NDnano Undergraduate Research Fellowship (NURF)
2014 Project Summary

1. Student name: Santiago Martínez

2. Faculty mentor name: Prof. David B. Go

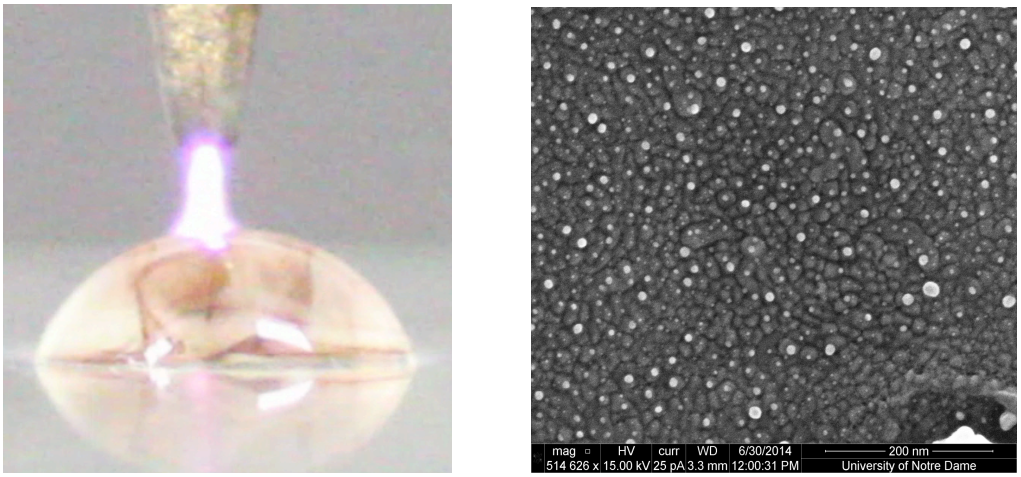
3. Project title: Synthesis of Silver Nanoparticles in Microdroplets using a Plasma Jet

4. Briefly describe any new skills you acquired during your summer research:
During this summer I learned to improve a setup for an experiment making it able to control more variables while still maintaining its simplicity. I learned the importance of refining what you are looking for while still keeping in mind the overall view of the experiment and its goal. To do this, I learned how to use a basic analysis to model my system. Finally, I improved my data analysis skills and realized how crucial this step is on any kind of research.

5. Briefly share a practical application/end use of your research:
The ultimate application of my research is to synthesize nanomaterials *in place.* By using a micro plasma jet integrated with an inkjet or 3D printing, it will be possible to synthesize a nanomaterial in any desired pattern in, for example, a nanocircuit.

Begin two-paragraph project summary here (~ one type-written page) to describe problem and project goal and your activities / results:

Recently it has been shown that plasmas can be used to synthesize nanoparticles in solution, and if done in the right fluidic system, it could also potentially be used to synthesize nanomaterials *in place*. Using an argon gas flow to generate a plasma jet, a rich source of free electrons is created in ambient, atmospheric air that can induce electrochemical reactions. In this work, a plasma jet was generated over a droplet of diluted silver nitrate and fructose as seen in Figure 1. Free electrons from the plasma were used to reduce silver ions [Ag^+] present in the solution, forming a layer of silver nanoparticles where the droplet was placed as seen below.



(a) (b)

***Figure 1**: Examples of (a)Microplasma jet and droplet containing silver nitrate and (b)SEM image of silver nanoparticles*

Preliminary studies showed that the nanoparticles formed a “coffee stain” where the nanoparticles are deposited at the edge of the droplet but not in the middle. Various parameters have been taken into account in order to study the impact of various variables on the synthesis and deposition process. The gas flow, droplet volume and height of the plasma were among some of the parameters controlled, while various concentrations of silver nitrate and droplet contact angles, determined by the concentration of fructose, were analyzed. The silver nanoparticles formed after each experiment were characterized using a scanning electron microscope (SEM). Parallel to this, a numerical analysis of the mathematical model of the chemical reaction kinetics was made to check the reduction time of the silver in the solution. After analyzing the data, three important things were discovered. First, the concentration of silver that produces the best results are in the order of magnitude of 0.01M. Second, the fructose was not changing the contact angle in a significant way. And third, the formation of the coffee ring seems to be influenced by when the plasma was turned off. Given the opportunity to continue with this project, I would work on the repeatability of the experiments by working on the accurate control of more parameters and in a theoretical model that would sustain the experiment. I would also start working with smaller droplets to try to get a more controlled synthesis in a smaller area.

Publications (papers/posters/presentations):
-Summer Undergraduate Research Symposium Presentation.