Improving EUV Sources for EUVL—

How Code Comparison for Plasma Modeling of Sn LPP Plasmas can help

Vivek Bakshi, EUV Litho, Inc.

August 16, 2020

EUV Lithography (EUVL) continues to extend Moore’s Law by driving the dimensional scaling and EUV light sources will remain key enablers of EUVL. However, continued work will be needed on further improving them in the coming decade, as they need to do more every year to keep delivering additional power with more efficiency and with increasingly less debris. The increased performance of sources resulting in higher throughput of scanners and more efficient generation of EUV photons translates into increased uptime of scanners. Also, if the industry chooses the option of further reduction of wavelength for scanners, or the Blue-X option, a lot more work will be needed on EUV sources of even smaller wavelengths. Moore’s Law will continue in the coming decade, but help from EUV sources is critical.

There are several key areas for continued improvement in EUV sources. The main areas of current focus are the potential switch of driver lasers to 2 microns from the present 10 micron of CO2 lasers, further fine-tuning of the process of photon generation to increase efficiency, reduction of out of band (OOB) radiation, and reduction and management of plasma debris.

So how do we go about improving these EUV sources for EUVL? This is where plasma modeling of these sources becomes important. The value of plasma modeling toward continued improvement of sources is enormous. Models can help guide the experiments and development of new technology, as well as help look for potential solutions. As the current Sn laser produced plasma (LPP) tools become mature, we have to look deeper into their workings to get the last bit of possible improvement in conversion efficiency (current 5% to 8% predicted) and evaluate the potential benefits of switching driver lasers, before the experiments occur.

There are many plasma modeling codes available around the world, and they have been used by suppliers and R&D groups for a long time. However, they differ in their predictions, due to the inclusion of different sets of physics, and variation in values of fundamental data such as opacity and several other details of modeling. For several of the models, physics included, and the input data set is not known, so objective comparison is difficult. It would be nice to calibrate codes with experimental data, but first we need them to have better agreement among themselves, before moving to experimental calibrations. Luckily, we have some guidance from another workshop of a plasma modeling community called NLTE Workshop, or Workshop for

Modeling of Plasma, which are in non-local thermodynamic equilibrium. Working with these types of plasma sources happens to be the area of my PhD and post-doctoral work www.euvlitho.com 2 (although now over 30 years ago) and most of my professional life, so I was happy to organize this activity.

In this code-comparison workshop, our first step will be to compare simulation results from simple problems in order to evaluate various modeling codes and input data. Below is the first set of draft problems, which was put together by plasma modeling experts at ARCNL and LLNL. *These sets of problems will be further fine-tuned in online Zoom meetings in the coming months, and the results of models will be presented at the November Source Workshop. If you are interested in taking part in this code comparison workshop or want to attend meetings to help us formulate these problems, please reach out to me at vivek.bakshi@euvlitho.com.* In case you are wondering, the final comparison results will be anonymous and only a given group will know which results belong to their model. The results from this first round will be presented in the upcoming 2020 Source Workshop (October 31-November 4, 2020) which is being held online this year, with more info available at www.euvlitho.com.