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DocMASE Project Proposal DAAD-2017-1

Project Title	**Nano-crystalline and nano-structured metallic composites: synthesis and characterisation of thermal and mechanical properties**
Main University and Advisor	Saarland University, Prof. Dr. Christian Motz (Chair of Material Science and Methods)
Associated Partner(s) (if applicable)	Saarland University, Prof. Dr. Frank Mücklich (Chair of Functional Materials)
Project Description (with **image**, if applicable)	Nano-crystalline metals exhibits outstanding mechanical properties, like high strength and hardness, and show some interesting physical properties. On the other hand, caused by their high internal boundary area and therefore high interfacial energy, they are prone for grain growth under thermal and/or mechanical load, which degrades their excellent properties. Usually, impurities of elements with small atomic sizes (e.g. C, S, P), which segregate to the grain boundaries and reduce their mobility or driving force, are used to stabilize the nano-sized grain structure. However, these elements usually decrease the boundary strength especially at higher temperatures. Metallic nano-composites consisting of immiscible metals, e.g. Cu and Co, can overcome these problems. As conventional synthesis routes cannot produce these composites, new methods are needed including mechanical alloying and electro-chemical deposition. Here supersaturated solid solutions can be produced in a wide range of concentrations. Subsequent annealing procedures can be used to decompose the solid solution, e.g. by spinodal decomposition processes, and to produce a metallic nano-composite. Due to the immiscibility of the elements and the usually bad interdiffusion these structure are very stable, both mechanically and thermally. The aim of this project is the production of supersaturated solid solutions of a model system (e.g. Cu-Co-system) and the creation of different nano-structures by subsequent annealing procedures. For characterisation of the decomposition process and the microstructural evolution at higher temperatures modern methods (SEM, TEM, XRD, APT, etc.) will be utilized. Furthermore, the mechanical properties of this nano-composite will be investigated with the focus on fatigue properties. This should lead to a better understand of the interplay between nano-structure, mechanical properties and thermal stability, which will lead to the possibility to design optimized nano-composites for different applications.
Previous Publications	1. Bachmaier, A., Neubauer, E., Kitzmantel, M., Pippan, R., Motz, C., Micro-structural evolution in immiscible alloys processed by High-Pressure Torsion, IOP Conference Series: Materials Science and Engineering, Volume 63, Issue 1, 2014, Article number 012023 2. Bachmaier, A., Motz, C., Pippan, R., Manufacture of ultra high-strength and thermally stable nano-crystalline metallic composite materials with high deformation, Metall, Volume 68, Issue 11, 1 November 2014, Page 860 3. Bachmaier, A., Aboulfadl, H., Pfaff, M., Mücklich, F., Motz, C., Structural evolution and strain induced mixing in Cu-Co composites studied by transmission electron microscopy and atom probe tomography, Materials Characterization, Volume 100, February 2015, Pages 178-191 4. Bachmaier, A., Motz, C., On the remarkable thermal stability of nanocrystalline cobalt via alloying, Materials Science and Engineering A, Volume 624, January 09, 2015, Pages 41-51
Requirements of the candidates / Requirements during the doctoral programme (courses, seminars, etc.)	Very good English command. Bachelor in Materials Science, Chemistry, Physics or related disciplines. Master in Materials Science or related disciplines. Knowledge of German will be appreciated but not compulsory. The general requirements for the DocMASE program regarding courses, seminars, summer schools, etc must be fulfilled. Particulraly, 30 ECTS of lectures have to be validated at the end of the PhD and you are expected to publish the results of your studies in international peer-reviewed journals.