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Development of New Analytical Approaches by a 300 keV CFE-TEM/STEM

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For R&D or QC of recent semiconductor devices, MEMS, or nano-materials, visualization and quantitative analysis with high spatial resolution on chemical characteristics, internal stress mapping, two-dimensional dopant-profile and distributions of electric/magnetic field are becoming crucial. Authors propose new analytical approaches by using a 300kV cold field emission (CFE) TEM/STEM equipped with those dedicated functions as follows.

(1) Spatially-resolved EELS for chemical analysis
Spatially-resolved EELS technique was proposed to arrange multiple spectra detected from line shape area simultaneously [1]. Fig. 1 shows an example showing the ability to detect precise chemical shift values ranging from less than 0.5 to a few eV due to small energy spread of CFE gun [2].

(2) Nano-diffraction method for stress analysis
Nano-diffraction method was proposed to visualize 2D-internal stress mapping of the strained Si substrate. Fig. 2(a) shows two-dimensional stress mapping with contour lines of stressed bits in memory cell obtained by this method [3]. Stressed and unstressed bits are compared in Fig. 2(b) showing that some defects in the stressed bit cause slow read/write characteristics. Higher gun brightness achieved with CFE is necessary to perform nano-diffraction with smaller illumination angle and larger probe current.

(3) Electron holography for visualizing dopant profile and electric/magnetic field
The distribution of electrostatic potential formed by dopant atoms in MOS transistor became clearly visible in Fig. 3 [4]. Holographic technique would also be more effective to evaluate electric/magnetic field in such as magnetic devices, ferroelectric nano-particles and so on.
Higher accelerating voltage allows better penetration and also higher sensitivity to phase shift because of shorter wavelength.

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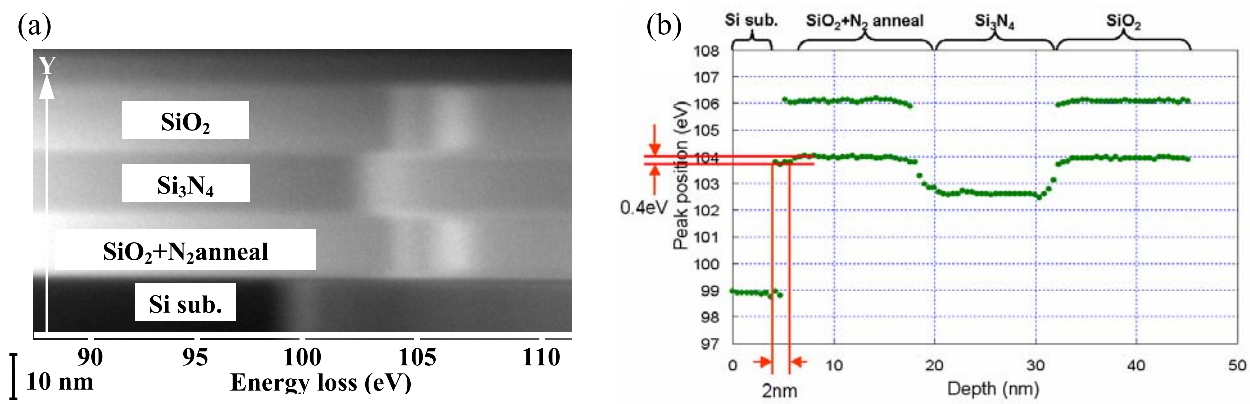

FIG. 1. (a) Two-dimensional spatially-resolved EELS image of silicon L edge obtained from a multi layer specimen on a silicon wafer. (b) Peak positions of these spectra [2].

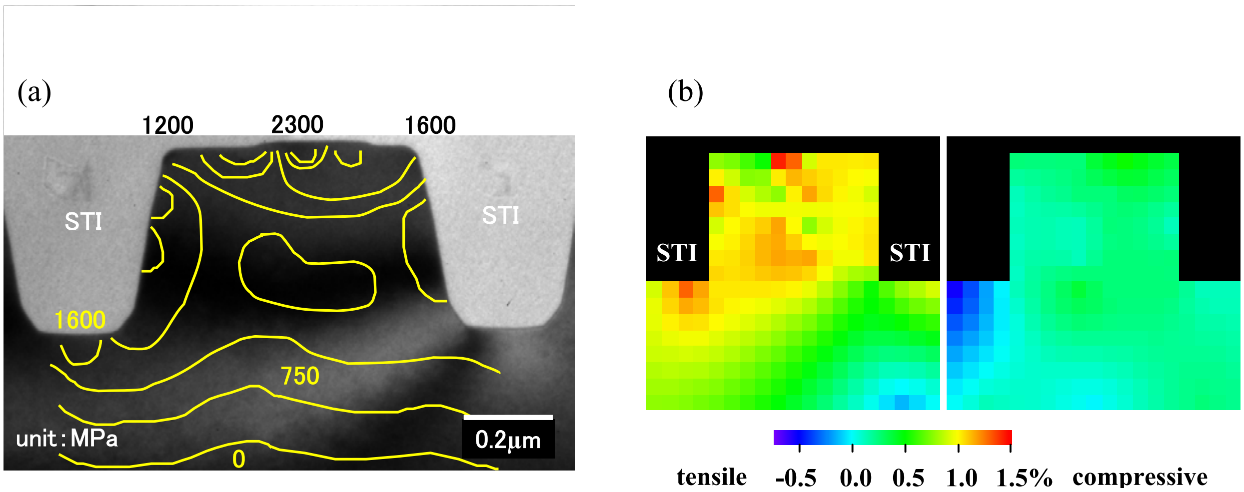

FIG. 2. (a) Stress mapping of memory. (b) Comparison of stressed/unstressed bits of memory [3].

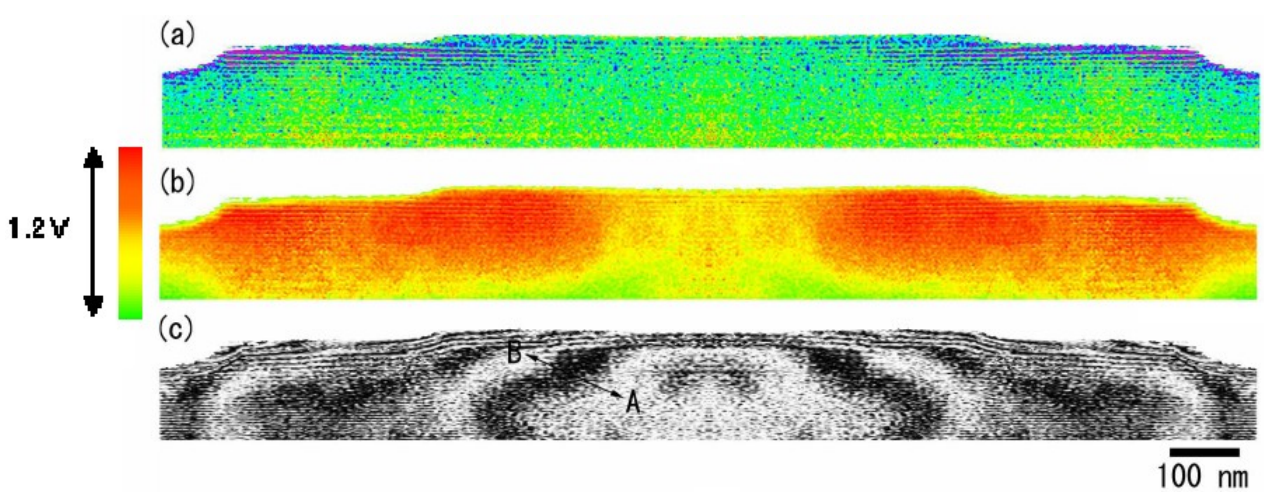

FIG. 3. Pseudo-color representation of the reconstructed amplitude (a), potential (b), and interference micrograph (c). Color table corresponds to a range of 1.2 V in (b) [4].

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