PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To: JOHN PAUL MELLO
STRATEGIC PATENTS, P.C.
P.O. BOX 920629
NEEDHAM, MA 02492

PCT

WRITTEN OPINION OF THE
INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43*bis*.1)

Date of mailing *(day/month/year)*	02 JAN 2018
Applicant's or agent's file reference DESK0023PWO	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2017/049669	31 August 2017	

International Patent Classification (IPC) or both national classification and IPC
IPC(8) - B33Y 70/00; B22F 1/00; B22F 3/00; B22F 3/10; B22F 3/12 (2017.01)
CPC - B22F 1/0096; B22F 1/00; B22F 1/0081; B22F 3/00; B33Y 70/00 (2017.08)

Applicant DESKTOP METAL, INC.

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☒ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1*bis*(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.

For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/US	Date of completion of this opinion	Authorized officer
Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 Facsimile No. 571-273-8300	05 December 2017	Blaine R. Copenheaver PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of:

   ☒ the international application in the language in which it was filed.

   ☐ a translation of the international application into _____ which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b)).

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a)).

3. ☐ With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of a sequence listing:

   a. ☐ forming part of the international application as filed:

      ☐ in the form of an Annex C/ST.25 text file.

      ☐ on paper or in the form of an image file.

   b. ☐ furnished together with the international application under PCT Rule 13*ter*.1(a) for the purposes of international search only in the form of an Annex C/ST.25 text file.

   c. ☐ furnished subsequent to the international filing date for the purposes of international search only:

      ☐ in the form of an Annex C/ST.25 text file (Rule 13*ter*.1(a)).

      ☐ on paper or in the form of an image file (Rule 13*ter*.1(b) and Administrative Instructions, Section 713).

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that forming part of the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

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Box No. IV Lack of unity of invention

1. ☒ In response to the invitation (Form PCT/ISA/206) to pay additional fees the applicant has, within the applicable time limit:

   ☒ paid additional fees.

   ☐ paid additional fees under protest and, where applicable, the protest fee.

   ☐ paid additional fees under protest but the applicable protest fee was not paid.

   ☐ not paid additional fees.

2. ☐ This Authority found that the requirement of unity of invention is not complied with and chose not to invite the applicant to pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rule 13.1, 13.2 and 13.3 is

   ☐ complied with.

   ☒ not complied with for the following reasons:

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees need to be paid.

Group I: Claims 1-40 are drawn to an additive manufacturing method.

Group II: Claims 41-69 are drawn to a powder for additive manufacturing of a three-dimensional object.

Group III: Claims 70-96 are drawn to a three-dimensional object comprising a plurality of different materials.

The inventions listed in Groups I through III do not relate to a single general inventive concept under PCT Rule 13.1, because under PCT Rule 13.2 they lack the same or corresponding special technical features for the following reasons:

The special technical features of Group I, an additive manufacturing method, are not present in Groups II and III; the special technical features of Group II, a powder for additive manufacturing of a three-dimensional object, are not present in Groups I and III; and the special technical features of Group III, a three-dimensional object comprising a plurality of different materials, are not present in Groups I and II.

The Groups I through III share the technical features of additive manufacturing of a three-dimensional object using a powder comprising first metallic particles and at least one component of a binder system, the first metallic particles agglomerated in the at least one component of the binder system in the form of discrete granules; and a plurality of layers, each layer defining a respective two-dimensional pattern. However, these shared technical features do not represent a contribution over the prior art.

Specifically, US 2017/0173692 A1 to Desktop Metal, Inc. teaches additive manufacturing of a three-dimensional object (Para. [0003], ... additive manufacturing, and more specifically to the three-dimensional printing of metal objects) using a powder comprising first metallic particles (Para. [0075], ... materials similarly composed of metal powder and a binder system, may be used to fabricate green parts ...) and at least one component of a binder system (Para. [0075]); and a plurallty of layers, each layer defining a respective two-dimensional pattern (Para. [0071], ... a bead of material is extruded as "roads" or "paths," in a layered series of two dimensional patterns to form a three-dimensional object ...).

Further, US 2017/0120339 A1 to Metalvalue SAS teaches the first metallic particles agglomerated in the at least one component of the binder system in the form of discrete granules (Para. [0015], ... a process where metal powder is agglomerated with a binder in water; Para. [0030], ... providing a spherical metal powder, b) mixing the powder with a hydrocolloid in water to obtain an agglomerated metal powder, c) compacting the agglomerated metal powder to obtain a part of compacted agglomerated metal powder ...).

The inventions listed in Groups I through III therefore lack unity under Rule 13 because they do not share a same or corresponding special technical feature.

4. Consequently, this opinion has been established in respect of the following parts of the international application:

   ☒ all parts.

   ☐ the parts relating to claims Nos. _____

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Box No. V **Reasoned statement under Rule 43*bis*.1(a)(i) with regard to novelty, inventive step and industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	1-96	YES
	Claims	None	NO
Inventive step (IS)	Claims	1-40, 48-50, 55-69, 71-75, 77-82, 84, 85, 89-92, 95	YES
	Claims	41-47, 51-54, 70, 76, 83, 86-88, 93, 94, 96	NO
Industrial applicability (IA)	Claims	1-96	YES
	Claims	None	NO

2. Citations and explanations:

Claims 41-47, 51, 52, and 54 lack an inventive step under PCT Article 33(3) as being obvious over Ningbo Guangbo New Nanomaterials Stock Co., Ltd. (hereinafter Ningbo) in view of Shanghai Institute of Ceramics - Chinese Academy of Sciences (hereinafter Shanghai).

Regarding Claim 41, Ningbo discloses a powder for additive manufacturing of a three-dimensional object (Abstract), the powder comprising: first metallic particles (Paras. [0007] through [0011], The invention further provides a preparation method for the metal powder for 3D printers, characterized by comprising the specific steps of: (1) firstly preparing the submicron order metal powder...wherein the average grain size of the submicron order metal powder is 0.1-3 microns...); and at least one component of a binder system (Paras. [0007] through [0011], ...(3) adding an organic adhesive which accounts for 0.1-10% by weight of the submicron order metal powder (solid) into the metal powder slurry obtained in step (2), and uniformly stirring and mixing the slurry...), the first metallic particles agglomerated in the at least one component of the binder system in the form of discrete granules flowable relative to one another (Paras. [0007] through [0011], ...and (4) preparing the uniformly stirred and mixed slurry in step (3) to the spherical metal powder for 3D printers with the average grain size of 10-50 microns through a centrifugal spray granulator...; Para. [0017], The metal powder for 3D printers provided by the invention is prepared by agglomerating the submicron order (the grain size is 0.1-3 microns) metal powder to the metal powder with the average grain size of 10-50 microns rather than complete integrated metal powder but is prepared from various submicron order metal powder which are bonded and agglomerated. Therefore, the metal powder...also has dispersibility and conveying property of atomized metal powder), but fails to explicitly disclose forming a layer having a thickness greater than about 30 microns and less than about 70 microns. However, Shanghai is in the field of 3D printing (Shanghai Abstract) and teaches forming a layer having a thickness greater than about 30 microns and less than about 70 microns (Shanghai Pg. 3 in 4th through 9th Paras., The present invention provides a method of manufacturing the porous alumina ceramic material, comprising: 1) the aluminum or aluminum alloy powder is added to the three-dimensional printer in the feeding box, through the three-dimensional printer to print out the porous body...preferably, step 1) in, the three-dimensional printing parameters are: the porous body of the monolayer thickness was 50-200 μm...). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the powder of Ningbo by forming a layer having a thickness greater than about 30 microns and less than about 70 microns as taught by Shanghai. The motivation would have been to form a layer having sufficient thickness to be used as a layer in 3D printing an object (Shanghai Abstact; Pg. 3 in 4th through 9th Paras.).

Regarding Claim 42, modified Ningbo discloses the powder of claim 41. Ningbo further discloses the first metallic particles (Paras. [0007] through [0011]), but fails to explicitly disclose wherein the first metallic particles have an average particle size of greater than about 1 micron and less than about 5 microns. However, Ningbo teaches first metallic particles having an average particle size of greater than about 1 micron and less than about 5 microns (Paras. [0007] through [0011]). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the first metallic particles in the powder of Ningbo to have an average particle size of greater than about 1 micron and less than about 5 microns, since where the general conditions of the claim are disclosed in the prior art, discovering the optimum or workable ranges involves only routine skill in the art. The motivation would have been to provide metallic particles of a suitable size that can be agglomerated to provide a metal powder for 3D prining with high sphericity, dispersibility, and good conveying property (Paras. [0007] through [0011]; Para. [0017], The metal powder for 3D printers provided by the invention is prepared by agglomerating the submicron order (the grain size is 0.1-3 microns) metal powder to the metal powder with the average grain size of 10-50 microns...the metal powder for 3D printers not only has various advantages of submicron particles (for example, high degree of sphericity, uniform component and low oxygen content), but also has dispersibility and conveying property of atomized metal powder).

Regarding Claim 43, modified Ningbo discloses the powder of claim 41. Ningbo further discloses wherein the first metallic particles have an average particle size in a nanoparticle range (Paras. [0007] through [0011]; Para. [0034], The nickel-based alloy powder (FIG. 7) with the average grain size of 0.25 micron produced by the physical vapor deposition method and ethanol are prepared...).

Regarding Claim 44, modified Ningbo discloses the powder of claim 41. Ningbo further discloses wherein the discrete granules have an average particle size of greater than about 20 microns and less than about 100 microns (Paras. [0007] through [0011]; Para. [0014], Preferably, the average grain size of the metal powder for 3D printers in step (4) is 20-30 microns).

Regarding Claim 45, modified Ningbo discloses the powder of claim 41, wherein the discrete granules are substantially spherical (Paras. [0007] through [0011]; Para. [0017]).

Regarding Claim 46, modified Ningbo discloses the powder of claim 41. Ningbo further discloses wherein the first metallic particles include a plurality of materials alloyable with one another (Paras. [0007] through [0011]; Para. [0014], Preferably, the metal powder provided by the invention can be pure metal powder of titanium, nickel, copper etc., or can be nickel-based alloy powder, for example, NiCr21Fe18Mo9...).

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Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of:

Regarding Claim 47, modified Ningbo discloses the powder of claim 46. Ningbo further discloses wherein the plurality of materials includes two or more of tungsten, copper, nickel, cobalt, and iron (Paras. [0007] through [0011]; Para. [0014], ...NiCr21Fe18Mo9...).

Regarding Claim 51, modified Ningbo discloses the powder of claim 41, wherein the at least one component of the binder system includes an organic binder (Paras. [0007] through [0011], ...an organic adhesive...).

Regarding Claim 52, modified Ningbo discloses the powder of claim 41. Ningbo further discloses wherein the at least one component of the binder system includes one or more polymers (Paras. [0007] through [0011]; Para. [0016], The organic adhesive provided by the invention is polyvinyl alcohol...).

Regarding Claim 54, modified Ningbo discloses the powder of claim 41. Ningbo further discloses wherein the at least one component of the binder system has a melt temperature of greater than about 100°C and less than a melt temperature of the first metallic particles (Paras. [0007] through [0011]; Para. [0016]; see Tubbs Abstract, The melting point of PVA was found to be 228°C...; Para. [0015]; all shown metal powders are well known to have melting points well above 228°C).

Claim 53 lacks an inventive step under PCT Article 33(3) as being obvious over Ningbo Guangbo New Nanomaterials Stock Co., Ltd. (hereinafter Ningbo) in view of Shanghai Institute of Ceramics - Chinese Academy of Sciences (hereinafter Shanghai) and Northwestern University (hereinafter Northwestern).

Regarding Claim 53, modified Ningbo discloses the powder of claim 52. Ningbo further discloses the at least one component of the binder (Paras. [0007] through [0011], ...an organic adhesive...), but fails to explicitly disclose wherein the at least one component of the binder includes one or more of polyethylene glycol, polyethylene, polylactic acid, polyacrylic acid, and polypropylene. However, Northwestern is in the field of forming three-dimensional objects (Northwestern Abstract) and teaches at least one component of a binder that includes one or more of polyethylene glycol, polyethylene, polylactic acid, polyacrylic acid, and polypropylene (Northwestern Para. [0023]). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the at least one component of the binder in the powder of Ningbo to include one or more of polyethylene glycol, polyethylene, polylactic acid, polyacrylic acid, and polypropylene as taught by Northwestern. The motivation would have been that these compounds can be used as binders for binding metal particles together for formation of three-dimensional objects (Northwestern Para. [0023]; Para. [0003]).

Claims 70, 83, and 86 lack an inventive step under PCT Article 33(3) as being obvious over BAM Bundesanstalt Fur Materialforschung Und Prufung (hereinafter BAM) in view of Dow Global Technologies LLC (hereinafter Dow).

Regarding Claim 70, BAM discloses a three-dimensional object (Abstract) comprising: a plurality of layers, each layer defining a respective two-dimensional pattern (Paras. [0016] through [0021], The invention includes the idea of a method for producing a moulded body from metallic or ceramic material, wherein the method comprises the steps of: forming a moulding body from a metallic or ceramic material by performing the following steps repeatedly: applying a layer of a suspension of metallic or ceramic particles that are dispersed in a suspension fluid in a working volume, dehumidifying the applied layer in the working volume, and applying a binder locally to the dehumidified layer and curing the binder in accordance with layer model of the moulded body to be produced in such manner that particles in the dehumidified layer are adhesively bonded to each other locally and optionally also to particles of at least one layer below the dehumidified layer, and demoulding the moulded body by detaching binder-free residual material from the particles that are bonded to each other with the aid of the binder; Para. [0031], Rather, the exterior shape of the moulded body is created through the local application of the binder, which ensures that the particles continue to hold together after curing; the two-dimensional pattern is therefore the predetermined shape of the moulded body in each layer, as determined by the application of binder); particles dispersed in each layer (Paras. [0016] through [0021]; Para. [0031]); and a binder system including at least one component, the binder system binding the particles in each layer to one another and to one or more adjacent layers (Paras. [0016] through [0021]; Para. [0031]), but fails to explicitly disclose wherein the particles include a plurality of different materials, or wherein the three-dimensional object is sinterable to form a brown part having microstructures of at least one of the plurality of different materials distributed in a matrix of at least another one of the plurality of different materials. However, Dow is in the field of additive manufacturing (Dow Abstract) and teaches particles including a plurality of different materials (Dow Pg. 2 Ln. 22 through Pg. 3 Ln. 4, We have discovered an improved method of selective sintering additive manufacturing comprising, (i) providing a powder comprising composite particulates comprising a first thermoplastic polymer and a second thermoplastic polymer interspersed with each other, (ii) depositing a layer of said powder at a target surface, (iii) irradiating a selected portion of said powder so that said powder sinters, bonding said portion of the composite particles within the layer to form a sintered layer, (iv) repeating steps (i) and (iii) to form successive sintered layers that are also bonded to one another, and (v) removing the unbonded portions of the powder to yield an additive manufactured part), and a three-dimensional object that is sinterable to form a brown part having microstructures of at least one of the plurality of different materials distributed in a matrix of at least another one of the plurality of different materials (Dow Pg. 2 Ln. 22 through Pg. 3 Ln. 4; Pg. 9 Lns. 12-20, The method produces a novel additive manufactured part wherein the part is comprised of at least two layers of powder that has been sintered together within the layer and between the layers, the powder being comprised of a first and second thermoplastic polymer...in a particular embodiment, the first thermoplastic polymer is dispersed in a continuous matrix of the second thermoplastic polymer...). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the particles in the three-dimensional object of BAM to include a plurality of different materials as taught by Dow; and to modify the three-dimensional object of BAM to be sinterable to form a brown part having microstructures of at least one of the plurality of different materials distributed in a matrix of at least another one of the plurality of different materials as taught by Dow. The motivation would have been to allow for formation of additive manufactured parts by selective layer sintering method of polymers that typically cannot be made into suitable parts, as the ability to disperse said polymers on a micro scale within particles allows for absorbance to be tailored and for uniform distribution of heating within the powders (Dow Pg. 4 Lns. 19-25).

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Regarding Claim 83, modified BAM discloses the three-dimensional object of claim 70, but BAM fails to explicitly disclose wherein the different materials of the plurality of different materials are unalloyable with one another. However, Dow teaches different materials of a plurality of different materials that are unalloyable with one another (Dow Pg. 2 Ln. 22 through Pg. 3 Ln. 4; Pg. 9 Lns. 12-20). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the object of BAM to include different materials of a plurality of different materials that are unalloyable with one another as taught by Dow. The motivation would have been that polymers are inherently unalloyable with one another, as they are not metals, and distribution of microstructures of a first polymer in a matrix of a second polymer will allow for formation of additive manufactured parts by selective layer sintering method of polymers that typically cannot be made into suitable parts, as the ability to disperse said polymers on a micro scale within particles allows for absorbance to be tailored and for uniform distribution of heating within the powders (Dow Pg. 4 Lns. 19-25).

Regarding Claim 86, modified BAM discloses the three-dimensional object of claim 70. BAM further discloses wherein the at least one component of the binder system includes an organic binder (Paras. [0016] through [0021]; Para. [0031]; Para. [0041], An advantageous embodiment of the invention provides for the use of an organic binder...).

Claim 76 lacks an inventive step under PCT Article 33(3) as being obvious over BAM Bundesanstalt Fur Materialforschung Und Prufung (hereinafter BAM) in view of Dow Global Technologies LLC (hereinafter Dow) and Shanghai Institute of Ceramics - Chinese Academy of Sciences (hereinafter Shanghai).

Regarding Claim 76, modified BAM discloses the three-dimensional object of claim 70. BAM further discloses each layer (Paras. [0016] through [0021], ...forming a moulding body from a metallic or ceramic material by performing the following steps repeatedly: applying a layer of a suspension of metallic or ceramic particles that are dispersed in a suspension fluid in a working volume...), but fails to explicitly disclose wherein each layer has a thickness of about 50 microns. However, Shanghai is in the field of 3D printing (Shanghai Abstract) and teaches layers having a thickness of about 50 microns (Shanghai Pg. 3 in 4th through 9th Paras., The present invention provides a method of manufacturing the porous alumina ceramic material, comprising: 1) the aluminum or aluminum alloy powder is added to the three-dimensional printer in the feeding box, through the three-dimensional printer to print out the porous body...preferably, step 1) in, the three-dimensional printing parameters are: the porous body of the monolayer thickness was 50-200 μm...). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify each layer in the object of BAM to have a thickness of about 50 microns as taught by Shanghai. The motivation would have been to form a layer having sufficient thickness to be used as a layer in 3D printing an object (Shanghai Abstact; Pg. 3 in 4th through 9th Paras.).

Claims 87, 88, 93, 94, and 96 lack an inventive step under PCT Article 33(3) as being obvious over BAM Bundesanstalt Fur Materialforschung Und Prufung (hereinafter BAM) in view of Dow Global Technologies LLC (hereinafter Dow) and Northwestern University (hereinafter Northwestern).

Regarding Claim 87, modified BAM discloses the three-dimensional object of claim 70. BAM further discloses the at least one component of the binder system (Paras. [0016] through [0021], ...applying a binder locally to the dehumidified layer...), but fails to explicitly disclose wherein the at least one component of the binder system includes one or more polymers. However, Northwestern is in the field of forming three-dimensional objects (Northwestern Abstract) and teaches at least one component of a binder system includes one or more polymers (Northwestern Para. [0023]). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the at least one component of the binder system in the object of BAM to include one or more polymers as taught by Northwestern. The motivation would have been that polymers can be used as binders for binding metal particles together for formation of three-dimensional objects (Northwestern Para. [0023]; Para. [0003]).

Regarding Claim 88, modified BAM discloses the three-dimensional object of claim 87. BAM further discloses the at least one component of the binder system (Paras. [0016] through [0021]), but fails to explicitly disclose wherein the at least one component of the binder system includes one or more of polyethylene glycol, polyethylene, polylactic acid, polyacrylic acid, and polypropylene. However, Northwestern teaches at least one component of a binder system that includes one or more of polyethylene glycol, polyethylene, polylactic acid, polyacrylic acid, and polypropylene (Northwestern Para. [0023]). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the at least one component of the binder system in the object of BAM to include one or more of polyethylene glycol, polyethylene, polylactic acid, polyacrylic acid, and polypropylene as taught by Northwestern. The motivation would have been that these compounds can be used as binders for binding metal particles together for formation of three-dimensional objects (Northwestern Para. [0023]; Para. [0003]).

Regarding Claim 93, modified BAM discloses the three-dimensional object of claim 70. BAM further discloses the at least component of the binder system (Paras. [0016] through [0021]), but fails to explicitly disclose wherein the at least one component of the binder system includes a first component and a second component, and the first component is different from the second component. However, Northwestern teaches at least one component of a binder system that includes a first component and a second component, the first component being different from the second component (Northwestern Para. [0023], Combinations of different polymeric binders may be used). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the at least component of the binder system in the object of BAM to include a first component and a second component, the first component being different from the second component as taught by Northwestern. The motivation would have been that a mixture of polymeric binders can be used for binding metal particles together for formation of three-dimensional objects (Northwestern Para. [0023]; Para. [0003]).

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Regarding Claim 94, modified BAM discloses the three-dimensional object of claim 93, but BAM fails to explicitly disclose wherein the first component and the second component have different melt temperatures. However, Northwestern teaches a first component and second component having different melt temperatures (Northwestern Para. [0023]; depending on the polymeric binders used, these polymeric binders would inherently have different melt temperatures). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the object of BAM to include a first component and second component having different melt temperatures as taught by Northwestern. The motivation would have been that a mixture of different polymeric binders can be used for binding metal particles together for formation of three-dimensional objects (Northwestern Para. [0023]; Para. [0003]).

Regarding Claim 96, modified BAM discloses the three-dimensional object of claim 70. BAM further discloses the binder system in the three-dimensional object (Paras. [0016] through [0021]), but fails to explicitly disclose wherein a volume percentage of the binder system in the three-dimensional object is about one-third. However, Northwestern teaches a volume percentage of a binder system in a three-dimensional object that is about one-third (Northwestern Para. [0003]; Para. [0046], The corresponding volume % of the polymeric binder (i.e., (volume of the polymeric binder)/(volume of the metal oxide/ceramic particles plus the volume of the polymeric binder)) was in the range of from about 30% to about 10%). It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the binder system in the three-dimensional object of BAM so that a volume percentage of the binder system in the three-dimensional object is about one-third as taught by Northwestern. The motivation would have been to provide a sufficient amount of the binder to be able to bind metal particles together for formation of three-dimensional objects (Northwestern Para. [0003]; Para. [0046]).

Claims 1-40, 48-50, 55-69, 71-75, 77-82, 84, 85, 89-92, and 95 meet the criteria set out in PCT Article 33(2)-(3), because the prior art does not teach or fairly suggest:

Regarding claim 1, the prior art of record, individually or in combination, does not teach or fairly suggest an additive manufacturing method, the method comprising: spreading a layer of a powder across a powder bed, the powder including granules, and each granule including an agglomeration of first metallic particles in at least one component of a binder system; reflowing the granules along a predetermined two-dimensional pattern in the layer, the at least one component of the binder system from the reflowed granules binding the first metallic particles in the layer to one another and to one or more adjacent layer; and repeating the steps of spreading and reflowing for each layer of a plurality of sequential layers to form a three-dimensional object in the powder bed.

Claims 2-40 depend from claim 1, and therefore meet the criteria set out in PCT Article 33(2)-(3) for at least the same reasons as claim 1.

Regarding claim 48, the prior art of record, individually or in combination, does not teach or fairly suggest the powder of claim 41, wherein the first metallic particles in respective granules are lightly sintered to one another.

Regarding claim 49, the prior art of record, individually or in combination, does not teach or fairly suggest the powder of claim 41, wherein the at least one component of the binder system is water soluble to reflow the at least one component of the binder system in the discrete granules.

Regarding claim 50, the prior art of record, individually or in combination, does not teach or fairly suggest the powder of claim 41, wherein the at least one component of the binder system is soluble in one or more of hexane, alcohol, and limonene to reflow the at least one component of the binder system in the discrete granules.

Regarding claim 55, the prior art of record, individually or in combination, does not teach or fairly suggest the powder of claim 54, wherein a temperature difference between the melt temperature of the at least one component of the binder system and a burn off temperature of the at least one component of the binder system is between about 100°C and about 300°C.

Regarding claim 56, the prior art of record, individually or in combination, does not teach or fairly suggest the powder of claim 41, further comprising second metallic particles, wherein the discrete granules are dispersed in the second metallic particles in a flowable mixture.

Claims 57-69 depend from claim 56, and therefore meet the criteria set out in PCT Article 33(2)-(3) for at least the same reasons as claim 56.

Regarding claim 71, the prior art of record, individually or in combination, does not teach or fairly suggest the three-dimensional object of claim 70, wherein the different materials of the plurality of different materials are alloyable with one another.

Regarding claim 72, the prior art of record, individually or in combination, does not teach or fairly suggest the three-dimensional object of claim 70, wherein the particles include first metallic particles and second metallic particles, the first metallic particles having an average particle size less than an average particle size of the second metallic particles.

Claims 73-75 depend from claim 72, and therefore meet the criteria set out in PCT Article 33(2)-(3) for at least the same reasons as claim 72.

Regarding claim 77, the prior art of record, individually or in combination, does not teach or fairly suggest the three-dimensional object of claim 70, wherein at least one of the plurality of different materials is harder than at least another one of the plurality of different materials.

Regarding claim 78, the prior art of record, individually or in combination, does not teach or fairly suggest the three-dimensional object of claim 70, wherein at least one of the plurality of different materials includes a metal matrix composite.

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Regarding claim 79, the prior art of record, individually or in combination, does not teach or fairly suggest the three-dimensional object of claim 70, wherein an alloy formed of the plurality of different materials has a smaller grain structure than an alloy formed of at least one of the plurality of different materials alone.

Regarding claim 80, the prior art of record, individually or in combination, does not teach or fairly suggest the three-dimensional object of claim 70, wherein the different materials are alloyable with one another to form steel.

Claims 81 and 82 depend from claim 80, and therefore meet the criteria set out in PCT Article 33(2)-(3) for at least the same reasons as claim 80.

Regarding claim 84, the prior art of record, individually or in combination, does not teach or fairly suggest the three-dimensional object of claim 83, wherein at least one of the plurality of different materials includes tungsten.

Regarding claim 85, the prior art of record, individually or in combination, does not teach or fairly suggest the three-dimensional object of claim 83, wherein at least one of the plurality of different materials includes one or more of molybdenum and copper.

Regarding claim 89, the prior art of record, individually or in combination, does not teach or fairly suggest the three-dimensional object of claim 70, wherein the at least one component of the binder system is soluble in water.

Regarding claim 90, the prior art of record, individually or in combination, does not teach or fairly suggest the three-dimensional object of claim 70, wherein the at least one component of the binder system is soluble in one or more of hexane, alcohol, and limonene.

Regarding claim 91, the prior art of record, individually or in combination, does not teach or fairly suggest the three-dimensional object of claim 70, wherein the at least one component of the binder system has a melt temperature of greater than about 100°C and less than a melt temperature of the plurality of different materials.

Claim 92 depends from claim 91, and therefore meets the criteria set out in PCT Article 33(2)-(3) for at least the same reasons as claim 91.

Regarding claim 95, the prior art of record, individually or in combination, does not teach or fairly suggest the three-dimensional object of claim 93, wherein the first component and the second component are cross-linked with one another.

The following prior art is made of record to support and further define the reasons for meeting the criteria set out in PCT Article 33(2)-(3) for claims 1, 48-50, 55, 56, 71, 72, 77-80, 84, 85, 89-91, and 95:

(i) Ningbo discloses an additive manufacturing method (Abstract), the method comprising: providing a layer of a powder across a powder bed, the powder including granules (Paras. [0007] through [0011], The invention further provides a preparation method for the metal powder for 3D printers, characterized by comprising the specific steps of: (1) firstly preparing the submicron order metal powder... wherein the average grain size of the submicron order metal powder is 0.1-3 microns...(3) adding an organic adhesive which accounts for 0.1-10% by weight of the submicron order metal powder (solid) into the metal powder slurry obtained in step (2), and uniformly stirring and mixing the slurry; and (4) preparing the uniformly stirred and mixed slurry in step (3) to the spherical metal powder for 3D printers with the average grain size of 10-50 microns through a centrifugal spray granulator...), and each granule including an agglomeration of first metallic particles in at least one component of a binder system (Paras. [0007] through [0011]). However, Ningbo fails to fairly teach or suggest, either alone or in combination with the prior art, reflowing the granules along a predetermined two-dimensional pattern in the layer, the at least one component of the binder system from the reflowed granules binding the first metallic particles in the layer to one another and to one or more adjacent layer; and repeating the steps of spreading and reflowing for each layer of a plurality of sequential layers to form a three-dimensional object in the powder bed; wherein the first metallic particles in respective granules are lightly sintered to one another; wherein the at least one component of the binder system is water soluble to reflow the at least one component of the binder system in the discrete granules; wherein the at least one component of the binder system is soluble in one or more of hexane, alcohol, and limonene to reflow the at least one component of the binder system in the discrete granules; wherein a temperature difference between the melt temperature of the at least one component of the binder system and a burn off temperature of the at least one component of the binder system is between about 100°C and about 300°C; wherein the powder comprises second metallic particles, or wherein the discrete granules are dispersed in the second metallic particles in a flowable mixture.

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(ii) Dow teaches particles including a plurality of different materials (Pg. 2 Ln. 22 through Pg. 3 Ln. 4, We have discovered an improved method of selective sintering additive manufacturing comprising, (i) providing a powder comprising composite particulates comprising a first thermoplastic polymer and a second thermoplastic polymer interspersed with each other, (ii) depositing a layer of said powder at a target surface, (iii) irradiating a selected portion of said powder so that said powder sinters, bonding said portion of the composite particles within the layer to form a sintered layer, (iv) repeating steps (i) and (iii) to form successive sintered layers that are also bonded to one another, and (v) removing the unbonded portions of the powder to yield an additive manufactured part). However, Dow fails to fairly teach or suggest, either alone or in combination with the art, wherein the different materials of the plurality of different materials are alloyable with one another; wherein the particles include first metallic particles and second metallic particles, the first metallic particles having an average particle size less than an average particle size of the second metallic particles; wherein at least one of the plurality of different materials is harder than at least another one of the plurality of different materials; wherein at least one of the plurality of different materials includes a metal matrix composite; wherein an alloy formed of the plurality of different materials has a smaller grain structure than an alloy formed of at least one of the plurality of different materials alone; wherein at least one of the plurality of different materials includes tungsten; or wherein at least one of the plurality of different materials includes one or more of molybdenum and copper.

(iii) Northwestern teaches at least one component of a binder system that includes a first component and a second component, the first component being different from the second component (Northwestern Para. [0023], Combinations of different polymeric binders may be used). However, Northwestern fails to fairly teach or suggest with motivation to combine, either alone or in combination with the art, the three-dimensional object of claim 70, wherein the at least one component of the binder system has a melt temperature of greater than about 100°C and less than a melt temperature of the plurality of different materials; or wherein the first component and the second component are cross-linked with one another.

Claims 1-96 meet the criteria set out in PCT Article 33(4), and thus have industrial applicability because the subject matter claimed can be made or used in industry.