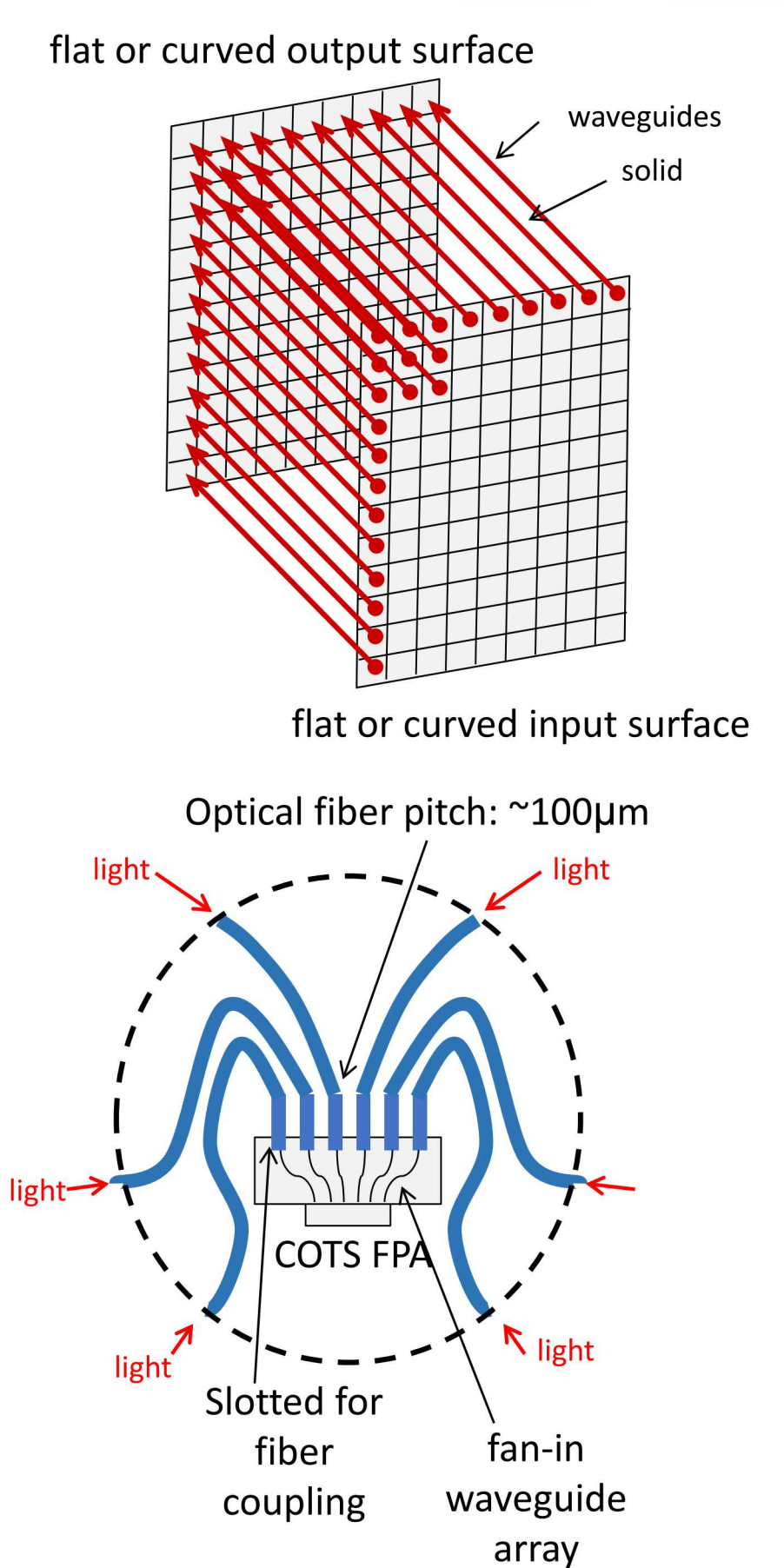


Fabrication of Optical Interconnects Using Direct Laser Writing

Michael Gallegos, Daryl Dagel, Amber Dagel, Andy Pomerene, Allen Vawter, Erik Skogen & Bryan Kaehr

Sandia National Laboratories, Albuquerque, NM, USA

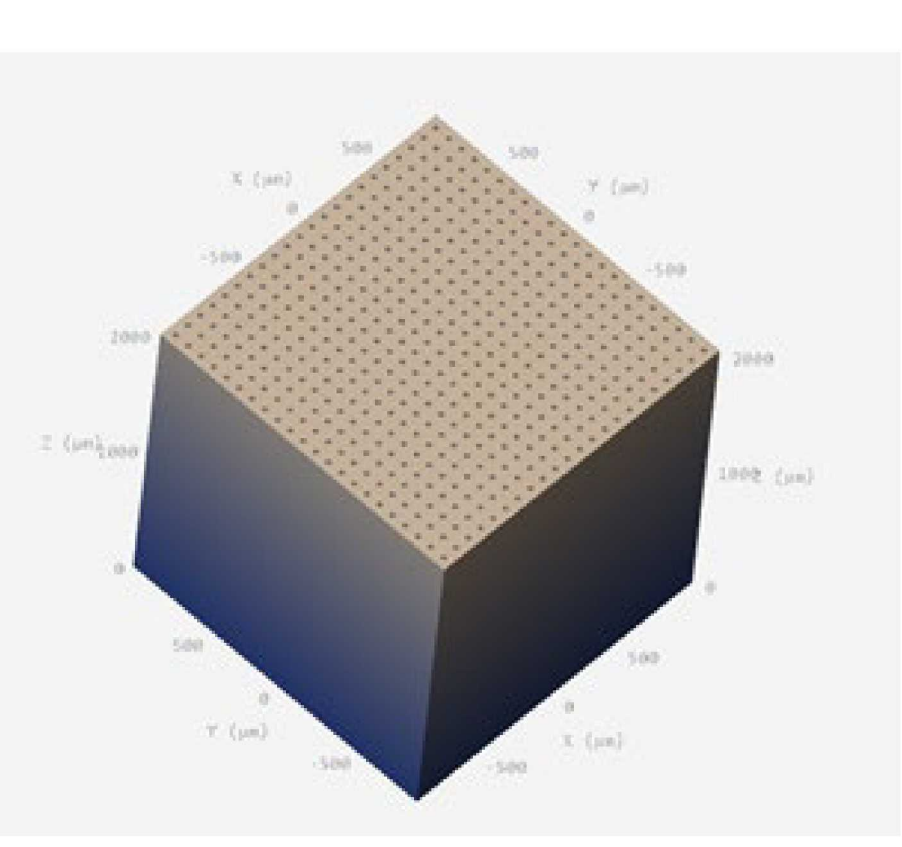
Problem



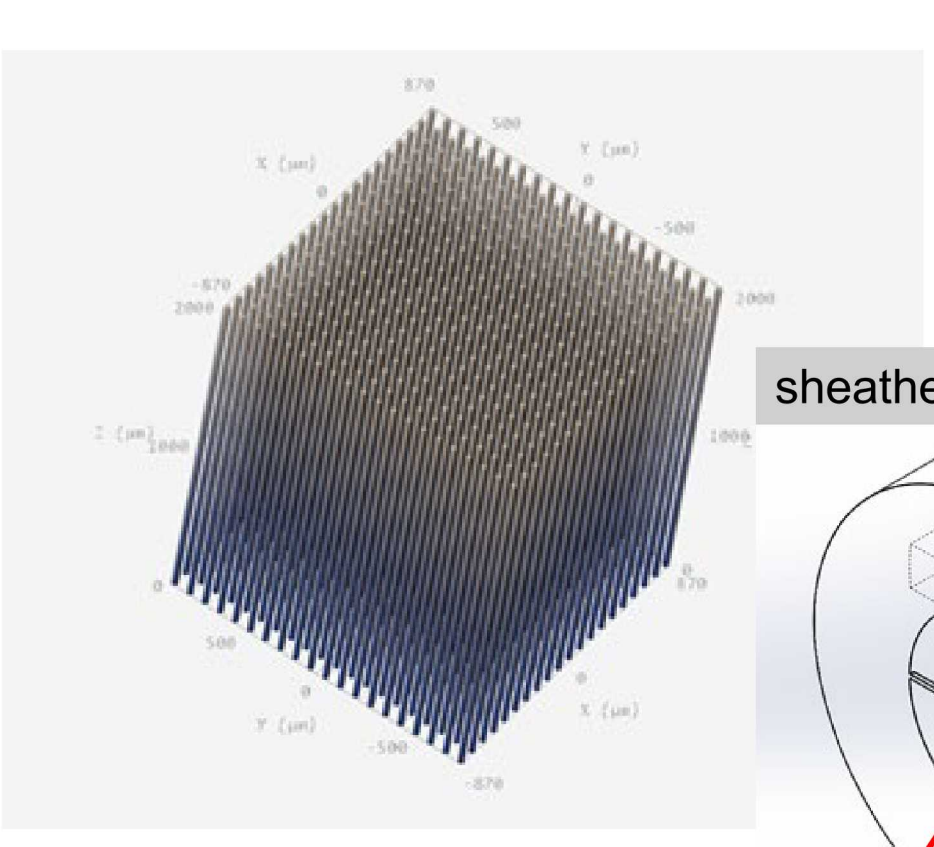
Abilities to capture, guide, and direct light into pixelated detectors (CCDs, CMOS sensors, FPAs, etc.) using free-form trajectories would be transformative for a range of technologies that currently use traditional optic lenses (mirrors, prisms, etc.) for light coupling. However, **few manufacturing techniques provide the appropriate scale and surface quality to address this task.** In this work, we consider “free-form waveguides” using the high-resolution 3D printing technique of multiphoton lithography (MPL; also known as direct laser writing, DLW).

Approach

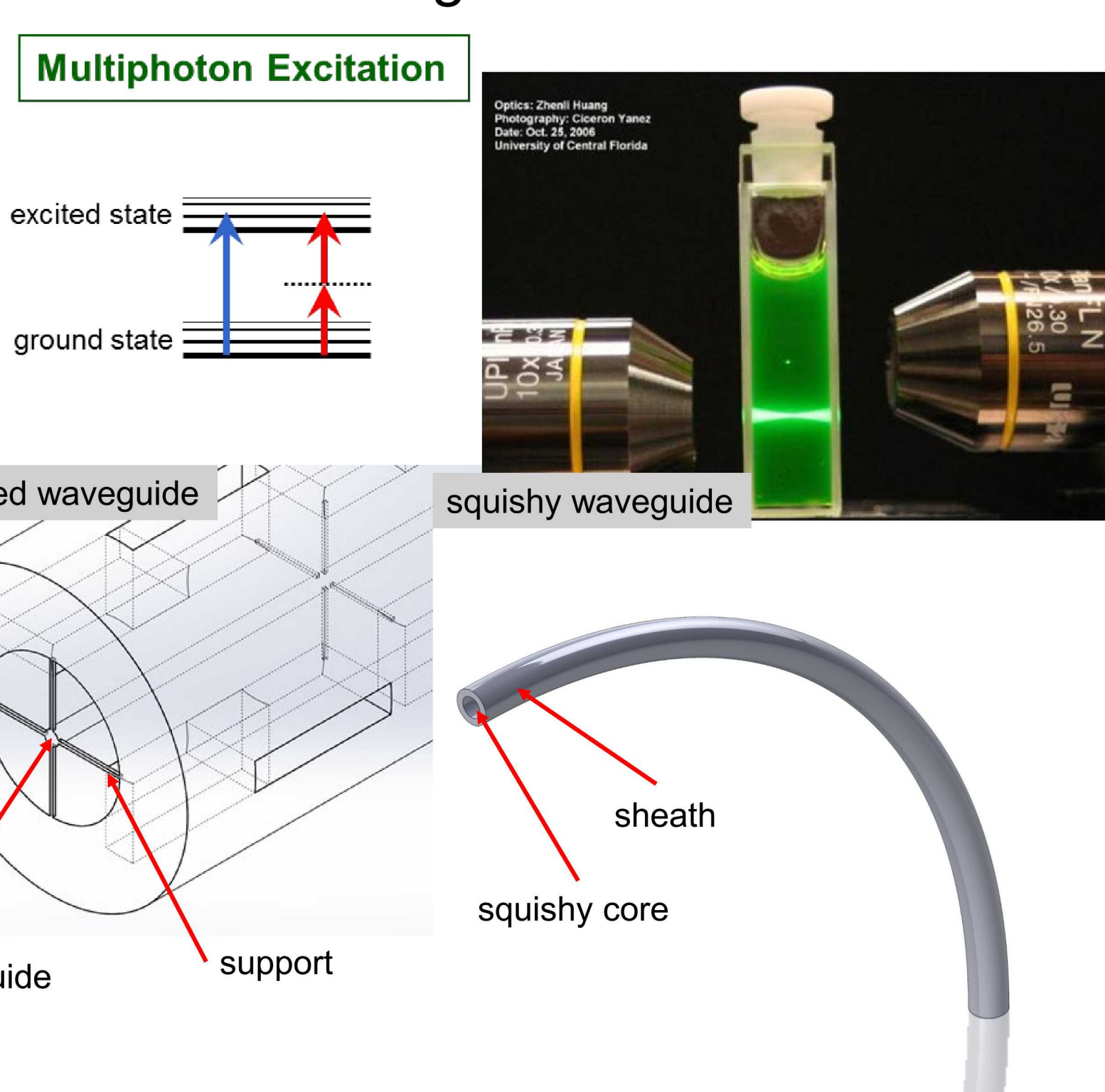
Multiphoton lithography (MPL) uses nonlinear excitation to restrict photochemical reactions in a photoresist to the focus of a laser beam. By scanning this “intrinsically 3D” fabrication voxel through the photoresist, complex three-dimensional microscale objects can be produced. The high resolution and freedom of design that is achieved with MPL allows for several ideas to be rapidly prototyped and tested.



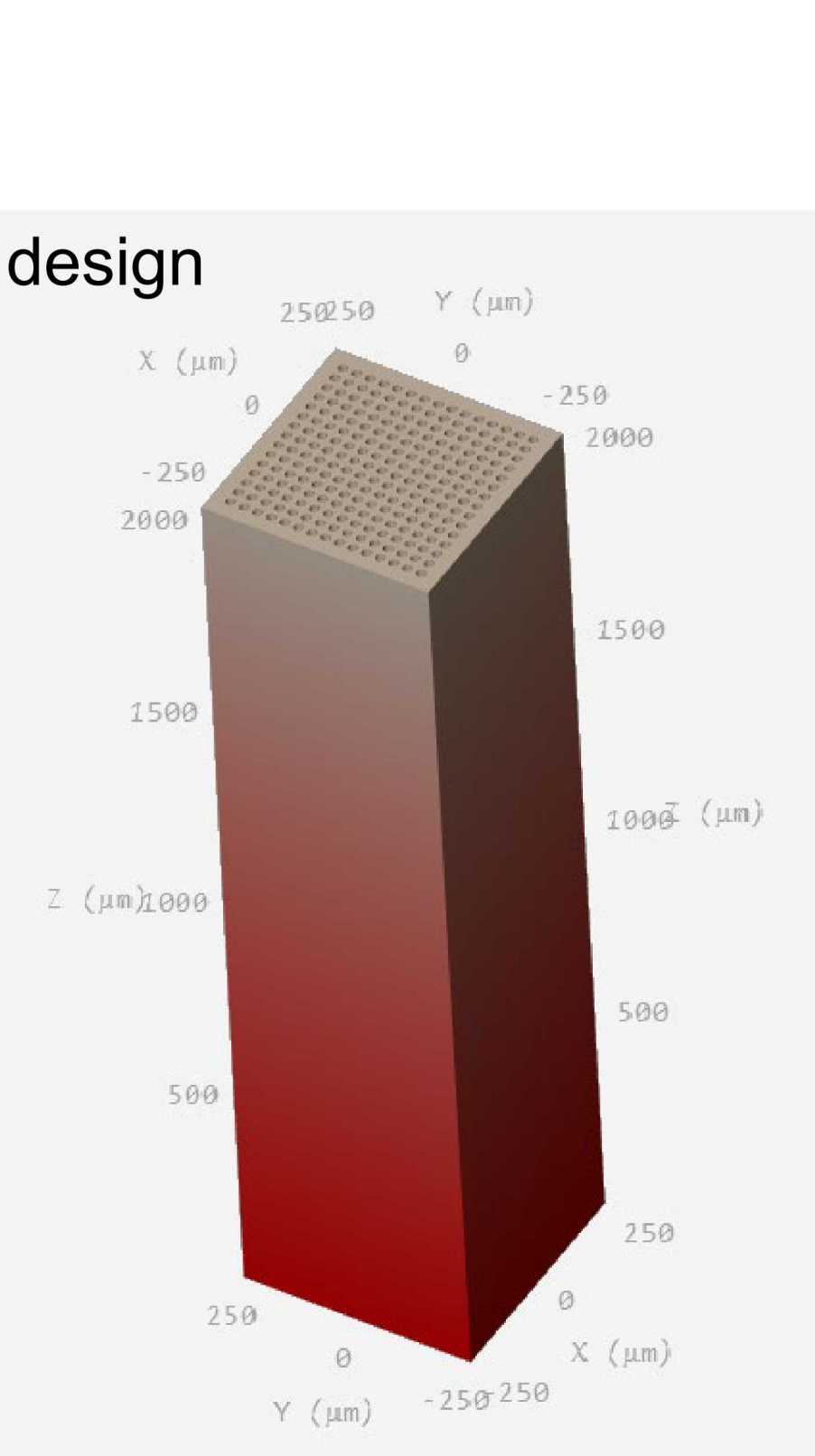
Vertical hollow fiber is 2x2 mm (w x h); 30 micron diameter cores at a 90 micron pitch.



Inverse structure (print only core) same overall dimensions.

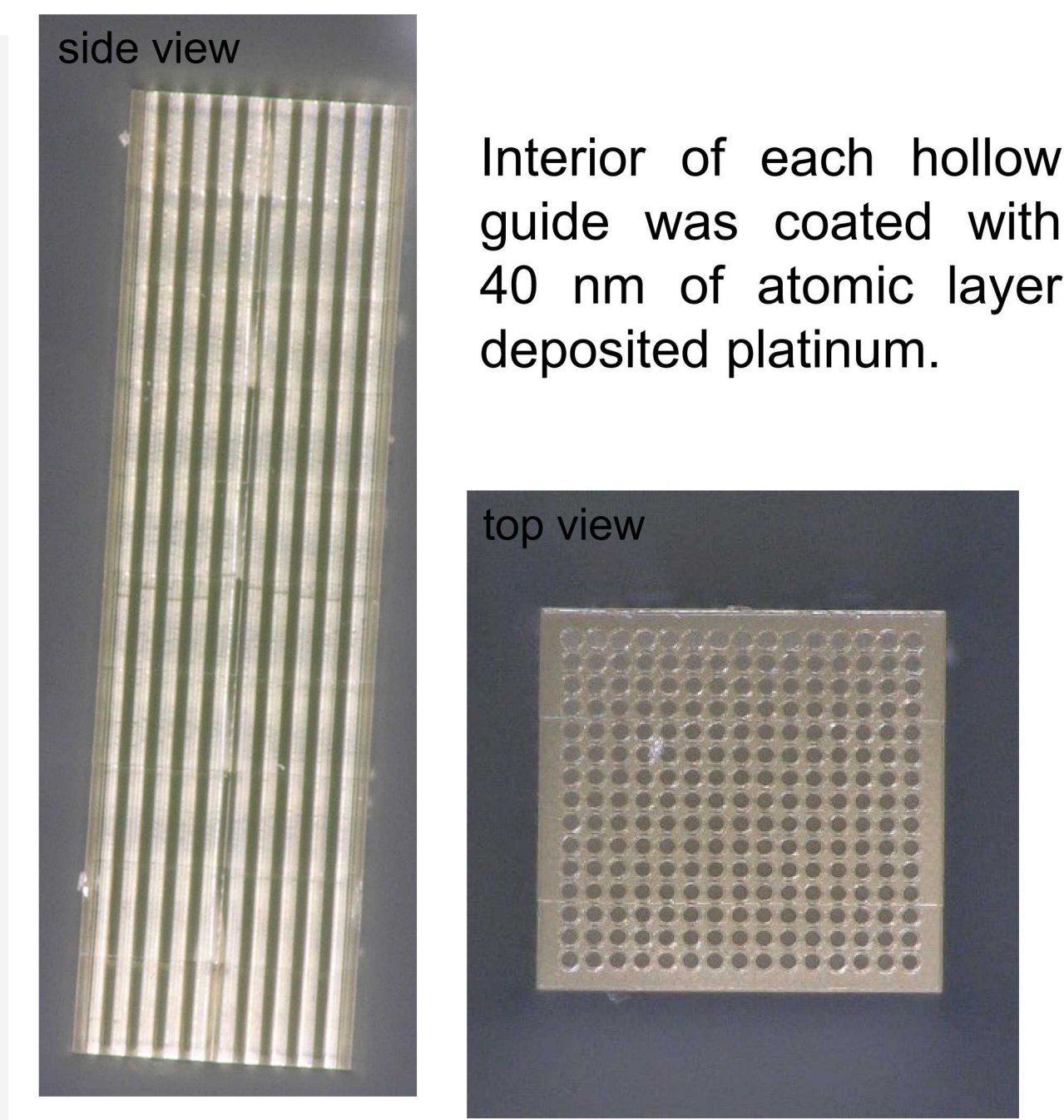


Results



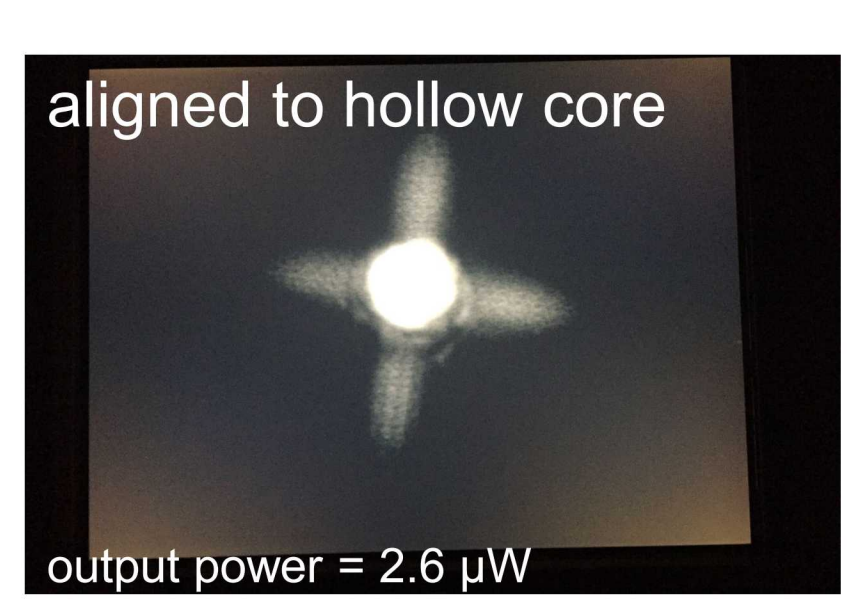
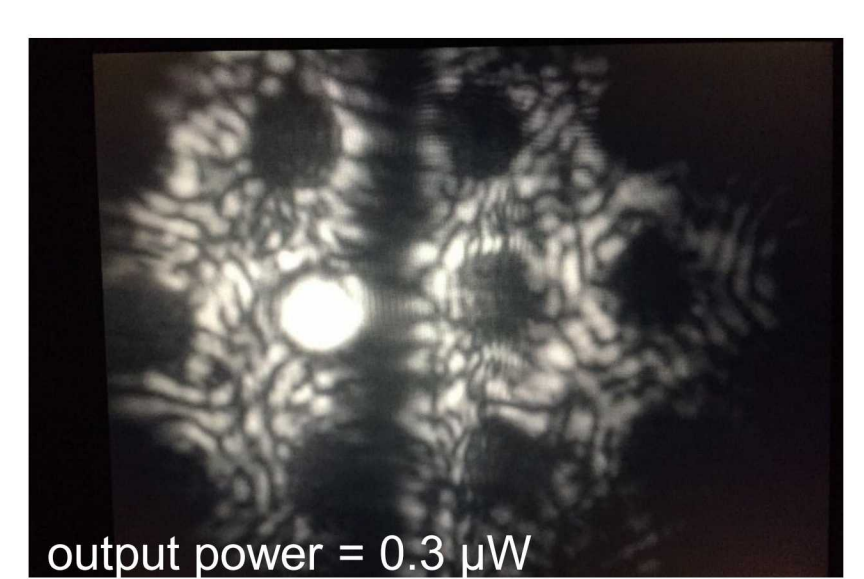
Vertical hollow fiber is 0.5 x 2 mm (w x h); 30 micron diameter cores with 50 microns pitch

vertical hollow light-guide



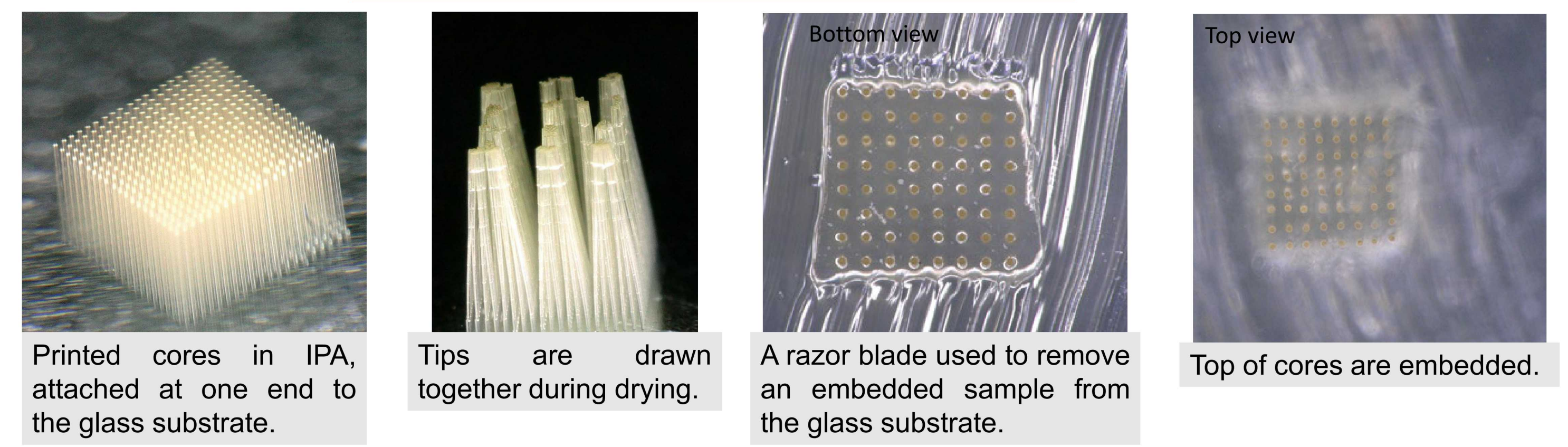
Interior of each hollow guide was coated with 40 nm of atomic layer deposited platinum.

Output near field image



Results

waveguides; PDMS embedded



Printed cores in IPA, attached at one end to the glass substrate.

Tips are drawn together during drying.

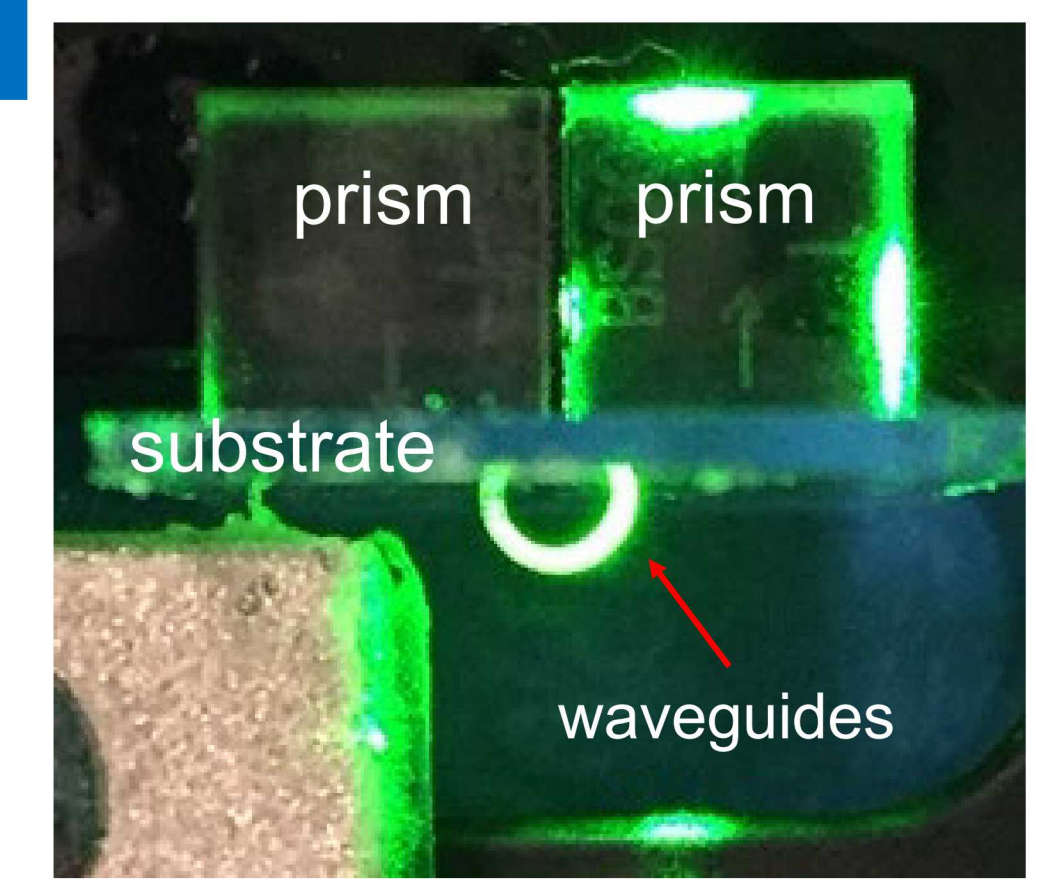
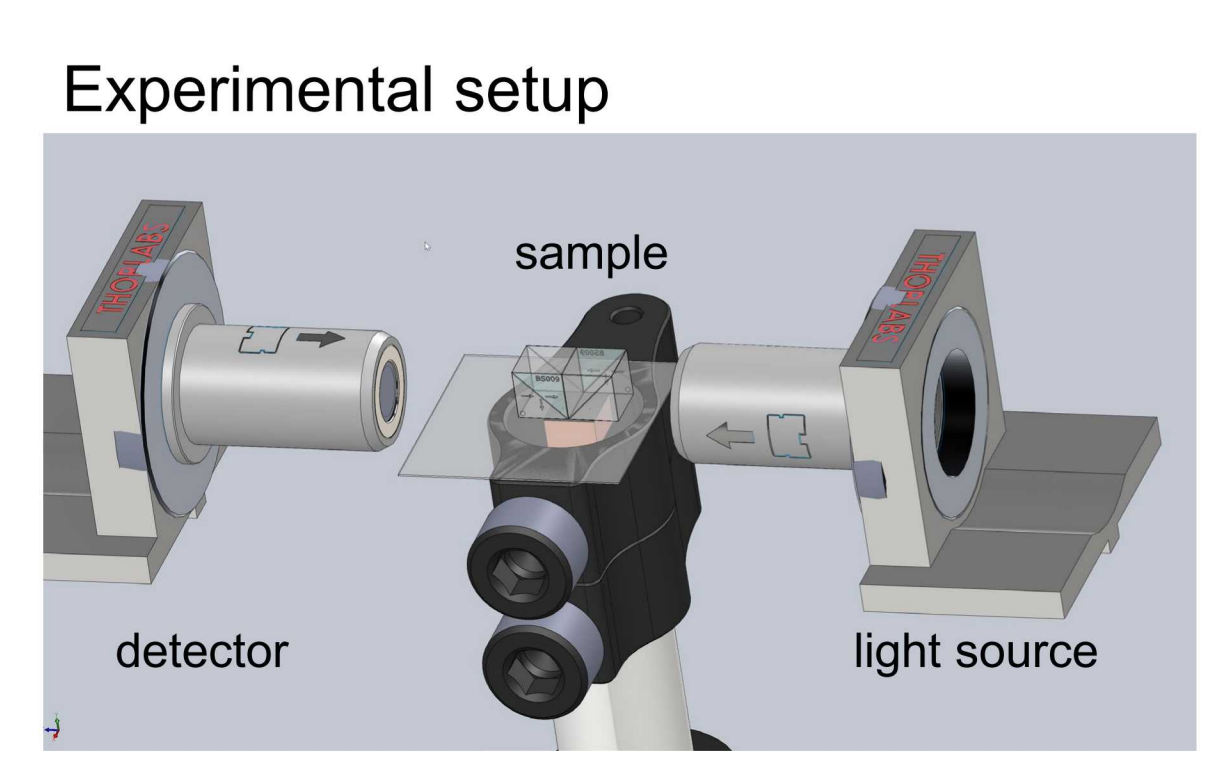
A razor blade used to remove an embedded sample from the glass substrate.

Top of cores are embedded.

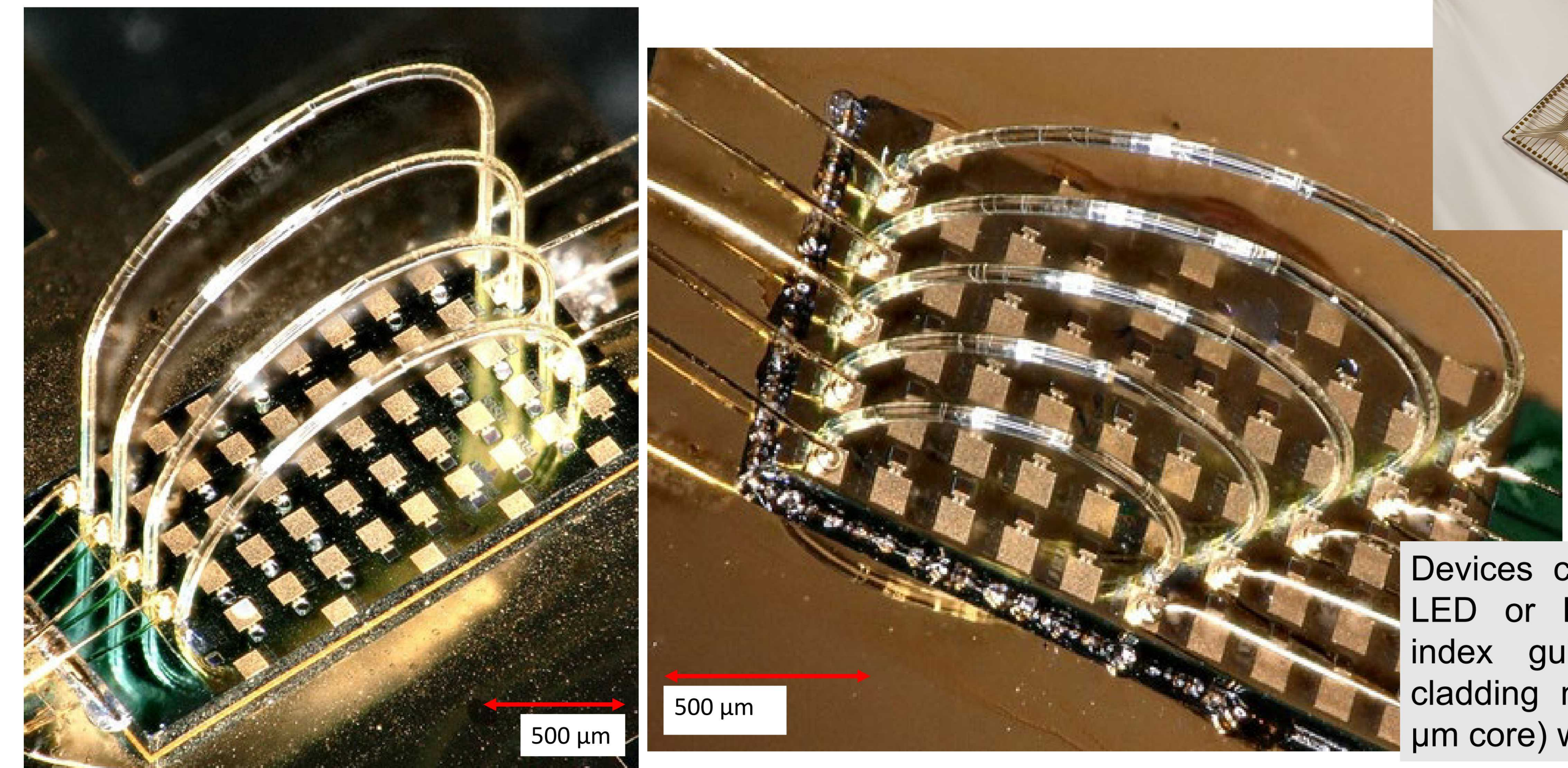
small diameter, supported waveguide



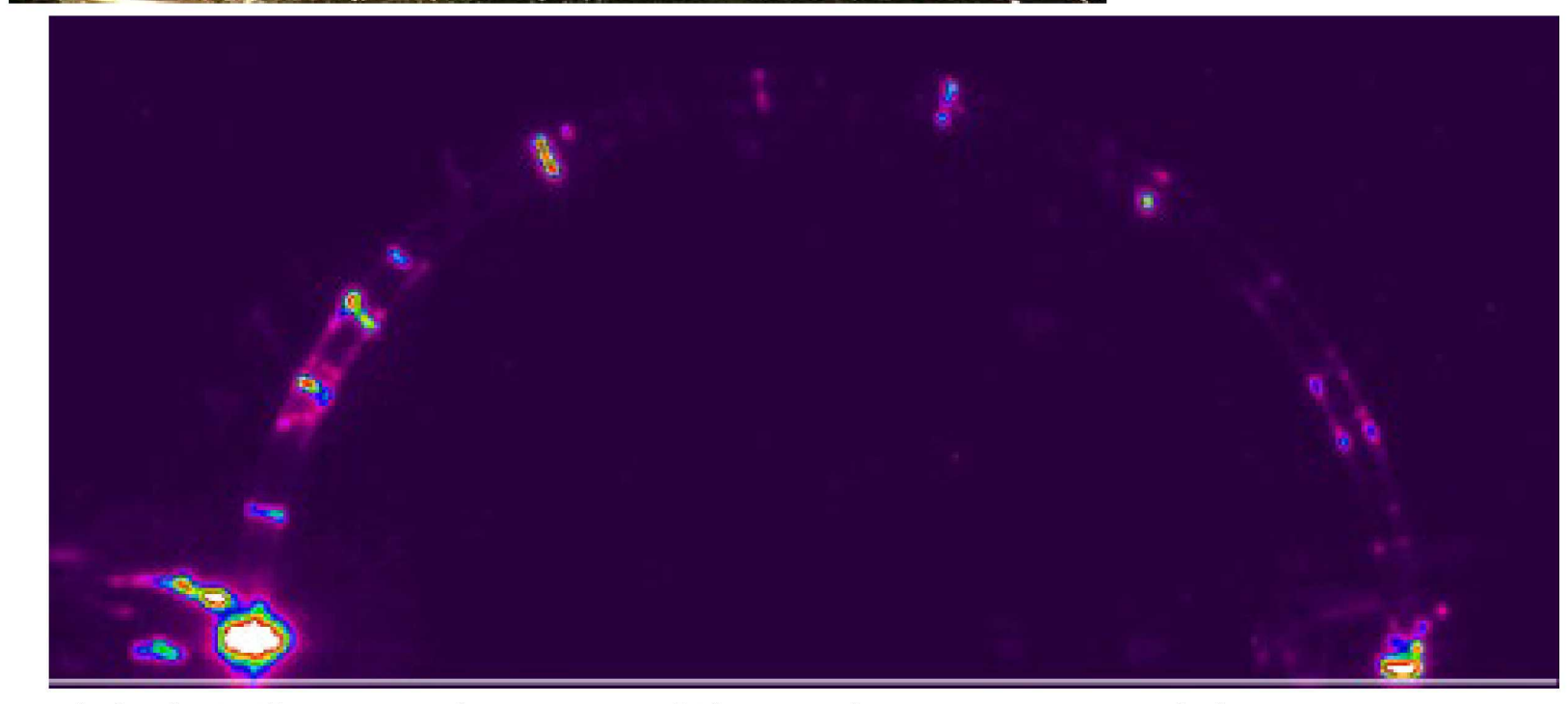
Radius of curvature 636.62 microns
Length of waveguide 2 mm
Waveguide diameter 5 microns



large diameter light guide printed on LED/PD

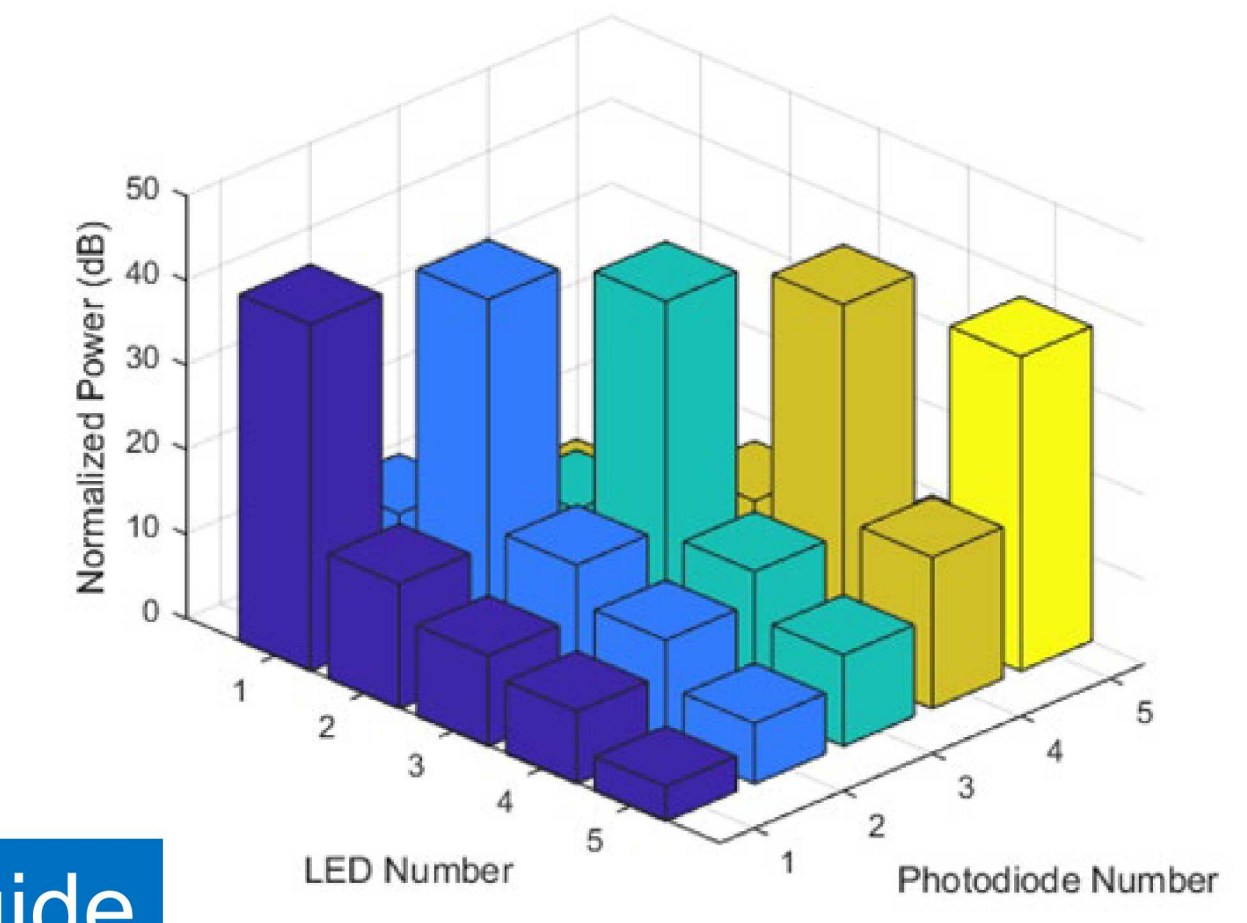


Devices can operate as LED or PD. Refractive index guided with air cladding multi-mode (50 μ m core) waveguide.



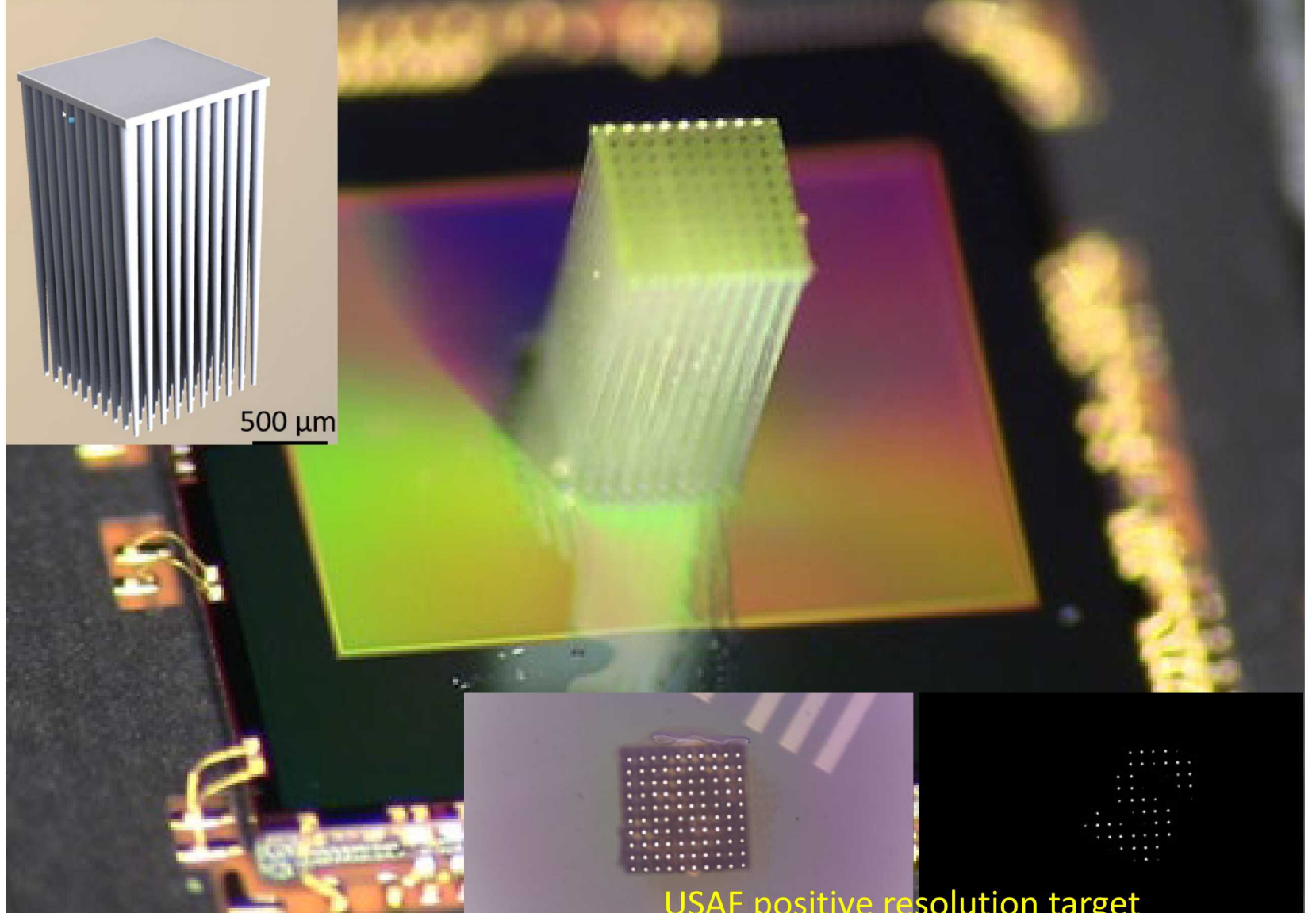
Light through a multimode waveguide

squishy waveguide



Significance

Tapered waveguides attached to Raspberry Pi camera (lens and filter/housing removed) with optical adhesive.



Here we have demonstrated printing of waveguides on active semiconductor devices, demonstrating the ability to align the printed waveguide to existing features while not disturbing nearby wire-bonds. Additionally, we show an optical concentrator device mounted directly to an imaging sensor (left). Overall, this project has laid a foundation to realize free-form and complex optical interconnects, thereby reducing the risk for future work in this area.

