Mechanical properties of Al/Al-Cu-Fe composites newly elaborated by Spark Plasma Sintering

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Thanks to their mechanical (high hardness together with high elastic modulus and yield stress) and tribological properties, Al-Cu-Fe particles appear as good candidates for reinforcement particles in Al matrix composites. Moreover, metal/metal interfaces between Al matrix and Al-Cu-Fe particles are supposed to play a benefic role in the mechanical properties of the composite.

Depending on the synthesis temperature, Al-based composites are reinforced either with quasicristalline i-Al-Cu-Fe phase or with tetragonal ω-Al-Cu-Fe phase.

In this work, Al/Al-Cu-Fe composites were produced by Hot Isostatic Pressing (HIP) and Spark Plasma Sintering (SPS). Compression tests of HIP Al/i and Al/ω composites were performed at constant strain-rate and at different temperatures (273K<T<823K). For T<550K, Al/□ composites exhibit a larger $\sigma_{0,2\%}$ than the Al/i composites. Transmission electron microscopy observations suggest that the size and spatial distribution of Al-Cu-Fe particles in the Al matrix play different roles in the strengthening of the two composites.

In order to understand the role of the particle crystallographic structure, the mechanical properties of ω-Al-Cu-Fe phase are compared to those of i-Al-Cu-Fe. Despite their antinomic periodic/quasi-periodic character, i- and □- phases show strong similarities that rules out a key role of the reinforcement structure.

Complete mechanical property characterization requires production of large samples by SPS. Sintering processing parameters (temperature, pressure, duration) have been optimized to adjust the microstructure of the composites. The objective is to produce high density composites with a uniform spatial distribution of reinforcement particles in the Al matrix. Large and regular nanoindentation arrays have been performed in order to build hardness maps across the different phases of the composite. The detailed analysis of the individual deformation curves shows serrated behavior characteristic of dislocation pinning by solute atoms in the Al matrix. These results are correlated with SEM observations coupled with EDXS analyses. The comparison between chemical and hardness maps as well as the quantitative analysis of the deformation curves give evidence of a strong correlation between the chemical heterogeneities and mechanical properties of the Al matrix.