Focused Acoustic Wave Generators using Thin Film Photolithography
Jiankun Wu, 2021

This summer I was very fortunate to work with Professor Msall on the properties of surface acoustic waves (SAW). SAWs, also called Rayleigh Waves, were discovered by Lord Rayleigh in 1885. Compared to bulk acoustic waves which take place in the entire crystal body, SAW are strain waves that propagate only at the surface. Interdigital transducers (IDTs), discovered by White and Voltmer in 1965, consist of interlaced fingers. The application of AC electric fields to the fingers can launch waves perpendicular to the finger orientation (Fig.1). The purpose of my project is to understand how to best design IDT patterns to produce the desired waves. To begin, I studied Mathematica models of acoustic waves and read textbook excerpts, graduate students' thesis and some published physics research papers. In the Bowdoin clean room, I learned the photolithography procedures used to make IDT patterns (Fig.2) and tested the new metals deposition system. I also visited the Paul-Drude-Institute in Berlin. For three weeks, I worked in Dr. Paulo V. Santos' *Control of Elementary Excitations by Acoustic Fields* group. PhD student Yi-Ting Liou taught me about the set up and the operation of the interferometer system that measures the SAW displacement of a material surface. A half-silvered mirror splits the incoming light into two identical beams, which then travel different paths, and are reflected by different surfaces. The detector sense changes in the path difference for the two reflected beams and gives us data that can be converted to the images of SAWs (Fig.3).

Lithium Niobate ($LiNbO_3$) is an excellent substrate for our experiments. The main difficulty in our research was the optimal IDT shape to produce the best focused SAWs, considering the limitations posed by diffraction. Fig.4 shows the focused wave front generated by a curved IDT. The center region shows the waves are concentrated in a small focused region. Further experiment is needed to explain the influences of IDT shape, AC frequency and substrate material on SAWs and decrease the impact of noise. I hope to continue studying this topic with Prof. Msall in the next two years and be better versed in the theoretical mechanism behind it.

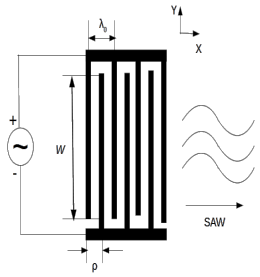


Fig.1 Single Finger IDT

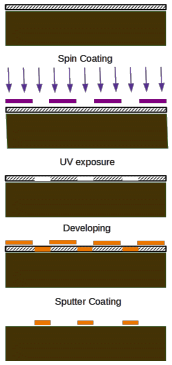
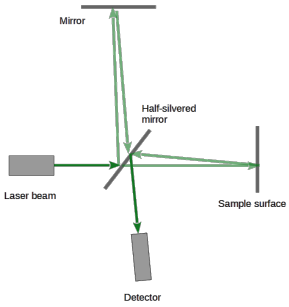


Fig.2 Photolithography Procedure



g.3 The mechanism behind
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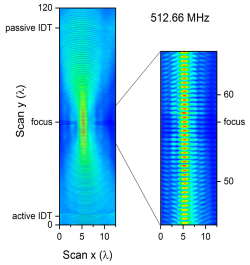

Fig.4 The wave front in a focused region (graph credited to Prof. Msall).

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Reference:
[1] James P. Wolfe. *Imaging Phonons: acoustic wave propagation in solids.* Cambridge University Press, 2005.
[2] Enrique J. Galvez. *Gaussian Beams.* Colgate University: 2009.