Abstract
The scale of semiconductor devices is continuously shrinking, and the critical dimension is now expected to reach down close to ten nanometers in the near future. The performance of such a device can be easily affected by a slight variation in the shape of the resist pattern. It is, therefore, important to carry out quality control over the cross-sectional profile of resists. We have developed a new SAXS-based metrology tool (CD-SAXS). The system utilizes the grazing incidence geometry in order to perform quick measurements on mass production lines. Resist line & space and hole patterns were measured by the new x-ray metrology. The obtained cross-sectional profiles were consistent with those observed by cross-sectional SEM.

Current status of RIGAKU CD-SAXS
CD-SAXS measures only signal from periodic structure, such as line & space, dot and hole. The signal cannot be affected by the under-layer structure. OCD metrology is low robustness for a slight variation of optical parameters of under-layer structure. Recently, verification metrology system (VMS) has been proposed and introduced on mass production lines.

Characterization of Cross-Sectional Profile of Resist Pattern
Using Grazing-Incidence Small Angle X-Ray Scattering

Grazing incidence small-angle x-ray scattering
- Monochromatic x-ray irradiates to the sample surface. The incident angle is set to be very close to the critical angle of total external reflection.
- The sample is to be rotated around the vertical axis at the irradiated point during the measurement.
- Diffraction x-rays are collected by a two dimensional pixel array detector.

Experimental
- Sample preparation
  - Four kinds of resist L/S pattern wafers with pitch size of 130 nm were fabricated with different material composition and exposure condition, intentionally, in order to obtain different cross-sectional profile between four resists.
  - Resist A is NG product. Resist B, C, and D are OK products.
- Motivation
  - Our challenge is to distinguish the OK products and NG products.

Results
- Obtained cross-sectional profiles show an inverse tapered shape in the four resists.
- Top corner rounding shape of the resist A (NG product) is different from the others (OK products).
- These results can be regarded as consistent with the cross-sectional SEM results.
- Our new x-ray metrology has the potential to distinguish the OK product and NG product.

Conclusion
Our newly-developed x-ray metrology tool, CD-SAXS, has been demonstrated. Cross-sectional profiles of resist patterns were measured by the instrument. The results obtained by the CD-SAXS were consistent with those obtained by cross-sectional SEM observation. CD-SAXS has a capability for measuring cross-sectional profile non-destructively. Our new x-ray method is very effective in CD metrology on mass production lines.

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