Terahertz & Infrared Photonic Crystal Structure

CNF Project # 1183-03
Principal Investigator: Yujie J. Ding

Abstract:
Photonic crystal structure is a promising candidate for manipulating light. Previous works are most focused on infrared photonic crystal. For the Terahertz (1 THz = 10^{12} Hz) far infrared range, which is of great interest to people for its application in bio-sensing, imaging etc., only a few result has been obtained [1]. In this project, we are working on designing and fabricating 1 D (Bragg reflector) and 2 D photonic crystal structures for THz frequency range. Apart from THz photonic crystal structures, we are also interested in fabricating 2 D photonic crystal slab structures for 1.55 µm infrared range. This structure is designed to demonstrate a low loss sharp bending waveguide to be applied for optical interconnect on single Si chip.

Summary:
In the previous year, we worked on optimizing both the design and fabrication of our photonic crystal structures. For our THz 2 D photonic crystal structures, we selected high resistivity Si wafer with a thickness of around 300 µm, which is thinner than the wafer we used before. We also selected new patterns for the 2 D photonic crystal. Besides etching circular air holes to form either the square lattice or hexagonal lattice which we tried before, we tried some new structures with square shaped air holes arrayed in square lattice and hexagonal shaped air holes arrayed in hexagonal lattice. We also optimized the parameter of the hole diameter and the lattice constant to achieve a broader photonic bandgap. The fabrication process of our THz photonic crystal remains almost the same; the major steps are thermal oxidation to grow SiO\(_2\) mask layer, HTG photo lithography, PT72 SiO\(_2\) etching, and Unaxis 770 Si through wafer deep etching.

For the 1.55 µm infrared photonic crystal slab waveguide, we selected silicon on insulator (SOI) wafers with a thicker SiO\(_2\) insulating layer. This will help to reduce the leakage loss of the SOI slab waveguide. In fabrication, we used PECVD to deposit the SiO\(_2\) mask layer. Unlike the thermal oxidation method, deposition will not change the top Si device layer thickness. Since the feature size of this structure is sub-micron (around 500 nm), electron-beam lithography was selected to write the patterns on the wafer. For SiO\(_2\) mask etching, we used the PT72 and for top Si layer etching the PT770 is selected.

From our experimental characterization, we have identified the photonic bandgap for both of our 2 D THz photonic crystal and infrared photonic crystal structures. Further measurement and optimization of structures are still expected.

Reference:
**Terahertz & Infrared Photonic Crystal Structure**

CNF Project # II83-03  
Principal Investigator: Yujie J. Ding  
Users: Hongqian Sun, Wei Shi  

Affiliation: Electrical & Computer Engineering Dept., Lehigh University  
Primary Funding: State of Pennsylvania  
Contact: yud2@lehigh.edu, hos4@lehigh.edu, wes4@lehigh.edu