Ultrafast digital printing toward 4D shape changing materials

Subject Code：B04

Under the financial support of the National Natural Science Foundation of China，the research team led by Prof. Xie Tao（谢涛）at the State Key Laboratory of Chemical Engineering，College of Chemical and Biological Engineering，Zhejiang University，developed an ultrafast process to produce shape changing materials with complex 3D geometries. This work was published in *Advanced Materials*（2016，DOI：10.1002/adma.201605390）.

Engineering applications of functional devices（e. g. biomedical）and structures（e. g. aerospace）are increasingly limited by the sophistication of accessible shapes that cannot be easily fabricated by traditional molding techniques. 3D printing offers an attractive option given its flexibility to create complex shapes. Its layer by layer nature，however，limits its speed and consequently its practical potential. In contrast，4D printing relies on the time evolution（the fourth dimension）of a 2D film into a 3D object. While forgoing the time consuming multi-layer buildup in the *z*-dimension，currently known 4D printing methods are mostly based on ink-writing processes with their sequential nature prohibiting improvement in the fabrication speed. Overall，current 3D and 4D printing methods typically produce parts in the timescale of hours.

In the ultrafast 4D printing process by Xie's group，commercial monomers were photo-polymerized via a projector（Figure a）. The light exposure time can be digitally controlled，thus a 2D polymer film with spatially defined monomer conversion and crosslinking density can be produced（Figure b）. After swelling in water，the mechanical stress due to this material heterogeneity is released，turning the planar sheet into a hydrogel with a 3D shape. Depending on the printing layout，diverse 3D shapes such as the cartoon face（Figure c）and theatre complex（Figure d）can be fabricated. When hydrophobic instead of hydrophilic monomers are used，the printed 2D film can swell in hydrophobic solvents such as melted wax，leading to a wax-swollen polymer with shape memory functions（Figure e）. The new printing method requires neither the layer by layer process in the vertical dimension nor the sequential ink-writing in the planar dimensions，leading to its exceptionally high printing speed in the timescale of seconds. Amongst numerous application possibilities，the 4D wax can be used as smart molds to significantly increase productivity in industrial processes.

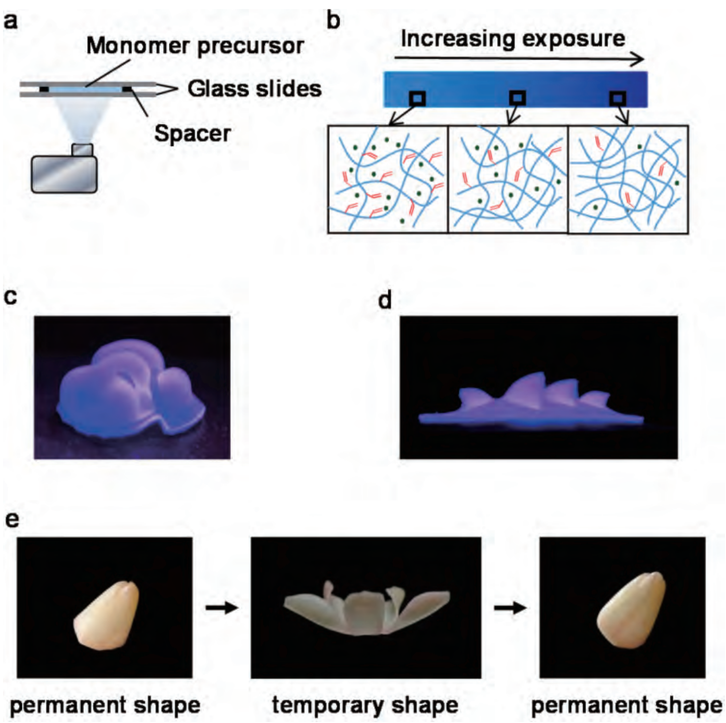

Figure Digital 4D printing. a，Printing setup；b，digital light curing and resulting networks；c，hydrogel carbon face；d，hydrogel theater complex；e，wax-based shape memory polymer.