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IT-13-P-1861 Measurement of TEM lamella thickness and Ga implantation in the FIB

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Accurate control over sample thickness and quality is paramount in order to take full advantage of the ever increasing resolution in aberration corrected TEMs. For instruments combining a focused ion beam with an electron beam methods based on either back scattered electron contrast [1] or transmissivity of electrons [2] have been demonstrated for measuring the sample thickness. However, these methods only work on homogenous samples without compositional variations. They also don't provide any information on the degree of ion implantation.

Here we show a method that uses X-rays generated by the electron beam - lamella interaction to accurately and rapidly measure the lamella composition and thickness. In order to measure the thickness and composition of the lamella, we used Oxford Instruments' AZtec LayerProbe software [3] and X-Max 150 EDS detectors to acquire and process EDS spectra. LayerProbe refines a starting model of the sample structure against the EDS spectra to calculate the film thickness and composition of the layers. The first layer is defined as the material comprising the lamella. The top layer can be defined to contain the element used as the ion source (e.g. Gallium) to obtain a measure of the degree of ion implantation in the specimen.

Fig. 1a shows an electron image of a TEM lamella prepared from a Ni based superalloy . Fig. 1b shows a surface plot of the lamella thickness and Fig. 1c the Ga thickness calculated from a grid of EDS spectra. The thickness of the lamella is clearly decreasing from the area close to the weld towards the free end of the lamella with the lowest thickness of the lamella measured at around 75nm. The Ga thickness profile shows a different trend with an increase Ga thickness close to the left lower corner and also close to the weld. Fig. 2 shows an X-ray map of a TEM lamella prepared from a silicon semiconductor device. The device structures containing Cu and W are clearly visible in the X-ray maps. One of the Cu lines fades and disappears from the right side to the left of the lamella indicating that the line runs at an angle to the direction of the FIB cut. With LayerProbe it is possible to measure the projected Cu thickness and Si thickness from X-ray spectra reconstructed from the X-ray map. By comparing measurements taken from the right side of the lamella with measurements towards the left side we can see how the thickness increase of the lamella affects the ratio of device vs surrounding Si matrix for both the W and Cu rich device areas.

[1] A. R. Hall, Microscopy and Microanalysis 19 (2013), p. 740.
[2] U. Golla-Schindler, Conference Proceedings EMC (2008), p 667.
[3] C. Lang et al., Microscopy and Microanalysis 19 (2013), p. 1872.

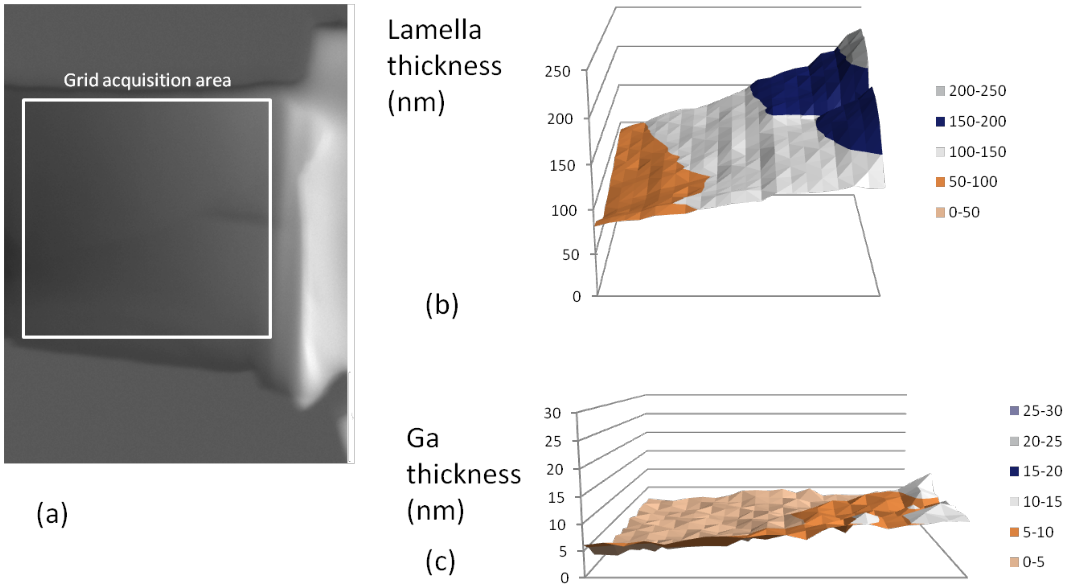

Fig. 1: (a) shows an electron image of a TEM lamella of Ni superalloy 600 and the area for which the lamella thickness in (b) and the equivalent Ga thickness (c) have been calculated.

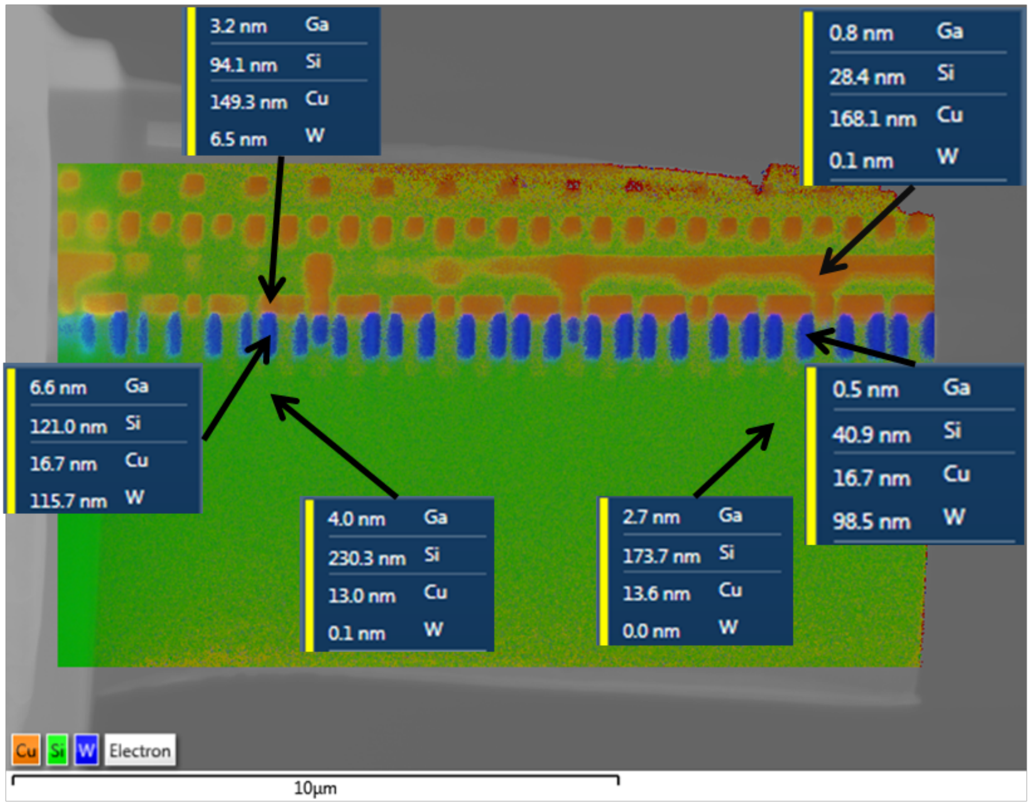

Fig. 2: The local lamella thickness as well as the contribution of different device layers to this thickness was calculated from spectra reconstructed from an X-ray map.