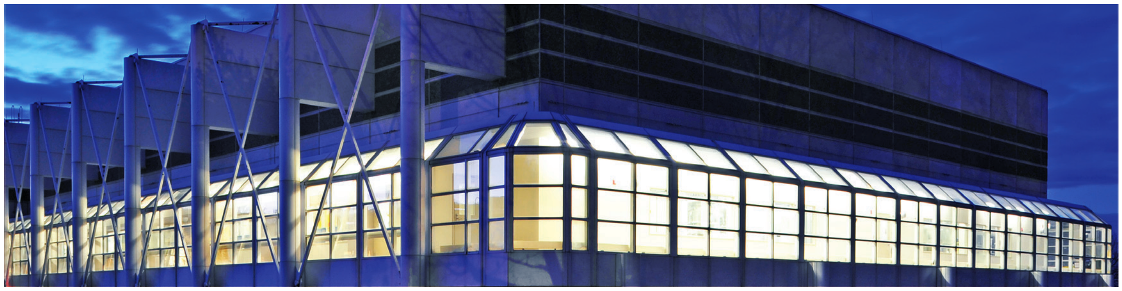
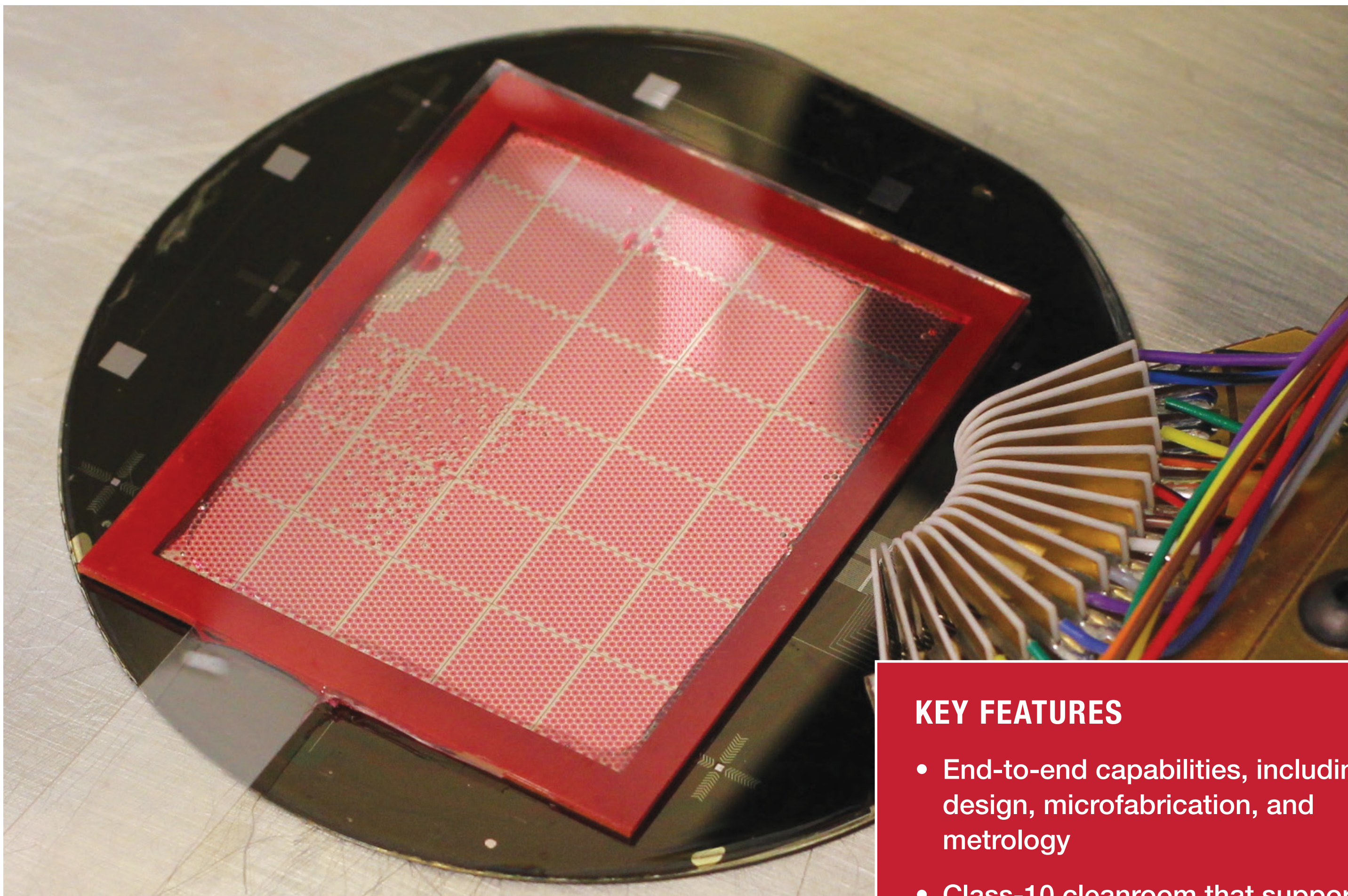
MICROELECTRONICS LABORATORY



SPOTLIGHT ON

Optofluidic Microsystems



Fully sealed liquid-pixel display made up of 500-μm-diameter circular pixels.

Lincoln Laboratory has developed processes for the design, fabrication, and demonstration of novel optofluidic microsystems. Our capillary-driven and electrowetting-controlled optofluidic devices find application in liquid lenses, displays, and optical shutters.

KEY FEATURES

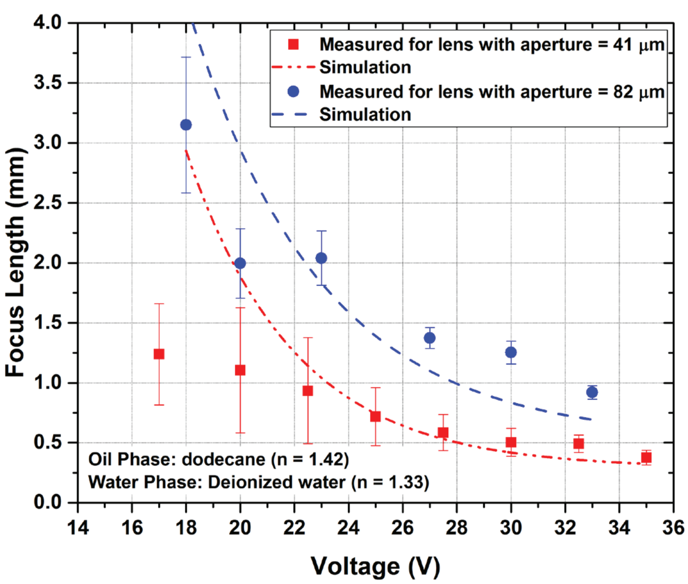
- End-to-end capabilities, including design, microfabrication, and metrology
- Class-10 cleanroom that supports fabrication over feature sizes from nanoscale to mesoscale, and large-scale wafer processing on diverse materials for substrates, thin films, and coatings
- Packaging and integration capabilities, including wafer-scale bonding, chip-level bonding, wire bonding, dicing and fluid handling

The Laboratory's process for developing optofluidic microsystems has several beneficial attributes:

- Device design and optimization with multiphysics software package
- Potential to use grayscale lithography and deep etching, including in silicon and silicon dioxide
- Dynamical metrology with application-specific optical test beds, including the potential to use multiple wavelengths

Liquid Microlenses with Adjustable Focusing and Beam Steering

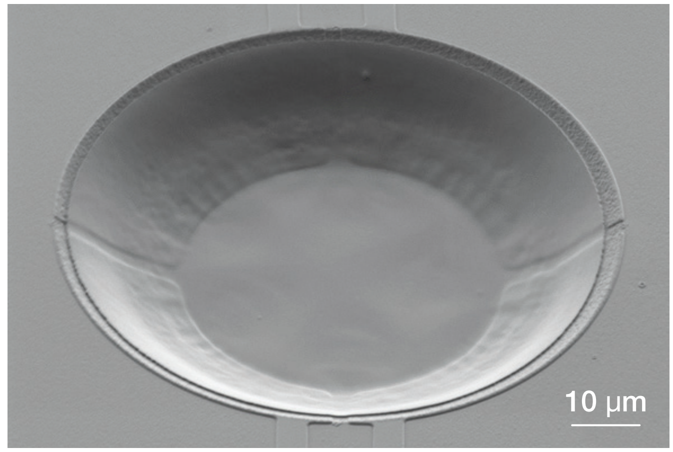
Recently developed electrically controlled micron-scale liquid lenses provide adjustable focusing and beam steering for use in optogenetic in vivo mapping of brain activity. The liquid lens is formed by the interface between two immiscible liquids contained in a 45° conically tapered lens cavity etch 15 µm deep in fused silica. Interdigitated electrodes are patterned along the sidewall of the taper to control lens curvature and tilt.



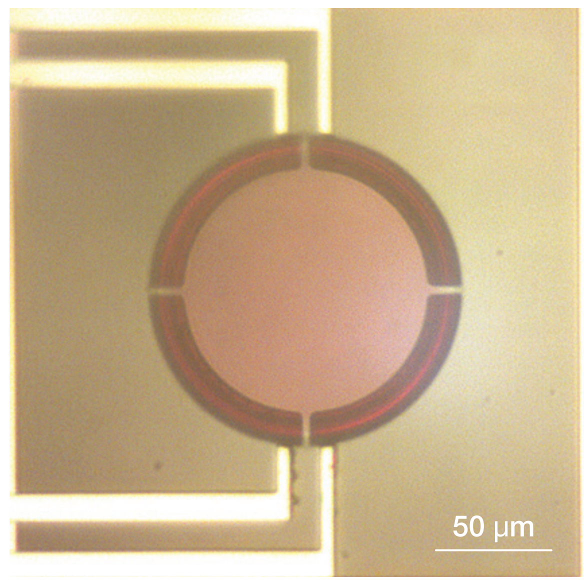
Focus length vs voltage results are shown for two different liquid microlens geometries. Data points are focal length measurements gathered using an optical measurement system developed at Lincoln Laboratory specifically for small-aperture lenses. Also included are numerical simulation results that were used to help guide the liquid lens design.

Recent Publication

S. Berry, S. Redmond, P. Robinson, T. Thorsen, M. Rothschild, and E. Boyden, "Fluidic microoptics with adjustable focusing and beam steering for single cell optogenetics," *Optics Express* 25(14), 16825–16839, 2017.



Development of micron-scale liquid lenses that integrates both focus and beam steering requires advanced microfabrication capabilities. This scanning electron microscope image of a 45° conically tapered lens cavity etched 15 µm deep was created using grayscale lithography. Additionally, metal electrodes and a hydrophobic film have been patterned just within the lens cavity, demonstrating the ability to pattern non-planar structures with high accuracy.



Liquid filling with the correct volume of liquids is a critical step for successful device operation. Shown here is a top-down microscope image of a liquid microlens containing oil (with red dye for clarity) just in the etched tapered cavity, surrounded by a water ambient.

TECHNICAL CONTACT

Shaun Berry
Chemical, Microsystem, and Nanoscale Technologies Group

MIT Lincoln Laboratory,
244 Wood Street, Lexington, MA 02421

sberry@ll.mit.edu

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