Design of Locally Resonant Phononic Crystal to Manipulate Acoustic Waves, PS&ED Cluster 2014-2015

Graduate Student Fellows:
Xiang Chen, Jiadong Deng, Kenan Li

Faculty Advisors:
Oluwaseyi Balogun, Wei Chen, Cheng Sun

Academic Disciplines:
MECHANICAL ENGINEERING

June 09, 2015

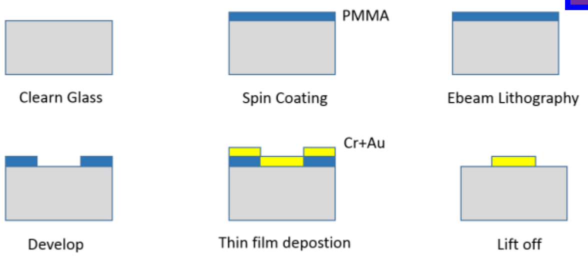
RESEARCH OBJECTIVE

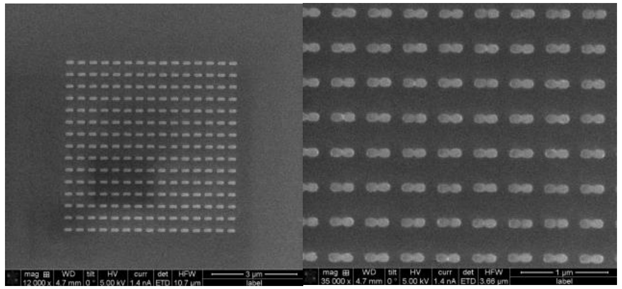
Ultrasound imaging plays a critical role in medical diagnosis and therapy. Basically, it relies on detection of mechanical properties of acoustic wave propagating in material such biological tissues, and has been irreplaceable because of its real time imaging capabilities, nondestructive properties and safe of use for both doctors and patients. During the past few decades, the frontiers of high frequency ultrasound has been greatly expanded with its tremendous applications in dermatology, ophthalmology and intravascular imaging. Piezoelectric transducer arrays have been widely used with its frequency operating at less than 10MHz, but it is extremely difficult to generate acoustic wave with its wavelength as small as few micrometers to nanometers. The limitations of piezoelectric transducer provides motivation for the investigation of another transducer: optoacoustic transducer. In this project, we propose to design two kinds of optoacoustic transducers based on pattering of gold nanoparticles on glass substrate: one for ultrafast ultrasound imaging, and another with the aim of generating focused acoustic wave.

Optoacoustic Transducer

Ultrafast optoacoustic transducer

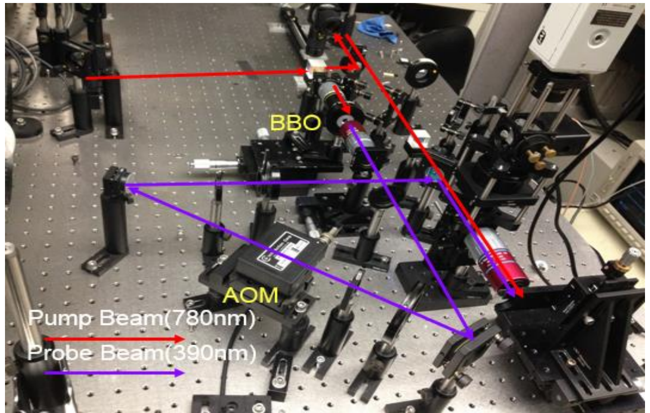
Sample Fabrication





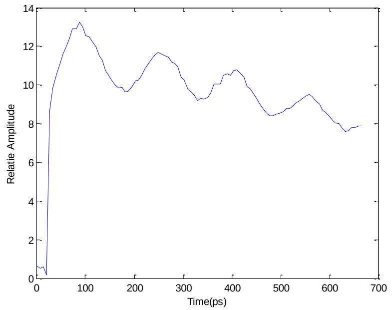
- Probe pulses (wavelength 780 nm, duration 150 fs).
- Pump pulses were generated by feeding part of the pulses into a BBO crystal.The wavelength of pump pulses was 390nm
- Both pump and probe pulses were focused with a numeric aperture (NA) of 0.65 objective on the sample surface.
- The optical delay length of the probe pulses was varied with micro-positioning motorized stage.

Experimental Characterization



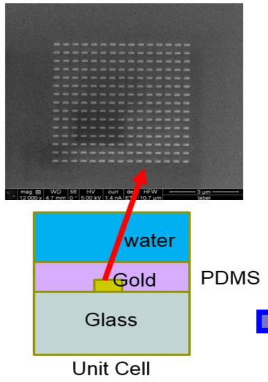
Experimental Results

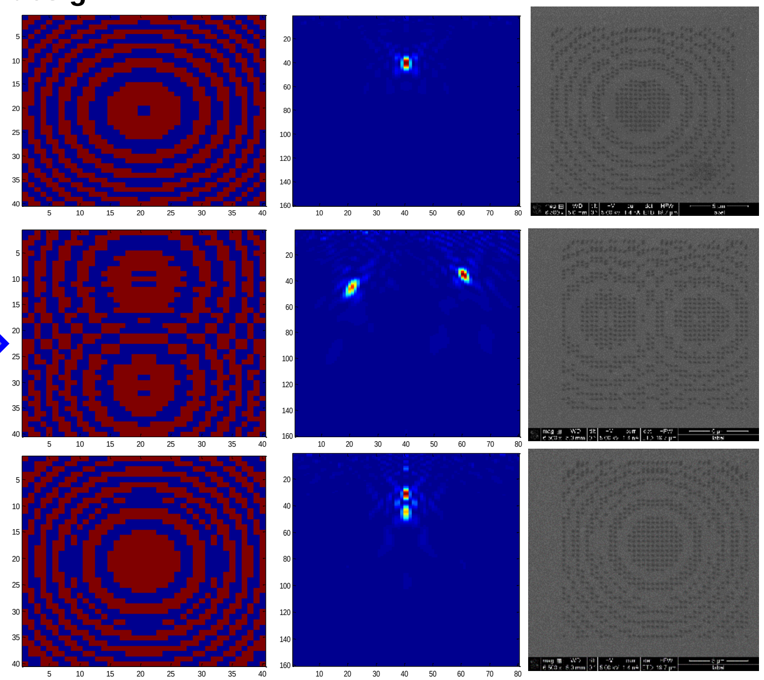
- The Fourier transform of this time trance yields the frequency response (6.6GHz) of the vibrating nanostructure:



Focused optoacoustic transducer

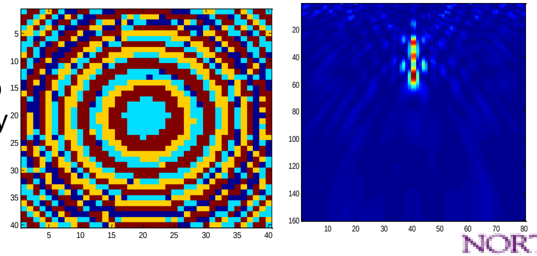
Topology optimization design





- Optoacoustic transducer designed to concentrate acoustic wave at different distinct locations.

- we also designed optoacoustic transducer having more than one type of phase element, to demonstrate the tenability of optoacoustic transducer with different polarization illumination condition.



NORTHWESTERN UNIVERSITY