perspective, coupling single molecules to propagating light fields in nanophotonic waveguides is a promising approach[11,12]. In the same way as a lens can achieve tight focusing of an incident beam in bulk optics, waveguide structures confine the electromagnetic field in the transverse direction and can thus greatly improve the light–molecule coupling efficiency. Importantly, nanophotonic waveguides are also compatible with optical fibre networks. Future work may aim at enhancing the coupling efficiencies to eventually reach near-unity. This might be achieved through an increase in the focusing strength of the optical system, or perhaps through the combination of an optical resonator of moderate finesse with a tight focusing geometry or with the strong transverse light confinement in a nanophotonic waveguide. In conclusion, nonlinear effects at the single-photon level mediated by single molecules have a bright future ahead. ❐

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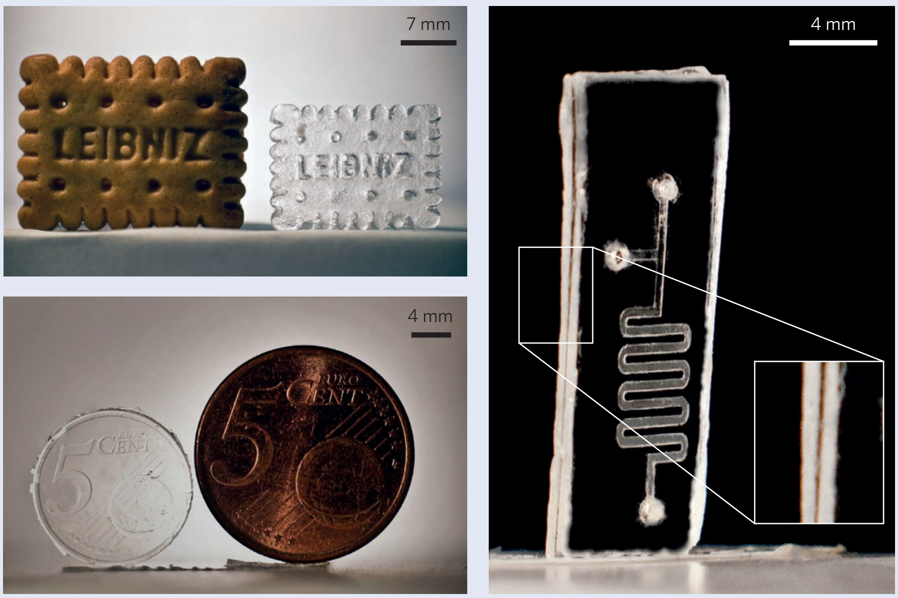
OPTICAL FABRICATION

Liquid glass

A convenient means for fabricating silica structures that makes use of a photocurable free-flowing silica nanocomposite is opening up new opportunities for glass manufacture. The viscous material, dubbed LiqGlass, is the inspiration of scientists from Karlsruhe Institute of Technology (KIT) in Germany (*Adv. Mater*. http://doi.org/f3mkqz; 2016). It consists of amorphous silica nanoparticles (~40 nm in diameter) that are blended with a photocurable monomer and a photoinitiator. By placing the LiqGlass into a mould, and then curing it with ultraviolet light and sintering it at a high temperature, the LiqGlass can be converted into a high-quality solid silica glass of an arbitrary shape — for example, a coin or biscuit as shown.



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"We have manufactured micro-optical as well as microfluidic devices from this material," commented Bastian Rapp, from KIT. "Once sintered, LiqGlass cannot be distinguished from fused silica glass in terms of its optical, chemical or mechanical properties."

Usually, custom-shaped structures in glass are made by etching solid samples with hydrofluoric acid. However, such etching is isotropic in its nature, which means that it is not possible to create asymmetric structures such as tall, vertical pillars or walls. In addition, the use of a dangerous acid is not convenient.

In contrast, with the new process the LiqGlass is simply poured into an elastomer mould of the desired shape and then cured with ultraviolet light for about 2 min. The solidified sample is then removed from the mould and heated to remove organic binders and then finally sintered at a temperature of up to 1,400 °C to fuse the silica nanoparticles together. The entire fabrication process takes ~61 hours and does not require a cleanroom or any hazardous chemicals.

The team says that feature sizes in the range of a few tens of micrometres can be achieved with a surface roughness of just a few nanometres. Larger, complex structures containing hollow channels or cavities, such as the microfluidic waveguide circuit shown in the figure, can be made by simply laminating multiple layers of the cured LiqGlass.

While complex optical parts can already be made from polymers using two-photon polymerization via direct laser writing, the use of glass has some important benefits in some applications, such as a very high optical clarity, high mechanical strength and unmatched chemical resistance.

"Currently we are developing LiqGlass 2.0 — a version which can be used for additive manufacturing, stereolithography and 3D printing," explained Rapp. "This would allow, for the very first time, to create fused silica 3D objects by a rapid prototyping process." Rapp says that they are currently filing for a patent for LiqGlass 2.0 and plan to commercialize it.

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