Tunable RF Plasma Cleaner for the Recovery of Contaminated Optics

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Introduction

Carbon contamination of optics in a laser system can cause irreversible damage to expensive optics. Carbon-based molecules can come in contact with an optic and adhere to it when that optic is shot with a high-intensity laser, leaving contamination behind. Optics can easily be damaged by this process and replacing them can be both expensive and time consuming. In order to reduce carbon build up on these optics, they must be cleaned. However most processes are difficult and have the possibility to damage the optic. One non-harmful way to clean contaminated optics is with an oxygen plasma that interacts with the carbon contamination and removes it in the form of CO_2 or CO.

Overview

The RF plasma cleaner consists of a few main systems: the **Generation and Amplification** equipment, the **Chamber,** the **Antenna**, and the **Gas and Vacuum System**.

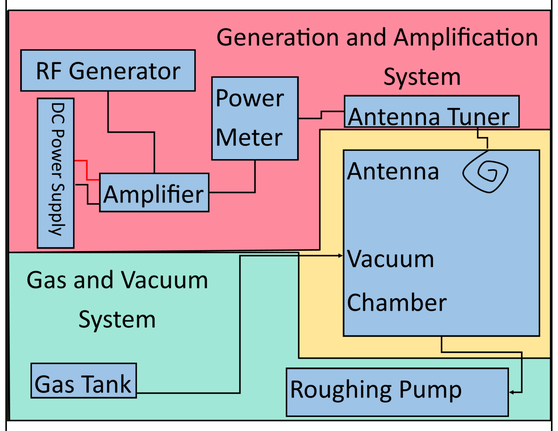

Figure 1. This drawing of the design outlines the basic components of the system.

Generation and Amplification

The generation and amplification equipment consists of a RF generator, a DC power supply, an amplifier, a power meter, and an antenna tuner. This equipment allows the user to generate specific RF frequencies and amplify and tune them so they have enough power to create an oxygen plasma.

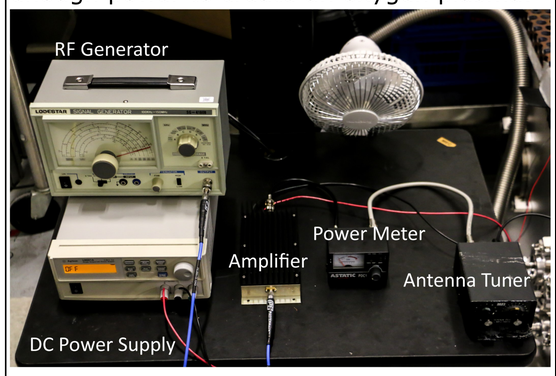

Figure 2. Here you can see the set up of the generation and amplification equipment.

Vacuum Chamber

The chamber houses the antenna. The Lexan lid is attached with a continuous hinge in the back and a gas spring on the side to make lifting easier.

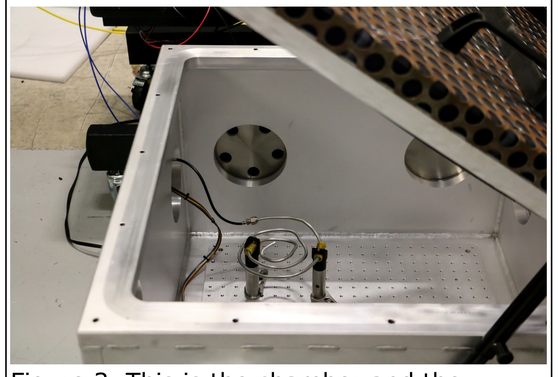

Figure 3. This is the chamber and the antenna with no plasma being generated.

Antenna

The antenna can be made into many shapes and lengths to fit a variety of optics. This makes being able to tune the frequency crucial because you need to match the antenna length to reduce the standing wave ratio. Designing the antennas and how to mount them was important because the size and shape of the antenna effects how the plasma is created and the area it will cover.

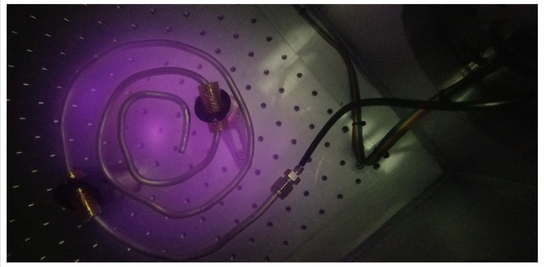

Figure 4. This is what the system looks like when generating a DC plasma.

Safety

To ensure that this system was safe to use we put a few safety measures into effect. First we covered the Lexan lid in perforated metal so that there would not be any non-ionizing radiation emitted. Second we interlocked the lid to the chamber so that if the lid is raised then power will not run to the RF Generator. This ensures that no one will be exposed to any non-ionizing radiation higher than the permitted levels.

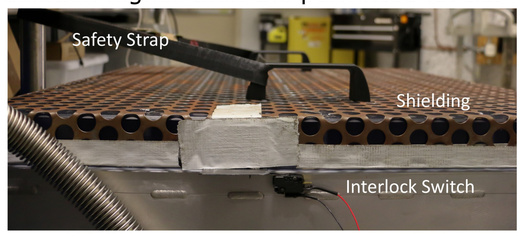

Figure 5. This shows the metal mesh that covers the chamber, as well as the interlock switch that controls power to the generator.

Gas and Vacuum System

The gas and vacuum system is made up of a scroll pump, a needle valve, and a gas cylinder. This simple setup allows you to quickly get to a few millitorr of pressure then using the needle valve bleed in enough gas so you keep a strong plasma being created around the antenna.

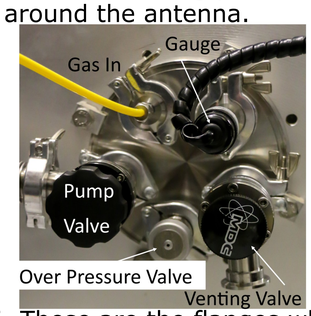

Figure 6. These are the flanges where the gas and vacuum equipment is hooked up.

Conclusions

I built an RF plasma cleaner for LCLS during the summer of 2018. The device shown was built and used in building 999 next to the MEC hutch. This RF device emits at 140MHz with a power less than 28W and will be used to clean various parts that acquire carbon build-up. There are plans to install another setup almost identical to this one on the short pulse compressor box. One future improvement would be to change from a visual inspection to a laser monitoring system that measures reflected intensity.

Acknowledgments

I learned a lot from not just my mentor, Eric, but also from the many people who have helped me fix or improve many different parts of this system. Thank you to everyone who helped me with this project. I couldn't have done it without all of you.

Use of the Linac Coherent Light Source (LCLS), SLAC National Accelerator Laboratory, is supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences under Contract No. DE-AC02-76SF00515.

Date: 8/3/2018