

Abstract of Doctoral Thesis

Title : Study on Harmonic Structure Design Process in Single and Dual Phase Materials

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Strength and Ductility are most important and fundamental properties in metallic materials. However, it is difficult to deal with strength and ductility at same time due to trade-off relationship. In previous studies, Harmonic Structure was proposed which resulted in a combination of high strength and high ductility. The harmonic structure design is essentially a bimodal microstructure consisting of a three-dimensional continuous network of fine-grained regions which encircles the uniformly distributed coarse grained regions. However, the mechanism of structure-fabrication and deformation behavior are not determined. The aim of this research is to clarify the mechanism of structure fabrication and deformation behavior in Harmonic Structure designed materials, which have different phase, particle size and process.

By controlled mechanical milling, deformed layer is fabricated near the surface of individual powder particles and nano-grains are generated in the uppermost layer region. By the sintering, these deformed layers of powder particles are connected and network structure is constructed. In case of the single-phase pure Nickel, it has been made clear that the nano-grains, which are generated by severe plastic deformation, transform to fine-grained network due to dynamic recrystallization and grain-growth during sintering. The case of $\alpha + \gamma$ two phase stainless steel made it clear that fine-grained network is consisted of two layers, i.e. Mid-Shell and Outer-Shell. Mid-Shell is fabricated by pinning of γ phase during grain growth and Outer-Shell is fabricated by competition of γ precipitation and recovery/recrystallization. In small-sized pure Titanium powder particles, Harmonic Structure was successfully fabricated by High pressure gas jet milling process and it resulted in high strength and high ductility. Finally, a comparison of collision energy during Severe Plastic Deformation process, which was imparted by planetary ball milling and high pressure gas milling, demonstrated that the planetary ball milling provides high energy and low frequency and high pressure gas jet milling provides low energy and high frequency to powder particles, respectively. Therefore it made clear High pressure gas milling is effective process, which fabricate harmonic structure, for small size particle.