

# Microstructure engineering for ductility enhancement of a lightweight Fe<sub>32</sub>Cu<sub>12</sub>Ni<sub>11</sub>Ti<sub>16</sub>Al<sub>29</sub> alloy via powder metallurgy

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Complex concentrated alloys (CCAs) can combine favorable mechanical properties, oxidation resistance, and low density by utilizing the correct alloying strategies and heat treatment, making them attractive candidates for next-generation high-temperature applications. A recently developed lightweight Fe<sub>32</sub>Cu<sub>12</sub>Ni<sub>11</sub>Ti<sub>16</sub>Al<sub>29</sub> CCA (5.6 g/cm<sup>3</sup>) [1] exhibits a two-phase microstructure consisting of an Fe-rich matrix and Cu-rich precipitates, providing high hardness and competitive compressive strength at elevated temperatures. However, later it was found that the matrix consists of the an intermetallic L<sub>21</sub>-type phase [2] typical of Ti-rich iron aluminides, characterized by a high brittle-to-ductile transition temperature (up to 1000 °C) [3], which limits plasticity at moderate temperatures and motivates further alloy and microstructure optimization.

In this study, two complementary strategies were employed to overcome the limited plasticity of the alloy: (i) grain refinement via powder metallurgy and (ii) dispersion strengthening through in situ TiC formation during sintering. Powders were produced by mechanical alloying in an *n*-Heptane environment and consolidated by spark plasma sintering (SPS). The microstructure of fully dense samples was characterized using SEM, EBSD, and TEM, while mechanical behavior was evaluated by compression tests at temperatures up to 1000 °C. The L<sub>21</sub> intermetallic matrix exhibited a submicron grain size. TiC, distributed along grain boundaries was found to stabilize the grain growth, stabilizing the fine-grained microstructure. As a result, the brittle-to-ductile transition temperature was reduced to approximately 500 °C.

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