Application of Helium Ion Microscope in Material Characterization

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A Helium Ion Microscope (HIM) of Carl Zeiss based on the Atomic Level Ion Source (ALIS) technology has high brightness source, sub-nanometer probe size, low energy spread and unique sample interaction mechanism. Due to the shorter effective wavelength of helium ions and smaller interaction volume of the ion beam with the sample as compared to electrons, a helium ion beam in the HIM can provide distinguished advantages over an electron beam in a Scanning Electron Microscope (SEM) for imaging [1-2].

The small interaction volume of helium ions means that the helium ion beam induced secondary electrons come from a small local area close to the helium beam impact spot on the sample, which can resolve more surface details. The excellent image contrast is due to the high sensitive material dependence of the secondary electron yield. The generated low energy secondary electrons provide good surface-sensitive information. The larger interaction cross-section of the helium ions compared to electrons with the specimen allows for imaging low atomic weight materials such as carbon nanotubes, polymers etc. The small probe size of the HIM demonstrates a high sensitivity for high dopant concentration in dopant contrast profiling. The secondary electron signal also offers new opportunities for various voltage contrasts in local failure analysis of small semiconductor devices which are limited for focus gallium ion beam. The image of Rutherford backscattered helium ions contains useful structure information, surface composition and material contrast in materials characterization and analysis [3-6].

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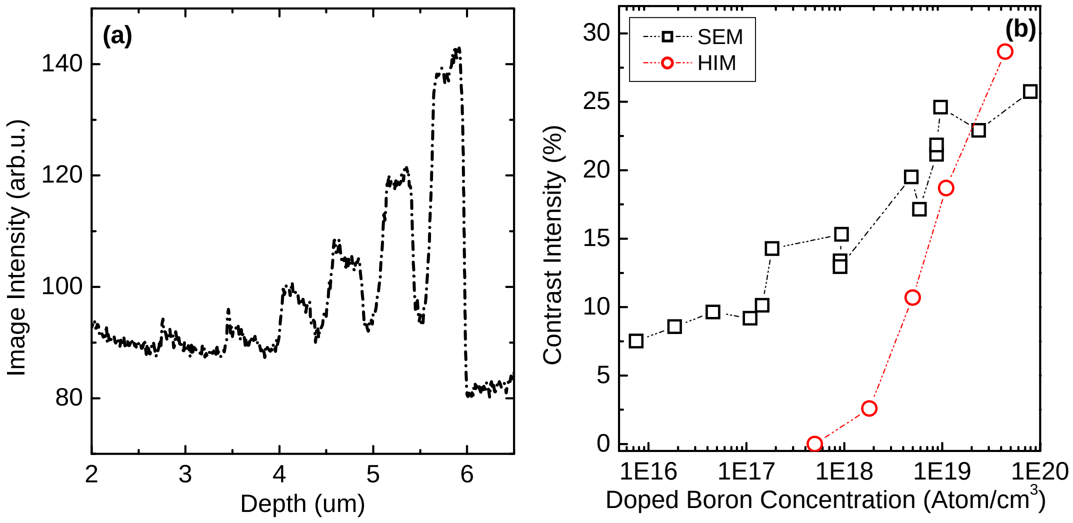

Figure 1. (a) Gray intensity profile extracted from a HIM image of a boron doped silicon wafer containing 7 different doping level layers as a function of distance along the epitaxial growth direction; (b) Comparison of the relationship between the doping concentration and contrast in SEM and HIM.

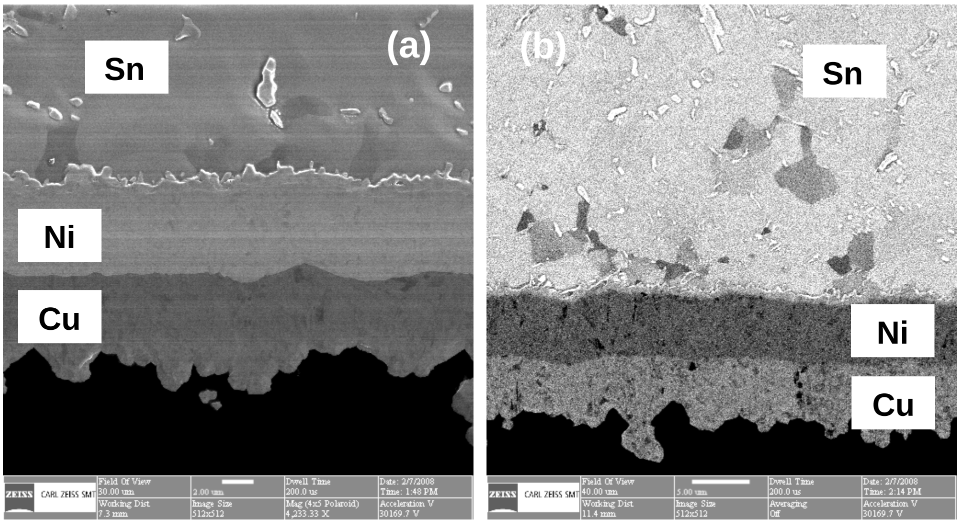

Figure 2. HIM images of a solder joint showing different materials contrast: (a) the secondary electron image, (b) the Rutherford backscattered helium ion image.

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