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Material selection, fabrication and characterization of magnesium matrix particulate nanocomposites for biomedical applications

Magnesium alloys have a similar mechanical strength and elastic modulus to those of human bones and are dissolvable in the physiological environment, representing a new generation of biomaterials for orthopaedic and cardiovascular applications. However, the alloys lack adequate strength and corrosion resistance as the implant material. The present work was carried out to develop an optimum route for fabricating magnesium matrix particulate nanocomposites with controllable strength and degradability. The matrix alloy was selected with cytotoxicity free alloying elements and minimum amount of second-phase particles. The reinforcing particles including biocompatible hydroxyapatite (HA), beta-tricalcium phosphate and magnesium oxide (MgO) were chosen to improve strength and corrosion resistance. The composites were fabricated by combined high shear solidification (HSS) and severe plastic deformation via equal channel angular extrusion (ECAE) or conventional extrusion. The cast nanocomposites obtained by HSS showed a fine and equiaxed grain structure with the globally uniform distribution of nanoparticles, although HA showed the best wetting effect. Both ECAE and conventional extrusion at 350°C resulted in further microstructural refinement and the improvement of particle distribution, but the latter led to a finer grain structure. The microstructure and particle distribution in the as-cast state and after deformation processing were characterized by optical and electron microscopy, EDS and XRD, etc. The mechanical properties were tested by compression and electrochemical performance was assessed by static polarization tests. Corrosion behaviour was studied by immersion tests and electrical impedance analysis. The detailed experimental results are presented in this paper together with discussions on the benefits of both HSS and ECAE and the mechanisms responsible for the enhanced materials performance.

Speaker Biography

Yan Huang leads metallic biomaterials research at Brunel, working on both traditional permanent titanium implants and novel biodegradable magnesium medical devices for orthopaedic cardiovascular applications. He recently won three research grants in biomaterials research from the Royal Society, EPSRC and European Commission. Huang is a founding member and co-investigator of the EPSRC Future Liquid Metal Engineering (LiME) HUB where he leads the activities on process development and light alloy processing involving both solidification and plastic deformation. He has extensive experience in process innovation for combined solidification and thermomechanical processing (semisolid forming, twin roll casting, and integrated cast-forming), solid state joining, severe plastic deformation for light alloys and light metal matrix composites. He has long-term interests in the characterization of microstructure and texture evolution during thermomechanical processing and fundamental issues of strengthening, plastic deformation and grain boundary migration.

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