Surface Plasmon Enhanced Silicon-on-Insulator Metal-Semiconductor-Metal Photodetectors

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Abstract
Surface plasmons and optical resonant modes were studied in complex grating structures. It was shown that surface plasmons are not responsible for anomalously large transmission and that instead, waveguide modes are responsible. Polarization independent transmission in grating structures is described along with optoelectronic and photonic device applications.

Summary of Research
During the last year, several significant accomplishments were made in this project. While accomplishments in device fabrication were made, the most important advancement was made during our studies of surface plasmon and optical modes in complex lamellar grating structures. It was found that what had previously been thought as responsible for the anomalously large transmission in periodically perforated structures, namely surface plasmons [1-6], was not responsible and that the phenomenon is simply caused by another type of mode; waveguide modes [7, 8]. Because waveguide modes produce this phenomenon, both polarizations and randomly polarized light can experience anomalously large transmission.

This result is important not just on a theoretical basis but especially important when it comes to using this phenomenon to develop optoelectronic and photonic devices because light incident on a photodetector is generally unpolarized. Our research last year fully and accurately described the mechanisms for anomalously large transmission, and how the energies at which this transmission occur for each wavelength can be tuned by adjusting various parameters of the device.

The three cases, shown in Figure 1, of anomalously large transmission, were considered. Case 1 was the commonly observed case of TM polarized light being entirely transmitted while TE light is reflected. Case 2 was the opposite where TE light is transmitted and TM light is reflected. Finally, Case 3, which had not been observed, was where both TE and TM polarized light can simultaneously be anomalously transmitted [8].

The ability to have both polarizations transmitted is a significant advancement and opens up this area of research for the development of numerous device applications. Currently in this project, we are fabricating the structure shown in Case 3 at the CNF to experimentally verify or theoretical results. We are also collaborating with research groups at the University of Exeter to demonstrate these same phenomena in the microwave spectral region.

References
Figure 1: The three different cases of anomalously large transmission in 1-D metal gratings described in this paper. Note that the cross-sections of the gratings are shown.