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Functional micro-concrete 3D hybrid structures fabricated by two-photon polymerization

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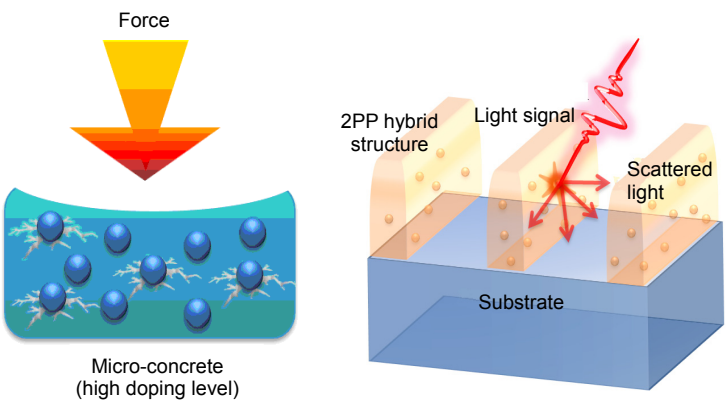

Schematics of the principles of strength and absorption modifications.

Abstract: Arbitrary micro-scale three-dimensional (3D) structures fabrication is a dream to achieve many exciting goals that have been persuaded for a long time. Among all these applications, the direct 3D printing to fabricate human organs and integrated photonic circuits are extraordinarily attractive as they can promote the current technology to a new level. Among all the 3D printing methods available, two-photon polymerization (2PP) is very competitive as it is a unique method to achieve sub-micron resolution to make any desired tiny true 3D structures. To achieve it, 2PP relies on the direct laser writing to transfer the pattern into the photoresist material by the two photon absorption to initialize the in-situ polymerization. However, the requirements for the building blocks are different for different purposes. Even though 2PP is of many superior properties, it is often considered as a supporting role to make the initial polymer structural molds or backbones for further processing steps. The reason is that the photoresist used in 2PP lacks the proper material properties to act as the functional materials in different applications. To realize it, it is the key to study how to make the photo-resist controllable according to different demands. In this paper, we presented one hybrid method to modify the mechanical strength and light trapping efficiency of the photoresist, which transfers the photoresist into the micro-concretes. Compared with other lithographic technologies, our approach is more favorable since the fabrication is fast. Hence, it is more suitable for scalable production. Specifically, the 2PP process is adapted to directly process three hybrid composites with different functionalities: 1) ±22% strength modification is realized in experiment via a silica nano-particles doping, which can be used to achieve tunable mechanical strength for bio-structure construction; 2) the structures doped with gold nano-particles show tunable plasmonic absorption to be used in light trapping sensors; 3) dye doped hybrid structure shows great potentials to fabricate 3D micro-chip laser. These three specific works serve as good examples to demonstrate that the hybrid 2PP method can be introduced as a unique and powerful 3D nano-printing technique for massive scale effective fabrications to make the key functional components for many unique applications.

Keywords: 3D nano-printing; two-photon polymerization; hybrid; micro-concrete
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