Mitigation of EUV emission from laser-induced oxygen plasmas for atom-surface interaction studies in a simulated space environment

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Synopsis The relationship between the operation conditions and EUV spectrum emitted from O_2 plasma in the laser detonation AO beam source was investigated to reduce the EUV emission level during the materials tests in a simulated space environment. It was clearly indicated that the high backpressure of the target gas drastically reduces the emission of EUV. It also provides high flux of the AO beam. Thus, it was concluded that the high backpressure should be used for material tests for AO in LEO.

The environmental factors in space, for example, ultraviolet (including EUV and VUV wavelength), x-rays, ion and electron radiations, thermal cycling, and neutral species such as atomic oxygen (AO), give serious effects on many thin film materials used in space systems [1]. The incompleteness of the ground-based simulation technology arises problems on the accuracy of assessment of the material survivability in real space environment. One of the discrepancies between space and laboratory data is obvious in AO-induced erosion of fluorinated ethylene polymer (FEP) Teflon films. It has been reported that FEP Teflon eroded much faster in ground-based facilities than in space. This discrepancy is believed due to the ultraviolet which is a byproduct from the oxygen plasma [2]. A laser detonation AO source, which has widely been used as a ground-based AO environmental simulator, uses high-power CO_2 laser to create laser-induced oxygen plasma [3]. The basic configuration of laser detonation AO beam source is similar to that of EUV light source using xenon gas. However, EUV from laser-detonation AO beam source has not been evaluated.

In this presentation, EUV spectra from laser-induced oxygen plasmas were reported. The flat-field EUV spectrometer especially designed for this purpose was equipped to laser-detonation AO beam source, and confirmed the capability to measure EUV spectra from oxygen plasma [4].

Figure 1 shows the EUV intensities at 29.3, 33.8, 42.7 and 49.2 nm as a function of the backpressure of the pulsed supersonic valve (PSV). The beam formation conditions are as follows: PSV voltage: 800 V, PSV opening time: 400 μs and beam energy: 5 eV. It was clearly indicated that the peak intensities drastically decreases with increasing the backpressure from 0.2 to 0.6 MPa. The EUV intensities are kept constant higher than 0.6 MPa.

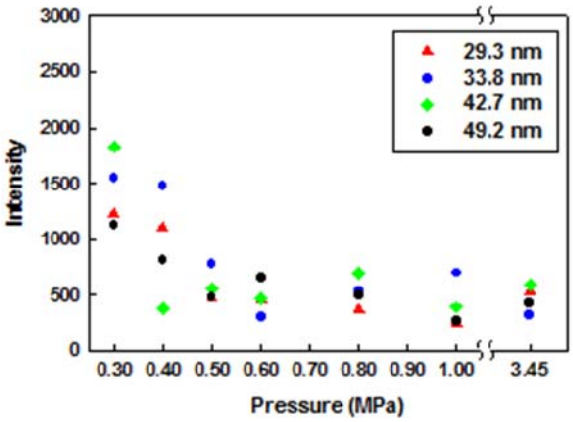

Fig. 1. Relationship between EUV emission intensities from oxygen plasma and the back pressure of the PSV.

Since EUV lines observed in this wavelength region are originated from highly ionized oxygen ions [5], it was suggested that the formation of highly charged oxygen ions in the laser plasma are restricted by high backpressure.

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References

[1] L. Leger, J. Visentine, J. Schliesing, AIAA Paper **85-0476** (1985).
[2] B. Weihs and M. V. Eesbeek, Proc. 6th Int. Symp. Materials in a Space Environment, **ESA-SP368**, 277 (1994).
[3] M. Tagawa, K. Yokota, Acta Astronautica, **62** 203 (2008).
[4] T. Harada, T. Kita, Applied Optics, **19**, 3987 (1980)