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On the Contrast and Resolution of Secondary and Backscattered Electron Images in a FE-SEM

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Since the famous picture of Ogura[1], it is known that high resolution Backscattered Electron (BSE) and Secondary Electron Images (SE) images can be obtained in a Field Emission Scanning Electron Microscope (FE-SEM) at the nanometer level. Since then, there have been some new ideas about the contrast and resolution mechanisms of BSE and SE images in the FE-SEM[2]. The main idea being that for SE images, all the secondary electrons contains information meaning that the SE II are not a noise contribution, even at 30 keV where it is believed that they are a noise contribution. It is clear that this view is highly controversial since it is believed that a picture taken at a magnification of 100 000 times will have a constant interaction volume and therefore a SE II component that should be insensitive with the beam position. In order to determine if SE II carries high resolution information, even at high incident electron energies, a new Monte Carlo program is under development to simulate SE and also BSE images in multilayered structures. The simulation of BSE images follows the principles that were published previously[3]. The simulation of SE electron images is based on an extension of Joy model[4] for the case of vertical layers of different compositions.

Figure [1] shows a SE picture of AlGaAs layers embedded in GaAs of various width taken with a Hitachi S-4700 FE-SEM at 5 keV, a working distance of 12mm and with a bias of -2.5 V applied in the plates in front of the upper detector. The AlGaAs lines have width between 300 and 20 nm. Clearly, all the lines are visible with high contrast. Figure [2] shows a SE line scans simulated for incident electron energy of 5 keV and an AlGaAs line of 20 nm with the new Monte Carlo program. These simulations were performed with 150 000 primary electron trajectories. In this figure, the SE I and SE II contributions are separated from the total contribution of SE. These simulations suggest that SE II are responsible of the observed contrast, which would make sense since the interaction volume is smaller at 5 keV that at 30 keV, but it is too early to make any definitive conclusions since of SE model needs further validations.

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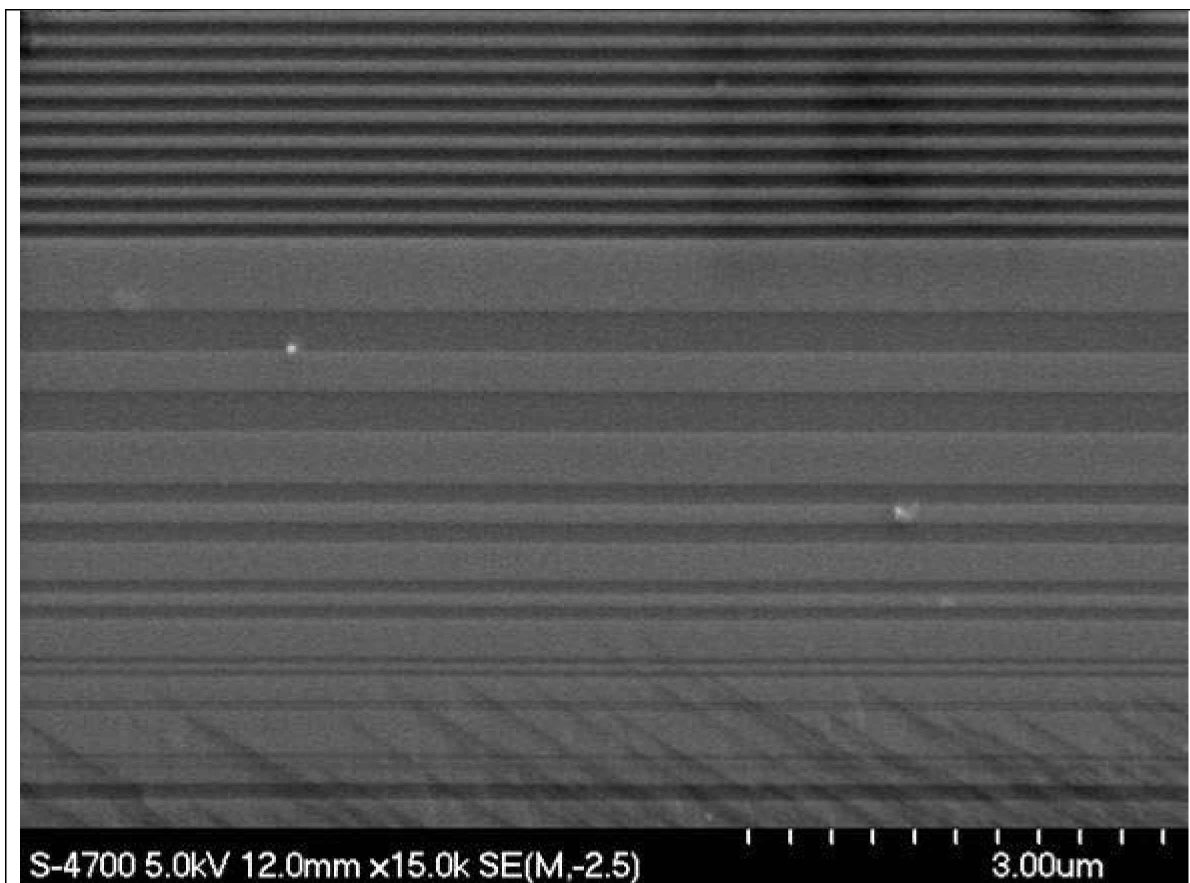

Figure [1] SE picture of AlGaAs layers in GaAs taken in a FE-SEM at 5 keV.

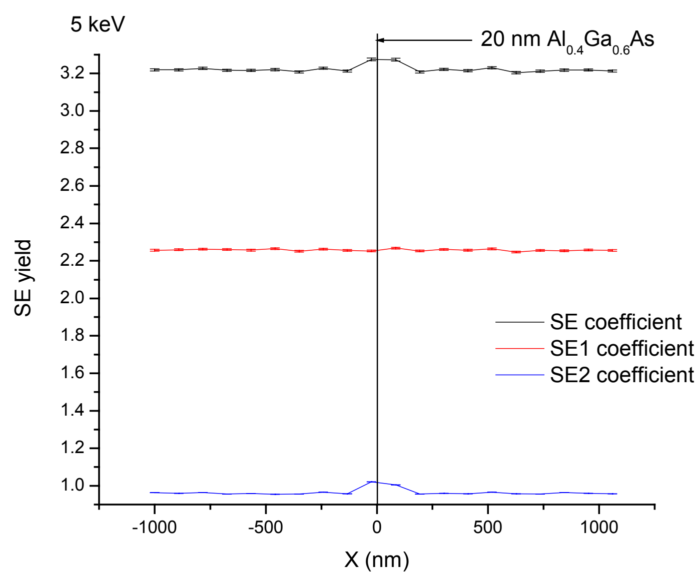

Figure [2] Simulated SE line scans of a 20 nm AlGaAs layer in GaAs at 5 keV.

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