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Optimization of a negative oxygen ion beam

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Negative ion beams are of interest to a wide range of applications. Many previous studies investigated properties of H- or D- with beam diameters on the centimeter scale or larger due to their relevant applications in fusion or accelerators. However, less work has been done with other ion species and beam sizes in the millimeter range or smaller. Such beam properties are particularly important in the application of Secondary Ion Mass Spectroscopy (SIMS). SIMS analysis relies on measurements of secondary ions generated by the sputtering of a sample with primary ion beams (i.e. O-, O2-, etc). Radio frequency plasmas have been shown to be a successful primary stage to generate ion beams for SIMS instruments. High spatial resolution on the target requires a highly collimated beam with high current density. In addition, such a plasma source needs to deliver a very stable current, which improves precision and reproducibility of the resulting measurements. In this context, we are developing a negative oxygen ion source capable of long-term (days) steady state operation. The source generates inductively coupled plasmas using a novel antenna, and can produce positive or negative ion beams. A filter magnetic field is applied at the beam exit to deflect electrons. The ion beam current is measured using a Faraday cup with a secondary-electron suppressor plate. An optical spectrometer in the visible range is used to monitor the neutral composition inside the plasma.
Preliminary results showed that the extracted positive ion beam has a beam current ten times higher than that of negative ions. In both extraction polarities, a linear relationship between beam current with RF power, and non-linear relationship with filter magnetic field strength, chamber pressure, and voltage on the beam extraction grids are found. Changes in chamber size and wall temperature are also found to affect the beam quality, indicating the significance of surface effects in the creation/destruction of negative oxygen ions. To enhance plasma density, an additional DC magnetic field is installed along the axis of the chamber. Results will be presented in comparison with a traditional solenoid coil antenna.

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