METHOD FOR 3D PRINTING IMPARTING REPROCESSABILITY TO PRINTED STRUCTURES

PRIORITY CLAIM

[0013] This application claims priority from Singapore Patent Application No. 10201802321Q filed on 21 March 2018 and Singapore Patent Application No. 10201802825W filed on 04 April 2018.

TECHNICAL FIELD

[0014] The present invention generally relates to three-dimensional (3D) printing, and more particularly relates to digital light processing 3D printing systems capable of fabricating components made of multiple materials including reprocessable thermosets in a quick and fully-automated manner.

BACKGROUND OF THE DISCLOSURE

[0015] Three-dimensional (3D) printing is an additive manufacturing process which is providing new capabilities to fabricate highly detailed, complex 3D micro-architectures composed of a wide range of materials and has become a powerful technique enabling a wide variety of applications, including tissue engineering, soft robotics, nano-devices, optical engineering, and metamaterials. One of the unique capabilities of 3D printing is the fabrication of multimaterial components in a single build process, which can vastly broaden the applications offering multiple mechanical, electrical, chemical or biological properties not otherwise possible using single-material systems.

[0016] Fabricated lightweight lattice structures have been demonstrated that exhibit tunable negative thermal expansion in three directions with the aid of multimaterial fabrication techniques. Such multimaterial fabrication can be realized in fused deposition modeling (FDM) and direct-ink writing (DIW) by simply adding extra printing nozzles to deposit different materials. These multimaterial 3D printing methods have been successfully applied to fabricate biomaterials and tissue scaffolds.

However, the manner of printing 3D structures using an extrusion nozzle constrains the geometric complexity to 2.5 dimensions or to simple 3D structures, and the hundreds micrometer scale of the printing nozzles limits the printing resolution. Multimaterial 3D printing has also been successfully realized in Polyjet 3D printing technology in which photocurable resin is jetted over a surface through micro-nozzles followed by curing with ultraviolet (UV) light. However, the finest edge

enable reprocessability including self-healing, remolding, and welding offer a possibility of making thermoset printing materials reprocessable. While an example of recyclable 3D printing with a DCB based epoxy has been reported, the complicated preparation procedure used constrained the material to direct-ink-writing (DIW) 3D printing technology, thereby limiting both the printing resolution as well as the product geometric complexity.

[0017] Thus, there is a need in the art for a novel material exchange mechanism for building a high-efficiency, high-resolution DLP based multimaterial 3D printing system. Also, there is a need for reprocessable, recyclable thermoset printing materials compatible with various 3D printing technologies. Furthermore, other desirable features and characteristics will become apparent from the subsequent detailed description and the appended claims, taken in conjunction with the accompanying drawings and this background of the disclosure.

SUMMARY

[0018] According to at least one aspect of the present embodiments, a method for three-dimensional (3D) printing is provided. The method includes photopolymerizing a photocurable resin to form a fabricated structure and programmed thermal treating of the fabricated structure for transesterification of material of the fabricated structure.

[0019] According to another aspect of the present embodiments, photopolymerizing a photocurable resin to form a fabricated structure includes photopolymerizing 3D printing reprocessable thermosets to form the fabricated structure and/or applying patterned ultraviolet (UV) radiation to a UV curable thermoset layer-by-layer to 3D print the fabricated structure, and programmed thermal treating of the fabricated structure for transesterification of material of the fabricated structure includes heating the fabricated structure at a predetermined temperature, such as 180°C, for a predetermined time duration, such as greater than four hours, for transesterification of material of the fabricated structure.

[0020] And according to a further aspect of the present embodiments, the method includes photopolymerizing a photocurable resin to form a fabricated structure and programmed thermal treating of the fabricated structure for transesterification of material of the fabricated structure. The method further includes polishing a damage site on the fabricated structure after it is damaged until a surface at the damage site is flat, 3D printing new material on the flat surface at the damage site by repeating the photopolymerizing to reform a

missing portion of the fabricated structure, and programmed thermal treatment of the fabricated structure including the reformed missing portion.

CLAIMS

What is claimed is:

1. A method for three-dimensional (3D) printing comprising:

photopolymerizing a photocurable resin to form a fabricated structure; and

programmed thermal treating of the fabricated structure for transesterification of material of the fabricated structure.

2. The method in accordance with Claim 1 wherein the photopolymerizing step comprises photopolymerizing 3D printing reprocessable thermosets to form the fabricated structure.

3. The method of either Claim 1 or Claim 2 wherein the photopolymerizing step comprises applying patterned ultraviolet (UV) radiation to a UV curable thermoset layer-by-layer to 3D print the fabricated structure.

4. The method of any of Claims 1 to 3 wherein the programmed thermal treatment step comprises heating the fabricated structure at a predetermined temperature for a predetermined time duration for transesterification of material of the fabricated structure.

5. The method of Claim 4 wherein the predetermined temperature is 180°C.

6. The method of either Claim 4 or Claim 5 wherein the predetermined time duration is greater than four hours.

7. The method of any of Claims 1 to 6 wherein the photocurable resin is a UV curable recyclable thermoset.

8. The method of any of Claims 1 to 7 further comprising:

polishing a damage site on the fabricated structure after it is damaged until a surface at the damage site is flat;

3D printing new material on the flat surface at the damage site by repeating the photopolymerizing to reform a missing portion of the fabricated structure; and

programmed thermal treatment of the fabricated structure including the reformed missing portion.