

Internal interfaces – fundamental microstructure features in nanocomposites

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The properties of nanocrystalline materials and nanocomposites are strongly influenced by the structure of internal interfaces. Therefore, the understanding of the formation of such interfaces is the first step in the design of nanocomposites with tailored materials properties. Two examples of the systematic materials design that is based on the knowledge of the mechanisms and processes running on the atomic scale are the improvement of mechanical properties and the enhancement of the thermal stability of hard materials. Modern hard materials are usually produced in form of nanocomposites containing immiscible phases. Regarding the properties of such nanocomposites, the crucial issue is the presence of coherent internal interfaces, as the coherent interfaces are known to generate local lattice strains that are believed to affect the formation and mobility of microstructure defects and to stabilize metastable phases.

This talk will give an overview over the possible ways of controlled formation of hard nanocomposites consisting of immiscible phases like physical vapour deposition, precursor methods, mechanical alloying and high-pressure/high-temperature synthesis. For individual technological routes, the mechanisms of nanocomposite formation like spinodal decomposition, stabilization of metastable phases through the local epitaxy, interplay between diffusion and local lattice strains, and uncompleted phase transformation will be discussed. The effect of coherent internal interfaces on the hardness and thermal stability of nanocomposites will be illustrated on the transition metal nitrides containing aluminium and/or silicon and on the boron nitrides. In addition, this talk will recapitulate the recent developments in the microstructure analytics on the nanoscale, which were necessary to be able to reproduce the constitution of the nanocomposites, to be able to visualise the atomic structure of the internal interfaces in the nanocomposites, to assess their coherence and to understand their formation.