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**Metal Nanorod Structures: Electromagnetic and quantum confinement properties**

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The purpose of this work is to study a modified rectenna energy harvesting scheme based on metal-insulator-metal (MIM) nanorod device structures. We are studying two aspects of the MIM devices: the electromagnetic plasmonic response and the electron quantum confinement in a metallic nanorod. We present theoretical results based on Surface Plasmon Resonance (SPR) theory and the electron density of states.

Objective/Motivation
This project is focus on the application of MIM nanowire for direct conversion of solar spectrum to electrical energy. The ultimate goal of our project is a theoretical understanding of the energy harvest efficiency for the nanowire MIM structures. First, we calculate the electromagnetic field inside and around the nanowires. This field will be maximized and subsequently inserted into our calculations for electronic quantum tunneling through the insulating barrier. The results of these steps will be necessary inputs to determining the solar energy conversation efficiency of our MIM nanowire rectenna model. However, our results can also be modified to design a new generation of photo detectors. Finally, we would like to make an experimental design with an array of nanowires composed of two different metals on top and bottom and a thin insulator between them (see Fig. 1). The asymmetry in the electron tunneling current through the insulating junction due to the different work functions of each metal.

Methodology/Material
- Calculate the field near a SPR of metallic nanorods (Ag, Au, Cu, etc) based on Mie theory is studied for different geometries and physical environments (Fig. 2 and Fig. 3).
- The electron density of states is calculated for the nanowire geometry. Combining the density of state with the Fermi-Dirac distribution produces very sharp electron energy distribution (Fig. 4).
- Perform computer simulations based on the SPR excitations. The SPR of metallic nanorod can be controlled by changing the ratio of its minor to major axes. The stronger resonance is due to the field along the z-axis. The two resonances overlap in the limit of a sphere (Principal axes ratio: $r=1$).
- Determine the localized field enhancement at the insulator junction for an ellipsoidal MIM nanorod. We note that the strongest field confinement is at the tip of the nanorod based on SPR theory as in Fig. 5.

Conclusion
Simulation method resulted in the electromagnetic response of an ellipsoidal metallic nanorods. From simulated result comparable with Matlab and Comsol software that the strong field confinement at the tip of the nanorods with the correct magnitudes.

Future work
The programs will continued the simulations by using COMSOL which is a finite element method (FEM). We will calculate the electromagnetic field inside and around the nanowires. This field will be maximized and subsequently inserted into our calculations for electronic quantum tunneling through the insulating barrier as illustrated in Fig. 6. The WKB approximation method will be used to calculate the electron tunneling probability between two metals. We expected the tunneling probability is dependent with applied field of forward and backward direction.