Optical properties of Plasmonic nanogap structures fabricated with nanomasking technique (E, Herzog)

Plasmonics, which is the study of electron oscillations on surfaces, can benefit a variety of optical applications by enabling highly sensitive optical detectors and improving efficiencies in photodetectors, nano-lasers, and photovoltaic devices. Nanostructures can tune and magnified the amplitude of the plasmonic electron oscillations which generate very strong localized optical intensities; it is these strong field which can be utilized to improve optical applications. Nanogaps between metal nanostructures can increase the optical fields by order of magnitudes and can provide more tunability in the optical frequency of these devices. Fabricating these nanogaps can be challenging; however, the Herzog Lab has unique capabilities and innovations which can overcome this challenge.

For this proposal the REU student will learn about plasmonics and the unique nanomasking fabrication method[1] which can fabricate sub-10 nm gaps at large scales. This project will continue to explore the limits of the nanomasking technique to understand more fundamental physics and optical properties of unique nanogap structures so future scientist can utilize these new structures in the most useful way. There is still many application and new designs to explore which can be made with this technique. The ongoing project consists of three main components: (1) structure modeling and design, (2) nanofabrication, and (3) optical characterization. Optical modeling is executed using a finite element method computational electromagnetic model. Previous NSF REU students have had great success quickly learning this modeling technique and have produced relevant results[1,2,3,4] with the most recent results shown in Fig. N below: simulating the and optimizing the silicon dioxide layer for an optical sensor substrate.

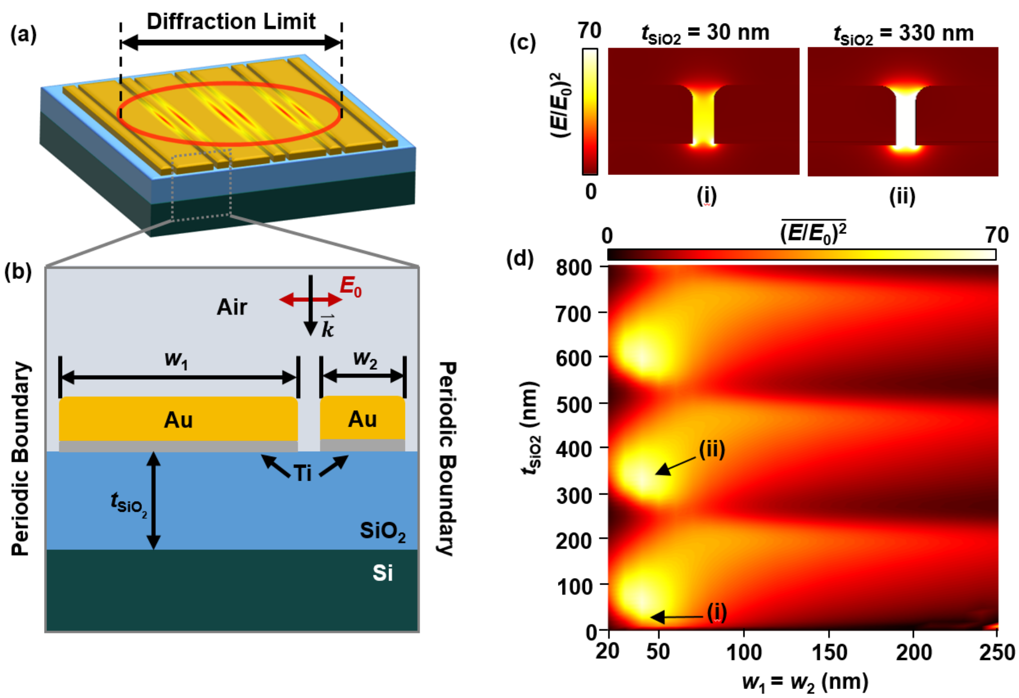

Figure – Simulated results of plasmonic hotspot in nanogap region. (a) Proposed plasmonic sensor substrate (b) model and cross-section of device, (c) calculated hotspot in nanogap (d) hot spot intensity as function of SiO_2 thickness and gold (Au) wire width. (source: [5])

The example above designs and optimizes a 2D plasmonic array of nanogaps. Future work in this proposed project with explore 3D designs of these structures and begin fabricating the devices.

The REU students will have the opportunity to learn the nanomasking fabrication technique in order to create the new plasmonic devices that they design. The process will give the student experience and knowledge in spin-coat processing, electron beam lithography, electron beam evaporation, and other chemical processes. After fabricating the structures, the student will also have the opportunity to gain experience with device characterization with electron imaging and optical spectroscopy in order to verify the results and design optimization. This include experience with scanning electron microscopy, cathodoluminescence, photoluminescence spectroscopy, dark field scattering spectroscopy, and Raman spectroscopy.

After learning these valuable research areas that span from computation to experiments, the REU student will have a good background knowledge for future research in theory or experimental work. Further, many of the NSF REU in the Herzog lab have had the experience to give a presentation at a national conference and publish their results. Therefore, the student will also gain scientific communication skills throughout the experience.

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