Abstract of Main Thesis

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Study on Microstructure Evolution and Mechanical Properties of Harmonic Structure Materials with Strain Induced Martensitic Transformations

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Harmonic structure design concept has been applied to metallic materials for achieving excellent combination of strength and ductility. In the present work, microstructure evolution in the harmonic-structured single phase pure Cu and multi-phase biomedical Co-Cr-Mo alloys were examined to understand the formation mechanism and its effect on the mechanical properties.

The pure Cu and Co-Cr-Mo alloy compacts were successfully fabricated by severe plastic deformation - powder metallurgy (SPD-PM) process, consisting of controlling mechanical milling (MM) and spark plasma sintering (SPS). The MM powders had a bimodal structure, i.e. coarse-grained (CG) structure, “core regions”, located at center and ultra-fine grained (UFG) structure, “shell regions”, located near the surface of the each milled powder particle. The evolution of harmonic structure with different process parameters has been discussed. The harmonic-structured compacts of pure Cu and Co-Cr-Mo alloy reveal superior combination of strength and ductility as compared to their CG counterpart. The microstructure characteristics and mechanical performance were evaluated in wide range in order to clearly understand the effects of microstructural factors, such as grain size and shell / core fractions, on mechanical properties of harmonic structure materials. The harmonic structured pure Cu and Co-Cr-Mo alloys exhibit uniform deformation behavior, leading to improved mechanical properties. The unusual deformation behaviour is attributed to a 3-dimensional shell/core network structure. In addition, it was also found that strain induced martensitic transformation (SIMT) plays an important role in the deformation behavior of Co-Cr-Mo alloys. The formation of ε-HCP phase from γ-FCC phase easily takes place in continuous network of shell regions and affects the ductility. Accordingly, it was concluded that the optimal balance between shell and core fractions is an extremely important factor to control ductility of the Co-Cr-Mo alloys. As a general observation, the shell/core ratio was found to be a critical parameter for controlling the mechanical properties of both harmonic structure single phase pure Cu and multi-phase Co-Cr-Mo alloy.