Multiscale analysis of damage behaviour of sintered NiAl-based materials with ceramic addition

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The present study aims to establish a quantitative relationship between sintering parameters, microstructural evolution, and the resulting mechanical properties of NiAl-based porous composites. Special emphasis is placed on capturing the deformation process and damage mechanisms by accounting not only for the bulk microstructure and macroscopic mechanical response, but also for the evolution of interfacial regions [1]. These include the formation and transformation of metal-metal and metal-ceramic interfaces, which critically influence the effective material behavior.

To achieve this, a comprehensive multiscale framework is employed (see Fig. 1), integrating advanced experimental characterization techniques - such as scanning electron microscopy, X-ray micro-computed tomography, and mechanical testing combined with digital image correlation together with numerical multiscale modeling approach. The latter encompasses finite element and discrete element methods at the mesoscale [2], as well as molecular dynamics simulations at the atomic scale to resolve interfacial phenomena [3]. The inherently heterogeneous microstructure of the porous NiAl composite, reconstructed from experimental observations, and the interfacial constitutive behavior, informed by microscale/atomistic simulations complement elastic-plastic properties of the NiAl material within grains. This integrated approach enables a physically consistent analysis of deformation and damage processes of sintered NiAl-based composites under mechanical loading.

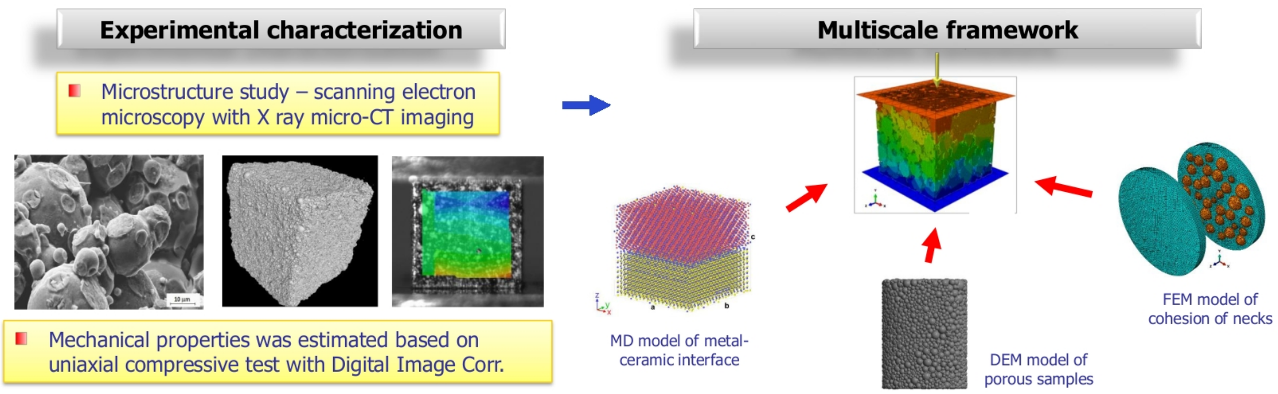

Figure 1. Summary of the multiscale framework.

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