Microstructural study of cured HSQ resin coated on a patterned wafer using scanning transmission electron microscopy (STEM) with electron energy loss spectroscopy (EELS)

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To optimize hydrogen silsesquioxane (HSQ) resin to achieve excellent gap filling capability and etch-resistance, quantitative analysis of HSQ materials coated on a patterned wafer, as a function of curing and processing condition has been considered quite essential. For this, spectroscopy techniques, such as FTIR, has been used (1, 2). However, the characterization of spin on materials incorporated in the inter oxide gates on a wafer has been a challenge. This study describes the application of scanning transmission electron microscopy (STEM) with electron energy loss spectroscopy (EELS) for the analysis of spin-on hydrogen-silsesquioxane based dielectric materials coated on a patterned Si wafer for a possible pre-metal dielectric (PMD) application.

The specimens were prepared using focused ion beam (FIB) to get electron transparent thin section (~100 nm thickness) with relatively homogeneous thickness and transferred to lacey carbon coated Cu TEM grids. To prevent hydrocarbon contamination and reduce electron beam damage of the specimen, a cold trap was used and the specimen was cooled down to –120 °C using a cold stage in TEM. EELS data were collected using Phillips CM20 FEG TEM with a Gatan Enfina system.

The principle and application of imaging EELS is when electron beam is incident into specimen, part of the electrons lose energy partly due to the electron inelastic scattering with a specimen (3). Elemental composition and atomic bonding state can be determined by analyzing the amount of energy loss and spectrum profile shape with the spectroscope attached under the transmission electron microscope (TEM). Using a STEM with a high angle annular dark field (HAADF) detector, a cross-sectional dark field STEM image of a HSQ coated patterned Si wafer was obtained (Fig.1). A small analyzing region of resin and gate materials is selected from a part of the enlarged electron microscopic image (Fig. 2a). The EELS signal intensity ratio profiles of O/Si and N/Si from a line scanning, as shown in Fig.2, indicate that the resin was cured to SiO_2 structure like gate oxides (Fig.2b). However, the zero loss signal intensity profile from EELS signifies density difference between cured resin and oxide gates (Fig. 2c).

References

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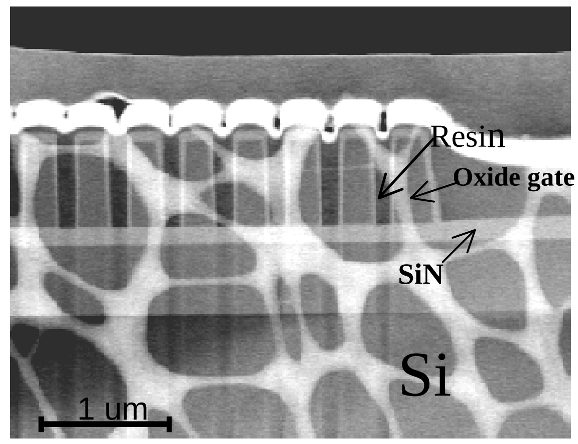

Figure 1. HADDF STEM image

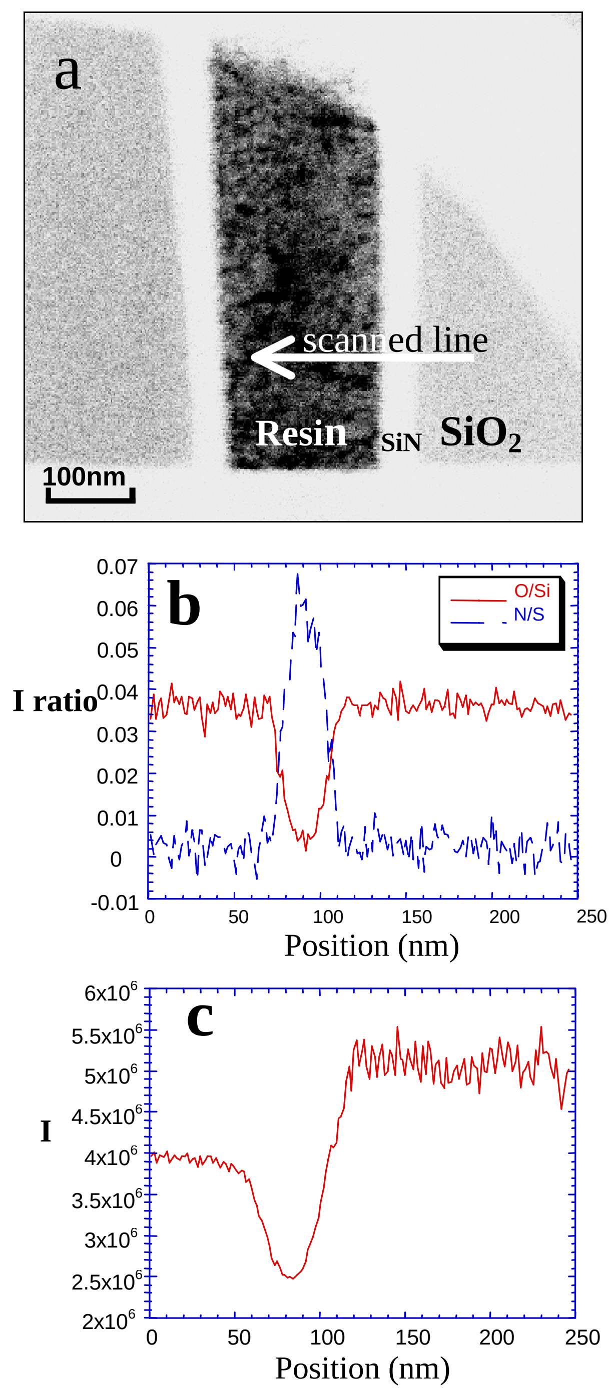

Figure 2. (a) HADDF STEM image and a line scanned region; (b) relative intensity ratio profile of O/Si and N/Si from the line scan; (c) zero-loss intensity profile from the line scan