ADDITIVE MANUFACTURING OF INTELLIGENT AND SELF-LUBRICATING POLYIMIDE SURFACES

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ABSTRACT
Surface patterning has been widely utilized in structure enhancement, bionics, and surface lubrication. Drawing inspiration from the layer-by-layer forming principle of additive manufacturing and the Yin-Yang theory of traditional Chinese culture, we herein tailor patterned surfaces with various stripes of width using photosensitive polyimide and photosensitive polyimide-polytetrafluoroethylene composites that exhibit tough and lubricated properties by changing inks. To further optimize the self-lubricating surfaces, we present an accurate screening of the tribological data using machine learning (ML) and the optimized surfaces demonstrated the exceptional comprehensive properties. The combination of ML design and vat photopolymerization 3D printing is believed to enhance toughness and lubrication of surfaces, has the potential to the applications of the mechanical engineering, space equipment, and automobile manufacturing.

To meet the service requirement of polyimide (PI) parts in the harsh Low Earth Orbit (LEO), vat photopolymerization (VP) three-dimensional (3D) printing of a novel PI composite with superior tribological and atomic oxygen (AO) irradiation resistant properties was proposed by employing meth-acryloxypropyl polyhedral oligomeric silsesquioxane (MPA-POSS) into the photosensitive PI inks as the crosslinking agent to obtain POSS-contained PI composite (PI-POSS composite). The resultant PI-POSS exhibits unique comprehensive performance including excellent AO irradiation resistance of an erosion yield of 2.86 × 10−24 cm3/atom, 50% lower than that of PI without POSS, and anti-wear and friction reducing properties with coefficient of friction of 0.1 and wear rate of 4.4 × 10-6 mm3/N·m. Importantly, the PI-POSS inks show excellent VP 3D printability, and various AO irradiation

resistant self-lubricating PI-POSS parts with structural complexity can be readily built, revealing their great potential in aerospace used in LEO.

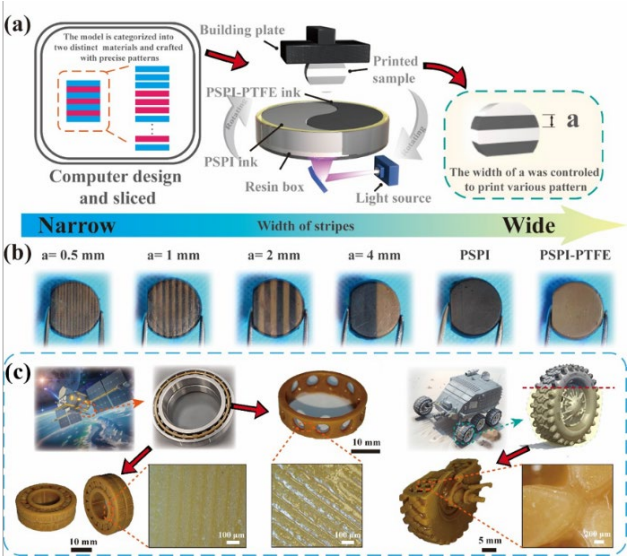

Fig.1 (a)(b) fabricating method of patterned self-lubricating polyimide surfaces; (c) Schematic diagram of 3D printing polyimide-POSS composites with AO irradiation resistant properties.

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