Forming fluids to focus photons

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Electrowetting as a means to form fluid surfaces has played a major role in optofluidics, in which fluid surfaces are used to dynamically modulate optical fields. Optofluidic optical systems have been developed for a wide variety of applications, including tunable lenses; fluidic waveguides; optical switches; liquid lasers; and tunable apertures. For the classical optical engineer, however, optofluidic devices have only had limited relevance, since optical imaging systems require components delivering high imaging quality and controlled aberrations. To address these issues, our recent work on fluidic optical components has yielded liquid-based micro-optical imaging systems which demonstrate tunability, ultra-compact design, and viability for real optical imaging applications.

We will present new concepts in aberration-controlled, multi-element tunable optofluidic devices and systems which advance the state-of-the-art in ultra-miniaturized tunable and adaptive optics. By combining concepts and technologies from micro-fluidics, micro-optics and micro-fabrication, a three-dimensional fluidic system has been realized inside a cylinder, as seen in Figure 1, using complex electrode patterns on its inner surface for highly-flexible electrowetting actuation. A variety of density-matched, immiscible liquids with optimized refractive and dispersive properties, all individually tunable, fills the tube and is used to generate a variety of optical functions. These include individual and multiple tunable lenses; astigmatism-tunable optics; variable and rotatable prisms; tunable apertures; and an all-fluidic zoom system, all with excellent imaging properties. These developments pave the way for the use of optofluidics in an increasingly broad spectrum of imaging applications.

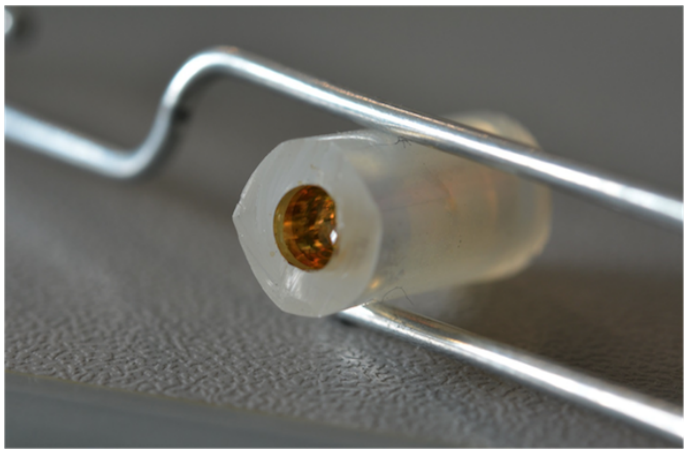

Figure 1: A complete electrowetting-actuated fluidic optical zoom system in a tube.