Absorption Enhancement in Silicon Solar Cells due to Surface Plasmons of Nanotoroids
Nathan Burford and Magda El-Shenawee
Electrical Engineering Department, University of Arkansas, Fayetteville, AR 72701, USA

Abstract
Enhanced absorption in silicon is needed to improve the efficiency of solar cells. Analysis of Silver nanotoroids placed on top of a silicon substrate demonstrates enhanced absorption, will be presented. The method of moments model and Ansys® HFSS are employed to compute the near electric fields absorbed in silicon substrate. The results show surface waves represented by large electric fields normal to the silicon surface, and decayed as it gets deeper in the medium.

Background of Nanoantennas
Antennas made of noble metals such as gold or silver have the ability to sustain surface plasmon polarizations at the boundary between the metal and a dielectric, when excited at optical frequency. A combination of the antenna shape resonance and the surface Plasmon resonances will contribute to the antenna performance to exhibit strong enhanced local fields.

Motivation
Intensive research efforts are currently underway for using plasmonic nanoparticles to increase the light absorption in photovoltaic (PV) devices [1][2]. The reported results in the literature show the improved absorption in silicon using nearby nanoantennas were employed [3]. Although numerous works were published reporting the enhanced localized near fields due to these surface plasmon, work was focused on the red and blue shift of these plasmon in air. While the majority of published work focused on the assumption of infinite arrays of nanoparticles, less work was reported on characterizing the absorption in silicon due to finite number of nanoparticles [3]. Modeling is a necessary tool to help understand the interactions between the nanoparticles and the silicon. The goal of the current work is to use computational electromagnetics to investigate the effect of surface plasmon of nanotoroids on the absorption in solar cells.

Statement of the Problem
In this work, computational methods are used to investigate the plasmonic behavior of silver nanotoroids located on a layer of silicon. Two methods of analysis, the method of moments (MoM) surface integral equation and Ansys® HFSS are used and compared. Effects of the silicon layer on the shift of the resonant nanotoroid frequency are investigated. In addition, a comparison is made between nanotoroid and disk-shaped nanoparticles tuned to the same resonant frequency.

REFERENCES