

Lightweight Single-Phase Al-based Complex Concentrated Alloy with High Specific Strength

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Abstract: Developing light yet strong aluminum (Al)-based alloys has been attracting unremitting efforts due to the soaring demand for energy-efficient structural materials. However, this endeavor is impeded by the limited solubility of other lighter components in Al. Here, we propose to surmount this challenge by converting multiple brittle phases into a ductile solid solution in Al-based complex concentrated alloys (CCA) by applying high pressure and temperature. We successfully develop a face-centered-cubic single-phase Al-based CCA, Al₅₅Mg₃₅Li₅Zn₅, with a low density of 2.40 g/cm³ and a high specific yield strength of 344×10³ N·m/kg (typically ~ 200×10³ N·m/kg in conventional Al-based alloys). Our analysis reveals that formation of the single-phase CCA can be attributed to the decreased difference in atomic size and electronegativity between the solute elements and Al under high pressure, as well as the synergistic high entropy effect caused by high temperature and high pressure. The increase in strength originates mainly from high solid solution and nanoscale chemical fluctuations. Our findings could offer a viable route to explore lightweight single-phase CCAs in a vast composition-temperature-pressure space with enhanced mechanical properties.

Keywords: Lightweight ; Al-based ; Complex Concentrated Alloy; High Specific Strength