Quantitative Techniques and Image Simulation in TEM/STEM, SEM and Diffraction

IM2.P065
Nanometrology with a TEM - determining the position of an amorphous interface

S. Majert[1], H. Kohl[1]

[1]Westfälische Wilhelms-Universität Münster, Physikalisches Institut, Münster, Germany

stephan.majert@gmail.com

With the miniaturization of components in computers and other electronic devices, the task of controlling the size of such components becomes more demanding. For the smallest components a Transmission Electron Microscope (TEM) can be used to measure the positions of interfaces with high resolution. However, the position of an interface is not always clearly discernible from a TEM image. To determine the position of an amorphous interface one often uses the mean value between the average intensities in the image domains on both sides of an estimated interface position [1]. The result is the interface position as it a appears on the TEM image, which may or may not be identical to the actual interface position in the specimen. To test whether the apparent interface position corresponds to the actual interface position in the specimen, we developed a multislice program to simulate TEM images of amorphous interfaces as found in cross-sectional preparations of semiconductor devices. With this program, we can compare the apparent interface position on the simulated TEM image with the actual position of the interface known from the atomic coordinates used in the simulation.

In [1], a specimen containing amorphous platinum, amorphous silicon dioxide and crystalline silicon was examined. Therefore we simulated a TEM image of this specimen. The results are shown in fig.1, with the red lines marking the actual interface positions. We find that the interface between the silicon crystal and the amorphous silicon dioxide can be clearly discerned from the TEM image. In addition, our simulations show that the crystal only marginally influences the image intensities at the position of the amorphous interface between platinum and silicon dioxide. We therefore neglected the crystal-amorphous interface and focused on simulating the interface between amorphous platinum and amorphous silicon dioxide.

Fig.2 shows the simulated TEM image of a Pt-SiO_2 amorphous interface where the actual interface is located at x=30.0Å. We define the apparent interface position as the point where the intensity has reached the mean value of the average intensity in the platinum and the average intensity in the SiO_2 image domain [1]. By plotting the average intensity parallel to the interface in a graph (fig.3), the apparent position of the interface (blue arrow) can be determined as x=31.2Å, which means that the apparent interface position deviates from the actual interface position by 1.2Å. This deviation stems from the different scattering behaviors of platinum and SiO_2.

1. G. Dai et al., Measurement Science and Technology 24 (2013) 085001. http://dx.doi.org/10.1088/0957-0233/24/8/085001
2. We thank Dr. G. Dai and Dr. G. Frase for valuable discussions.

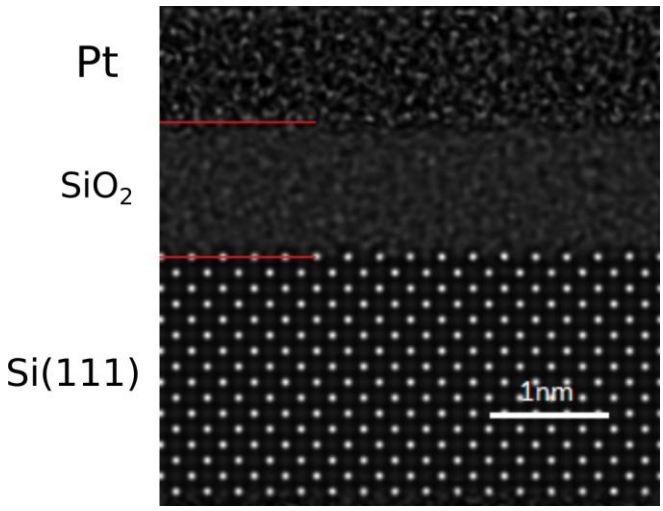

Figure 1. Simulated TEM image of a specimen containing amorphous platinum, amorphous SiO_2 and crystalline silicon. The actual interface positions are marked with red lines.

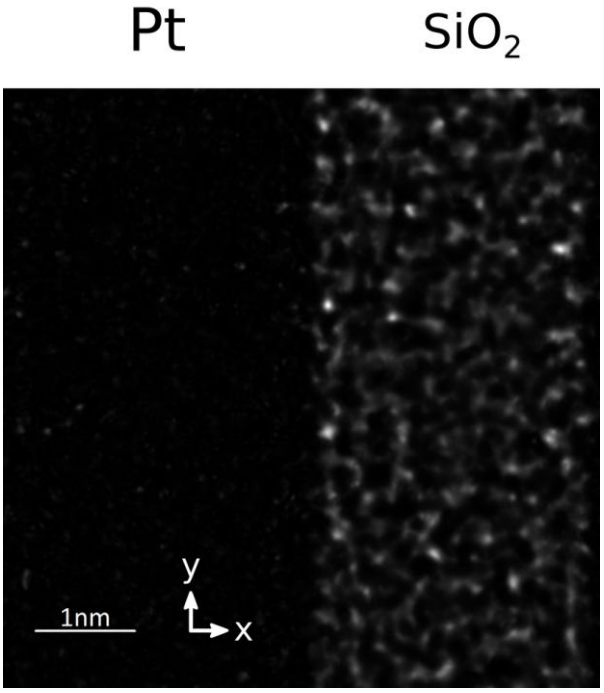

Figure 2. Simulated TEM image of a 50nm thick interface between amorphous platinum and amorphous SiO_2, assuming an aberration corrected microscope with an objective aperture half angle of 25mrad, an acceleration voltage of 300kV and spherical aberration coefficients of C_1 = 2Å, C_3 = -0.002mm and C_5 = 2.5mm.