Docket #: S15-353

Optical Device Fabrication with 3D printing

Stanford researchers successfully manufactured high quality optical components using commercially available 3D printing. The 3D printed optics were easy to fabricate and inexpensive. Additionally, the resulting product can be customizable, light weight, and low on material waste due to the additive nature of 3D printing.

The researchers 3D-printed surfaces and coated it with an smoothing gel to create optics (mirrors, arrays, aspheric lens molds). Following curing, the optically smooth surfaces can be vacuum coated with di-electrics/metals and finished as mirrors or used directly as molds. The method can be used to print mirrors, solar concentrators, lenses and optical elements of microscopes at a much lower cost and fast using this rapid prototyping process. This gel smoothing technique can be readily used with commercial 3D printers (resolution of tens of microns).

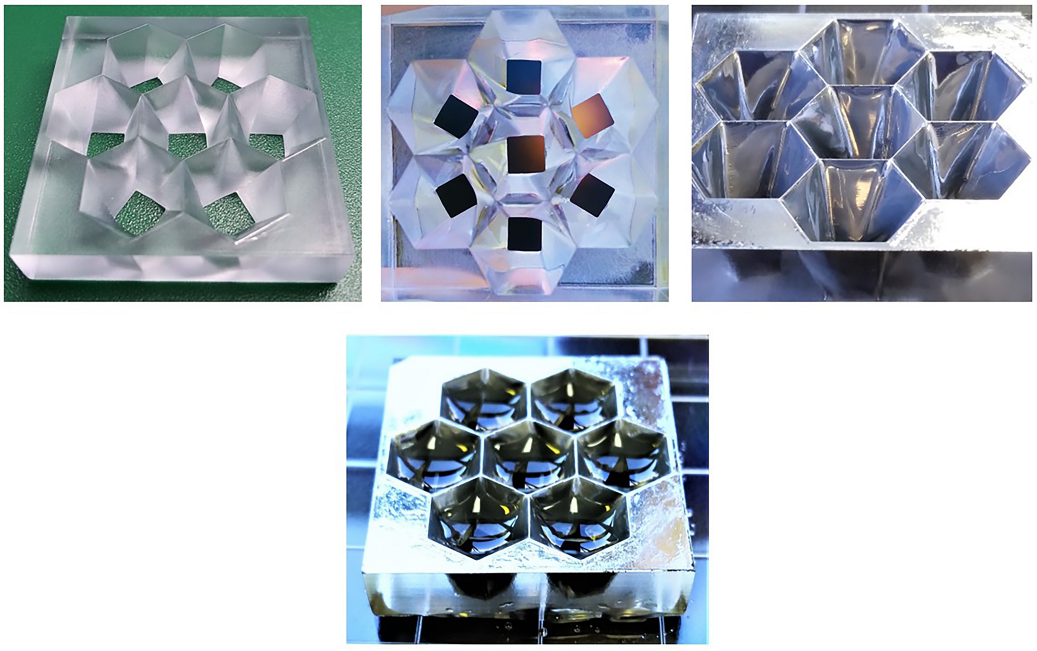

Figure 1- stages of solar concentrator lens arrays fabricated seen from as-3D printed part to finished graded-index polymer lenses

The as printed 3D surfaces have a roughness of several microns rms (root mean square surface roughness) which are unsuitable to use directly as optical devices. The smoothing technique reduced this roughness by more than one order of magnitude to a few nm rms (see Figure 2) eliminating light scatter. A few nanometer-scale smoothness is well within the criterion for high-quality optical surfaces where the surface roughness has to be several orders lower than the application wavelength. It is possible to go from a digital conceptual design to a functional high quality optical-quality prototype in a few hours using this method.

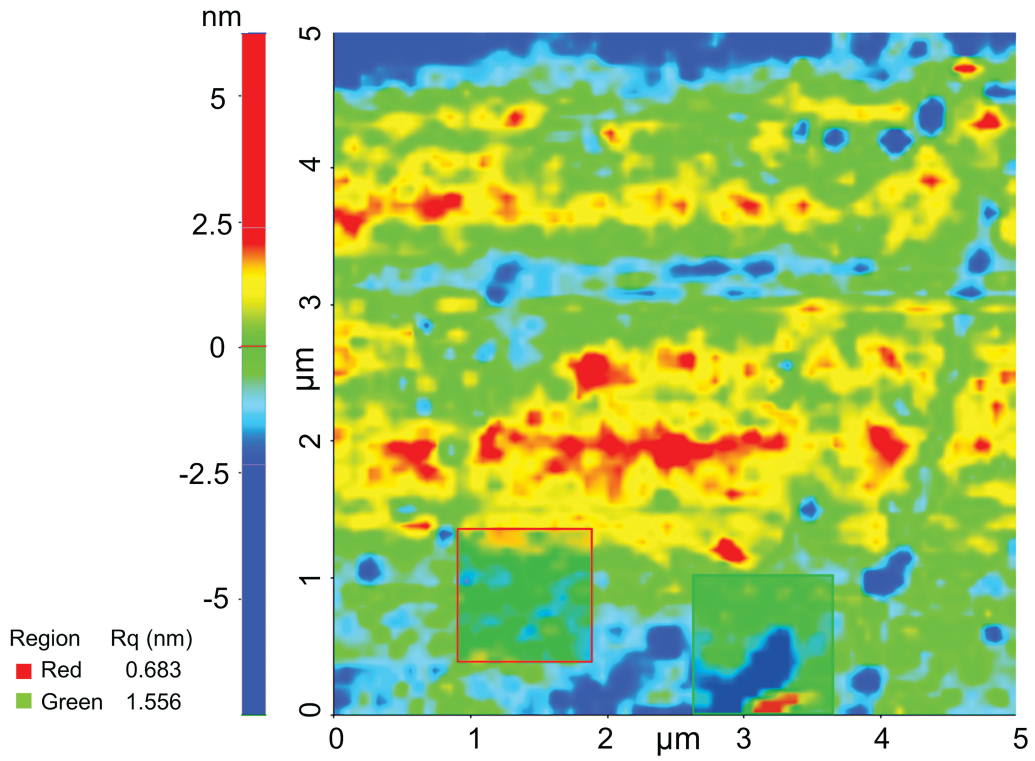

Figure 2- AFM image of lens surface made using 3D printing and the gel smoothing method

Applications

- **High Resolution 3D Printing of:**
  - Flat and aspheric mirrors/ultralightweight reflectors
  - Solar concentrator lens arrays
  - Custom index matched lenses/Optical elements of microscope/augmented reality optics/Waveguides/Displays

Advantages

- **Rapid and low cost process** - Can produce near-mirror finish without the labor-intensive, time-consuming, and expensive precision polishing in typical optical processing
- **Flexible design and complex shapes** can be made in a simple process
- **High quality**– smooth (2 nm roughness), uniform, and void free
- **Light weight polymer structures**
- **Low temperature fabrication processes**
- **Low waste-** additive manufacture and hence low material waste

Publications

- Nina Vaidya & Olav Solgaard, "3D printed optics with nanometer scale surface roughness," *Microsystems & Nanoengineering* Vol. 4, Article number: 18 (2018).

Patents

- Published Application: 20180319110
- Published Application: WO2017106341
- Issued: 10,946,579 (USA)

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