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High-Strength High-Ductility Polymer Derived Ceramic Metal Matrix Composites

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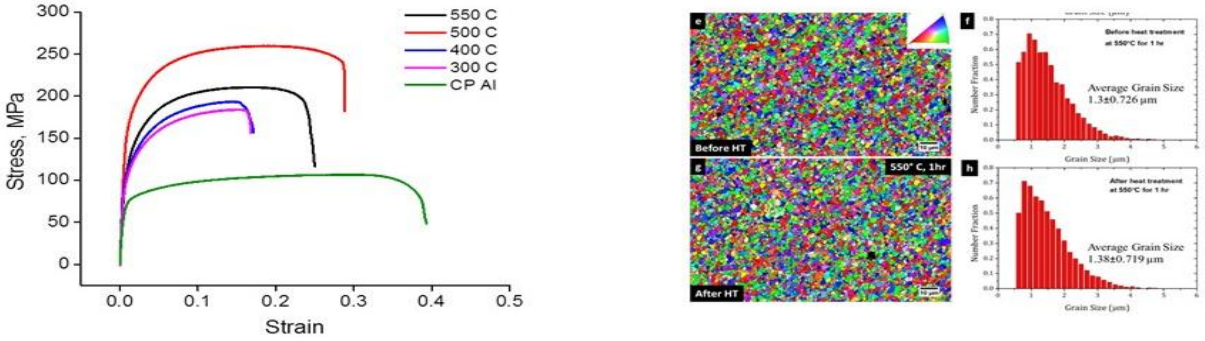
Producing high strength - high ductility materials is of great importance. In this talk a new kind of metal matrix composite is presented having such properties, using the polymer derived ceramic route. In this process, a brittle polymer is mixed in the base metal using different severe plastic deformation routes; Friction Stir Processing (FSP) for bulk base metal, and Friction Assisted Lateral Extrusion Process (FALEP) for powder metal. These processes fracture the polymer to nano level (ranging from a few nano meters to sub-micron level). Once this mixing is done, the 'composite' is heated to 500^0C for 10 hours. This step pyrolysis the polymer to a ceramic. A further processing step is used to close the pores that are generated due to gases that are produced during the pyrolysis. Such Polymer Derived Ceramic Metal Matrix Composites (PDCMMC) have grain sizes close to 1 micron, and an increase of more than three times in yield strength, without significant loss in ductility. Further, the material also shows remarkable grain boundary stability even at temperatures up to 550^0C [1]. The high strength is attributed to dislocation pinning at the larger ceramic particles and high ductility is attributed to the dislocation generation due to bowing of dislocations and dislocation generation around the nano-meter size particles. Grain boundary pinning by ceramic nano-particles stabilizes the microstructure at high temperatures.



(a) (b)

Fig. 1. (a): Stress-strain curves after pyrolysis at various temperatures for an aluminum-magnesium alloy PDCMMC. (b) Microstructure before and after heat treatment at 550°C.

Keywords: High-Strength, High-Ductility, Metal Matrix Composite, Polymer Derived Ceramic, Severe Plastic Deformation

[1] Abhishek Pariyar, Laszlo S. Toth, Satish V. Kailas, Laurent Peltier, Imparting high-temperature grain stability to an Al-Mg alloy, Scripta Materialia, 190 (2021) 141-146.