Undergraduate Student Mr. Eric Mannarino

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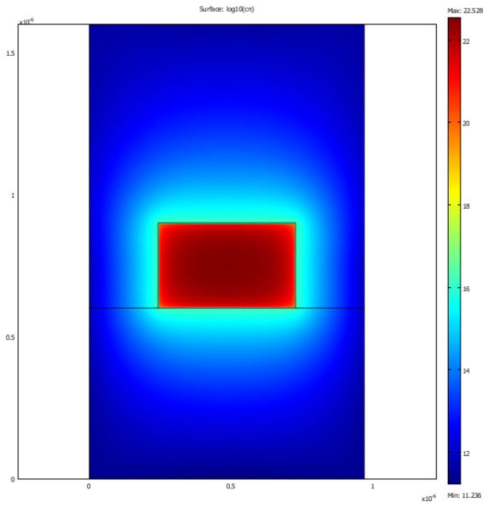
NSF Undergraduate Summer Internship under Prof. Filippo Capolino:
Studying charge carrier distribution in an OLWA device using COMSOL

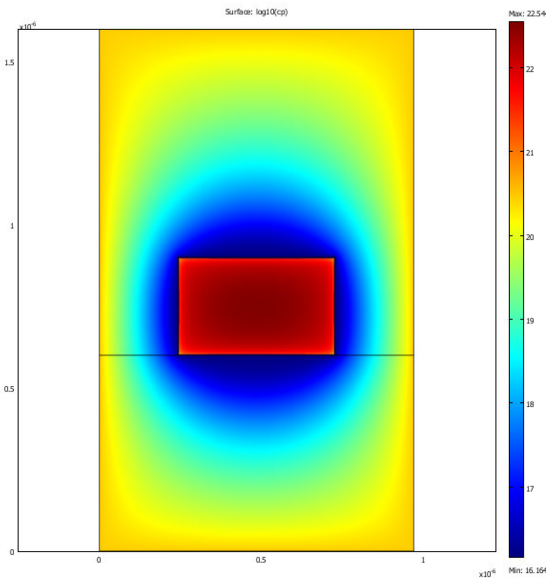
I met Professor Filippo Capolino during the Spring quarter while he was my professor for my circuit analysis class. One day after class, he introduced his research topic and discussed possible internship options, and I inquired into his research topics. Up to that point I had an opportunity to explore research opportunities in power systems design, especially subject related to solar energy, but his short explanation about the OLWA research sparked my interest. I believe that the opportunity to do research into OLWA devices will help me garner a greater understanding of CMOS compatible antennas as well as the operation of semiconductor devices in general. I hoped to take the knowledge that I gain from this project and extrapolate it to my interests in improving the efficiency of solar panels.

Since I have yet to take any semiconductor or electromagnetics classes in my course of study, I have spent the last couple months studying the subjects under the supervision of the graduate student, Caner Guclu, I had a chance to understand fundamental concepts and also I had an opportunity to pass that knowledge to high student interns. Along with graduate students we helped them work on their objective while I was gaining the knowledge to complete my modeling project. The experience of teaching to the high school students helped to reinforce my understanding of the subject, as well as to give me a better appreciation of the difficulties of being a teacher. It requires a lot of time and patience to explain difficult concepts.

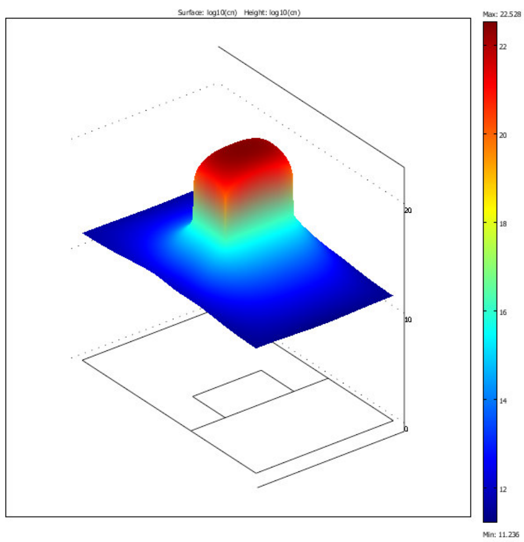
Toward the end of my internship, I channeled my efforts to use COMSOL 3.5a to model a single unit cell of proposed OLWA antenna in two dimensions. This effort helped me to learn the functionality and use of COMSOL as a modeling platform, as well as to be able to apply the concepts and mathematics that I have learned to a computational model. The initial objective was to model carrier distribution through the unit cell's silicon perturbation to determine that they are adequately spaced.

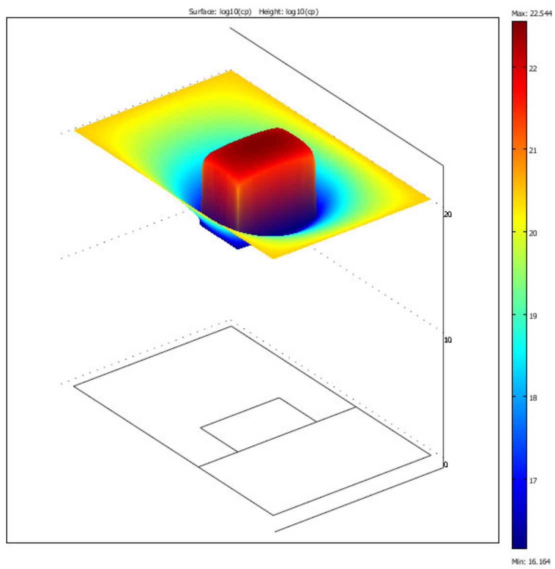
For instance, the following graphs (Fig1-Fig4) show the $\log_{10}$ of the electron (cn) and hole (cp) carrier concentrations in a unit cell. The graphs themselves are representative of what the expected carrier distribution should be. Actual results may differ from my estimations illustrated in graphs nelow. The difference mainly arises from the lack of accurate information optical and electrical parameters of dielectric I used in my calculations. As a first order estimate the properties of silicon nitride were estimated based on silicon dioxide instead of silicon nitride parameters. This proves sufficient for an initial modelling, but more accurate numbers are desired in a more accurate study.





Figures 1 and 2 show the logarithmic count of negative charge carriers with some generation rate in the silicon perturbation. This generation rate creates pairs of electrons and holes, which diffuse out of the perturbation.





Figures 3 and 4 show the corresponding logarithmic count of positive charge carriers with the same generation rate (holes and electrons are created equally).