

BACK SCATTER

A scanning electron micrograph showing several parabolic glass lenses. The lenses are arranged in a grid-like pattern on a dark, textured surface. Each lens has a smooth, curved, dome-like shape with a flat top. The lighting creates highlights on the edges and shadows in the center of each lens, emphasizing their three-dimensional structure.

Nanoprinting low-temperature glass

How most glass is manufactured today is similar to how it was made in ancient times. During the process, large volumes of silica particles are heated in a binding resin to around 1100°C and then compacted to form a solid mass of material. Not only is the method energy-intensive, but it also prevents manufacturers from using glass in various optoelectrical systems: Other compounds that are necessary in advanced electronics have much lower melting points. This micrograph shows novel parabolic glass lenses that were manufactured at a temperature 500°C lower than that of the usual method of making glass. These optical-grade lenses are just a few tens of micrometers in diameter. They could be used, for example, to precisely focus light onto individual pixels of camera sensors.

Jens Bauer, of the Karlsruhe Institute of Technology in Germany, and colleagues developed a 3D-printing protocol to make the microlenses and many other structures with complex geometries. An organic-inorganic liquid resin with silicon-oxygen nano-clusters is first cast onto a substrate. Then an ultrafast laser beam is pulsed into the resin to initiate the simultaneous absorption of two photons into organic functional groups. The organic components then link to form polymers. Finally, the sample undergoes thermal decomposition at a relatively cool 650°C to remove the organic components and convert the prestructure into the fused silica glasses shown here. Because the microlens array is made at low temperature, it could be printed onto a chip, which would avoid the need for a more elaborate series of assembly steps. (J. Bauer, C. Crook, T. Baldacchini, *Science* **380**, 960, 2023; image courtesy of Jens Bauer.) —AL

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