# Optical Emission Spectroscopy (OES) measurement of EUV-induced plasma parameters in hydrogen

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The EUV light source is widely used in the semiconductor engineering applications as the technology named Extreme ultraviolet lithography (EUVL). Today EUVL utilizes laser ablation of Sn droplets as the EUV source. Since Sn contamination on the first Mo/Si mirror and following deterioration of the reflectance has been critical issue for sustainable operation of the source, many EUV sources now introduce $H_2$ gas to the chamber trying to clean the Sn layer. Hydrogen atom in excited electron state, so called as “hydrogen radial H*”, is known for its chemical reaction to form stannane ($Sn + 4H^{*} \rightarrow SnH_4$), which is gaseous states in room temperature. A $H_2$ molecule also interact with a photon from the EUV source resulting in Hydrogen radical formation ($h\upsilon + H_2 \rightarrow e^{-} + H^{*} + H^{+}$), This study aims to verify the feasibility of using EUV induced H* radicals for cleaning of Sn layers seeking the optimum parameters for H* production. First, we need to determine the parameters which effect the H* yield. Secondly, the H* numbers should be large enough to clean the Sn ions. For these purposes, an Optical Emission Spectroscopy (OES) system was used to measure the H* yield in the $H_2$ / EUV interaction. A laser produced Xe plasma EUV source at Institute of Laser Engineering was used in the experiment. The OES systems consist of a set of optical system, a spectrometer and control systems. The key plasma parameters, plasma electron temperature ($T_e$) and plasma electron density ($n_e$) were derived from the hydrogen Balmer series profile. The parameters were verified by the 2-D self-emission images and EUV/hydrogen cross-section estimation as well. H$\alpha$ (656.3 nm), H$\beta$ (486.1 nm) and H$\gamma$ (434 nm) line emissions from the electron transitions of n = 3 to n = 2, n=4 to n=2 and n=5 to n=2 respectively were detected showing the existence of the hydrogen radicals. From the OES data, the hydrogen plasma parameters and the H* yield can be derived. An atomic population simulation code which based on the Collisional Radiative (CR) model will also be used to verify the results. Together with the stannane cleaning experimental results, we are going to present the H* yield and its cleaning efficiency on the operational parameters.