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Effect of graphene on transformation temperature and mechanical properties of copper-zinc-aluminum (Cu-Zn-Al) shape memory alloy

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Abstract

This study focuses on enhancing the mechanical properties of copper-zinc-aluminum shape memory alloys (SMA) by incorporating graphene. Commercial copper, zinc, and aluminum bars alongside graphene nano-plate (3-10 nm particle size, 99.5% purity) were obtained. Four different samples were produced with varying SMA (71wt% Cu + 25wt% Zn + 4wt% Al) and graphene compositions: Sample A (100 wt.% SMA, 0 wt.% Gr), B (99.5 wt.% SMA, 0.5 wt.% Gr), C (99 wt.% SMA, 1 wt.% Gr), and D (98.5 wt.% SMA, 1.5 wt.% Gr). The alloys' structural characteristics were analyzed using XRD, revealing the formation of new metallic compounds upon graphene addition. Scanning Electron Microscope (SEM) equipped with Energy Dispersive X-Ray Analysis (EDX) confirmed even distribution of copper, zinc, aluminum, and graphene in the samples. Tensile testing demonstrated a significant increase in strength, with values rising from 200.6 Mpa for Sample A to 270.4 Mpa, 330.9 Mpa, and 402.6 Mpa for samples B, C, and D, respectively. Direct Scanning Calorimeter (DSC) results indicated that graphene raised the austenite formation commencement temperature while reducing the martensitic formation temperature. Austenite formation temperatures for samples A, B, C, and D were 35.5, 38.5, 41.5, and 43 °C. Conversely, martensitic formation temperatures decreased from 74°C for sample A to 60-69 °C for samples B-D. In summary, the addition of graphene to SMA (71wt% Cu + 25wt% Zn + 4wt% Al) significantly improved tensile strength, altered phase transformation temperatures, and is expected to enhance the alloy's performance in service.

Keywords
Graphene
Cu-Zn-Al alloy
Mechanical properties
Tensile strength
XRD
DSC