E·U·S·M·A·T

DocMASE

DAAD

DocMASE Project Proposal DAAD-2016-2

Project Title	***Investigation of the influence of Nickel on the toughness of low alloyed, low-medium carbon steels***
Main University and Advisor	Saarland University, Prof. Dr. Frank Mücklich (Chair of Functional Materials)
Associated Partner(s) (if applicable)	Saarland University, Prof. Dr. Christian Motz (Chair of Material Science and Methods)
Project Description (with **image**, if applicable)	Nickel is one of the most important alloying elements in steel, because it has very good influence on the toughness under dynamic load. The reason for these influence is not perfectly cleared. Besides the microstructure refinement due to the γ/α-transformation temperature reduction, other mechanisms have been proposed in the literature. Nickel has a strong influence on the segregation behavior on grain boundaries and the dislocation dynamic on steels. Jolley [1], Arsenault [2] and Norström [3] assume that screw dislocations can easily cross slipping due to the interaction with the Nickel atoms. Thus promotes the plastic deformation towards the brittle fracture, what should lead to a higher toughness. The presence of retained and reversed austenite, carbide distribution, and changes in the sulphide precipitation have been related with the improvement of toughness when Ni is added [4:5]. Furthermore, Mn/Ni enrichment in phase boundaries has been observed by atom probe tomography (APT) in transformation induced plasticity steels and it had been associated to the growth of an austenite layer, which can be related to an increase in the ductility of these steels [6]. Nevertheless, the effect of nickel – especially on the dislocation movement and its segregation with carbon has not yet been fully understood. Consequently, there is a great need for further fundamental investigation of the influence of nickel on the mechanical properties of steel. To find new steels without nickel but with an adequate toughness, the exact mechanism of the toughness improvement of nickel has to be understood. With this knowledge new processes like thermo-mechanical procedures or new alloying elements with the same effect on the toughness, could be developed. The aim of the work is the investigation of the influence of nickel on the toughness by combining thermodynamic simulations, mechanical testing and microstructure investigation with atomic resolution. With the help of the focused ion beam technique, it is possible to make a target preparation of the material and to studied specific phases and boundaries. The effect of segregation shall also be investigated by micromechanical tests in combination with the atom probe tomography.
Previous Publications	[1] W. Jolley, Effect of manganese and nickel on impact properties of iron and iron-carbon alloys, J. Iron Steel Inst., 2006 (1968) 170-173. [2] R:J: Arenault, The double-kink model for low-temperature deformation of BCC metls and solid solutions, Acta Mater., 15 (1967) 501-511. [3] L.-A. Norström, O. Vingsbo, Influence of nickel on toughness and ductile-brittle transition in low-carbon martensite steels, Metal Science, 13 (1979) 677-684. [4] W. M. Garrison, Metall. Mater. Trans. A, 17 (1986), 669-678. [5] J. Krawczyk, J. Pacyna, P. Bała, Mater. Sci. Technol., 31 (2015), 795-802. [6] O. Dmitrieva, D. Ponge, G. Inden, J. Millán, P. Choi, J. Sietsma, D. Raabe, Acta Mater., 59(1) (2011), 364-374.
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.