DESCRIPTION FOR THE GENERAL PUBLIC

Hybrid metal matrix composites (HMMCs) are the new and improved version of metal matrix composites (MMCs) becoming one of the most advanced materials group used for aerospace, automotive, defense and general engineering applications. HMMCs are formed by reinforcing the metal matrix by two or more material types of varying properties, or two different sizes of the same material. Comparing to MMCs, they can be tailored to have superior properties such as enhanced high-temperature performance, high specific strength and stiffness, increased wear resistance, better thermal and mechanical fatigue and creep resistance. Due to their possible applications, the deformation and damage behavior is one of the most crucial issues in the context of durability and long-term performance of HMMCs.

The mechanical properties of HMMCs can be efficiently predicted by the multiscale modeling approach, which has seen widespread application in various scientific and engineering disciplines. It allows taking into account the structural composite features at different scales, such as microscopic (the type of matrix material, reinforcement volume and size, the quality of the metal/ceramic interface) or/and atomistic one (the density of material defects, the grains orientations and the type of grain boundaries). The phenomena at lower scales affect the composite behavior at a macroscopic scale.

Within the proposed project, development, implementation and validation of numerical models predicting the deformation behavior up to damage of hybrid metal matrix composites will be performed for different scales: atomistic, microscopic and macroscopic one (Fig. 1). Different approaches and different numerical models appropriate for each scale will be employed. The molecular dynamics (MD) simulations will be performed to study at the atomistic scale the strength of each composites components: metal matrix, ceramic reinforcement and metal-ceramic interface. MD simulations allow determining the input parameters of micromechanical models - discrete and micro-CT finite element. By taking into account the composite microstructure, microscopic models will provide data for macroscopic modeling. The top of the multiscale approach will be a numerical simulation of small punch test, which is a new method of material strength determination gaining more and more recognition. The numerical models will be validated using the results of own experimental studies performed within this project. Experimental studies consist of mechanical properties tests performed at three scales: nano-, micro- and macroscopic one. The experimental and numerical approach will be used to model the deformation behavior and strength of three kinds of composites. The intermetallic (NiAl) based material reinforced with hybrid ceramic (Al_2O_3) particles with different size has been selected as a representative material of a class of novel composite materials characterized by the brittle type of deformation. The two representatives of ductile materials are the copper (Cu) and nickel (Ni) matrix composites reinforced by (micron+submicron+nano) multisized silicon carbide (SiC) particles. Ni-SiC composite will be developed as a new innovative metal matrix composite manufactured by sintering techniques. Deformation behavior and damage properties of composites will be studied in respect to their volume content and reinforcement composition.

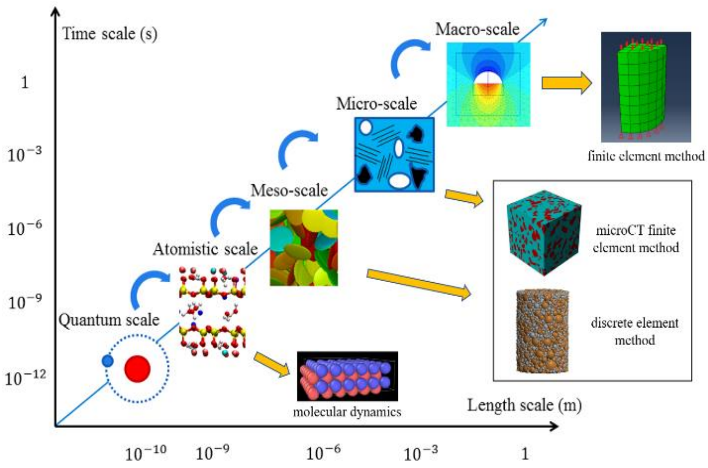

Fig 1. Overview of new multiscale model at different scales.