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3D and 4D printing of metallic and ceramic nanomaterials for biomedical applications

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The additive manufacturing is now a fast growing sector with its applications in the biomedical implants and aerospace components and structures. The directly 3D printed metallic materials have lower fatigue resistance compared to its counterparts produced by the powder metallurgy technologies including HIP. We will also introduce the post treatment of 3D printed components in Ti alloy to drastically enhance the fatigue resistance. Our research focuses on solving the problem of applying nano-ceramic materials with complex structure. The new concepts of SupraNano and Supranano Dual Phase were proposed, and the first supra-nanometre-sized dual-phase glass-crystal coatings were fabricated using the PVD process. The obtained supra nanostructure is consist of core of ~6 nm size crystals embedded in 2nm shells. The mechanical properties are 10 times higher than the conventional crystal alloys. Also, Four-dimensional (4D) printing technology, which combines traditional three-dimensional (3D) printing with structural deformation mechanism, was developed. 4D printing enables more complex shapes to be created than is possible with conventional 3D printing. Achieving this in ceramics, however, has been hindered by the fact that 3D-printed ceramic precursors are usually rigid and thus difficult to be deformed after fully crosslinked. Here we develop new ceramic precursors that can be printed, and then transformed into ceramics with precise structural retention. Meanwhile, the flexibility and stretchability of the new ceramic precursors shows great potentials in 4D printing and higher dimensional additive manufacturing. Furthermore, ceramics obtained from these printing techniques have achieved strength-scalability synergy, which broadens bio-implant applications of ceramics.

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