Diffusion coefficient measurement by LEIS in Cu/Si grain boundary systems

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Surface islands formed by grain-boundary diffusion has been studied in Cu/Si and Ni/Cu nanolayers by in-situ low energy ion scattering spectroscopy (LEIS), X-ray photoelectron spectroscopy (XPS), scanning probe microscopy (STM) and ex-situ depth profiling based on secondary neutral mass spectrometry (SNMS). A new experimental approach of the measurement of grain boundary diffusion coefficients is presented [1]. It is based on appearing time measurement of silicone atoms diffused through a few nanometers thick copper layer and detected by surface sensitive LEIS method. The temperature range of 423–463 K insures the pure C-type diffusion kinetic regime. Grain boundary diffusion coefficients were estimated by the relation used for calculation of diffusant distribution from a constant source in assumption that the diffusion path equals to the film thickness at the moment of appearing Si atoms on the Cu surface. At 453 K we estimated the surface segregation factor and detected formation of Cu–O–Si atomic bonds on the Cu film surface [2] measured by XPS. Depth distribution of Cu in Ni layer has been determined by SNMS depth profile analysis. A combined measurement technique of LEIS and SNMS gave a unique possibility to measure the fast diffusion in nanolayers at low temperatures. Furthermore, the advantage of this technique was that determination of grain boundary diffusion coefficient did not require a complicated calculation with segregation factors in order to remove the effect of B-type diffusion kinetic and, as a result of this, the diffusivity could be studied in a simply way, only by measurement of the appearing time.

[1] Viktor Takáts, et.al., Applied Surface Science 440, 2018, 257-281.
[2] Eszter Bodnár, et.al., Vacuum 203, 2022, 111260.