as in U.S. patent Application Ser. No. 08/066,475 titled "patterned Abrasive Material and Method" and Ser. No. 08/024,649 titled "Abrasive Cutting Tool".

Soft and flexible preforms of powders and/or fibers, including both metallic and non-metallic materials, are also known; but, to the knowledge of the present inventor, such preforms are not known in the art of manufacturing articles that include superabrasive particles. Presently, the soft and flexible preforms are made by casting, or extruding a composition of brazing filler metal, or ceramic components, or hard facing compositions including metallic components and non-metallic abrasive components such as tungsten carbide particles. Such soft and flexible preforms can be bent more than 90°, and can be cut by scissors or the like.

The earlier known soft and flexible preforms comprise a high content of various binders, up to 95% by volume, and up to 20% by weight. It is the binder that makes such preforms soft and flexible; but, even with the high content of binders, the preforms are flimsy and must be handled with care. This is especially true for the very thin preforms, around .005--.010", or 0.10--0.25 mm.

It is important to distinguish between the soft and flexible preforms and the products of roll compacting of powders, even in the presence of a binder. When a roll compacted product includes a binder, the binder is in a much

smaller quantity than in a flexible preform. The roll compacted product is held together, not by the binder, but by the mechanical interlocking of particles, which makes the roll compacted product much less flexible than the soft and flexible preforms.

Soft and flexible preforms made of brazing filler metal compositions are used to put some parts together through brazing, mostly through furnace brazing. Soft and flexible preforms made for hard facing compositions are used to repair worn parts. For this purpose, the preforms are applied to a worn spot on the part.

The brazing process using the soft and flexible preforms made of brazing filler metal has a significant time duration because of the necessity for removal of the substantial quantity of binder. The time for removal of the binder is called the "dewaxing" cycle, and it allows the binder to melt, evaporate, or run out from the preform. It has been found that, if the dewaxing time is shortened or omitted, the powder of the soft and flexible preform can be literally washed out by the liquefied binder.

In attempting to use the known soft and flexible preform to hold a plurality of superabrasive particles in order to produce abrasive articles, it will be recognized that:

1. Compositions of the brazing filler preform do not correspond to the desired matrix compositions to hold superabrasive particles;
2. Soft and flexible preforms are not produced with superabrasive particles on, or within, the preforms;
3. Soft and flexible preforms are quite flimsy and not as strong as desired for production of abrasive articles, especially for mass production requirements of abrasive articles requiring thin (.005--.020", or 0.1-- 0.5 mm) flexible preforms;
4. De-waxing time must be severely reduced to meet production rates, especially for mass production; and,

5. Heating and/or brazing processes alone do not provide the most reliable matrix for retaining superabrasive particles.

Disclosure of the Invention

The present invention provides a method for manufacturing abrasive articles and wear resistant parts, such articles or parts comprising a plurality of superabrasive particles such as diamond, cubic boron nitride or the like randomly or systematically distributed in a retaining matrix. Specifically, the method of the present invention includes the preparation and utilization of powdered preforms in the form of soft, easily deformable flexible (SEDF) bodies that may include a plurality of superabrasive particles.

In making the SEDF preforms, the powdered compositions will be chosen based on criteria related to the holding necessary for the superabrasive particles to be included. Any number of matrix materials, or powdered compositions may be used, with any number of binders. The binder will be selected to provide the desired integrity of the product, while maintaining the flexibility and processability. In any case it must be remembered that the concentration of powdered composition and abrasive particles (if included) is low, and the volume of the binder is high. The volume of the binder phase substantially exceeds the volume of the powdered composition and the abrasive particles within the SEDF preform.

In one preferred form of the present invention, a porous layer will be placed against the SEDF preform. The purpose of the porous layer is to hold the abrasive particles in place during subsequent processing of the material. Successful material can be made without the porous layer, but the porous layer provides a better quality product than is obtained without the porous layer.

Final processing of the SEDF preform of the present invention includes sintering or other heat treating. The result is a high quality abrasive material, with or without a

porous layer therein, which can be used for numerous cutting or abrasive tools and the like.

Brief Description of the Drawings

These and other features and advantages of the present invention will become apparent from consideration of the following specification when taken in conjunction with the accompanying drawings in which:

Fig. 1 is a cross-sectional view showing one form of preform made in accordance with the present invention, the preform having some superabrasive particles therein;

Fig. 2 is a cross-sectional view of another preform made in accordance with the present invention, the preform being formed on a substrate which may be a porous material;

Fig. 3 is a view similar to Fig. 1 but showing the superabrasive particles on the surface of the preform;

Fig. 4 is a view similar to Fig. 3 wherein the superabrasive particles are held by a carrier which is placed against the preform;

Fig. 5 is a cross-sectional view illustrating a continuous process for forming the preform, and placing superabrasive particles on one surface of the preform;

Fig. 6 is a view similar to Fig. 5, but showing the preform being formed on a substrate having superabrasive particles thereon;

Fig. 7 is a view similar to Fig. 1 and showing a comparison between the thickness of the preform and the size of the superabrasive particles;

Fig. 8 is a view similar to Fig. 7, but showing the preform after sintering;

Fig. 9 is a cross-sectional view illustrating a method and apparatus for casting preforms according to the present invention;

Fig. 10 is a cross-sectional view showing a process of sintering under pressure;

Fig. 10A is a view similar to Fig. 10 but showing a plurality of preforms within the mold;

Fig. 11 is a cross-sectional view illustrating an assembly of a preform with porous layers in accordance with the present invention;

Figs. 12--17 are similar to Fig. 11 and show various modifications thereof;

Fig. 18 is a cross-sectional view illustrating extrusion of the preform into openings of a porous layer;

Fig. 19 is a cross-sectional view showing a continuous process for assembling a preform in accordance with the present invention using rolls;

Fig. 19A is a cross-sectional view illustrating the casting of a profiled preform on a substrate;

Fig. 19B is a view similar to Fig. 19A but showing a preform being cast between two substrates;

Fig. 19C is a cross-sectional view showing the deformation of a flat preform;

Fig. 20 is an exploded, cross-sectional view showing an be mixed assembly for producing an abrasive article;

Fig. 20A is a view similar to Fig. 20 but showing a modification thereof;

Fig. 21 is a cross-sectional view showing the assembly of Fig. 20 after assembly and sintering;

Figs. 22 and 23 are similar to Figs 20 and 21 but showing a modification thereof;

Figs. 24 and 25 and Figs. 26 and 27 are similar to Figs 20 and 21 but showing additional modifications thereof; and,

Fig. 28 is a side elevational view showing the assembly of a cutting tool in accordance with the present invention.

Best Mode for Carrying Out the Invention

Referring now more particularly to the drawings, and to those embodiments of the invention here presented by way of illustration, the invention has two major parts: preparation of soft, easily deformed flexible (SEDF) preforms; and, utilization of SEDF preforms for making abrasive articles.

Preparation of Preform

The preform is prepared by mixing a binder with a powder composition in the required proportions. The mixture may or may not include a plurality of superabrasive particles. Thus, depending on the particular portions chosen, one may produce the binder-powder mixture in the form of a slurry, granulated powder, or a paste.

If the granulated powder is used, a plurality of superabrasive particles can be placed onto the granules by a supplementary process. The granules may be mixed with a plurality of superabrasive particles, and the superabrasive particles may stick to the granules either because of the binder in the granules, or because of an additional binder covering the granules and/or the superabrasive particles.

Mixing the binder with the retaining powder can be performed on a variety of standard equipment, including virtually any equipment suitable for mixing powder and liquid together. Thus, no detail discussion of the equipment is necessary herein.

There is a variety of materials that can be used as the binder for the preform. The binder may be organic or inorganic, but should be selected to carry the particles of the powder, keep the particles suspended, and provide integrity and flexibility to the final preform. It is preferable to choose a binder that allows air, a low vacuum, heat, or a combination of these, to evaporate at least some of the volatile components of the binder for at least partial curing of the binder. Such binders include water soluble binders.

It is well recognized that the prior art powder technology requires that a person mix powders and superabrasive particles. Such powders and superabrasive particles become air borne, and are deleterious to the health of workers. Safety masks and the like are available, but are uncomfortable to wear, and of course are not totally effective. The present invention overcomes this difficulty with the prior art in that the powders and superabrasive

particles can be handled by machines, appropriately covered to minimize the escape of particles. The material is available to be manipulated by people only after mixing powdered components with the binder, so there is no longer a hazard of air borne particles.

Those skilled in the art will understand that many materials will be acceptable as binders, depending on the precise characteristics desired. However, by way of example, the following have been found to be suitable binders: Sanford's Rubber Cement (commercially available from Sanford Corporation, Bellwood IL) in a combination with Carter's Rubber Cement Thinner (commercially available from Dennison Carter's Division, Dennison Manufacturing Company, Framington, MA); Microcoat Cements (available from Wall Colmanoy Company, Madison Heights, MI) in a combination with Exoson No. 40 (available from Smithkline Beckman Company, Lewistown, PA).

In the binder-powder composition, the binder is usually 3 to 20% by weight of the composition, but the ratio can be extended. By volume, the percentage of the powder within the binder-powder composition is usually from 1 to 5%, but it can be extended to a range of 0.3 to 10%. One successful preform has from 5.0 to 8.5% by weight of rubber cement and thinner. The retaining powder is dispersed in the binder and held thereby. Superabrasive particles may also be dispersed within the binder, and also held therein.

Referring to Fig. 1 of the drawings, it will be seen that the SEDF preform 10, comprises mostly binder 11. There is a plurality of particles 12 of a retaining powder distributed in the binder 11, and there are superabrasive particles 14 also distributed in the binder. From the above discussion it will be understood that the superabrasive particles 14 may or may not be included. This will also be discussed in more detail below.

Looking at Fig. 2, it will be seen that the SEDF preform 10 includes the binder 11 and retaining powder 12. Superabrasive particles 15 are here shown as fixed to a

substrate 16, the substrate 16 then being placed against the SEDF preform 10. The substrate 16 may take many forms, including a film having a low melting point or the like, but it is preferably a porous material, which will be discussed in more detail hereinafter.

Fig. 3 shows a modification of Fig. 2, the SEDF preform 10 being substantially the same. The superabrasive particles 18 in Fig. 3, however, are placed on the upper surface of the preform 10. The superabrasive particles may be pressed into the preform 10, or may be held by an adhesive. The adhesive may be the binder 11, or may be a separately applied adhesive. Similarly, Fig. 4 shows the arrangement of Fig. 3, but with a carrier 19 having the abrasive particles 20 adhered thereto. The particles 20 on the carrier 19 can therefore be brought into contact with the preform 10 when desired.

In accordance with the present invention, SEDF preforms can be formed by spreading a binder-powder composition on a substrate. The composition may be powdered slurry, granules, or a paste. The composition is then cured, e.g. dried, on the substrate, and one may use applied heat or pressure if desired.

When dealing with granules, an external pressure in the range of 50 to 200 kg/cm² is helpful to apply a binder to the granules while the granules are on the substrate. The binder, which may be spread on the substrate, may penetrate between the granules and assists in integrating the granules into a preform.

In some cases, especially when the superabrasive particles are substantially larger than the particles of the retaining powder, or the viscosity of the liquid is not balanced to suspend the superabrasive particles, some measure must be taken to prevent separation or sedimentation of the superabrasive particles after mixing has stopped. One might therefore pour immediately after mixing, or combine continuous mixing with simultaneous pouring or coating.

The superabrasive particles in the SEDF preforms are not surrounded by closely packed particles of a retaining powder as in the traditional green compacts. Rather, the superabrasive particles in the SEDF preform are suspended predominantly by the binder, and in contact with a very few particles of the retaining powder. This is illustrated in Figs. 1--4 of the drawings.

Superabrasive particles can be added to the SEDF preform during the process of forming or curing the preform. By way of example, attention is directed to Fig. 5 of the drawings. A binder-powder composition 21 is dispensed onto a substrate 22, and doctored to a uniform thickness by a doctor blade 24. After the doctor blade 24, superabrasive particles 25 are dispensed onto the surface of the preform 26. It will be understood that the composition 21 is not cured at the time the superabrasive particles 25 are placed onto the preform 26, so the particles will be adhered thereto. If desired, or necessary due to the viscosity of the preform and the weight of the particles 25, pressure can be applied to assist in urging the superabrasive particles 25 at least partially into the preform 26. Also, additional adhesives or the like can be applied as needed.

Fig. 6 illustrates a modification of the arrangement shown in Fig. 5. In Fig. 5, the binder-powder composition 21 is dispensed onto the substrate 22 and doctored to the desired thickness by doctor blade 24. In Fig. 6, however, the substrate 22 carries a plurality of superabrasive particles 28, and the binder-powder composition is dispensed onto the particles 28. The superabrasive particles 28 may be completely covered, or only partially covered by the binder-powder composition as desired.

The difference between the thickness of the SEDF preform and the size of the superabrasive particles can vary considerably; but, it will be realized that the difference will change significantly in sintering. Fig. 7 shows an SEDF preform 10 having superabrasive particles 14 therein. At this stage, the thickness t of the SEDF preform may be equal

to $3d$ to $10d$, where d is the dimension of the superabrasive particles in the direction of the thickness of the SEDF preform. After sintering, the same preform is shown in Fig. 8. It will of course be realized that the superabrasive particles 14 will not change in size during sintering, but the preform 10 will be significantly condensed. After sintering, the preferable ratio is that the thickness t is approximately equal to the dimension d , the desirable range being $t = 0.3--2d$. It should be mentioned that superabrasive particles of all sizes are suitable for use with the technology disclosed herein, but the preferable sizes are from 18 to 324 mesh (about 1.0 mm to about 0.035 mm).

The weight of the dry retaining powder per unit volume of the SEDF preform (grams of powder per cubic centimeter of preform) determines the thickness of the sintered abrasive material, it being realized that the binder will run off, or evaporate, during sintering or other heat processing. For example, the density of cobalt is 8.9 g/cm^3 , and a cobalt preform contains 0.8 g/cm^2 of the dry cobalt powder; therefore, the thickness of the fully densified, sintered product will be about 0.9 mm, which is found by dividing 0.8 g/cm^2 by 8.9 g/cm^3 . It will be noted that the thickness of the SEDF preform is not in the calculation, this being irrelevant. The important consideration is the quantity of the dry powder per unit area of the preform.

One technique for production of SEDF preforms of the present invention is illustrated in Fig. 9. Essentially, a plurality of trays 29 is moved under a hopper 30 which dispenses the binder-powder composition. Each tray 29 will receive a predetermined quantity of the composition to provide SEDF preforms of predetermined weight. As shown in Fig. 9, the trays 29 can be placed on a conveyor 31, or may be part of a conveyor 31 which can move continuously, or intermittently, and timed so the binder in the composition will be cured before the preforms are removed from the trays 29. In the system illustrated, the preforms are received by another conveyor 32 which will carry the preforms to the next

processing step. It should be understood that the conveyor 31 can take various geometrical arrangements, including a zig-zag shape in the horizontal plane and a stepped shape in vertical plane.

In using the system shown in Fig. 9, if a substrate is desired on the preform, the substrate, with or without superabrasive particles thereon, can be placed in the bottom of the trays 29. Also, superabrasive particles, with or without a substrate, can be placed on top of the preform after the tray 29 is filled to the desired extent.

It will therefore be realized that the SEDF preform may be made in the form of discrete plates as shown in Fig. 9, or may be made in the form of continuous tapes as shown in Figs. 5 and 6. Either form can then be cut easily with scissors, paper cutter, die cutting or the like.

Preparation of Abrasive Articles

Fig. 10 of the drawings shows the preferred means and method for heating an SEDF preform and condensing the preform. Fig. 10 illustrates a generally conventional sinter fixture for sintering under pressure. It will be seen that there is a bottom punch 34 and a top punch 35, the space between the punches 34 and 35 being closed by the side plates 36. Within the cavity so defined, there is an SEDF preform 38, here shown as having superabrasive particles 39 distributed therein, and a plurality of superabrasive particles 40 on the top side of the preform 38.

Those skilled in the art will understand that the punches 34 and 35 will be urged towards each other as indicated by the arrows, and an electric current will be passed through the sinter fixture and/or the preform to heat the preform. An important feature of the present method is that the side plates 36 will tend to restrain lateral movement of the SEDF preform during sintering, even though there may be a flow of liquid as the binder and/or retaining matrix melt and run.

A further advantage of the SEDF preform in a sintering fixture as shown in Fig. 10 is that the softness of the preform makes redistribution of material quite easy. As a result, variations in thickness and stress can be made uniform simply through the usual pressure on the preform during sintering. The preform therefore has less sensitivity to various non-uniformities, and tends to reduce damage to the sinter molds. The inventor has experienced a 50-fold reduction in consumption of graphite mold parts since using the technique disclosed herein. It should be noted that, because of the softness and deformability of the SEDF preform, abrasive articles with a corrugated shape can be mass produced without significant consumption of corrugated (hence expensive) punches, e.g. graphite or metal punches.

It should be understood that the sinter mold can be loaded with several assemblies of SEDF preforms, the assemblies being separated from one another by punches and/or separators as disclosed in U. S. Patent No. 5,203,080, "Method and Apparatus for Making Abrasive Tools", by the present inventor. Such sintering "in stock" is illustrated in Fig. 10A. The unique uniformity, softness and deformability of the SEDF preform make sintering in stock acceptable for mass production technology.

While the heating of the SEDF preforms under pressure has many advantages, there is one severe disadvantage: the heating melts and vaporizes the binder, which runs; and, the liquid or vaporized binder, intensified by the applied pressure, tends to carry the retaining powder and superabrasive particles out of the mold. If most of the retaining powder is washed out of the mold, there will of course be practically no matrix material to hold the left over superabrasive particles in place. Also, melted binder and/or melted or moved retaining matrix of SEDF preform will catch the superabrasive particles, which can be washed out of the mold.

To solve the problem of the loss of retaining powder and superabrasive particles, it has been found that a porous

layer can be placed against the SEDF preform to prevent lateral movement of the particles. The porous layer may take many forms, but will not be held together by a binder as used in the SEDF preform. Rather, the porous layer may be screen wire, a conventional compacted preform, egg-crate or reticulated metal structures or the like.

Looking at Fig. 11, it will be noticed that the superabrasive particles 41 are larger than the openings in the porous layer 42. Under pressure, the particles 41 may cut into the porous layer 42. The particles 44 of the retaining powder are smaller than the opening in the layer 42, so these particles will pass easily into the openings of the layer 42.

As shown in Fig. 11, there is a second porous layer 45 on the opposite side of the SEDF preform; and, the assembly shown in Fig. 11 will be urged together and heated under pressure. The porous layers 42 and 45 will support the superabrasive particles and prevent lateral movement (perpendicular to the direction of the applied compaction force), and will provide additional volume to receive the SEDF preform, and restrain lateral motion of the particles of retaining powder in the SEDF preform. The porous layers will also temporarily absorb liquid binder to reduce the flow of binder and thereby help prevent washout of retaining powder and superabrasive particles.

The porous layer, or layers, can be placed in various positions relative to the SEDF preform and other layers of an assembly to be sintered. By way of example, and not by way of limitation, Fig. 12 shows the SEDF preform 46 having a porous layer 48 on one side, and a layer of abrasive particles 49 on the opposite side of the porous layer 48, a substrate, or carrier 50 holding the particles 49 in place. Fig. 13 shows the same arrangement, but the substrate 50 is between the particles 49 and the porous layer 48.

Fig. 14 shows the SEDF preform 46 in the middle with the porous layer 48 on one side, and the superabrasive particles 49 and substrate 50 on the opposite side. Fig. 15 shows the

superabrasive particles 49 and substrate in the middle, with the SEDF preform 46 on one side, and the porous layer 48 on the opposite side. Fig. 16 is like Fig. 15, except that the positions of the superabrasive particles 49 and the substrate 50 are reversed.

Fig. 17 shows two SEDF preforms 46 and 46'. A porous layer 48 is between the preforms, and the superabrasive particles 49 with the substrate 50 are on the opposite side of one of the preforms.

The porous layer may take the form of a woven mesh, a nonwoven material, expanded foil, knitted materials and textile fabrics. Also, a material that is roll-compacted, extruded, sintered or the like can be used. Virtually any material can be used so long as the material is highly porous (about 30% to 99.5% porosity), having pores open to the surface and interconnected, with sufficient integrity to support the superabrasive particles and to restrain motion of the retaining powder in the process of sintering.

Presently, the best material known for use as porous layers are metallic non-woven materials, and particularly a nickel fiber powder non-woven mat, manufactured by National Standard, Woven production Division, Corbin KY, and sold under the trademark "Fibrex". The porosity of this mat is 85-98%; the fiber is 20 microns in diameter and is about 80 weight percent of the mat, while the powder is about 20 weight percent.

It has also been found that copper wire mesh, in the range of 20 to 200 mesh, works well as the porous layer. Some expanded metals (manufactured by Dalkor Corporation) have been used, for the same purpose.

Fig. 18 of the drawings illustrate an SEDF preform 51 after the preform 51 has been urged against a porous layer 52. The porous layer 52 is here shown as having some substantial thickness, and being made up of a plurality of cells 54 so the porous layer 52 comprises a cellular type of material. It will be seen, then, that the material of the preform 51 has been urged into the cells 54. It has been

found desirable in some cases to compress the preform 51 with the porous layer 52 prior to applying heat and pressure during sintering. The material of the preform 51, being received in the openings, or cells, 54 of the porous layer 42, tends to stay within the openings and not to move laterally.

It should be understood that the role of the porous layer 52 can be limited to the restriction of flow of the material of the SEDF preform 51. Thus, a porous layer 52 may be made of a material having a melting point below the sintering temperatures. In this case, after at least a portion of the binder has been removed from the preform in the process of heating, and the retaining powder is at least partially solidified, the porous layer will melt onto the preform, and thereby modify the retaining composition. For example, a cobalt-nickel SEDF preform may utilize a porous layer made of copper, bronze, brass, zinc, aluminum, or various combinations of these, as well as other porous layers.

Another function of a porous layer 52 may be conduction of heat and/or electricity during heating of the preform. For example, a mesh or expanded foil of copper will readily conduct heat or electricity to facilitate uniform heating. Further, the porous layer may include superabrasive particles within the cells 54. A preform as shown in Fig. 18 may be placed against a porous layer 52 having superabrasive particles therein, or the porous layer may be used as a substrate in an arrangement such as that shown in Fig. 6 of the drawings.

In any arrangement, it must be realized that, if the porous layer is filled with superabrasive particles, the ability of the porous layer to absorb binder during heating is reduced. Thus, if one wish to provide a full, or nearly full, layer of superabrasive particles through the use of a porous layer, an additional porous layer may be needed, or desired, to absorb the binder and prevent displacement of the retaining powder.

Looking at Fig. 19 of the drawings, it will be seen that the SEDF preform of the present invention is admirably suited to mass production techniques. The arrangement shown in Fig. 19 includes rolls 55 and 56 for assembling a plurality of layers to be sintered. There is a roll of preform 58 to form one side of the assembly, and a roll of substrate 59 to form the opposite side of the assembly. Optionally, a roll of a porous layer 60 is placed between the preform 58 and the substrate 59.

The substrate 59 may have a plurality of superabrasive particles 61 previously placed thereon; or, as here illustrated, a dispenser 62 may place superabrasive particles on the substrate 59 during the assembling process. In either case it is contemplated that the substrate, or carrier, 59 will have an adhesive to hold the superabrasive particles 61 temporarily.

The SEDF preform 58 may take many forms as discussed above. The preform 58 may include a plurality of superabrasive and abrasive particles, or may not. Further, the preform may be placed on a substrate in order to give the preform greater integrity.

The porous layer 60 may or may not be included in the assembly. As is mentioned above, the preform 58 may utilize a porous layer as a substrate, or carrier, and this may be sufficient for some products. However, if one or more additional porous layers are desired, they may be fed to the assembly as shown in Fig. 19. Fig. 19 also shows separators 66 and 67. Such separators are disclosed in U. S. patent No. 5,203,880, "Method and Apparatus for Making Abrasive Tools", by the present inventor. In accordance with the disclosure in that patent, these separators assist in protrusion of the superabrasive particles through the retaining matrix, and in distribution of the temperature within the sinter mold during the sintering process. These separators 66 and 67 may or may not be attached to the SEDF preform assembly. When attached to the preform, the separators will be part of the assembly itself.

It should be understood that, in all techniques disclosed in the present application, separators such as the separators 66 and 67 may or may not be used. If separators are used, they may also be utilized as the substrate for SEDF preform (see numeral 22 in Figs. 5 and 6). It should be understood that, in the majority of the figures in the drawings, separators are not shown for the sake of simplification of the illustration.

Those skilled in the art will understand that the rolls 55 and 56 will urge the layers 58, 59 and 60, and separators 66 and 67 together into a single assembly 64. It is contemplated that the assembly 64 will then be cut into discrete pieces, or plates, 65 by a cutter 66. The individual plates 65 can be received by a conveyor 68 for transport to means for sintering.

Examples

Figs. 20 and 21 of the drawings show one assembly and one resulting sintered abrasive material respectively in accordance with the present invention. There is an SEDF preform 70 having superabrasive particles 71 distributed therein. The opposite side of the assembly is an SEDF preform 72 without abrasive particles. Between these two outside layers, there are two additional preforms 74 and 75, both having superabrasive particles distributed therein. Then, between the preforms 70 and 74 there is a porous layer 76; and between the preforms 74 and 75 there is a porous layer 78.

In Fig. 21 it can be seen that the superabrasive particles remain in layers; and, on one side, the superabrasive particles 71 are at the surface of the sintered assembly, while on the opposite side the preform 72 provides a backing without superabrasive particles. This sintered abrasive material can now be used to manufacture cutting and grinding tools.

The SEDF preform may have a profiled shape, which may or may not correspond to the shape of a compacting means, e.g. punches used for providing pressure during sintering. The

profiled SEDF preform, along with the non-profiled, or flat ones, are utilized by the present inventor for manufacturing abrasive articles according to U. S. patent No. 5,190,568 titled "Abrasive Tool with Contoured Surface".

Fig. 19A illustrates a one-sided profiled SEDF preform. One-way to manufacture the one-sided profiled SEDF preform includes the use of a profiled substrate 111, a binder-powder composition 112 being poured onto the substrate 111.

Fig. 19B illustrates the formation of a two-sided profiled SEDF preform. Fig. 19B shows two substrates, or walls, 114 and 115 and a binder-powder composition 116 between the walls 114 and 115. According to the method illustrated in Fig. 19B, the two-sided profiled SEDF preform is manufactured by pouring a binder-powder slurry between the two profiled walls 114 and 115, resulting in the formation of the two-sided profiled SEDF preform 116.

It should be understood that wall 114 and wall 115 may have different profiles, and each side of the SEDF preform has a profile corresponding to the profile (relief) of the respective wall. It also should be understood that the walls can be positioned vertically or horizontally; and, application of pressure and/or changing the distance between the walls in the process of solidification of the binder-powder composition 116 are optional.

A non-profiled, or flat, SEDF preform can be converted prior to sintering into a profiled one. The flat profile 118 can be shaped between profiled compacting means. Fig. 19C illustrates one of the processes for shaping a flat SEDF preform 118 into a profiled SEDF preform 119 by two profiled rolls or gears 120 and 121. The preferable arrangement does not require change of the thickness of the SEDF preform as a result of the shaping. This type of shaping does not require very great pressure because of the easy deformability of the SEDF preform.

Fig. 20 also shows separators 66a and 67a placed against SEDF preforms 70 and 72 as a part of the assembly itself. Fig. 21 does not show these separators, indicating that at

least some of the separators have been removed from the sintered abrasive material in the process of after-sintering cleaning, or in the process of dressing the abrasive tool.

One method for utilization of the separators in combination with the SEDF preform is shown in Fig. 20A. The separator 100 is placed on one side of the assembly 103 that includes an SEDF preform 101, a layer of porous material 102 and a layer of superabrasive particles 104 on a substrate 105. A mesh type material 106 having openings 108 is applied against the separator 100; and, the preferable mesh type material 106 has orderly distributed openings 108. Under pressure provided by one or both of the punches 35a and 35b, the assembly 103 extrudes at least partially into openings 108 of the mesh type material 106, de forming the separator 100 and leaving imprints on the surface of the assembly 103. The whole assembly 103 is put into the sintering mold as is shown in Figs. 10 and 10A, and then sintered, providing that sintering under pressure is preferable. The pressure to extrude the assembly 103 into the openings 108 can be applied prior to sintering, outside of the sinter mold and/or within this sinter mold, and/or in the process of sintering. After sintering the mesh type material 106 is removed from the mold, as well as the separator 100. The removal of the mesh type material 106 from the sintered abrasive article is not a problem because the separator 100 prevents diffusion between the assembly 103 and the mesh type material 106. The resulting abrasive article will comprise a profile corresponding to the design of the mesh type material 106.

It should be understood that there are additional options (some being shown in Fig. 20A) that may or may not be implemented: the mesh type material 106 can be placed against both sides of the SEDF preform 101 for making two-sided profiled abrasive article (see separator 109 in Fig. 20A); another separator 110 can be used to separate mesh type material 106 from the punch 35a, and separator 115 can be used to separate another side of the assembly 103 from the punch 35b. It also should be understood that several

assemblies comprising SEDF preforms and the mesh material for extrusion can be sintered in stock as is shown in Fig. 10A. Furthermore, separators of different thicknesses and different types can be used for opposite sides of the SEDF preform 101. The mesh type material 106 for extrusion can be made from different materials, e.g. steel woven mesh, expanded metal, machined crags, honeycomb or the like. It is also preferable that openings in the mesh 106 be big enough to allow at least one superabrasive particle 104 to go therethrough. For example, diamonds have sizes of 0.015 to 0.200 mm (80-100 mesh) while the mesh type material for extrusion comprises openings of 1.00 to 0.830 mm (18 to 20 mesh). It is also preferable that the mesh type material 106 for extrusion does not melt under, sintering temperatures, and have a minimum deformability under the pressure that makes this mesh multiusable.

Figs. 22 and 23 of the drawings show an assembly and a sintered single layer cutting tool respectively. Fig. 22 illustrates the layers to be assembled, and includes a central porous layer 79 having a plurality of superabrasive particles 80 in the openings thereof. It should be noticed that the particles 80 are at least as wide as the layer 79, so the particles 80 extend completely through the porous layer 79.

Each side of the central layer 79 includes two SEDF preforms 81, 82 and 81', 82', separated by porous layers 84, 84'.

When the assembly is heated under pressure, the material shown in Fig. 23 results. The present inventor has used this method to produce abrasive articles with one layer of diamonds as shown. It should be understood, however, that the abrasive article can include as many layers as desired, in accordance with other disclosures herein.

Figs. 24 and 25 show the production of a no-diamond foot on a conventional diamond segment. Current methods are difficult to use because the foot 85 is quite thin, requiring that powder be distributed very thinly, yet very uniformly,

in a sinter mold. Using the methods and apparatus of the present invention, however, an SEDF preform 86 can be placed against the segment 88, and the retaining powder is readily distributed uniformly. As is discussed in detail above, the final thickness of the foot 85 can be easily calculated.

Figs. 26 and 27 show the use of a conventional green compact having randomly distributed abrasive and/or superabrasive particles in combination with preforms of the present invention, and porous layers having orderly arranged superabrasive particles. The central green compact 89 has a porous layer 90, 90' on each side thereof, then an SEDF preform 91, 91'. The outside comprises a porous, or cellular, layer 92, 92' having a plurality of superabrasive particles 94, 94' distributed therein in an orderly fashion.

The assembly of Fig. 26 can be compressed in the direction indicated by the arrows 95, or in the direction indicated by the arrows 96. The inventor has used this technique, with pressure in the direction of the arrows 95, to manufacture diamond segments for saw blades, and a ream saw blade.

Fig. 28 illustrates the making of a cut-off disk. Individual pieces 98, or a complete ring, of the SEDF preform can be prepared of the proper shape, and placed around the periphery of a core 99. From the foregoing discussion it will be understood that the pieces 98 may include any number of layers, may or may not include porous layers, and may have as many or as few superabrasive particles as desired.

After the pieces 98, or the ring, is assembled on the core 99, the assembly will be sintered (preferably under pressure) so the sintering of the preform and fixing the preform to the core 99 are performed in one step.

Following are some specific examples of use of the technology of the present invention:

1. a) Make an SEDF preform in the form of a plate or a tape from a diamond retaining composition, e.g., from Wall Colmonoy's setting powder 50, or from Kennametal's powder N50, or from any other powdered composition suitable for an

application of the superabrasive articles. Do not mix these retaining powders with diamonds in the process of making SEDF preform.

b) Cut the preform with paper cutter or scissors into the shape suitable for the sintering mold and design of the abrasive articles.

c) Put diamonds into openings of the mesh type material and temporarily retain them with an adhesive carrier. As an option, the mesh type material can be then removed.

d) Apply SEDF preform against the carrier that includes superabrasive particles. As an option, pressure and/or adhesive can be applied to hold the assembly together. As another option, separators can be placed on at least one side of the assembly as disclosed in U.S. patent 5,203,880, "Method and Apparatus for Making Abrasive Tools".

e) Place the assembly into a heating device e.g., between heating plates or into a sintering mold. It can be several assemblies per one device.

f) Heat the assembly under a pressure, e.g., up to 1040°C and 300 kg/cm², so called "hot compacting".

g) Remove the sintered assembly from the device, clean and cut, if necessary, into pieces required by the design, then mount the pieces on a carrier, if necessary, to make the final product.

2. a) Make an SEDF preform in the form of a plate or a tape from a slurry mixture of the diamond particles and a diamond retaining composition, e.g., from Wall Colmonoy's setting powder 50, or from Kennametal's powder N50, or from any other powdered composition suitable for an application of the abrasive articles.

b) Cut the preform with paper cutter or scissors into the shape suitable for the sintering mold and design of the abrasive articles.

c) As an option, separators can be placed on at least one side of the preform as disclosed in U.S. patent

5,203,880, "Method and Apparatus for Making Abrasive Tools", forming an assembly.

d) Place the assembly into a heating device, e.g. between heating plates or into a sintering mold. It can be several assemblies per one device.

e) Heat the assembly under pressure, e.g. up to 1040°C and 300 kg/cm², so called "hot compacting".

f) Remove the sintered assembly from the device, clean and cut, if necessary, into pieces required by the design, then mount the pieces on a carrier, if necessary, to make the final product.

3. a) Make an SEDF preform in the form of a plate or a tape from a slurry mixture of a first plurality of diamonds and a diamond retaining composition, e.g. from Wall Colmonoy's setting powder 50, or from Kennametal's powder N50, or from any other powdered composition suitable for an application of the abrasive articles.

b) Cut the preform with paper cutter or scissors into the shape suitable for the sintering mold and design of the abrasive articles.

c) Put a second plurality of diamonds into openings of the mesh type material and temporarily retain them with an adhesive carrier. As an option, the mesh type material can be then removed.

d) Apply SEDF preform, including the first plurality of diamonds against the carrier including the second plurality of diamonds. As an option, pressure and/or adhesive can be applied to hold the assembly together. As another option, separators can be placed on at least one side of the assembly as disclosed in U.S. patent 5,203,880, "Method and Apparatus for Making Abrasive Tools".

e) Place the assembly into a heating device, e.g. between heating plates or into a sintering mold. It can be several assemblies per one device.

f) Heat the assembly under a pressure, e.g. up to 1040°C and 300 kg/cm², so called "hot compacting".

g) Remove the sintered assembly from the device, clean and cut, if necessary, into pieces required by the design, then mount the pieces on a carrier, if necessary, to make the final product.

It should be understood that the first and second pluralities of diamonds, and generally, any superabrasive particles, can be of the same or different origin, size, shape and physical-mechanical parameters.

4. a) Make an SEDF preform in the form of a tape from a diamond retaining composition, e.g. from Wall Colmonoy's setting powder 50, or from Kennametal's powder H50, or from any other powdered composition suitable for an application of the abrasive articles. Do not mix these retaining powders with diamonds in the process of making SEDF preform.

b) Cut the preform with paper cutter or scissors into the shape suitable for the sintering mold and design of the abrasive articles.

c) Take the nickel non-woven mat of National Standard, cut it into the proper pieces.

d) Assemble a sandwich "SEDF preform--the nickel mat--SEDF preform". As an option, apply pressure and/or an adhesive to improve the integrity of this assembly.

e) Put diamonds into openings of the mesh type material and temporarily retain with an adhesive carrier. As an option, the mesh type material can be then removed.

f) Apply this carrier including the superabrasive particles against the sandwich "SEDF preform--the nickel mat--SEDF preform". As an option, pressure and/or adhesive can be applied to hold the assembly together. As another option, separators can be placed on at least one side of the assembly as disclosed in U.S. patent 5,203,880, "Method and Apparatus for Making Abrasive Tools".

g) Place the assembly into a heating device, e.g. between heating plates or into a sintering mold. It can be several assemblies per one device.

f) Heat the assembly under a pressure, e.g. up to 1040°C and 300 kg/cm², so called "hot compacting".

g) Remove the sintered assembly from the device, clean and cut, if necessary, into pieces required by the design, then mount the pieces on a carrier, if necessary, to make the final product.

5. a) Make an SEDF preform in the form of a plate or a tape from a slurry mixture of the superabrasive particles and a diamond retaining composition, e.g. from Wall Colmonoy's setting powder 50, or from Kennametal's powder N30, or from any other powdered composition suitable for an application of the abrasive articles.

b) Cut the preform with paper cutter or scissors into the shape suitable for the sintering mold and design of the abrasive articles.

c) Take the nickel non-woven mat of National Standard, cut it into the proper pieces.

d) Assemble a sandwich "SEDF preform--the nickel mat--SEDF preform". As an option, apply pressure and/or an adhesive to improve the integrity of this assembly. As another option separators can be placed on at least one side of the assembly as disclosed in U.S. patent 5,203,860, "Method and Apparatus for Making Abrasive Tools".

e) Place the assembly into a heating device, e.g. between heating plates or into a sintering mold. It can be several assemblies per one device.

f) Heat the assembly under a pressure, e.g., up to 1040°C and 300 kg/cm², so called "hot compacting".

g) Remove the sintered assembly from the device, clean and cut, if necessary, into pieces required by the design, then mount the pieces on a carrier, if necessary, to make the final product.

6. a) Make an SEDF preform in the form of a plate or a tape from a slurry mixture of the superabrasive particles and a diamond retaining composition, e.g. from Wall Colmonoy's setting powder 50, or from Kennametal's powder

N50, or from any other powdered composition suitable for an application of the abrasive articles.

b) Cut the preform with paper cutter or scissors into the shape suitable for the sintering mold and design of the abrasive articles.

c) Take the nickel non-woven mat of National Standard, cut it into the proper pieces.

d) Assemble a sandwich "SEDF preform--the nickel mat--SEDF preform". As an option, apply pressure and/or an adhesive to improve the integrity of this assembly.

e) Put diamonds into openings of the mesh type material and temporarily retain with an adhesive carrier. As an option, the mesh type material can be then removed.

f) Apply this carrier including the superabrasive particles against the sandwich "SEDF preform--the nickel mat--SEDF preform". As an option, pressure and/or adhesive can be applied to hold the assembly together. As another option, separators can be placed on at least one side of the assembly as disclosed in U.S. patent 5,203,880, "Method and Apparatus for Making Abrasive Tools".

g) Place the assembly into a heating device, e.g. between heating plates or into a sintering mold. It can be several assemblies per one device.

h) Heat the assembly under a pressure, e.g. up to 1040°C and 300 kg/cm², so called "hot compacting".

i) Remove the sintered assembly from the device, clean and cut, if necessary, into pieces required by the design, then mount the pieces on a carrier, if necessary, to make the final product.

It should be understood that the preferred embodiments of the invention here presented comprise assemblies of superabrasive particles such as diamonds, cubic boron nitride or the like, distributed in an orderly fashion on a substrate, or a carrier, and a pre-made SEDF preform formed from metals, ceramics, epoxy materials with binders or other plastics. The assemblies of the above components are heated or sintered, preferably under an external pressure. The SEDF

preform may or may not include randomly distributed superabrasive particles therein; and, and a separator can be a part of the assembly itself to prevent contacting and/or diffusion between the SEDF preforms and the molding parts.

It will of course be understood by those skilled in the art that the particular embodiments of the invention here presented are by way of illustration only, and are meant to be in no way restrictive; therefore, numerous changes and modifications may be made, and the full use of equivalents resorted to, without departing from the spirit or scope of the invention as outlined in the appended claims.

Claims

1. In a method for making abrasive articles, wherein said abrasive articles comprise a quantity of a retaining powder and at least one plurality of superabrasive particles, said method including the steps of making a preform of said retaining powder, placing said plurality of superabrasive particles into said preform, and heating said preform, the improvement comprising the steps of making said preform of a binder and said quantity of retaining powder wherein the volume of said binder is greater than the volume of said quantity of retaining powder, so that said preform is soft, easily deformable and flexible.

2. In a method as claimed in claim 1, the further improvement wherein the said step of heating said preform includes the steps of heating said preform while exerting pressure on said preform.

3. In a method as claimed in claim 1, the improvement including the step of adding said superabrasive particles to said binder and retaining powder before the said step of making said preform.

4. In a method as claimed in claim 1, wherein the said step of placing said plurality of superabrasive particles into said preform comprises the step of placing said plurality of superabrasive particles on one side of said preform.

5. In a method as claimed in claim 1, the improvement wherein said step of placing said plurality of superabrasive particles into said preform comprises the step of randomly distributing said superabrasive particles.

6. In a method as claimed in claim 1, the improvement wherein said step of placing said plurality of superabrasive particles into said preform comprises the step of distributing said superabrasive particles in an orderly fashion.

7. In a method as claimed in claim 1, the further improvement wherein the said step of making said preform comprises the step of forming said preform on a substrate.

8. In a method as claimed in claim 7, the improvement including the step of placing said plurality of superabrasive particles on said substrate prior to the said step of forming said preform.

9. In a method as claimed in claim 8, the improvement wherein said superabrasive particles are randomly distributed on said substrate.

10. In a method as claimed in claim 8, the improvement wherein said superabrasive particles are distributed on said substrate in an orderly fashion.

11. In a method as claimed in claim 8, the improvement wherein said substrate includes a plurality of openings extending to the surface of said substrate, and including the step of placing said superabrasive particles in said openings of said substrate.

12. In a method as claimed in claim 1, the further improvement comprising the step of placing a porous layer against said preform for making an assembly prior to the said step of heating said preform, said porous layer having a plurality of openings extending to the surface thereof for restraining movement of said retaining powder and said superabrasive particles.

13. In a method as claimed in claim 12, the improvement including the step of placing said porous layer between said superabrasive particles and said preform.

14. In a method as claimed in claim 12, the improvement including the step of placing another preform against said porous layer prior to the said step of heating said preform.

15. In a method as claimed in claim 12, the further improvement wherein the said step of making a preform is carried out by making said preform on a substrate, said substrate having openings therein and acting as said porous layer.

16. In a method as claimed in claim 15, the improvement including the step of placing said superabrasive particles on said substrate prior to the step of making said preform.

17. In a method as claimed in claim 12, wherein the porous layer is selected to have a lower melting point than the retaining powder, and further including the step of heating the assembly sufficiently to melt said porous layer.

18. The product made in accordance with claim 13.

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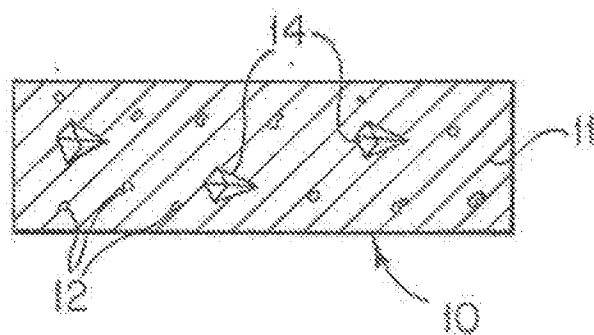


FIG. 1

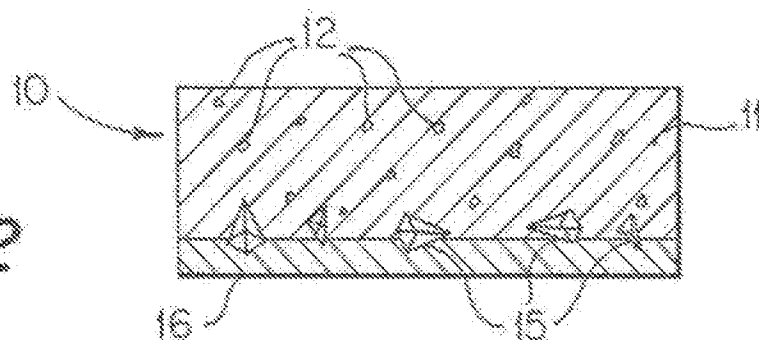


FIG. 2

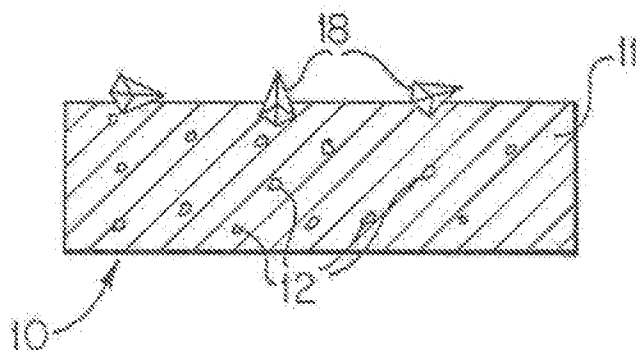


FIG. 3

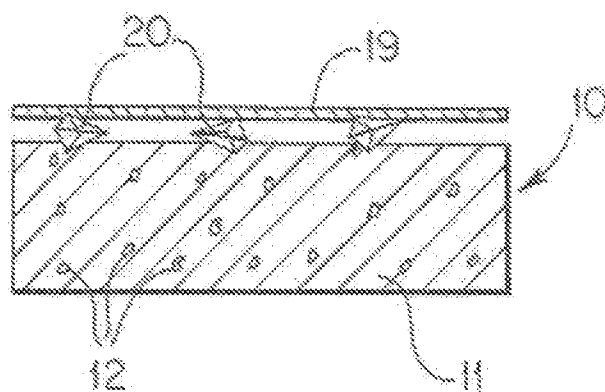
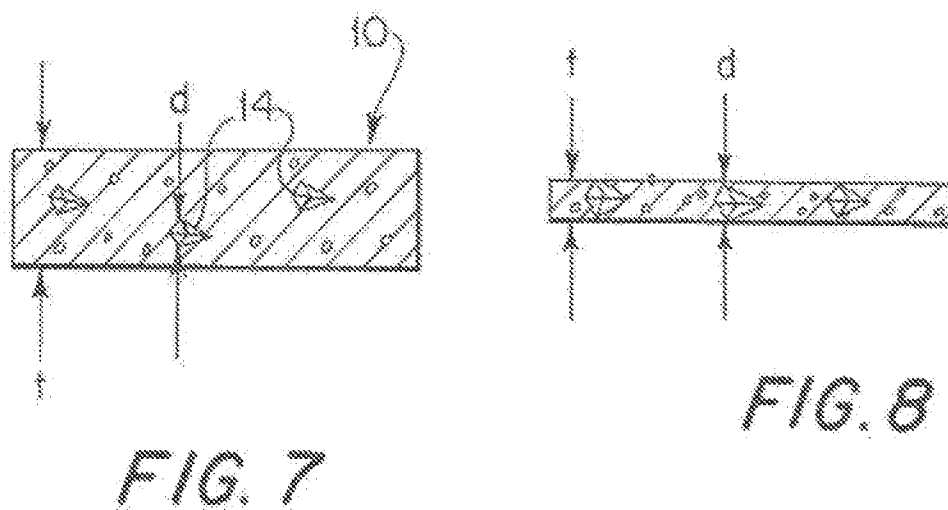
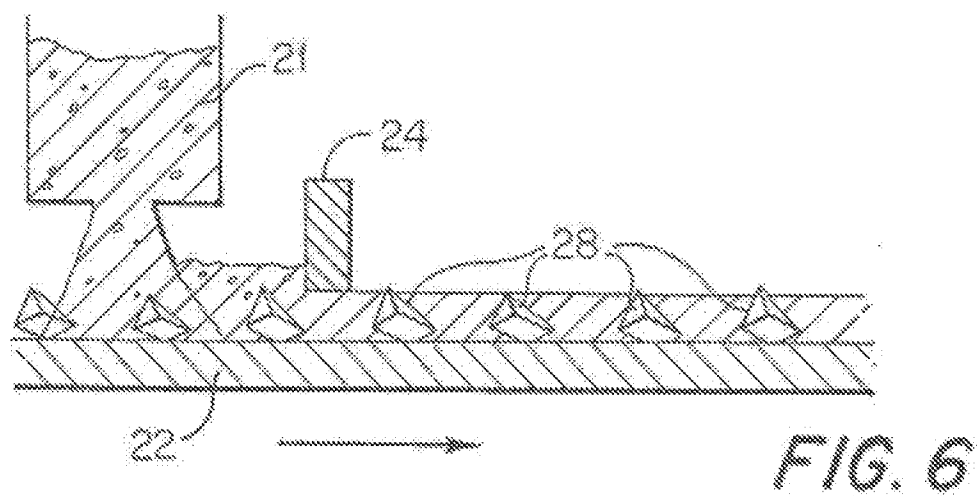
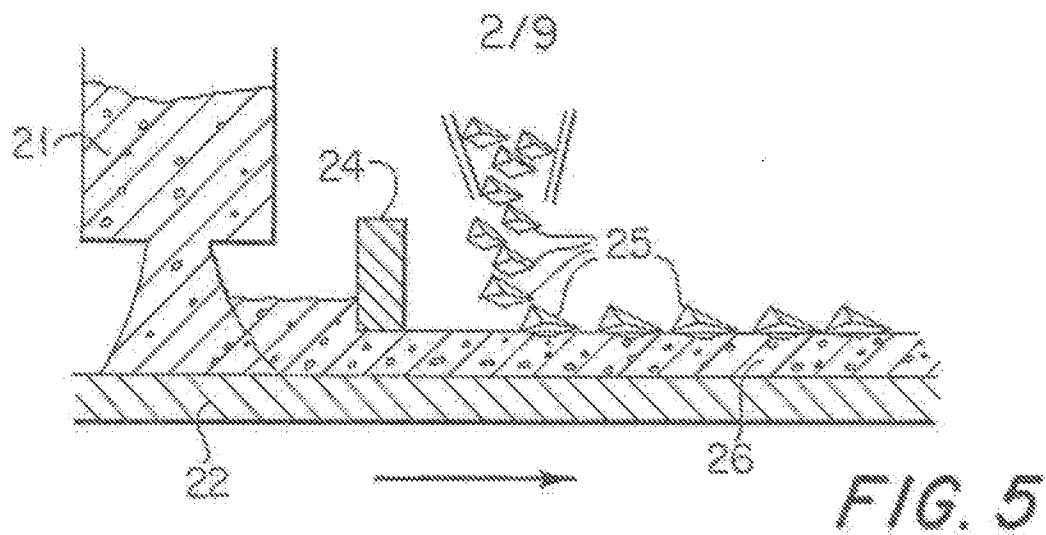


FIG. 4

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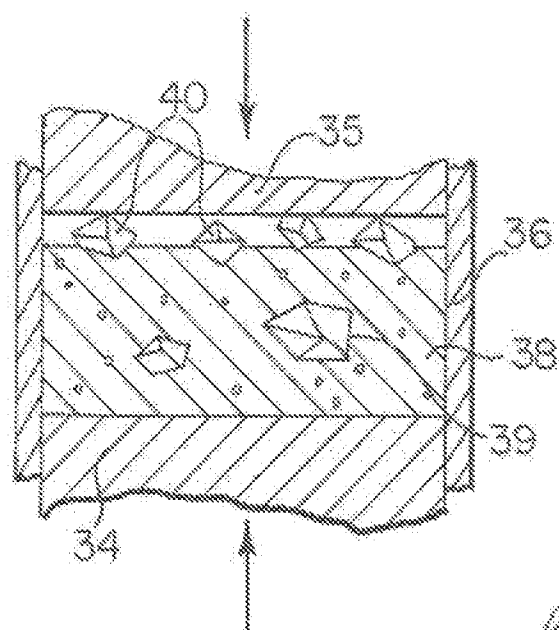
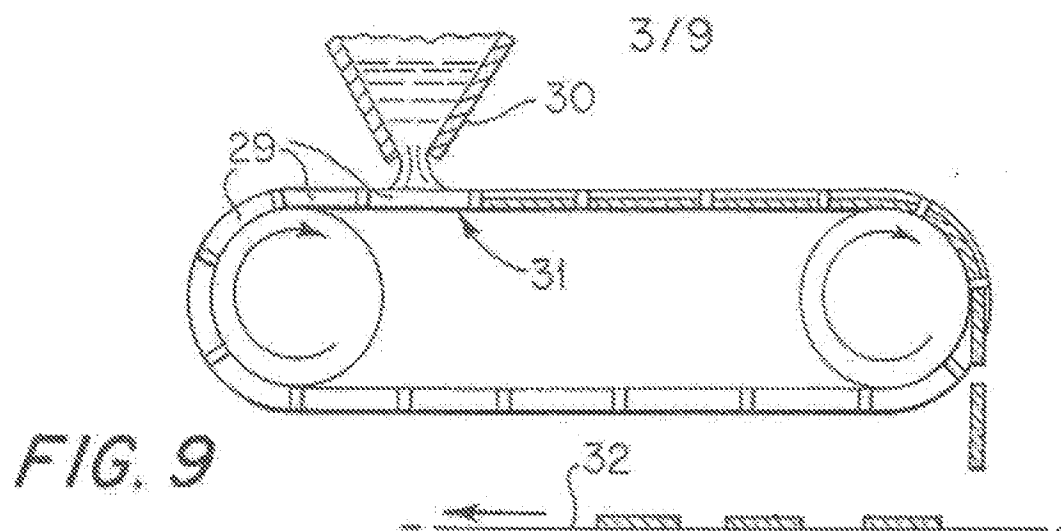
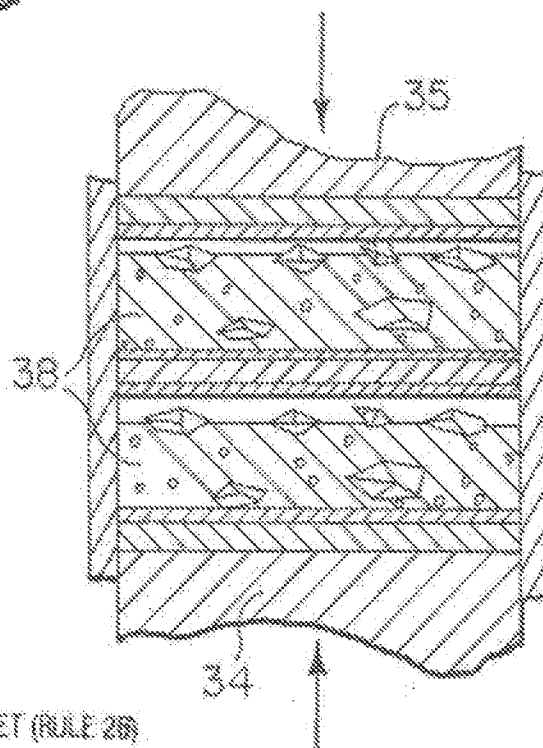


FIG. 10A



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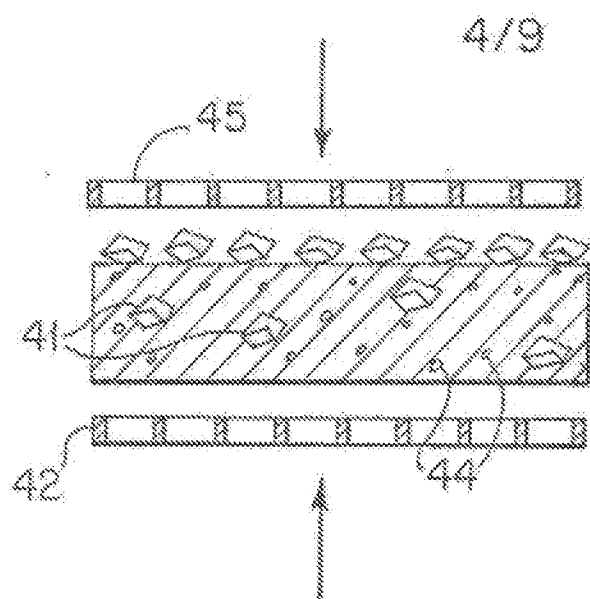


FIG. 11

FIG. 12

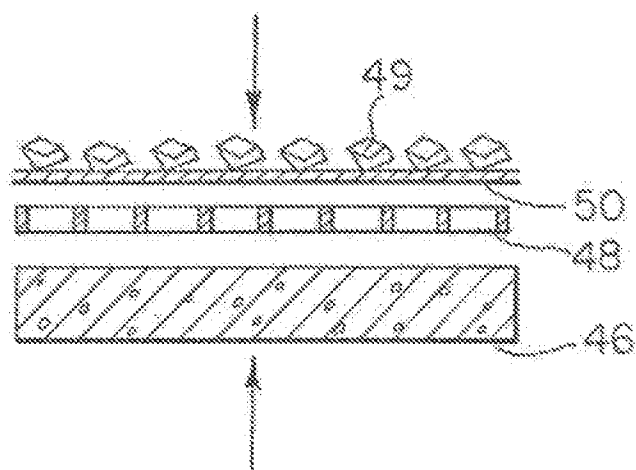
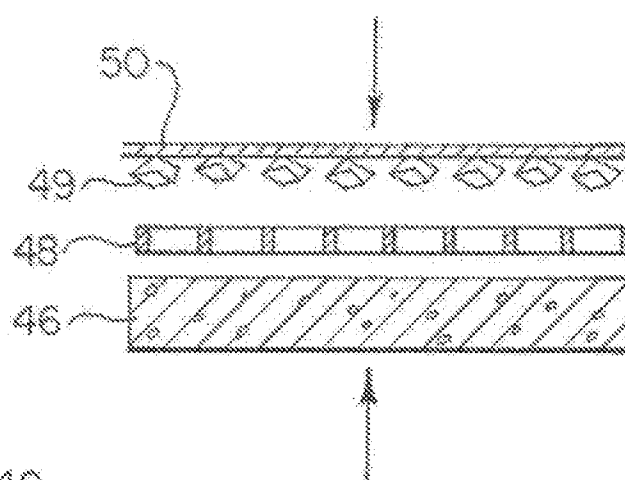
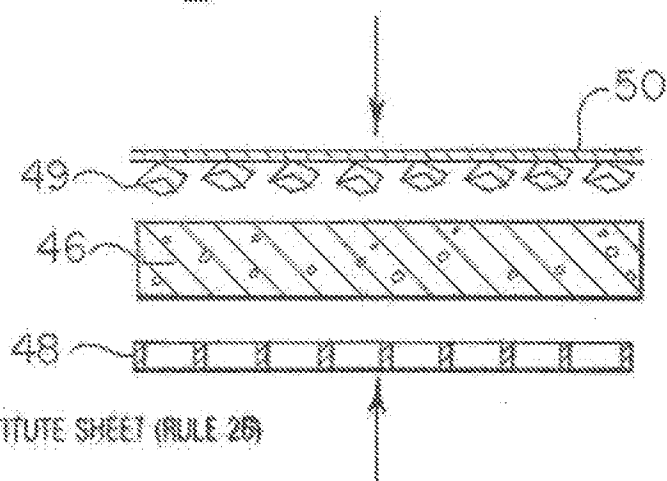


FIG. 13

FIG. 14



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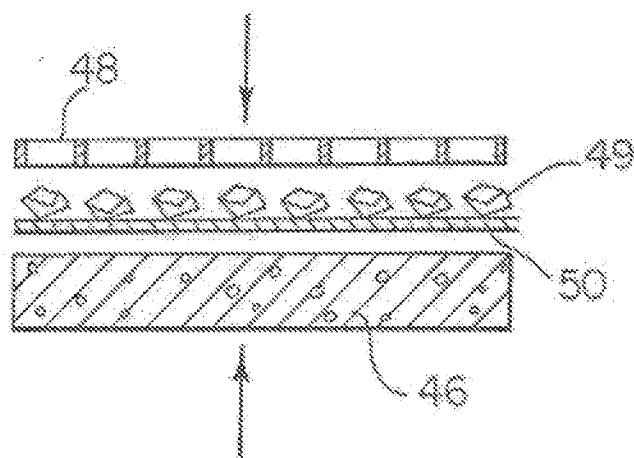


FIG. 15

FIG. 16

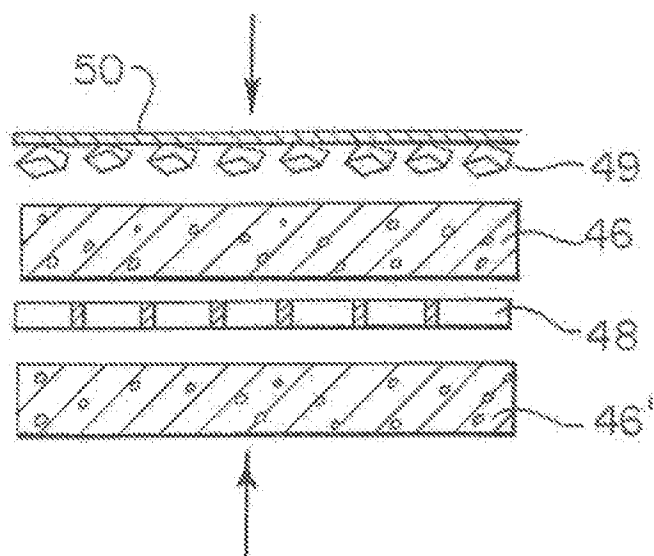
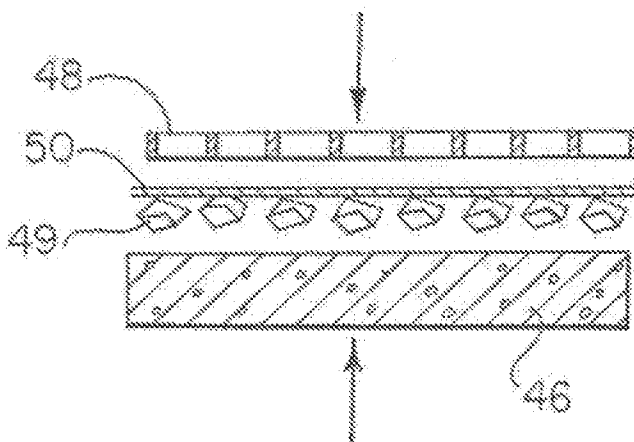
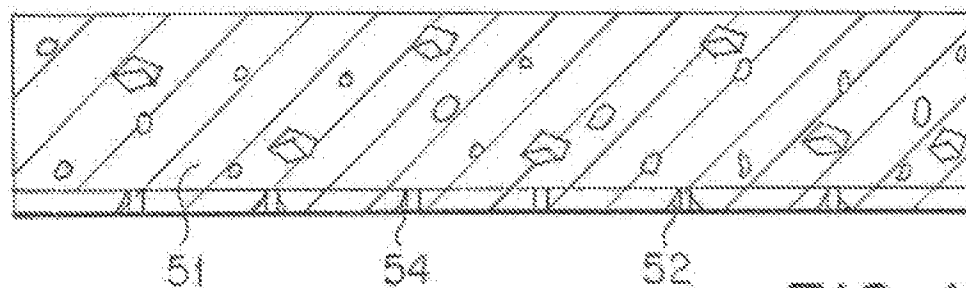


FIG. 17



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FIG. 18

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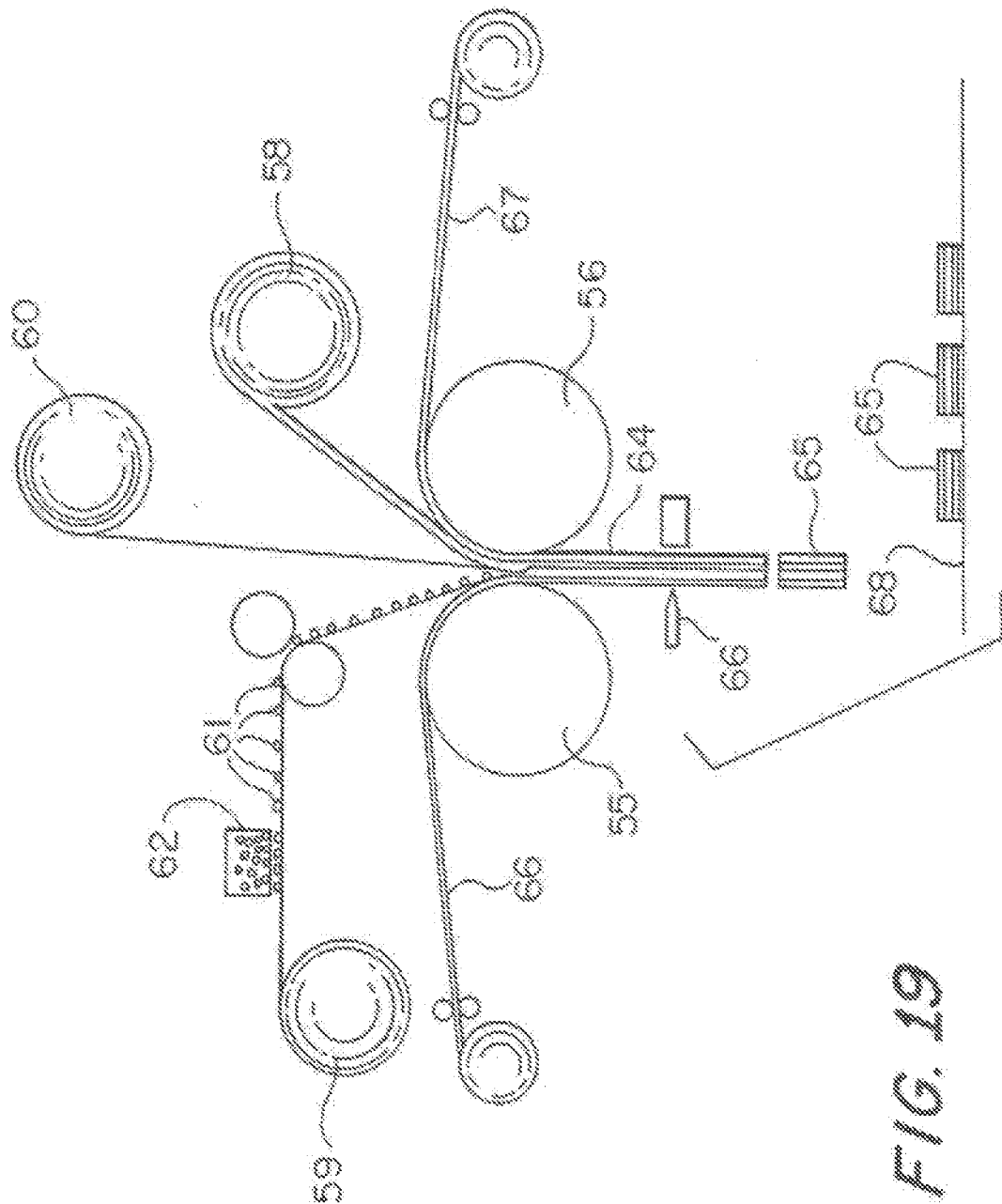


FIG. 19

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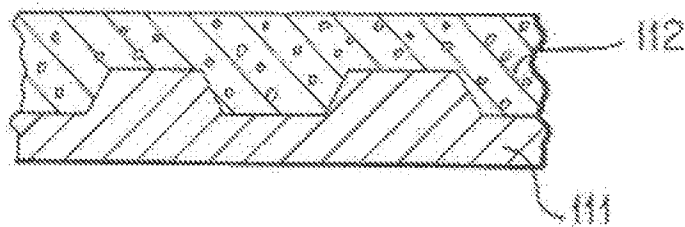


FIG. 19A

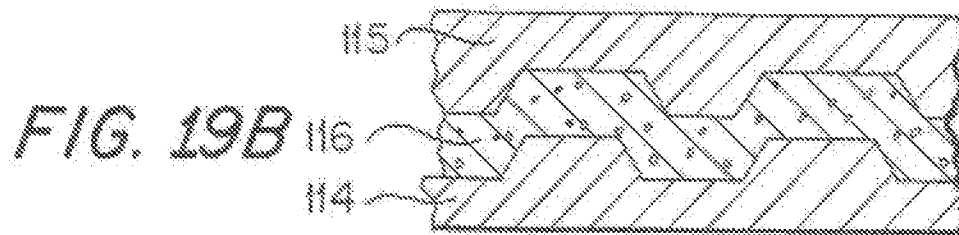


FIG. 19B

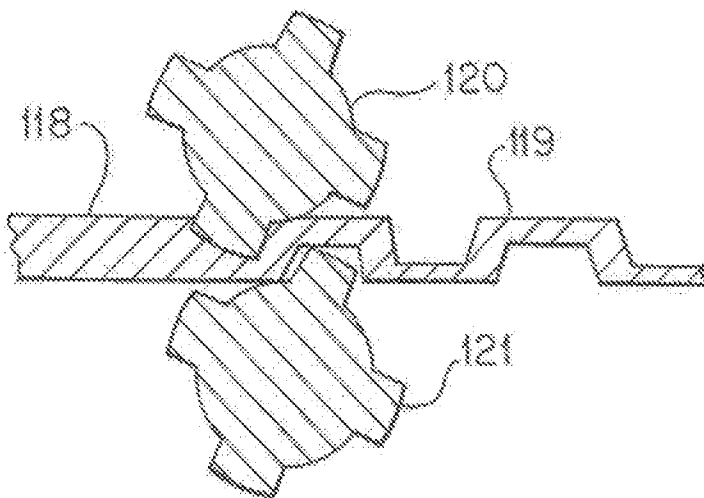


FIG. 19C

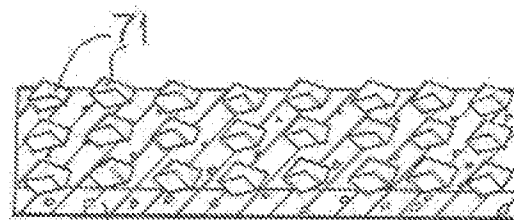


FIG. 21

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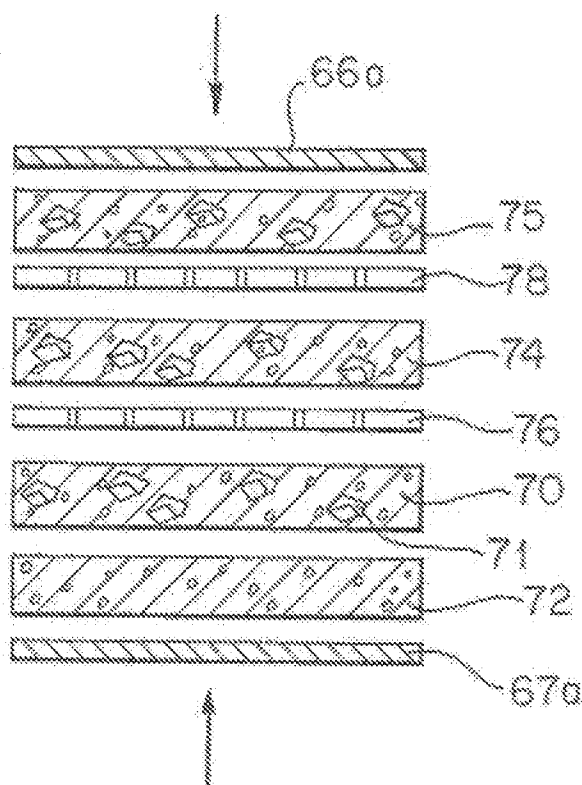


FIG. 20

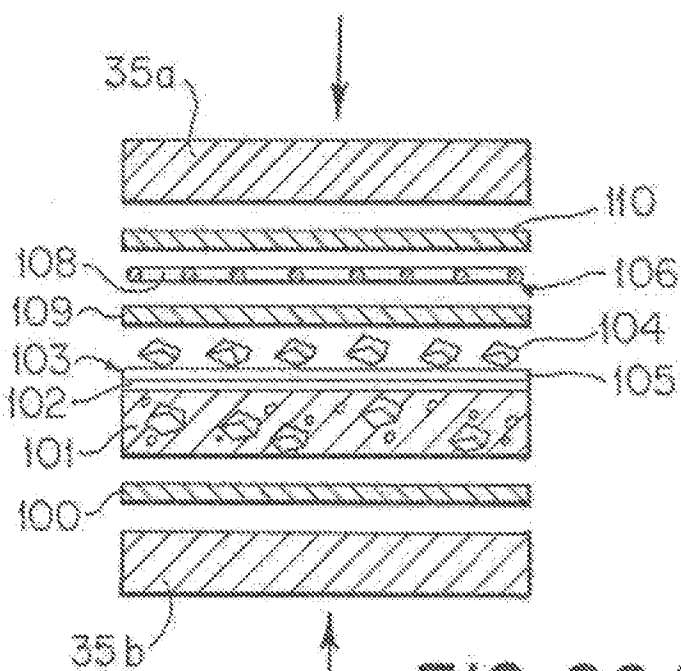


FIG. 20A

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FIG. 23

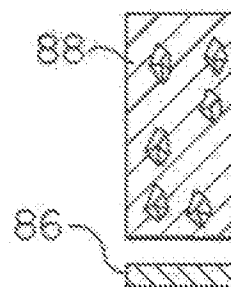


FIG. 24

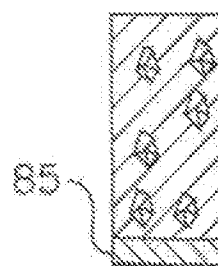


FIG. 25

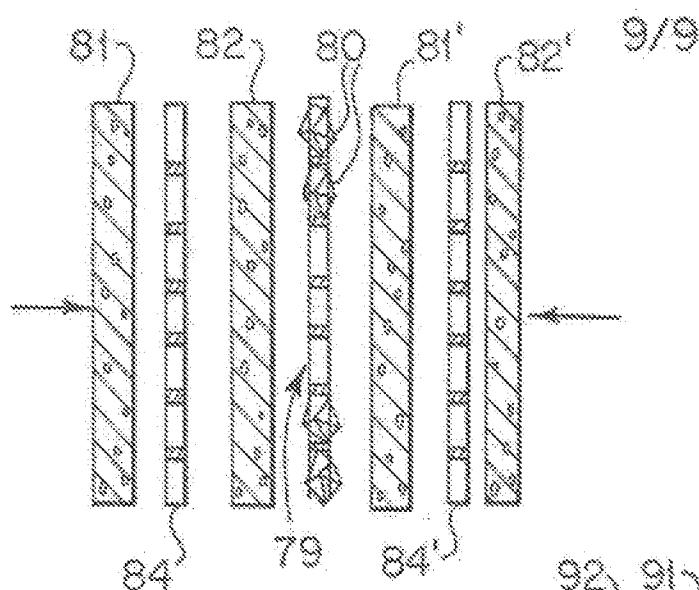


FIG. 22

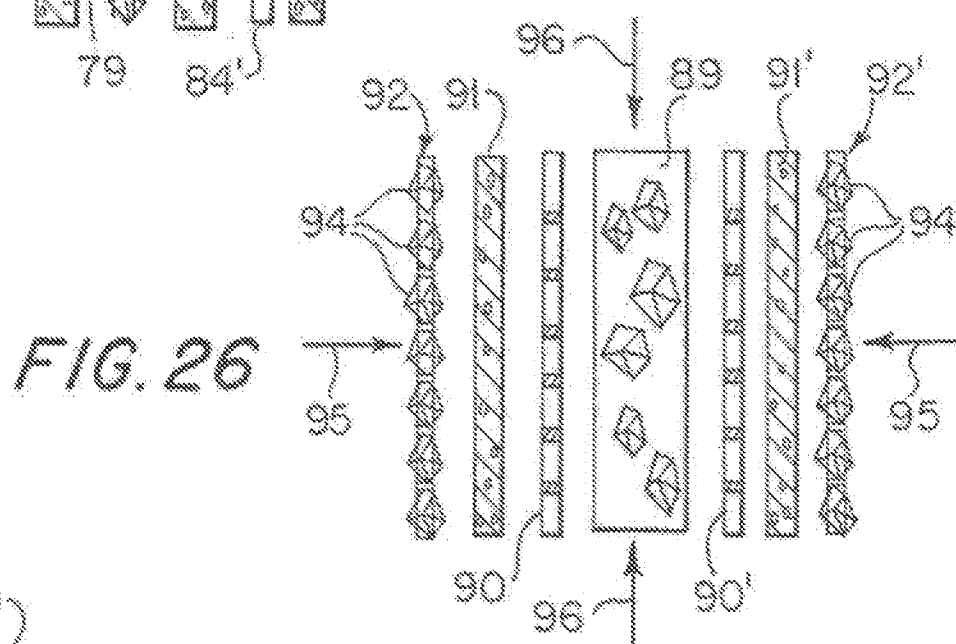


FIG. 26

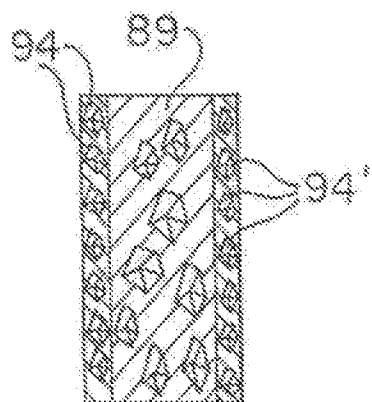


FIG. 27

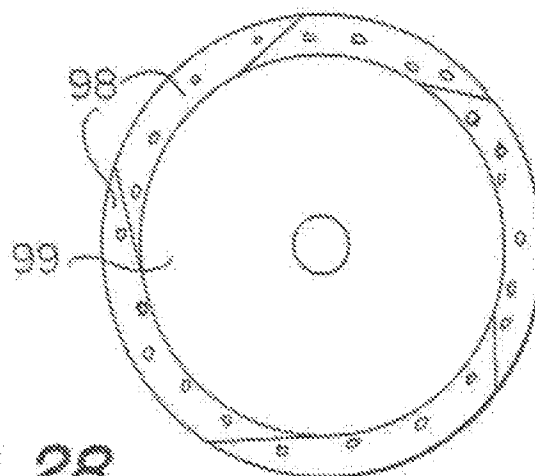


FIG. 28

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INTERNATIONAL SEARCH REPORT

Inventor: 1st Application No.
PCT/US 95/01503

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B24D18/00

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)
IPC 6 B24D 022F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US,A,5 264 011 (BROWN LAWRENCE E ET AL) 23 November 1993 see column 6, line 57 - column 7, line 32; figure 1	1
A	US,A,5 203 880 (TSELESIN NAUM N) 20 April 1993 cited in the application see claims	1
A	US,A,5 092 910 (BEKOK PETER T ET AL) 3 March 1992 cited in the application see claims	1
A	US,A,4 409 054 (RYAN EDWARD J) 11 October 1983 see claims	1

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- *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
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Date of the actual completion of the international search

1 June 1995

Date of mailing of the international search report

20.06.95

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A	EP,A,0 242 955 (DRESSER IND) 28 October 1987 see page 4, line 28 ~ line 37 -----	1
A	EP,A,0 533 443 (GEN ELECTRIC) 24 March 1993 see page 3, column 3, line 30 ~ column 4, line 21 -----	1
A	EP,A,0 407 069 (UNICORN IND PLC) 9 January 1991 see abstract; figure 3 -----	1
A	EP,A,0 204 195 (NORTON CO) 10 December 1986 see abstract; figure 1 -----	1
A	US,A,B 221 294 (CARMAN LEE A ET AL) 22 June 1993 see column 4, line 39 ~ line 43 -----	1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No.

PCT/US 95/01503

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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US-A-5203880	20-04-93	NONE	
US-A-5092910	03-03-92	US-A- 4925457	15-05-90
		AU-A- 5080090	05-09-90
		CA-A- 2025567	31-07-90
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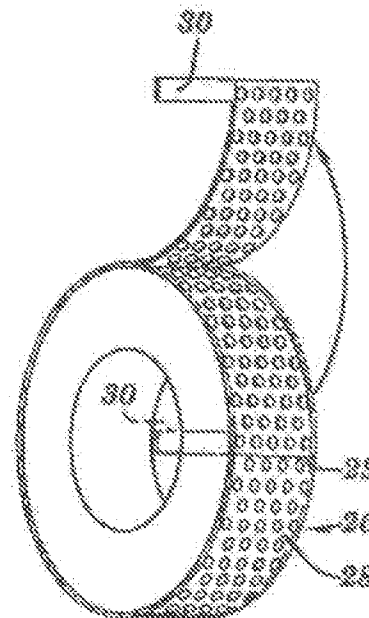
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification: B24D 3/28, 18/06, 5/00	AI	(11) International Publication Number: WO 98/10897 (43) International Publication Date: 19 March 1998 (19.03.98)
(21) International Application Number: PCT/US97/15724 (22) International Filing Date: 5 September 1997 (05.09.97) (30) Priority Data: 08/711,636 10 September 1996 (10.09.96) US (71) Applicant: NORTON COMPANY [US/US]; 1 New Bond Street, Box Number 15138, Worcester, MA 01615 (US). (72) Inventor: HOLDEN, Robert, L.; 12 Stillwater Heights Drive, West Boylston, MA 01585 (US); MC NAMARA, John, P.; 56 Berlin Street, Clinton, MA 01510 (US). (74) Agents: GORDON, David, P.; 65 Woods End Road, Stamford, CT 06905 (US) et al.	(81) Designated States: AU, BR, CA, CN, JP, KR, MX, RU, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE). Published With international search report.	

(54) Title: GRINDING WHEEL

(57) Abstract

A molded bonded abrasive grinding wheel adapted for relatively rough grinding operations is provided with a plurality of protuberances spaced in a predetermined pattern along the peripheral surface thereof and extending substantially orthogonally therefrom to define a textured grinding face. The protuberances are molded integrally with the grinding wheel and are performed by placing a perforated, or textured annular insert in a grinding wheel mold during molding wherein the insert is molded in-situ about the peripheral surface of the grinding wheel. The insert is removed from the peripheral surface after molding or during grinding to expose the protuberances defined by the perforations of the insert.



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GRINDING WHEEL

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to grinding wheels and more particularly, to a grinding wheel molded with a textured grinding face to facilitate use in rough grinding or conditioning operations.

2. Background Information

The grinding wheel art is highly developed and includes a wide range of wheel constructions and wheel fabrication processes adapted to optimize specific grinding operations and/or applications. One specific operation to which consideration has been given is known as conditioning. Conditioning is generally the removal of surface defects from ingots, blooms, billets and slabs of steel prior to further processing. Types of defects include cracks, folds, scale, scabs, seams, cinder patches and burned steel. Conditioning operations are generally characterized as "rough grinding" operations and utilize relatively large contact pressures between the wheel and the workpiece. Typically, grinding wheels optimized for these conditioning operations, commonly referred to as conditioning wheels, are fabricated from relatively heavy duty abrasive particulate, such as aluminum oxide, alumina zirconia, silicon carbide, or combinations thereof, of relatively large size (usually corresponding to an industry standard "grit size" of 4 through 46). Moreover, the particulate utilized for these wheels tends to be relatively hard or durable to provide resistance to the aforementioned relatively high grinding pressures. This particulate is generally maintained in a three-dimensional matrix of organic bonds, such as those provided by, for example, resinoid or phenolic resin bond material. Examples of conventional conditioning wheels are known as "BZZ Conditioning

Wheels" available from Norton Company of Worcester, Massachusetts.

As discussed hereinabove, the durability of the abrasive used in conditioning wheels serves to resist the relatively high pressures associated with the conditioning operation. The rough grinding face provided by the relatively large grit size, moreover, serves to effectively reduce the surface area of contact between the wheel and the workpiece to provide a relatively high pressure per unit area of contact therebetween. In this manner, contact pressure exerted between the exposed cutting edges of the abrasive and the workpiece is relatively high to facilitate the rough grinding or conditioning operation, while minimizing undesirable effects of excessive wheel pressure, such as uneven wheel wear or wheel breakage, as will be discussed hereinafter.

Conditioning wheels, like most other types of grinding wheels, are generally fabricated by hot or cold pressed molding operations. Disadvantageously, however, this fabrication method tends to produce wheels that emerge from the mold having substantially smooth peripheral grinding faces in which relatively few, if any, of the cutting edges of the abrasive are exposed. Thus, in the event such a smooth surface were brought into contact with a workpiece in a conditioning application, the increased contact area provided thereby would tend to reduce the contact pressure per unit area. To compensate for this condition, additional wheel pressure would generally be required to provide sufficient contact pressure between the wheel and workpiece to char or break the bonds of the grinding face and expose the cutting edges of the abrasive. Disadvantageously, however, this increased wheel pressure tends to generate non-uniform bond attrition which may lead to the wheel breaking or alternatively, becoming out of round and out of balance causing vibration during operation.

To overcome these disadvantages, most conventional conditioning wheels are subjected to an additional post-mold

operation commonly referred to as "dressing." Dressing generally includes applying a sharp implement, such as crush dressing, shot facing, or conical cutter, to the smooth face of the wheel during wheel rotation to remove the outer layer of bond material therefrom. This serves to expose the relatively coarse texture defined by the abrasive particulate to facilitate conditioning operations. Once the abrasive particulate has been exposed, the grinding wheel will wear away during subsequent grinding operations in a conventional manner, thus continually exposing new abrasive particulate in the bond matrix.

Although this dressing operation may serve to ameliorate the problem generated by the molding process, it is not without disadvantages. In particular, this additional operation contributes disadvantageously to the manufacturing cost, as well as to the length of time or lead time required to manufacture the wheel.

Thus, a need exists for an improved grinding wheel which overcomes the disadvantages of the prior art.

SUMMARY OF THE INVENTION

According to an embodiment of this invention, a molded grinding wheel includes bonded abrasive particulate, a substantially curved peripheral surface and a plurality of surface irregularities spaced in a predetermined pattern along the substantially curved peripheral surface to define a textured grinding face.

According to a second aspect of the present invention, an insert is adapted for use in conjunction with a grinding wheel mold having a mold cavity defined by at least one curved surface. The insert includes at least one liner sized and shaped for disposition in superimposed and concentric relation with the at least one curved surface of the grinding wheel mold. The at least one liner has a plurality of discontinuities disposed

therein and is adapted for being selectively molded in-situ with a grinding wheel in the grinding wheel mold, and removed from the grinding wheel, wherein the plurality of discontinuities define surface irregularities in a peripheral surface of the grinding wheel.

In a third aspect of the present invention, a method of forming a grinding wheel includes the steps of molding the grinding wheel to form a substantially curved peripheral surface and disposing a plurality of surface irregularities in a predetermined pattern along the substantially curved peripheral surface to define a textured grinding face.

In a fourth aspect of the present invention, a grinding wheel comprises a plurality of protuberances disposed on a peripheral surface thereof by providing at least one liner having a plurality of recesses disposed therein, molding the at least one liner in-situ about the peripheral surface and removing the at least one liner from the peripheral surface after molding.

The above and other features and advantages of this invention will be more readily apparent from a reading of the following detailed description of various aspects of the invention taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a grinding wheel of the subject invention;

FIG. 2 is a cross-section taken along 2-2 of FIG. 1;

FIG. 3 is a perspective view of a component utilized to fabricate the grinding wheel of FIG. 1; and

FIG. 4 is a perspective view, with portions in phantom, of

the grinding wheel of FIG. 1, during a step in the fabrication thereof.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Briefly described, as shown in FIG. 1, a molded, bonded abrasive grinding wheel 10 adapted for relatively rough grinding operations is provided with a plurality of surface irregularities, such as protuberances 20, spaced in a predetermined pattern along the peripheral surface thereof and extending substantially orthogonally or radially therefrom, to define a textured grinding face 18. Protuberances 20 are molded integrally with the grinding wheel and are formed by placing an annular insert 22 having a plurality of discontinuities, such as perforations 24, in a grinding wheel mold during molding of the wheel wherein the insert is molded in-situ about the peripheral surface of the grinding wheel. The insert is removed from the peripheral surface after molding to expose protuberances 20 defined by perforations 24.

For definitional purposes, throughout this disclosure, the term "axial" when used in connection with an element described herein, shall refer to a direction substantially parallel to the axis of a circular dimension thereof. The term "orthogonal" when used in connection with an element described herein, shall refer to a direction substantially perpendicular to a tangent of a curved surface at a point of intersection of the element with the curved surface.

Referring now to the drawings in detail, as shown in FIG. 1, grinding wheel 10 of the present invention is of conventional, generally disc-shaped construction, having a generally cylindrical inner surface or bore 12, planar side surfaces 14 and 16 (FIG. 2) and a substantially cylindrical outer surface or grinding face 18. The dimensions of the grinding wheel, including diameters of inner surface 12 and outer surface 18, as shown at a and b, respectively, as well as the thickness of the

wheel as shown at $\pm$ (FIG. 2), are predetermined in a conventional manner, based in part on the particular grinding application for which wheel 10 is to be employed. The grinding wheel may be fabricated from a conventional bonded abrasive material such as, for example, the type mentioned hereinabove.

In a preferred embodiment, grinding wheel 10 is a "conditioning wheel" as generally described hereinabove. Outer surface 18 has a diameter preferably within a range of from approximately 14 inches (in) to 36 in, or approximately 35 centimeters (cm) to 91 cm. Thickness $\pm$ (FIG. 2) is preferably within a range of from approximately 1.5 in to 6 in, or approximately 3 cm to 15 cm. Grinding wheel 10 also preferably comprises abrasive particulate having a grit size within a range of 4 to 46, or an average diameter within a range of .25 in (.65 cm) to .02 in (.05 cm). The abrasive is preferably maintained within hot or cold pressed phenolic resin or resinoid bonds.

As shown in FIGS. 1 and 2, outer surface 18 is provided with a series of surface irregularities such as protuberances 20 which, as shown, extend orthogonally or radially outwardly therefrom. Protuberances 20 are spaced at predetermined intervals from one another about outer surface 18 and serve to provide the outer surface with a relatively rough or "knobby" texture as shown.

Referring now to FIG. 3, a mold liner, insert or annulus 22 is provided to facilitate molding of protuberances 20. Mold band liner 22 comprises a generally cylindrical web of predetermined diameter g and width y sized to nominally define outer surface 18 of wheel 10 as will be discussed hereinafter. The liner is preferably provided with at least one axially extending scribe or cut 23, as shown in phantom, to facilitate removal of the insert from wheel 10 as will also be discussed hereinafter. Discontinuities such as apertures or perforations 24 are spaced at predetermined intervals throughout liner 22. The perforations serve to define protuberances 20 in a manner to be discussed in greater detail hereinafter. Liner 22 is adapted to slidably

interfit in a superimposed and concentric manner with an outermost cylindrical surface of the cavity of a conventional grinding wheel mold (not shown). In this manner, liner 22 serves as a template for outer surface 18, including integral protuberances 20, of a grinding wheel 10 molded therein, as will be discussed in greater detail hereinafter with respect to the operation and fabrication of the present invention.

Liner 22 is preferably fabricated from a material capable of resisting deformation due to heat and pressure generated during hot pressed molding operations commonly employed to fabricate grinding wheels. In addition, the material is preferably relatively flexible to facilitate removal from wheel 10, as will be discussed hereinafter. In a preferred embodiment, the liner is thus fabricated from a relatively light gauge steel or aluminum, or from a paper product such as cardboard or chipboard.

In an alternate embodiment (not shown), the liner may comprise an inflatable bladder fabricated from a suitable material such as a heat resistant polymer. Such a bladder may include a plurality of discrete inflatable portions disposed on the generally cylindrical surface of the mold cavity as discussed hereinabove. It may thus be inflated during molding to define the textured grinding face 18 of the wheel and subsequently deflated to facilitate removal of the wheel from the mold in the manner to be discussed hereinafter.

A preferred embodiment of the invention having been fully described, the following is a description of the fabrication and operation thereof.

As discussed hereinabove, liner 22 is placed in concentric and superimposed orientation with the outermost cylindrical surface of the cavity of a conventional grinding wheel mold (not shown). A grinding wheel 10 is then molded in a generally conventional manner. Briefly described, a grinding wheel mixture, such as the above-described abrasive particulate and phenolic resin mixture, is deposited into the mold and

subsequently either hot or cold pressed. A post bake operation may be provided, in which the wheel is maintained for a predetermined period at typical elevated cure temperatures. During these molding operations, the grinding wheel mixture will enter and fill apertures 24 of liner 22, to effectively form a grinding wheel 10 having liner 22 molded in-situ with the peripheral surface thereof.

Once the molding process is complete, grinding wheel 10 and liner 22 are preferably removed from the mold as a single unitary wheel/liner assembly 26, in which liner 22 is disposed in concentric, superimposed relation with the wheel, as shown partially in phantom, in FIG. 4. As also shown, when so disposed, wheel 10 and liner 22 cooperate to provide assembly 26 with a substantially smooth, cylindrical outer surface 28 which serves to facilitate removal of wheel/liner assembly 26 from the mold without disadvantageously damaging either the wheel or the mold. In this regard, cylindrical outer surface 28 enables removal of wheel/liner assembly 26 simply by sliding the wheel/liner assembly in an axial direction out of the mold.

One skilled in the art will recognize that a molded wheel having an irregular or textured circumferential grinding face wholly defined by a wall of the mold cavity generally would not be removable from the mold simply by axial movement. Rather, irregularities in the grinding face, such as protuberances of the type described hereinabove, would tend to engage the corresponding recesses within the mold cavity and thus prevent such axial movement relative to the mold. Such a wheel would not be removable from the mold without damaging the mold and/or wheel. To avoid this problem, a segmented mold with multiple discrete sections may be used to mold wheels of the invention without using a perforated liner. Other mold types may be used. Such molds must be adapted to allow removal of the textured side walls of the mold without disturbing the grinding face of the wheel.

Once removed from the mold, liner 22 is removed from wheel 10. This may be accomplished by suitably engaging the liner proximate scribe or cut 23, such as at a tab 30, and peeling the liner away from outer surface 18 of wheel 10 as shown in FIG. 4 and continuing until the liner is completely removed from the wheel.

Once the liner has been so removed, grinding wheel 10 may then be utilized in grinding operations without further dressing operations. Indeed, the textured grinding face defined by the surface irregularities or protuberances 20 serves to effectively lower the area of contact between the wheel and workpiece. This lower contact area serves to increase the contact pressure per unit area between the wheel and workpiece to facilitate charring or breaking the bonds of the grinding face to expose the cutting edges of the abrasive as discussed hereinabove. Once cutting edges are exposed, the grinding wheel will wear away during subsequent grinding operations in a conventional manner, thus continually exposing new abrasive particulate in the bond matrix as also discussed hereinabove.

In an alternate embodiment, the liner may be fabricated from a cardboard or chipboard material as discussed hereinabove, either with or without tab 30. This material is advantageously flexible to facilitate fabrication and insertion into the cavity of the wheel mold, while it also tends to become relatively brittle when subjected to the elevated temperatures of typical post-bake operations. Accordingly, such a liner 22 may be left in-situ, in concentric orientation about wheel 10 until the wheel is used for grinding, whereupon the grinding operation itself will tend to disintegrate the liner to remove it from wheel 10. Such a cardboard or chipboard liner may thus advantageously enable elimination of the aforementioned liner removal step to further reduce manufacturing costs of wheel 10 of the subject invention.

In a further alternative embodiment, the inflatable bladder liner discussed hereinabove may be utilized to provide the

textured face. In this embodiment, the step of removing the liner from the wheel may be effected simply by deflating the bladder. Moreover, the bladder may be fastened to the mold wherein deflation may be accomplished while the wheel is disposed within the mold to facilitate removal of the wheel from the mold.

The use of liner 22 thus enables a grinding wheel to be molded with an irregular outer surface to eliminate the necessity of subsequent "dressing" operations of the type mentioned hereinabove, while enabling use of substantially conventional and relatively inexpensive molds and molding techniques. Elimination of these operations advantageously serves to reduce the manufacturing cost of grinding wheels such as "conditioning wheels." Moreover, elimination of the need for dressing serves to substantially reduce the length of time or lead time required to manufacture such grinding wheels. This reduced lead time may advantageously serve to reduce inventory costs for both the wheel manufacturer and wheel purchasers. The reduced lead time also tends to enable the wheel manufacturer to provide improved service to customers, by enabling orders such as for custom or particularly large numbers of wheels to be filled relatively quickly.

The discontinuities of insert 22 and the surface irregularities of wheel 10 have been shown and described herein as generally concave recesses 24 and generally convex protuberances 20, respectively. However, it should be recognized by those skilled in the art that the discontinuities of insert 22 may comprise generally convex protuberances of the type shown and described hereinabove with respect to wheel 10, and the surface irregularities of wheel 10 may comprise generally concave recesses of the type shown and described hereinabove with respect to insert 22, without departing from the spirit and scope of the present invention.

Moreover, those skilled in the art should recognize that the discontinuities of insert 22 may be of any configuration, such as a series of troughs, striations or other convex or concave

structures sufficient to provide a grinding wheel with a substantially textured grinding face, without departing from the spirit and scope of the present invention.

Although the present invention has been described herein with respect to a grinding wheel having a substantially cylindrical grinding face, the invention may be practiced with grinding wheels having a grinding face of any other substantially curved geometry, including but not limited to substantially frusto-conical, dome shaped, bowl shaped, or other concave or convex geometries, without departing from the spirit and scope of the present invention.

Although the present invention is described herein with respect to conditioning wheels, it should be understood by one skilled in the art that any type of grinding wheel may be provided with a textured grinding face as set forth herein without departing from the spirit and scope of the present invention.

The foregoing description is intended primarily for purposes of illustration. Although the invention has been shown and described with respect to an exemplary embodiment thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omissions, and additions in the form and detail thereof may be made therein without departing from the spirit and scope of the invention.

Having thus described the invention, what is claimed is:

CLAIMS

1. A molded grinding wheel adapted for rough grinding operations comprising:

- bonded abrasive particulate;
- a substantially curved peripheral surface; and
- a plurality of surface irregularities spaced in a predetermined pattern along said substantially curved peripheral surface to define a textured grinding face.

2. The grinding wheel as set forth in claim 1, wherein said plurality of surface irregularities comprise protuberances extending substantially orthogonally from said substantially curved peripheral surface.

3. The grinding wheel as set forth in claim 1, wherein said grinding wheel comprises abrasive particulate dispersed in a phenolic resin bond material.

4. The grinding wheel as set forth in claim 1, wherein said plurality of surface irregularities are formed by selectively placing at least one insert in-situ about said substantially curved peripheral surface, in a grinding wheel mold having a cavity defined by at least one curved surface wherein said at least one insert is disposed within the cavity during molding of said grinding wheel, and removing said at least one insert from said substantially curved peripheral surface following molding.

5. The grinding wheel as set forth in claim 4, wherein said at least one insert comprises an annulus having a plurality of perforations.

6. An insert adapted for use in conjunction with a grinding wheel mold, the grinding wheel mold having a mold cavity defined by at least one curved surface, said insert comprising:

- at least one liner sized and shaped for disposition in substantially superimposed and concentric relation with the at

least one curved surface;

said at least one liner having a plurality of discontinuities disposed therein;

said at least one liner adapted for being selectively molded in-situ with a grinding wheel in the grinding wheel mold and removed from the grinding wheel, wherein said plurality of discontinuities define surface irregularities in a peripheral surface of the grinding wheel.

7. The insert as set forth in claim 6, wherein said at least one liner is adapted for being removed from the mold unitarily with the grinding wheel.

8. A method of forming a grinding wheel adapted for rough grinding operations comprising the steps of:

molding abrasive particulate dispersed in a bond material to form a substantially curved peripheral surface; and

disposing a plurality of surface irregularities in a predetermined pattern along the substantially curved peripheral surface to define a textured grinding face.

9. The method as set forth in claim 8, wherein said step of disposing a plurality of surface irregularities further comprises molding the surface irregularities integrally with the grinding wheel.

10. The method as set forth in claim 9, wherein said plurality of surface irregularities comprises a plurality of protuberances.

11. The method as set forth in claim 9, wherein said step of disposing a plurality of surface irregularities further comprises the steps of selectively:

placing at least one insert for molding in-situ about the substantially curved peripheral surface; disposing the at least one insert about an inner curved surface of a grinding wheel mold during molding of the grinding wheel, and

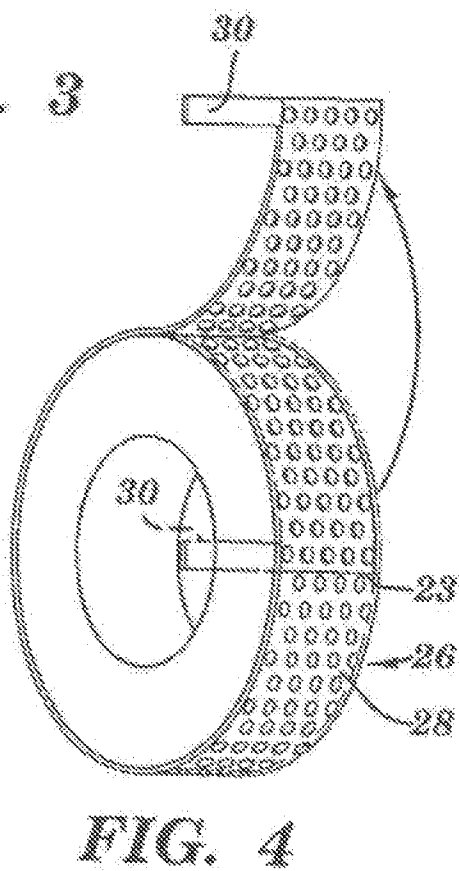
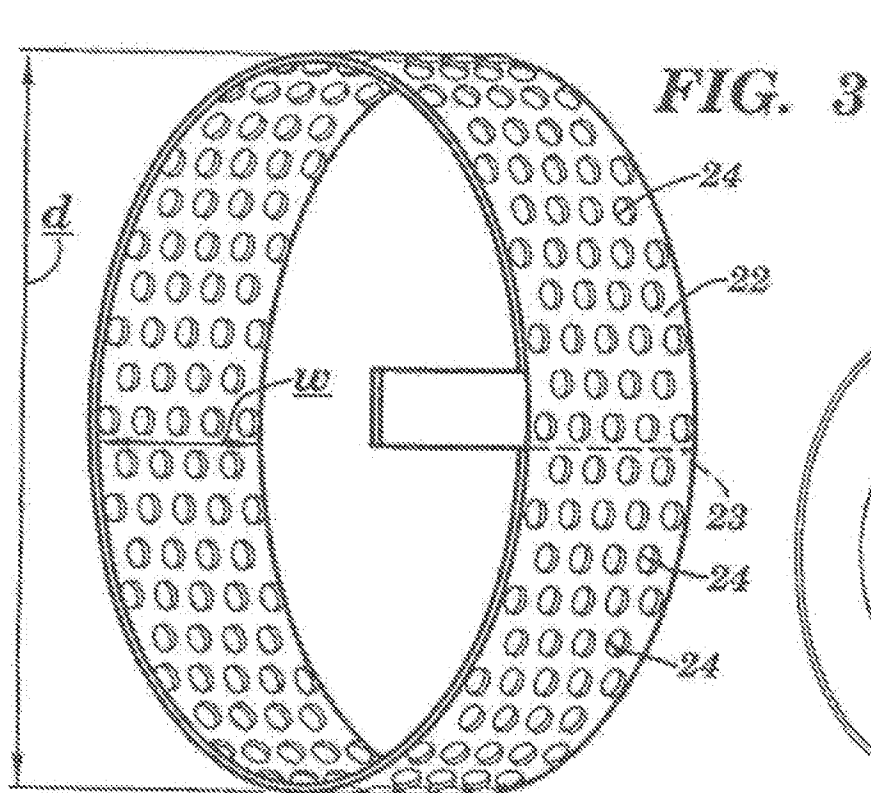
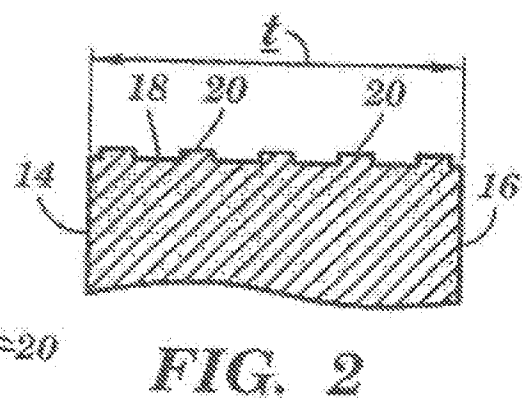
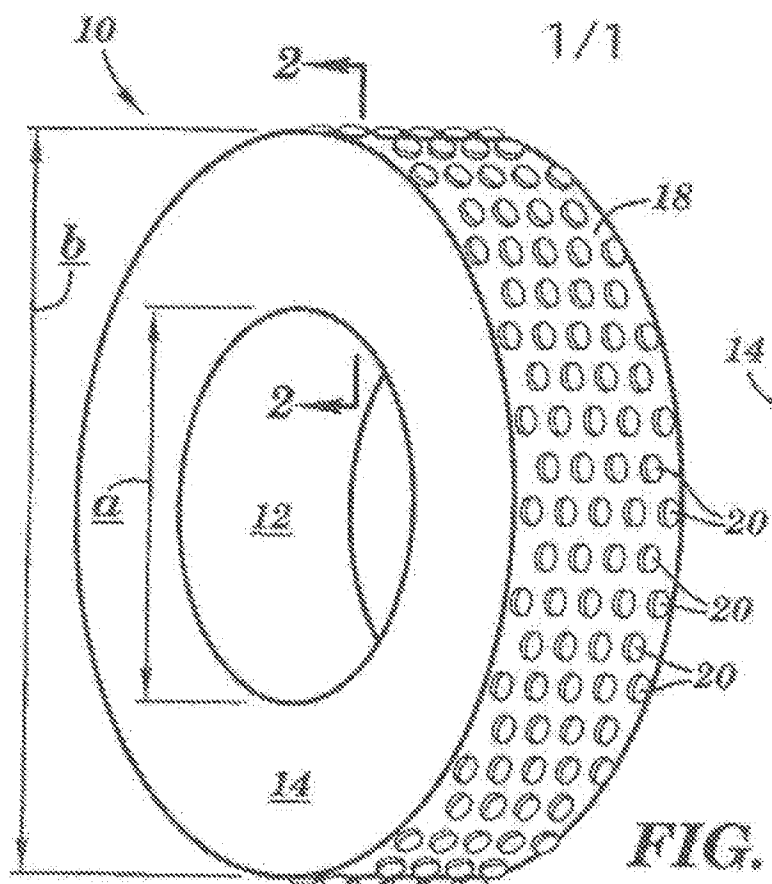
removing the at least one insert from the substantially curved peripheral surface following molding.

12. The method as set forth in claim 11, wherein said at least one insert comprises a perforated annulus.

13. A grinding wheel comprising:

a plurality of regularly spaced surface irregularities disposed on a peripheral surface thereof by providing a at least one liner having a plurality of recesses disposed therein, molding the at least one liner in-situ about the peripheral surface and removing the at least one liner from the peripheral surface after molding.

14. The grinding wheel of claim 13, wherein said at least one liner is removed from the mold unitarily with the grinding wheel.



INTERNATIONAL SEARCH REPORT

Int. Patent Application No.

PCT/US 97/15724

A. CLASSIFICATION OF SUBJECT MATTER

IPC 6 B2403/28 B24D18/00 B2405/00

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

IPC 6 B24D B24B C09K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during this international search phase of data base and, where practical, search terms used:

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	see the whole document	6-14
Y	EP C 010 408 A (ROBERT MICHAEL BARRON) 30 April 1980 see the whole document	6-14
X	EP O 530 536 A (TYROLIT SCHLEIFMITTELWERKE SWAROVSKI K.G.) 10 March 1993 see the whole document	1

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Further documents are noted in the continuation of box C.



Patent family members are listed in annex.

Special categories of cited documents:

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C. (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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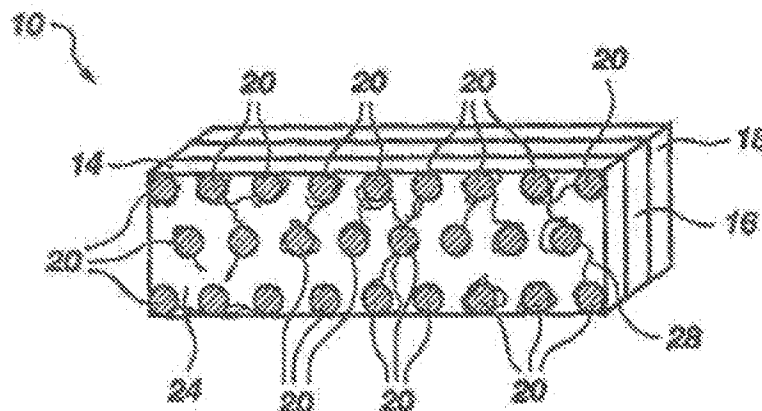
INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification: B24D	A2	(11) International Publication Number: WO 98/45091 (43) International Publication Date: 15 October 1998 (15.10.98)
(21) International Application Number: PCT/US98/05958 (22) International Filing Date: 26 March 1998 (26.03.98) (30) Priority Data: 08/835,117 4 April 1997 (04.04.97) US (71)(72) Applicant and Inventor: SUNG, Chien-Min (US-); 4, Lane 32, Chung-Cheng Road, Tamsui, Taipei County 251 (TW). (74) Agents: RATEMAN, Randall, B. et al.; Thorpe, North & Western, L.L.P., P.O. Box 1219, Sandy, UT 84091-1219 (US).	(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, GW, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LI, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published Without international search report and to be republished upon receipt of that report.	

(54) Title: BRAZED DIAMOND TOOLS BY INFILTRATION

(57) Abstract

The present invention describes a diamond tool with diamond bonded chemically by a bronze that contains either Cr, Mn, Si, or Al or mixtures or alloys thereof. The diamond tool is made by infiltrating the bronze into a matrix metal that contains diamond in either form of grits or polycrystalline bodies.



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BRAZED DIAMOND TOOLS BY INFILTRATION

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BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to tools having diamond particles formed thereon/therein, wherein the diamond particles are chemically bonded to matrix support material used to hold the diamond in place. More specifically, the diamond grit is bonded chemically in a matrix powder by a braze that can wet diamond. These tools are manufactured by the infiltration of the molten braze into a preform of matrix that contains diamond particles, thereby securing the diamond in place by a chemical bond.

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2. State of the Art

Abrasive tools have long been used in numerous applications, including cutting, drilling, sawing, grinding, lapping and polishing materials. Because diamond is the hardest abrasive material, it is widely used as a superabrasive on saws, drills, and other devices which utilize the abrasive to cut, form or polish other hard materials. The total value of such tools consumed is believed to be over 5 billion U.S. dollars per year. More than half of the value of these tools is consumed in sawing applications such as cutting stones, concretes, asphalts, etc.

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Diamond coated tools are particularly indispensable for applications where other tools lack the hardness and durability to be practical substitutes. For example, in the stone industry,

where rocks are cut, drilled, and sawed, diamond tools are about the only type which are sufficiently hard and durable to make the cutting, etc., economical. If diamond tools were not used, many such industries would be economically infeasible. Likewise, in the precision grinding industry, diamond tools, due to their superior wear resistance, are uniquely capable of developing the tight tolerances required, while simultaneously withstanding wear sufficiently to be practical.

Despite the prevailing use of diamond tools, these tools have suffered from several significant limitations which have placed unnecessary limits on the useful life of the tools. One such drawback is that the diamond grit is not attached to the matrix support material in a sufficiently strong attachment to maximize useful life of the cutting, drilling, polishing, etc., body. In fact, in most cases diamond grit is merely mechanically embedded in the matrix support material. As a result, diamond grit is often knocked out or pulled out prematurely during use. Moreover, the grit may receive inadequate mechanical support from the loosely bonded matrix under work conditions. Hence, the diamond particles could be shattered by the impact of the tool against the work piece to which the abrasive, etc., is applied.

It has been estimated that in a typical diamond tool, less than about one tenth of the grit is actually consumed in the intended application - i.e., during actual cutting, drilling, polishing, etc. The remainder of the diamond grit is either wasted by being leftover when the tool's useful life has expired, or is wasted by being pulled-out or broken during use due to poor attachment and inadequate support. Most of these diamond losses could be avoided if the diamond particles can be properly

positioned in and firmly attached to the surrounding matrix.

Furthermore, to ensure that the diamond grit is mechanically held sufficiently to remain in place, it must be buried deep in the matrix to prevent it falling out or being knocked free of the tool body during use. As a result, the protrusion of the diamond particle above the tool surface is insufficient. The low grit protrusion limits the cutting height for breaking the material to be cut. These limitations, in turn, limit the cutting speed of the cutting tool. If the diamond grit could be held more securely in the matrix, it could protrude higher from the matrix. The greater cutting depth would allow increased cutting speed and a greater useful life for the product. Moreover, due to the lower friction of the workpiece and tool matrix, the power required for cutting, drilling, etc., may also be reduced.

In order to anchor diamond grit firmly in the matrix, it is highly desirable for the matrix to form a carbide around the surface of the diamond. The chemical bond so formed is much stronger than the traditional mechanical attachment. The carbide may be formed by reacting diamond with a suitable carbide former such as a transition metal. Some examples of carbide forming transition metals are: titanium (Ti), vanadium (V), chromium (Cr), zirconium (Zr), molybdenum (Mo), and tungsten (W).

The formation of a carbide requires that the carbide former be deposited around the diamond and that the two subsequently be caused to react to form a carbide. Moreover, the non-reacted carbide former must also be consolidated by sintering or other means. All these steps require treatment at high temperatures. However, diamond may be degraded when exposed to a temperature above 1,000° C. The

degradation is due to either the reaction with the matrix material or the development of microcracks around metal inclusions inside the crystal. These inclusions are trapped catalysts used to synthesize the diamond.

Most carbide formers are refractory metals so they may not be consolidated below a temperature of about 1,200° C. Hence, refractory carbide formers are not suitable as the main constituent of the matrix support material.

There are, however, some carbide formers that may have a lower sintering temperature, such as manganese (Mn), iron (Fe), silicon (Si), and aluminum (Al). However, these carbide formers may have other undesirable properties that prohibit them from being used as the primary constituent of the matrix support material. For example, both manganese and iron are used as catalysts for synthesizing diamond at high pressure (above 50 Kb). Hence, they can catalyze diamond back to graphite during the sintering of the matrix powder at a lower pressure. The back conversion is the main cause of diamond degradation at high temperature.

Aluminum, on the other hand, has a low melting point (660° C), thus, making it easy to work with for securing the diamond particles. However, the melting point of aluminum can be approached when a diamond grit is cutting aggressively. Hence, aluminum may become too soft to support the diamond grit during the cutting operation. Moreover, aluminum tends to form the carbide Al_4C_3 at the interface with diamond. This carbide is easily hydrolyzed so it may be disintegrated when exposed to coolant. Hence, aluminum typically is not a suitable carbide former to bond diamond in a matrix.

To avoid the high temperature of sintering, carbide formers, such as tungsten, are often diluted

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as minor constituents in the matrix that is made primarily, for example, of either cobalt or bronze. During the sintering process, there is a minimal amount, if any, of liquid phase formed. The diffusion
5 of carbide former through a solid medium toward diamond is very slow. As a result, the formation of carbide on the surface of diamond is negligible. Therefore, by adding a carbide former as a minor matrix constituent, the improvement of diamond
10 attachment is marginal at the best.

In order to ensure the formation of a carbide on the surface of diamond, the carbide former may be coated onto the diamond before mixing with the matrix powder. In this way, the carbide former, although it
15 may be a minor ingredient in the matrix, can be concentrated around diamond to form the desired bonding.

The coating of diamond may be applied chemically or physically. In the former case, the coated metal
20 is formed by a chemical reaction, generally at a relatively high temperature. For example, by mixing diamond with a carbide former such as titanium or chromium, and heated the mixture under a vacuum or in a protective atmosphere, a thin layer of the carbide
25 former may be deposited onto the diamond. The thickness of the coating may be increased by increasing temperature. The deposition rate may also be accelerated by adding a suitable gas (e.g., HCl vapor) that assists the transport of the metal. For
30 example, Chen and Sung (U.S. Patent No. 5,024,680) describes such a coating process.

Alternatively, the coating may be performed in a molten salt. For example, U.S. Patent No. 3,746,888 describes a method of coating a thin layer of titanium
35 over diamond in a molten salt of chlorides.

A commonly used chemical method for coating diamond is chemical vapor deposition (CVD). In this

case, the deposited metal is produced by the reaction of gases at a high temperature. Thus, U.S. Patent No. 3,520,667 describes a technique to deposit a thin layer of silicon (Si) onto the surface of diamond.

5 The temperature of this deposition is high enough so silicon carbide is formed instantaneously at the interface.

In order to prevent diamond from possible degradation by exposure to high temperatures, coating is produced at the lowest temperature possible.

10 However, coating often becomes too thin when deposited at a low temperature. For example, the coating produced by a typical chemical method is about one micrometer thick. There are some commercial diamond

15 grits that contain such thin coatings. For example, General Electric Company offers a saw grit that may be coated with a thin coating of either titanium or chromium.

However, when the thin coating is exposed to a

20 high temperature, such as that which may be encountered during the sintering process, it can be easily oxidized in the atmosphere, or dissolved into the matrix metal. Thus, although a significant benefit is claimed for such commercially coated

25 products, e.g., a one-third improvement in tool life, the ability for the thin coating to survive the manufacturing process is debatable.

In order to protect the thin metal coating, multiple layers of coating may be applied. Thus, U.S.

30 Patent Nos. 5,232,469 and 5,250,086 described a second layer made of nickel, or another non-carbide former. The second layer may be deposited by an electroless process that is performed at a lower temperature. For more layers, Chen and Sung (U.S. Patent Nos. 5,024,680

35 or 5,062,865) describe a diamond grit with three layers of coating. In this case, the inner most layer is made of chromium, and it is overlaid by a secondary

metal layer such as titanium. The double layers are further wrapped in a third overcoat of a material such as tungsten. However, such a complicated coating system may be too costly to be economically feasible in the production of many cutting, drilling or polishing tools.

Alternatively, a chemical coating may be deposited relatively thick by a CVD method. For example, Sung, et al. (U.S. Patent Nos. 4,943,488 or 5,116,568) describes a fluidized bed system that can coat diamond with tungsten of a few tens of micrometers. But again, such a coating is expensive, and its application has not been widely used.

In contrast to chemical methods, a physical method may be inexpensive. Moreover, it may deposit a thick metal coating onto diamond at a very low temperature. For example, the author evaluated "Metal Coating of Saw Diamond Grit by Fluidized Bed" (see p267-271 of Fabrication and Characterization of Advanced Materials, edited by S. W. Kim and S. J. Park of The Materials Research Society of Korea 1995). The coating system is based on the method as described in U.S. Patent No. 4,770,907 (a similar concept is disclosed in U.S. Patent 5,143,523 or European Patent No. 0 533 443 A1). However, such a method, like many other similar processes, often produces coatings with different thickness. Moreover, only very fine (<5 micrometers) metal powders can be coated effectively onto the surface of diamond. Hence, although physical methods may be used to coat a diamond grit with an alloy that contains a carbide former, their benefits are limited.

When diamond is coated mechanically by a metal powder, as described in the above example, the powder is held loosely by an organic binder (e.g., PVA, or PEG). Such a coating may be easily rubbed off during the subsequent treatments, e.g., mixing or pressing.

Although heat treatment may increase the mechanical strength of the coating, it may not consolidate the coating to the full density. A porous coating lacks the mechanical strength necessary to support a diamond
5 grit that is impacted repeatedly during the cutting operation.

Carbide formers may also be diluted in an alloy. If the alloy can melt below 1100° C, it may be used to braze the diamond without causing much degradation of
10 the latter. Many diamond brazes are known in the art. Most are based on Group Ib solvents (copper, silver and gold) that contain one or more carbide formers, e.g., gold-tantalum (Au-Ta), or silver-copper-titanium (Ag-Cu-Ti). These brazes, however, are typically too
15 expensive for commercial use. Moreover, they are soft and unsuitable as ingredients for the matrix support material of diamond tools.

There are some high temperature filler metals that may be used to braze diamond. Such brazes may be
20 hard enough to hold a diamond grit in place during cutting. For example, U.S. Patent Nos. 3,894,673 and 4,018,576 describe diamond tools made by brazing a hard facing alloy that contains nickel-chromium (Ni-Cr) as the major constituent. However, these brazed
25 diamond tools, although useful, are generally limited as surface set tools that contains only one layer of diamond. Such tools may not last when they are used to cut highly abrasive materials, e.g., granite. Moreover, the braze in these tools, in addition to
30 holding the diamond, must also serve as the hard facing. The compromise of these dual-functions may not always be possible as the optimal wear resistance of the tool surface may need to be adjusted for specific applications.

35 Alternatively, a diamond bonding alloy may be used to infiltrate a high concentration (i.e. greater than 40 % by volume) of diamond particles. Thus, Chen

and Sung (U.S. Patent Nos. 5,030,276 or 5,096,465) describe such a product and the process of making the same. However, the infiltration is very difficult due to the high concentration of diamond. Moreover, such products have limited applications, such as a drill bit. They are not applicable for most applications that require a lower concentration (i.e., less than 40 % by volume) of diamond, such as saw blades and grinding wheels.

10 The hard facing alloys may also be used as the matrix support material. For example, U.S. patent 4,378,975 describes a method to coat diamond with a very thin layer of chromium, and subsequently palletizing the coated grit with a nickel-chromium alloy. The palletized particles are then consolidated by sintering the alloy. However, as the consolidation process is taking place primarily in a solid phase, the bonding of matrix and diamond may not be sufficient.

20 In addition to sintering, infiltration is also a common technique for making diamond tools, in particular for drill bits and other specialty diamond tools that contain a large (i.e. greater than U.S. mesh 30/40) diamond grit. For example, U.S. Patent 25 No. 4,668,522 describes a process to infiltrate a rotary drill bit with a copper alloy at a temperature lower than 850° C (preferably 750° C). Most commonly used infiltrants for these tools are copper based alloys. These infiltrants must flow and penetrate the 30 small pores in the matrix powder. In order to avoid the diamond degradation at high temperature, the melting point of the infiltrant must be low. Hence, the infiltrant often contains a low melting point constituent, such as zinc (Zn). In addition to 35 lowering the melting point of the infiltrant, the low melting point constituent also reduces the viscosity so the infiltrant can flow with ease. However, as

most carbide formers tend to increase the melting point of the infiltrant, they are excluded from most infiltrants. As a result, these infiltrants cannot improve the bonding of diamond.

5 Some infiltrants do contain a carbide former that may facilitate the bonding of diamond. U.S. Patent No. 5,000,273 describes an abrasive tool that is produced by infiltrating a matrix powder with an alloy that contains the major constituents of copper,
10 manganese and zinc. However, as discussed above, zinc is added to increase the fluidity of the infiltrant, and it may not be suitable for making certain products that is produced under different environments. For example, if infiltration is performed under a vacuum,
15 zinc may be vaporized. As a result the remaining alloy may become too viscous to infiltrate completely the matrix powder.

 Thus, there is a need for an improved method of infiltrating the matrix powder to bond the diamond
20 thereto. Such a method should be able to be accomplished at a sufficiently low temperature to avoid potential damage to the diamond. Additionally, such a method should be designed to improve the bonding of the diamond to the matrix support material.

25

SUMMARY OF THE INVENTION

 It is an object of the present invention to provide an improved method for forming tools having diamond particles disposed therein/thereon.

30 It is another object of the present invention to provide such a method wherein the diamond particles are disposed in a matrix support material, and then the matrix support material infiltrated with a braze to bond the diamond particles to the matrix support
35 materials.

 It is yet another object of the present invention to provide such a method wherein the brazing occurs at

sufficiently low temperatures to prevent thermal damage to the diamond particles.

It is still another object of the present invention to provide such a method wherein the matrix support material is specifically selected to provide numerous pores through which the brazing material may flow and thereby facilitate chemical bonding of the diamond and matrix support material.

It is still yet another object of the present invention to provide such a method wherein the diamond particles are disposed in the matrix support material in some predetermined pattern, to thereby lengthen the useful life of the tool to which the diamond and matrix support material are attached.

The above and other objects of the invention are realized in specific illustrated embodiments of a novel method for forming brazed diamond tools, and for tools made by the novel method. The method includes forming a sheet of matrix support material, and then disposing a plurality of diamond particles in the matrix support material. Preferably, the amount of diamond particles to matrix support material is preferably less than 50 percent by volume, and most preferably less than 40 percent by volume. The diamond impregnated sheet is then infiltrated by a braze which is capable of wetting the diamond, so as to form a chemical bond with the diamond. The braze also bonds to the matrix support material, thereby creating a chemical bond connecting the diamond to the matrix support material, rather than relying on a simple mechanical attachment in accordance with the prior art. Although the technique is most suitable for making saw blades, its applications can extend to all diamond tools.

In accordance with one aspect of the present invention, the matrix support material may be made of common metal powder. Examples of such metal powder