Program Digest, 2019 IEEE International Ultrasonics Symposium (IUS)
Glasgow, Scotland, October 6-9, 2019

Acousto-Optic Modulation of Water in a Microfluidic Channel Using Planar Fresnel Type GHz Ultrasonic Transducer

Adarsh Ravi[1], Mamdouh Abdelmejeed[1], Justin Kuo[1], Amit Lal[1]
[1]SonicMEMS Laboratory, Cornell University, Ithaca, USA

Background, Motivation and Objective

Interaction of light with media perturbed by acoustic waves find applications in various optical signal processing devices. The photoelastic effect which causes a change in the atomic lattice spacing thereby changing the dielectric constant and the refractive index of the media is not only used to characterize elastic properties of solids, fluids and biological tissues, but are also used in acousto-optic modulators. As the wavelength of high frequency GHz ultrasonic waves are comparable to the wavelength of light, the light beam can be scattered through relatively larger angles. This paper describes the photoelastic effect in water, induced by a planar CMOS compatible GHz Fresnel type transducer. Using an ultra-high frequency (UHF) vibrometer, we were able to determine the change in refractive index and the optical phase modulation in water confined within a microchannel.

Statement of Contribution/Methods

The AlN based GHz transducer, uses focusing transducers placed in a Fresnel lens configuration (Fig.1a). The bulk acoustic waves propagate through the silicon substrate adding in phase at the focus. A five element Fresnel lens transmit transducer of outermost radius 165μm on a 725μm thick silicon wafer was used. A 2um radius transducer is placed on the opposite side of the wafer at the focus. A 27μm high PDMS microchannel fabricated using soft lithography process was attached such that the receive transducer was enclosed. Polytec UHF vibrometer was used to determine the surface displacement on the receive transducer when the microchannel was filled with water and with air.

Results/Discussion

The peak displacement with and without water in the microchannel was measured (Fig. 1b, c). Since the UHF vibrometer is sensitive to changes in the refractive index of the media, the change in refractive index was determined for green light (λ=532nm) and water n_0=1.335 at 20℃. When the Fresnel transducer was driven at 1.08GHz, 5V_p RF signal, we observed a change in refractive index (Δn) of 1.0517x10^{-5} and it varies linearly with the applied voltage. Further, the peak optical phase difference was calculated to be $\frac{\pi}{334}$ radians and modulates at 1.08GHz in water.

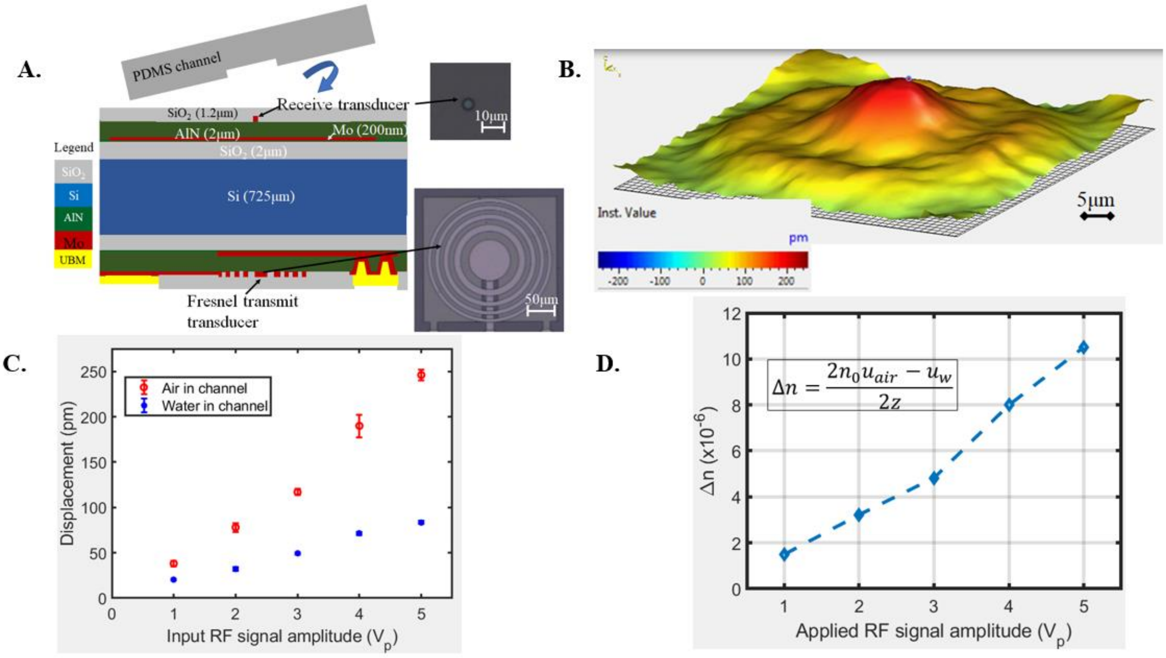

Fig.1: A. Schematic of the Planar AlN/Si Fresnel transducer with images of the fabricated devices; B. 3D surface displacement plot on the receive transducer; C. Peak displacement vs. applied RF input; D. Change in refractive index for different applied voltages