Measurement and analysis of EUV resist outgassing rate by pressure-rise method

Iwao Nishiyama and Hiroaki Oizumi
EUV Process Technology Research Laboratory
Association of Super-Advanced Electronics Technologies (ASET)
3-1 Morinosato Wakamiya, Atsugi, Kanagawa 243-0198, Japan
TEL: +81-462-70-6688, FAX: +81-462-70-6699, E-mail: nisiyama@aset-euv.jp

Resist outgassing is a big concern in EUV lithography because this type of lithography is conducted in vacuum environment, and hydrocarbon gas degrades EUV mirror reflectivity. To develop a low-outgassing resist material, we have to develop a reliable method of measuring the outgassing rate. ASET has constructed a new tool for measuring resist outgassing based on the pressure rise method, and has used it on a typical EUV resist. The measured outgassing rate is converted to production tool conditions by scaling the intensity of the EUV radiation. Finally, we examined the outgassing levels of current resist materials and compared them to the requirements of the exposure tool.

Figure 1 shows the newly constructed apparatus which employs ultrahigh vacuum technology and a load-lock sample-transfer system. The background pressure was kept at 2 x 10–7 Pa, even when a resist sample was placed inside the chamber. The pumping speed was controlled by means of a small opening between the chamber and a turbomolecular pump. These techniques help to increase the signal-to-background ratio, which is major factor in precision. The pumping speed was directly determined by measuring the pressure-down speed using the gas released by the resist itself, because the pumping speed depends on the chemical species. A synchrotron radiation beamline of the NTT SuperALIS facility was used as the light source. The EUV light was monochromated with a MoSi multilayer mirror.

Typical data of pressure-change caused by EUV induced outgassing are shown in Figure 2. In the process of analyzing the pumping speed based on this data, we found that the pressure decay after the EUV light was stopped was not described by a single exponential function. So, a more detailed analysis was made, assuming that the outgassed molecules consisted of multiple species. We found that a three-component approximation was sufficient to explain the pressure decay. The pressure change was calculated using this multicomponent pumping speed and then compared with the observed pressure change when the EUV light was on and off. As seen in Figure 2, the calculated curve agreed well with the observed one. Then, the outgassing rate was determined by the best fit calculated.

This new apparatus and analytical method were used on a model resist. The resist was originally synthesized at the MIT Lincoln Lab and was supplied by SEMATECH as part of the international round-robin activity on resist outgassing. The outgassing rate was determined to be 1.5E+12

molecules/cm2・s at an EUV dose of 0.21 mW/cm2, which corresponds to 3.9E+13 molecules/cm2 at an EUV dose of 5.6 x 1.5 mJ/cm2 dose. This value agrees well with the value reported in [1], even though they used a different measurement method, namely ex-situ GC-MS analysis.

To estimate the impact of this rate of outgassing in the production era, we estimated the outgassing rate under production-tool conditions by scaling the radiation intensity and overhead time. This yielded a value of 1.2E+15 molecules/cm2・s at an EUV dose of 0.4 W/cm2 for an overhead correction of 40%. This value is 25 times larger than the specification for hydrocarbon resist outgassing provisionally proposed by ASML. The refinement of resist materials is necessary to reduce the rate of outgassing. However, since current best-designed resists have lower outgassing rate, we are not so far from the required level.

References

[1] Kim R. Dean, Kenneth E. Gonsalves, and Muthiah Thiyagarajan, SPIE 6153-51.

Keywords:
EUV lithography, Resist outgassing, Pressure rise method, Mass analysis

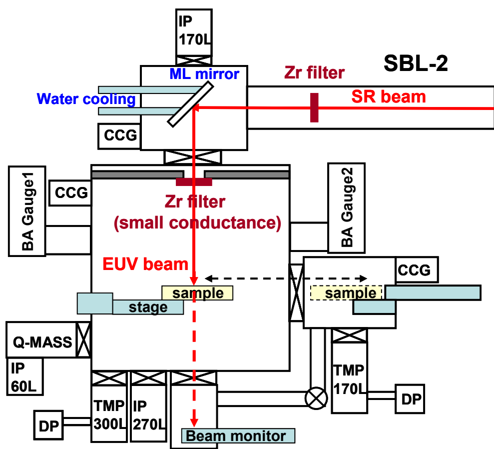

Figure 1. Apparatus for EUV resist outgassing measurement based on pressure-rise meshot and in situ quadrupole mass filter.

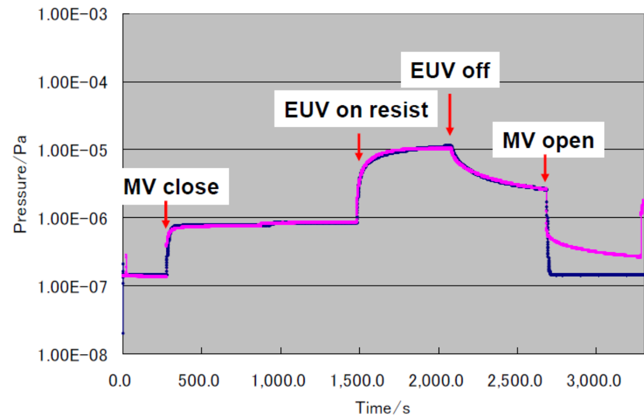

Figure 2. Time-wise pressure-change caused by EUV induced resist outgassing and it's simulation analysis based on multi-component approximation.