Thermal stability of FeCr Multilayer – Interface width and triple line diffusion

Patrick Stender[1], Guido Schmitz[1]

1. Institute of Material Physics, Westf. Wilhelms-Universität Münster, Wilhelm-Klemm-Str.10, D-48149 Münster, Germany

patricks@uni-muenster.de
Keywords: atom probe tomography, triple line diffusion, Iron, Chromium

The thermal stability of an iron – chromium multilayer system has been analyzed using 3D atom probe technique. For that purpose sample have been prepared using ion beam sputtering and focused ion beam technique. For this tungsten tips were produced by electrolytic polishing. These tips were carefully blunted using a focused ion beam. Thereupon layers of pure Iron and pure Chromium with a single layer thickness of 12 nm and a planar interface have been deposited on the blunted tungsten tips by ion beam sputtering. In total a stack of up to 50 layers was produced. Subsequent isothermal and isochronal annealing sequences in a vacuum oven were carried out to investigate the thermal behavior of the system. In a last processing step, samples were sharpened to 50 nm radius of curvature by annular milling using the focused ion beam again. In the end samples were analyzed by using the wide angle tomographic atom probe (WATAP) constructed at the Institute of Material Physics [1].

The layer thickness in the as-prepared samples has been varied for thickness calibration. Every 10 layers the thickness was increased by 2 nm. The produced layer structure is clearly revealed in the reconstruction of the obtained data (Fig.1a).

Although a miscibility gab between a chromium rich phase and a iron rich phase exist up to a temperature of 820 °C, the interface width between layers is analyzed, because in other non miscible system a broadening of the interface width due to the Cahn Hilliard effect has already been observed [2].

At 600 °C (30 minutes) triple line diffusion is noticed as can be seen from the iso-concentration plot at 30 at% Iron in Fig.1b. Furthermore it is obvious from the composition profile shown there, that iron does not diffuse into the chromium layers in volume contrary to the diffusion behavior of chromium. Also the high resolution at the interface is obvious from the composition profile and has been shown earlier [3]. The transition width at the interface accounts to 0.53 nm at 600 °C.

In Fig.2 a cross view of an single triple line is shown. As can be seen the triple line is non symmetric and does not posses the form of a triangle as can be estimated from the form of three grains in equilibrium. The triple line diameter varies between 4 and 7 nm. The data from the isothermal annealing sequence is used to determine the triple line diffusion coefficient of iron in chromium and will be presented in this talk.

[1]. P. Stender, C. Oberdorfer, M. Artmeier, P. Pelka, F. Spaleck, G. Schmitz: Ultramicr. 107 (2007) 726
[2]. P. Stender, C. B. Ene, H. Galinski, G. Schmitz: Int. J. Mat. Res 99 (2008) 5
[3]. P. Stender, T. Heil, H. Kohl, G. Schmitz: Ultramicr. 109 (2009) 612

a) b)

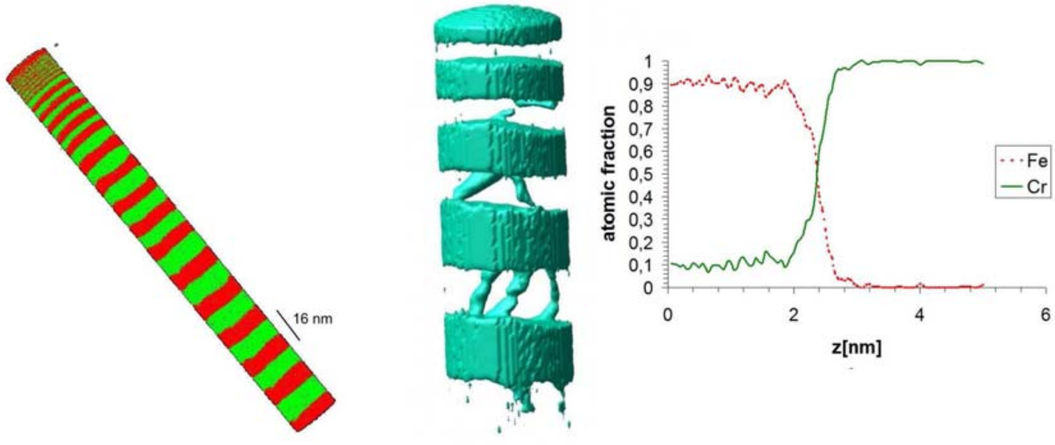

Figure 1. a) Reconstruction of an as-prepared sample consisting of 76 million atoms. (only part is shown) b) Isosurface plot (30 at% iron) of an annealed sample at 600°C

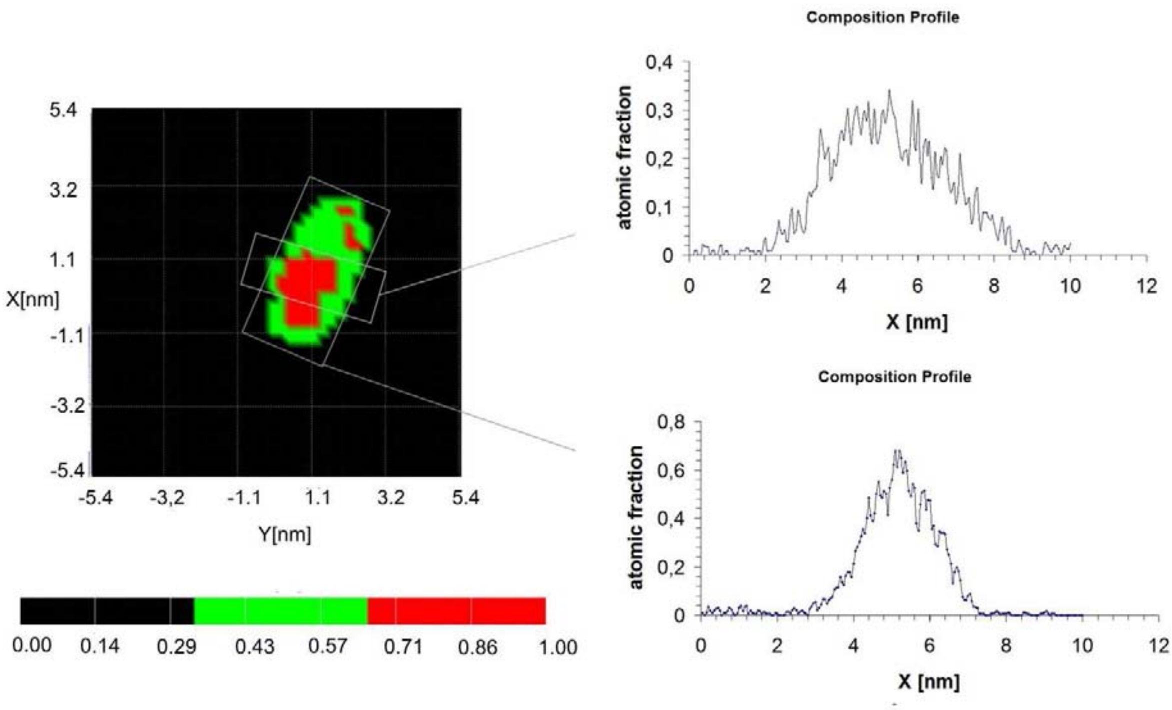

Figure 2. Top view onto one single triple line and the obtained composition profiles in two directions

DOI: 10.3217/978-3-85125-062-6-401 , © Verlag der TU Graz 2009