CLAIMS

1. A method of extrusion-based three-dimensional, 3D, printing a functionally graded article, **characterised in that**, the method comprising the steps:

providing a slurry feedstock, including:

preparing a build material comprising a metal, a ceramic or any combinations thereof, including:

providing the build material that is porous, non-porous or any combinations thereof; and

providing the build material in an amount from 10 vol.% to 90 vol.%, the build material having a multimodal particle size distribution including particles of ≤10 μm and ≥50 μm;

preparing an organic polymer binder selected from a group comprising a cellulose ester, a cellulose ether, and derivatives thereof, including:

providing the organic polymer binder in a concentration from 150 g/L to 550 g/L and having a number average molecular weight of not more than 100,000;

preparing an additive selected from a group comprising a plasticizer, a defoaming agent, a dispersing agent, a sacrificial material, a fugitive material, a scaffolding material, a water-soluble inorganic salt, a foaming agent, a graphene, a graphene oxide, a flame retardant, a toner, a release additive, a stabilizer, an anti-static agent, an impact modifier, a colourant, an antioxidant and any combinations thereof; and

preparing a volatile organic solvent;

forming a first pre-mix by mixing the build material mixed with the additive;

forming a second pre-mix by mixing the organic polymer binder dissolved with the volatile organic solvent;

mixing the first pre-mix and the second pre-mix to form a substantially homogeneous and flowable slurry mixture having a viscosity of 2 x 10^6 to 10 x 10^6 mPa·s at 25°C and a stability time of at least 24 hours without phase separation;

printing the substantially homogenous and flowable slurry mixture to form a preliminary part of the said functionally graded article;

debinding the organic polymer binder from the preliminary part in either or both a thermal decomposition treatment and a solvent debinding treatment; and

subjecting the preliminary part having the organic polymer binder debound therefrom to sintering for producing a final part of the functionally graded article

containing the build material selectively varied in composition, structure including infill pattern or any combinations thereof gradually over volume of the final part thereof in one or more directions.

2. The method according to Claim 1, wherein the method includes the step of forming two or more substantially homogeneous and flowable slurry mixtures, each comprising a respective first pre-mix and a respective second pre-mix.

3. The method according to Claim 2, wherein the method includes the step of instantaneously mixing the two or more substantially homogeneous and flowable slurry mixtures in situ in a static or active mixer to form one substantially homogeneous and flowable slurry mixture.

4. The method according to Claim 1, wherein the method includes the step of providing a support structure for an overhanging or cantilevered portion of the said functionally graded article, wherein the support structure comprises a substantially homogeneous and flowable support mixture formed from a support material.

5. A system for extrusion-based three-dimensional, 3D, printing a functionally graded article, **characterised in that**, the system comprising:

one or more receptacles configured for receiving a slurry feedstock comprising:

a build material comprising a metal, a ceramic or any combinations thereof,

wherein the build material is porous, non-porous or any combinations thereof,

wherein the build material is in an amount from 10 vol.% to 90 vol.%;

an organic polymer binder selected from a group comprising a cellulose ester, a cellulose ether, and derivatives thereof,

wherein the organic polymer binder is in a concentration from 150 g/L to 550 g/L;

an additive selected from a group comprising a plasticizer, a defoaming agent, a dispersing agent, a sacrificial material, a fugitive material, a scaffolding material, a water-soluble inorganic salt, a foaming agent, a graphene, a graphene oxide, a flame retardant, a toner, a release additive,

a stabilizer, an anti-static agent, an impact modifier, a colourant, an antioxidant and any combinations thereof; and

a volatile organic solvent,

wherein the build material mixed with the additive and the organic polymer binder dissolved with the volatile organic solvent form a first pre-mix and a second pre-mix, respectively, that are mixed to form a substantially homogeneous and flowable slurry mixture;

a means for regulating injection of the slurry feedstock contained in the one or more receptacles thereof,

wherein the means for regulating injection is selected from a group comprising a solenoid valve, a mechanical pump and a combination thereof;

a computing unit comprising a control unit configured for generating a control signal to the said means for regulating injection,

wherein the control unit is connected to a database comprising a predefined set of material and rheology profiles employed to operatively effect the control signal in respect of a final part of the said functionally graded article;

a fluid drive device configured for providing a fluidic pressure to the slurry feedstock contained in the one or more receptacles thereof or to the means for regulating injection, which, in turn, actuates the slurry feedstock in the one or more receptacles connected thereof to provide a pressurized slurry feedstock,

wherein the fluid drive device is selected from a group comprising a pneumatic drive device, a hydraulic drive device, a mechanical displacement device and any combinations thereof;

a print head operatively driven by the computing unit thereof configured for jetting the said substantially homogeneous and flowable slurry mixture to produce a preliminary part of the said functionally graded article; and

a static or active mixer configured for instantaneously mixing two or more substantially homogeneous and flowable slurry mixtures in situ to form one substantially homogeneous and flowable slurry mixture prior to transfer to the print head,

wherein the organic polymer binder is debound from the preliminary part in either or both a thermal decomposition treatment and a solvent debinding treatment followed by sintering to thereby produce the final part of the functionally graded article containing the build material having selectively varied in composition, structure including infill pattern or any combinations thereof gradually over volume of the final part thereof in one or more directions.

6. The system according to Claim 5, wherein the one or more receptacles receives a support material forming a substantially homogeneous and flowable support mixture that prints, through the said print head or another print head, a support structure for an overhanging or cantilevered portion of the said functionally graded article.

7. A slurry feedstock for casting an article under a low pressure at a room temperature, **characterised in that**, the slurry feedstock comprising:

a build material comprising a metal, a ceramic or any combinations thereof,

wherein the build material is porous, non-porous or any combinations thereof,

wherein the build material is in an amount from 10 vol.% to 90 vol.%, the build material having a multimodal particle size distribution including particles of ≤10 μm and ≥50 μm;

an organic polymer binder selected from a group comprising a cellulose ester, a cellulose ether, and derivatives thereof,

wherein the organic polymer binder is in a concentration from 50 g/L to 550 g/L;

an additive selected from a group comprising a plasticizer, a defoaming agent, a dispersing agent, a sacrificial material, a fugitive material, a scaffolding material, a water-soluble inorganic salt, a foaming agent, a graphene, a graphene oxide, a flame retardant, a toner, a release additive, a stabilizer, an anti-static agent, an impact modifier, a colourant, an antioxidant and any combinations thereof; and

a volatile organic solvent,

wherein the build material mixed with the additive and the organic polymer binder dissolved with the volatile organic solvent form a first pre-mix and a second pre-mix, respectively, that are mixed to form a substantially homogeneous and flowable slurry mixture that is subjected to moulding in a cavity of a mould substantially immersed in a coagulation bath for producing a preliminary part of the said article by way of phase inversion,

wherein the organic polymer binder is debound from the preliminary part in either or both a thermal decomposition treatment and a solvent debinding treatment followed by sintering to thereby produce a final part of the article,

wherein the slurry feedstock has a viscosity of 2×10^6 to 10×10^6 mPa·s at 25 °C and a stability time of at least 24 hours without phase separation.

8. A method of preparing a slurry feedstock for casting an article under a low pressure at a room temperature, **characterised in that**, the method comprising the steps:

preparing a build material comprising a metal, a ceramic or any combinations thereof, including:

providing the build material that is porous, non-porous or any combinations thereof; and

providing the build material in an amount from 10 vol.% to 90 vol.%, the build material having a multimodal particle size distribution including particles of ≤10 μm and ≥50 μm;

preparing an organic polymer binder selected from a group comprising a cellulose ester, a cellulose ether, and derivatives thereof, including:

providing the organic polymer binder in a concentration from 50 g/L to 550 g/L;

preparing an additive selected from a group comprising a plasticizer, a defoaming agent, a dispersing agent, a sacrificial material, a fugitive material, a scaffolding material, a water-soluble inorganic salt, a foaming agent, a graphene, a graphene oxide, a flame retardant, a toner, a release additive, a stabilizer, an anti-static agent, an impact modifier, a colourant, an antioxidant and any combinations thereof;

preparing a volatile organic solvent; and

forming a first pre-mix by mixing the build material with the additive;

forming a second pre-mix by mixing the organic polymer binder with the volatile organic solvent;

mixing the first pre-mix and the second pre-mix to form a substantially homogeneous and flowable slurry mixture that is subjected to moulding in a cavity of a mould substantially immersed in a coagulation bath for producing a preliminary part of the said article by way of phase inversion,

wherein the organic polymer binder is debound from the preliminary part in either or both a thermal decomposition treatment and a solvent debinding treatment followed by sintering to thereby produce a final part of the article,

wherein the slurry feedstock has a viscosity of 2×10^6 to 10×10^6 mPa·s at 25 °C and a stability time of at least 24 hours without phase separation.

9. A slurry feedstock for extrusion-based three-dimensional, 3D, printing of a functionally graded article, **characterised in that**, the slurry feedstock comprising:

a build material comprising a metal, a ceramic or any combinations thereof,

wherein the build material is porous, non-porous or any combinations thereof,

wherein the build material is in an amount from 10 vol.% to 90 vol.%, the build material having a multimodal particle size distribution including particles of ≤10 μm and ≥50 μm;

an organic polymer binder selected from a group comprising a cellulose ester, a cellulose ether, and derivatives thereof,

wherein the organic polymer binder is in a concentration from 150 g/L to 550 g/L;

an additive selected from a group comprising a plasticizer, a defoaming agent, a dispersing agent, a sacrificial material, a fugitive material, a scaffolding material, a water-soluble inorganic salt, a foaming agent, a graphene, a graphene oxide, a flame retardant, a toner, a release additive, a stabilizer, an anti-static agent, an impact modifier, a colourant, an antioxidant and any combinations thereof; and

a volatile organic solvent,

wherein the build material mixed with the additive and the organic polymer binder dissolved with the volatile organic solvent form a first pre-mix and a second pre-mix, respectively, that are mixed to form a substantially homogeneous and flowable slurry mixture that is printed as a preliminary part of the said functionally graded article,

wherein the organic polymer binder is debound from the preliminary part in either or both a thermal decomposition treatment and a solvent debinding treatment followed by sintering to thereby produce a final part of the functionally graded article containing the build material having selectively varied in composition, structure including infill pattern or any combinations thereof gradually over volume of the final part thereof in one or more directions,

wherein the slurry feedstock has a viscosity of 2 x 10° to 10 x 10^6 mPa·s at 25 °C and a stability time of at least 24 hours without phase separation.