CoBIT Spectroscopy of Mo and Y ions relevant to beyond EUV source development

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Synopsis A CoBIT has been used to produce Mo and Y ions and EUV spectra have been recorded. The data indicate that the CoBIT spectra are significantly different to laser-produced plasma emission spectra for similar ion stages. This difference is attributed to the different number density of electrons in the two kinds of plasmas.

The relevance of the spectroscopy of highly charged ions for EUV (13.5 nm) and beyond EUV (6.x nm) light source development is well established [1]. In 2009, ASML prompted by the availability of La/B_4C mirrors with a reflectivity of ~40% in a 0.06 nm bandwidth near 6.7 nm, announced that sources would be needed at 6.x nm for future lithography [2]. This would necessitate focus on shorter wavelengths than 13.5 nm which has been extensively studied [1]. Experiments on laser produced plasmas (LPPs) of elements in the second transition row of the periodic table show significant emission in the spectral range 2-8 nm. This is due to 3d-4p and 3d-4f transitions [3]. The present study was conducted using a CoBIT [4] and focuses on two of these elements; Yttrium (Z=39) and Molybdenum (Z=42) in the 5-12 nm range. Spectroscopic studies using electron beam ion traps are complimentary to spectra obtained from LPPs, as the electron beam energy of the CoBIT can be set to optimize the abundance of a particular ion stage in the trap. This study focused on ion stages in the vicinity of Ni-like Y^{11+} and Mo^{14+}, with ionization energies of 374 eV and 544 eV, respectively [5]. For each of the elements studied, the CoBIT spectra are far simpler than those obtained from LPPs. The major difference between the two plasmas is the number density of electrons and this factor strongly influences the lines that appear in the BEUV spectra. In LPPs the number density of electrons is sufficiently high that metastable levels are likely to be collisionally depopulated before they can radiate. In contrast in CoBIT plasmas, such metastable levels live long enough to radiate and may give rise to optically forbidden lines, such as the $3d^{10}$-$3d^{9}4s$ (J=2) line of MoXV [6]. The prominent appearance of these lines in the CoBIT spectra, indicate that the population of the $3d^{9}4s$ state is enhanced within the electron beam ion trap.

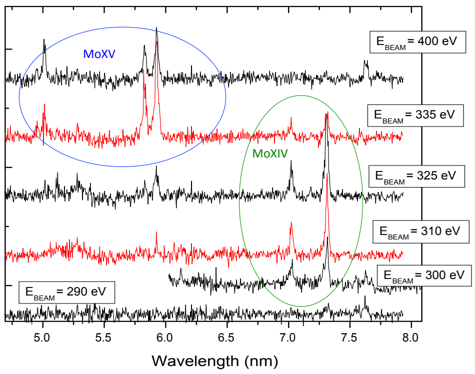

Figure 1. CoBIT spectra of Mo ions obtained at the electron beam energies indicated.

References

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