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Micromechanical response of multi-phase Al-alloy matrix composites under uniaxial compression

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Aluminum alloys are extensively used in the automotive industry. Particularly, squeeze casting production of Al-Si alloys is employed in the conception of metal matrix composites (MMC) for combustion engines. Such materials are of a high interest since they allow combining improved mechanical properties and reduced weight and hence improve efficiency. Being a multiphase material, most MMCs show complex micromechanical behavior under different load conditions. In this work we investigated the micromechanical behavior of two MMCs, both consisting of a near-eutectic cast AlSi12CuMgNi alloy, one reinforced with 15%vol. Al2O3 short fibers and the other with 7%vol. Al2O3 short fibers + 15%vol. SiC particles. Both MMCs have complex 3D microstructure consisting of four and five phases: Al-alloy matrix, eutectic Si, intermetallics, Al2O3 fibers and SiC particles.

The in-situ neutron diffraction compression experiments were carried out on the Stress-Spec beamline and disclosed the evolution of internal phase-specific stresses in both composites. In combination with the damage mechanism revealed by synchrotron X-ray computed tomography (SXCT) on plastically pre-strained samples, this allowed understanding the role of every composite's phase in the stress partitioning mechanism. Finally, based on the Maxwell scheme, a micromechanical model was utilized. The model perfectly rationalizes the experimental data and is able to predict the evolution of principal stresses in each phase.

Primary authors: EVSEVLEEV, Sergei; MISHUROVA, Tatiana (BAM); Dr GARCÉS, Gerardo (National Center for Metallurgical Research CENIM-CSIC, Madrid, Spain); Prof. SEVOSTIANOV, Igor (Department of Mechanical and Aerospace Engineering, New Mexico State University, USA); HOFMANN, Michael; Prof. BRUNO, Giovanni (BAM)

Presenter: EVSEVLEEV, Sergei

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