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Nanostructured Materials as Studied with the Tomographic Atom Probe (TAP)

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Nano-structured materials are currently of appreciable interest for different applications in materials science and engineering, e.g. for advanced magnetic and electronic devices. Since the macroscopic physical properties of these structures are largely controlled by the constitution of their internal interfaces, which exist in a large volume fraction, these materials exhibit unique attributes and were recently attracting a noticeable research activity. However, any application of such materials requires the preservation of the nanostructure, which is basically affected by thermal ageing resulting in grain growth, segregation of minor additives and the formation of second phases. Hence, to understand the link between the physical properties and their change with temperature, it becomes essential to study the evolution of these structures as a function of time and temperature on an atomic and microscopic scale.

The methods to produce such structures may range from deposition of thin layers via different physical and chemical technologies, electrostatic or pulsed deposition, precipitation of the super saturated solution on a suitable substrate, mechanical alloying and even to the phase separation in solids in bulk materials.

However, the analysis of such structures make high demands on many experimental techniques, since the relevant features may have the dimension of some nanometers. In particular, the determination of local chemical gradients appears to be extremely difficult. The Atom Probe Field-Ion Microscopy (APFIM) and its further development as a 3D-Atom Probe, e.g. the Tomographic Atom Probe, has been established as a sensitive analytical method for the investigation of chemical inhomogeneities on the atomic scale. The data collected by the TAP can be processed by means of reconstruction algorithms and special visualizing tools and reveal three dimensional images, which include all the information on microstructure and chemical composition of the sampled volume.

This paper reviews recent results obtained with the tomographic atom probe on the thermal stability of some nanostructured materials, such as Cu-Bi [1] and Al-Cu [2], after ageing. The nanostrucutres were prepared by means of Argon sputtering on pre treated tungsten substrate tips, as thin multilayers for Al-Cu and a highly super saturated alloy for the Cu-Bi system and subsequently aged at different temperatures[3].

References

[1] D. Wolde-Giorgis, PhD-thesis, University of Goettingen, in preparation
[2] P.-P. Choi, PhD-thesis, University of Goettingen, in preparation
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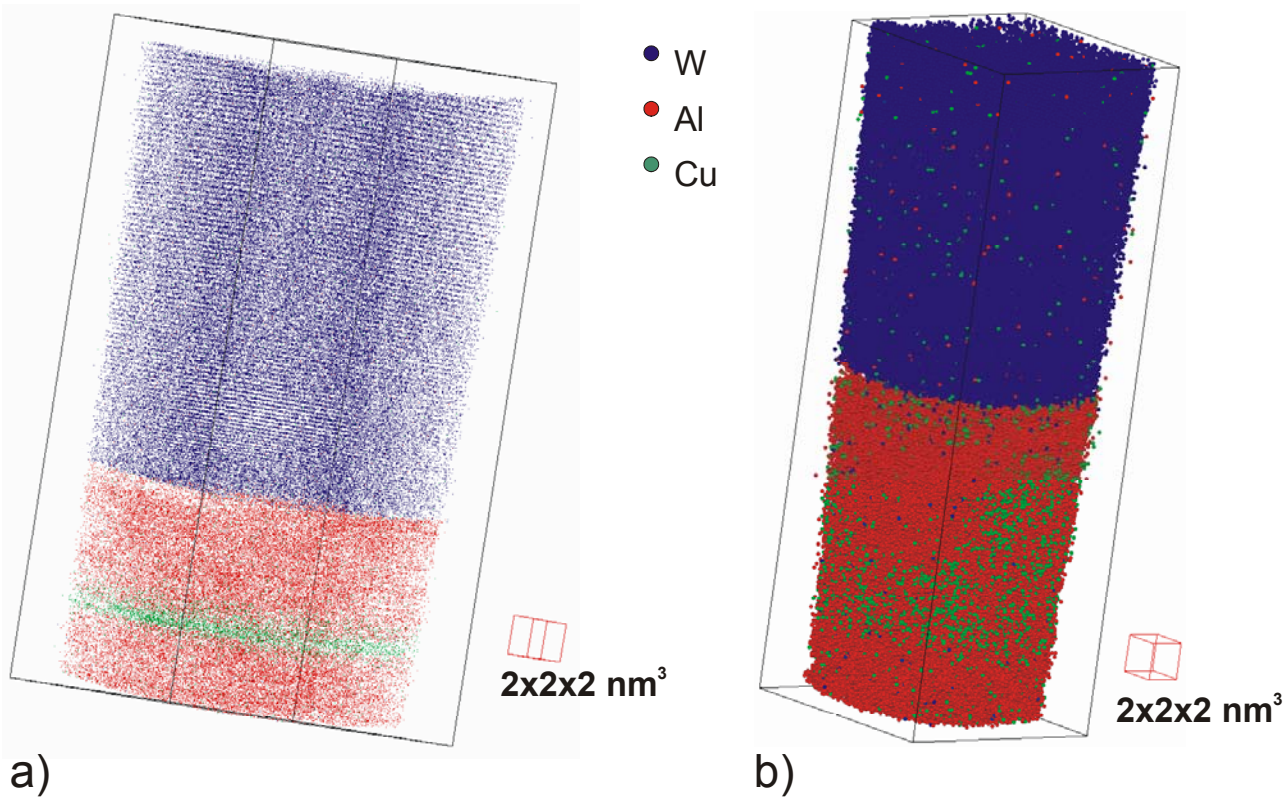

Fig.1. 3D-reconstruction of TAP-data of Al and Cu thin layers deposited by Ar-sputtering on W substrate tips in the (a) as prepared condition and (b) after annealing for 300 s at 423 K, showing the diffusion reaction between the deposited thin film layers.

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