Studying the interaction of scanner materials with EUV-generated plasma

A.S. Stodolna(*)[1], T.W. Mechielsen[1], K. Papamichou[1], S. Oostrom[1], M. van de Kerkhof [2], V. Navarro Parders[2]

[1] *TNO, P. O. Box 155, 2600AD Delft, The Netherlands*

[2] *ASML Netherlands B.V., De Run 6501, 5504 DR Veldhoven, The Netherlands*

(*) *aneta.stodolna@tno.nl*

Inside EUV lithography machines the propagating light ionizes a background gas resulting in a so-called EUV-generated hydrogen plasma. In the past at TNO we focused on investigating the properties of this plasma in order to mimic it in laboratory setups. In controlled experiments we studied the interaction between hydrogen plasma and EUV components, including construction materials. With increasing EUV source powers and repetition rates the density of the EUV-generated plasma and the amount of scattered light will also increase.

Taking a proactive approach together with ASML TNO is investigating interaction of selected construction materials with the EUV-generated plasma for higher source powers. As an example of this work, we studied behavior of an aluminum alloy in different types of hydrogen plasmas. Using the most common type of a plasma source, based on the electron cyclotron resonance (ECR) principle, we observed a process of Mg release from the alloy, which scales with total ion dose and depends on the background H_2O and N_2 pressures. In experiments employing a novel plasma setup at TNO called EBR (Electron Beam Research) the aluminum alloy was exposed both to hydrogen plasma generated by means of electron impact ionization and to a beam of electrons. The latter could be used to mimic EUV photons in processes like oxidation or carbon growth [1]. Post X-ray Photoemission Spectroscopy (XPS) measurements showed that at the locations illuminated with electrons the oxidation of the alloy extended to deeper layers in contrast to the locations exposed solely to hydrogen plasma. Moreover, a buildup of Mg underneath surface also depended on the electron beam location. Finally, to link the observations driven by electrons with EUV photons exposure have been scheduled at the EUV Beam Line 2 (EBL 2) facility at TNO early 2024. In this experiment the Al alloy will be exposed to EUV-generated plasma for ~1 day after which the sample will be analyzed with XPS (surface & depth profiles).

[1] Luo, C., et al., Review of recent advances in inorganic photoresists. RSC Advances, **10**, 8385 (2020)