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SPAWAR Systems Center PACIFIC

INNOVATIONS WITH LASERS AND OPTIMIZATION

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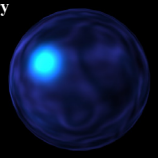
-INTRODUCTION-

This novel world is abundant with technology continuously evolving toward becoming more convenient, universally adaptable, and ubiquitous. Furthermore, it is important not only to explore new ways of developing these technologies to be more compact and cost efficient, but also it is important to explore the combination of all the facets of these advancements to find an optimized state.

The Space and Naval Warfare Systems (SPAWAR), San Diego, more locally known as SSC-Pacific, works to promote innovations that aid the United States Navy and Department of Defense (primarily in the area of communication).

In the Advanced Technology Branch at SSC-Pacific, projects are geared toward optimizing processes, the use of fiber optic communication, and the development of technology in the micro and nano level with the use of lasers.



Mentorship and outreach is very much a part of the mission at SPAWAR because for these innovations to continue in , it is extremely important for the next generation to be inspire to lead in the years to come. During this internship we had the opportunity to explore the projects in progress at SPAWAR, such as circulator optimization and coupling light around particles, to co- mentor high school interns, and to help organize outreach events. In this way, we were able to experience the full cycle of how technology is developed, improved, and passed on.

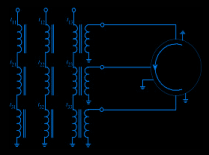
-GOALS-

- Develop a Pareto front tracker for circulators using multi- objective optimization methods.
- Learn how to use Matlab and utilize it for optimization
- Use laser to manufacture Silicon micro-spheres
- Etch fiber with Hydrofluoric Acid
- Couple light around micro spheres
- Help to put together a two-day workshop on Conservation of Energy
- Mentor high school interns to grasp main concepts behind the workings of these procedures

-METHOD-

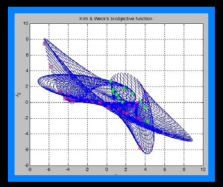
OPTIMIZATION

Optimization is an essential process in several business, management, and engineering applications to make systems that function to the fullest of their capacity. During this internship, we optimized the function of a circulator, a three-port device used to simultaneously send and receive signals through a single antenna. The objective is to create a circulator with maximum isolation (separation of signal levels) and minimum insertion (loss of signal power over the frequency band.)

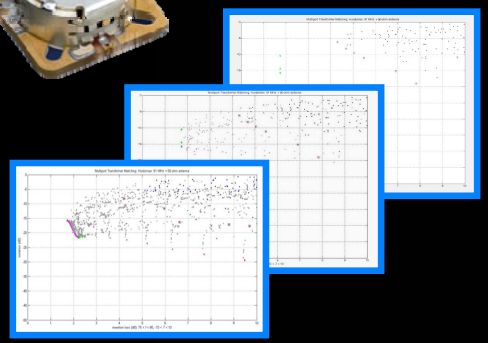


Multi-objective Optimization refers to a set of acceptable trade-off optimal solutions called a Pareto front. A solution belongs to the Pareto set if there is no other solution that has a lower value. Minimal points can be found with optimization methods, such as the Goal Attainment Method (GAM) and the Point and Line Method (PAL).

We estimated the Pareto point for multipart transformers matching our 81 MHz circulator. The transformers are parameterized by the 9-element turns ratios. The turns ratios are represented by a 3x3 matrix, and the ratio of the number of turns affects isolation and insertion.



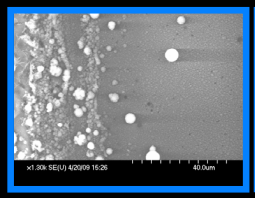
PROCESS

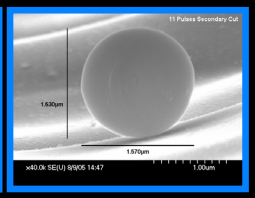


1. Get the circulator: Hurdsman circulator of 81 MHz.
2. Generate lots of suboptimal points in the performance image.
3. Select minimal elements of the performance image.
4. Apply the goal-attainment method (GAM) using each pre-image of the minimal elements as a starting point.
5. Apply the Point and Line Test (PAL).
6. Repeat the methods until getting a Pareto front.

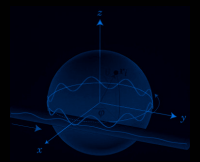
LASERS AND OPTICS

In the lab, the primary laser in use is a 308 nm Xenon Chloride XeCl pulsed laser. Because this laser functions in the Ultra Violet range of the electromagnetic spectrum, the beam is invisible to human eyes and can cause tissue damage if exposed. For this reason, caution must be used at all times in the lab, especially in processes such as ablation, where a material is superheated into a molten substance and small particles are ejected off the surface. We use this process to form particles in the micro level with a spherical shape so that we can couple light around them. Below are ablated samples of silicon seen using an scanning electron microscope (SEM).





After the spheres are fabricated in the laser lab, light can be coupled around the sphere because the internal reflection of the surface on the sphere can bend the light wave to propagate around the sphere as opposed to the expected result of it passing.



A challenging factor is being able to chemically etch the optical fibers using hydrofluoric acid close enough to the fibers core, where the light is propagating, so that light can be lost to couple around the microsphere.

This process can be used for many applications such as optical filters, fabricating Raman micro-lasers, optical switching, rotational detections, and several others that we may and may have not yet discovered.

PROCESS

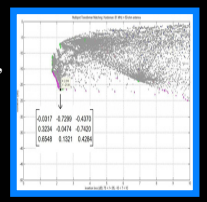
1. Fabricate silicon micro-spheres through laser ablation
2. Use SEM to categorize particles by shape and size
3. Chemically etch optical fiber to use to couple light around the spheres.
4. Create a feasible set-up to couple light around spheres
4. Apply this technology to improve other processes

OUTREACH

In the lab our high school student was Angie Lopez, a young lady from St. Mary's Academy. Who, by the end of her internship created a small hologram, assembled a computer, set up a laser communication system, and learned the fundamentals of waves, optics, and chemistry.

-RESULTS-

After running the GAM and PAL methods four times based on the 6 local minimal points of a random 100 points, we found 40 Pareto minimal points, chose one point, and found out the matrix that represents the turns ratios of that circulator.



In regards to the laser, unfortunately, the gases used to generate the laser were consumed near the end of the internship and we could not fabricate more micro spheres. However, we were able to etch the optical fiber and create a set-up that will ideally be able to couple light around the spheres after they are fabricated.

-CONCLUSION-

As mathematicians and engineers we were not only able to learn basic fundamentals such as critical thinking and concept adaptability, but also we were able to learn processes used in the industry. Through becoming familiar with software like Matlab and creating set-ups such as the ones described for coupling light around a micro-sphere, we gained invaluable training for research and observation in our future careers. Furthermore, the connections made in the industry level and exposure to other projects in the center helped in becoming more aware of the areas of study open to specific majors.

-ACKNOWLEDGEMENTS-

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