3-D inks that can be erased selectively

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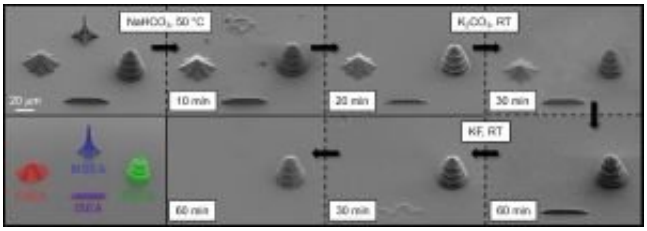

Three-dimensional microstructures made of various cleavable photoresists. The scanning electron microscopies show the selective degradation of the structures (scaling 20 µm). Credit: Nature Communications

3-D printing allows for the efficient manufacture of complex geometries. A promising method is direct laser writing—a computer-controlled, focused laser beam acts as a pen and produces the desired structure in a photoresist. In this way, three-dimensional structures with details in the sub-micrometer range can be produced.

"The high resolution is very attractive for applications requiring very precise filigree structures, such as in biomedicine, microfluidics, microelectronics or for optical metamaterials," says Professor Christopher Barner-Kowollik, head of the Macromolecular Architectures Group of KIT's Institute for Chemical Technology and Polymer Chemistry (ITCP) and of the Soft Matter Materials Group of Queensland University of Technology (QUT) in Brisbane, Australia. Over a year ago, the working groups of Professor Martin Wegener at the Institute of Applied Physics (APH) and the Institute of Nanotechnology

(INT) of KIT and of Professor Christopher Barner-Kowollik developed an erasable ink for 3-D printing. Thanks to reversible binding, the building blocks of the ink can be separated again.

Now, the scientists from Karlsruhe and Brisbane have largely refined their development. As reported in the journal *Nature Communications*, they have developed several inks, in different colors, so to speak, that can be erased independently of each other. This enables selective and sequential degradation and reassembly of the laser-written microstructures. In case of highly complex constructions, temporary supports can be produced and removed again later on. It may also be possible to add or remove parts to or from three-dimensional scaffolds for cell growth, the objective being to observe how the cells react to such changes. Moreover, the specifically erasable 3-D inks allow for the exchange of damaged or worn parts in complex structures.

When producing the cleavable photoresists, the researchers were inspired by degradable biomaterials. The photoresists are based on silane compounds that can be cleaved easily. Silanes are silicon-hydrogen compounds. The scientists used specific atom substitution for preparing the photoresists. In this way, microstructures can be degraded specifically under mild conditions without structures with other material properties being damaged. This is the major advantage over formerly used erasable 3-D inks. New photoresists also contain the monomer pentaerythritol triacrylate that significantly enhances writing without affecting cleavability.

More information: David Gräfe et al. Adding chemically selective subtraction to multi-material 3D additive manufacturing, *Nature Communications* (2018). DOI: 10.1038/s41467-018-05234-0

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