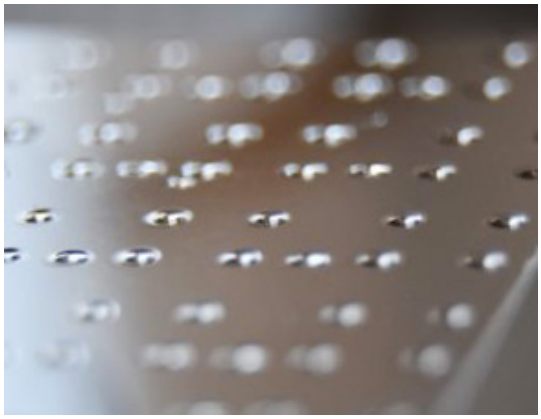
Using air to make bubbles in molten glass has been a known technique since Roman times. Now, researchers are applying that technique a microscopic scale to make specialised miniature cone-shaped lenses known as axicons.



Axicons are used to shape laser light in a beneficial way for optical drilling, imaging, and creating optical traps for manipulating particles or cells. When used with a laser, axicons create a beam of light that begins as a Bessel-like beam — a non-diffracting beam with maximum intensity on its axis — and then turns into a hollow beam further away from the axicon. Bessel-like beams feature a depth of field that can be orders of magnitude larger than that of a beam focused by a traditional rounded lens with a similar diameter. The beam's high depth of field allows optical drills to reach deeper and creates higher quality OCT images. For optical tweezers, both the Bessel-like and hollow portions of the beam can be used to trap particles or cells.

These lenses have been known for more than 60 years, but making them—especially making very small ones—is difficult. In the journal Optics Letters, the researchers describe the new fabrication approach based on the same processes used to make large numbers of photonic and electronic circuits in parallel on semiconductor wafers. The researchers used their approach to create glass axicons with diameters of 0.9 and 1.8 mm and showed that they successfully generated Bessel beams.

Glass microblowing has been used before to make microlenses, but it usually involves gas expansion from a single reservoir. Here, the researchers developed an axicon fabrication method that combines gas expansion from multiple reservoirs to produce the optical component's conical shape. The technique shapes the surface from underneath, leaving a high-quality optical surface, unlike commonly used methods like etching transfer from a 3D mask that engrave the wafer from above.

To carry out the new method, the researchers deposited silicon cavities in concentric rings that were then sealed with glass under atmospheric pressure. Placing the silicon and glass stack in a furnace caused gas trapped in the cavities to expand, creating ring-shaped bubbles. These bubbles pushed out the glass surface to form cone shapes and then the opposite side was polished away to leave only the shaped lenses.