University of New South Wales
Faculty of Science
School of Materials Science and Engineering

Research Plan

Synthesis and Properties Metallic Glasses for Biomedical Applications

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Metallic glasses are amorphous alloys produced by cooling directly from the liquid state with a smallest dimension of over 1 mm termed bulk metallic glasses (BMGs). The disordered atomic-scale structure offers unique and attractive features for this class of material. For instance, amorphous steels have been produced with much greater strengths than conventional steels. Because of the wide applications of engineering alloys and the excellent combination of properties of metallic glasses, these materials offer a bright future as new materials and have already attracted considerable research interest worldwide.

In recent years, there has been a growing interest in using BMGs as bioresorbable metals. For example, orthopaedic components made from these materials do not require removal by secondary surgery, and offer superior load bearing capability compared to the existing biodegradable polymers. Recent advances in materials science have enabled the synthesis of BMGs based on combinations of Mg, Zn and Ca constituents. Individually, these elements play important roles as nutrients and can lead to health benefits. Depending on the alloy composition, these BMGs may be tailored to corrode in a controlled manner, and can also be easily shaped into intricate components using thermoplastic forming techniques. Hence, these types of BMGs are regarded as worthy candidates as bioresorbable materials, as discussed below.

Over one million Australians have diabetes. This disease inhibits wound healing and can in turn lead to chronic infection, loss of limbs, and even loss of life. Current crystalline silver and iodine salts used in antibacterial wound dressings are also highly cytotoxic, killing both microbes and healthy cells and tissues normally recruited for wound healing. Regular replacement of dressings, contamination caused by dressing changes and the need for systemic antibiotics, are additional limitations of current wound management practice. A novel “leave-in” skin graft for treating diabetic ulcers is being developed by researchers in the School of Materials, UNSW in collaboration with colleagues at Royal Prince Alfred Hospital (RPAH). Here, new Mg-based BMG biomaterials developed by Prof Ferry and Dr Laws (UNSW), Dr Boughton (USyd) and Prof. McLennan (RPAH) have opened up opportunities to fight infection in a controlled and localized way while encouraging healthy vascularized tissue to bridge the wound.

In my thesis, elastic nanofilms based on BMGs containing Mg-Zn-Ca + other minor elemental additions will be deposited onto antibiotic-infused scaffolds using magnetron sputtering and related techniques. The BMG film is expected to impart antibacterial activity to the tissue scaffold, and also for forming a coherent enveloping layer to help retain infused antibiotics. The film is then expected to be absorbed gradually by the body as nutrients. BMG cytotoxicity testing will also be carried out using cell culture facilities at UNSW and RPAH. The physical and chemical properties of these films will be characterized using a range of techniques (FIB-SEM, XRD, EPMA, ICP etc), and their nanomechanical properties studied by nanoindentation etc.

Further details of the proposed project are available from Prof. Michael Ferry, School of Materials Science and Engineering, UNSW.