Nano Grain Formation Mechanism in Austenitic Stainless Steel Powders by Severe Plastic Deformation Process

Inomoto Hisashi

This synopsis is mentioned according to the contents of the main thesis.

Chapter 1 describes the prefaces and the purposes of this thesis. Grain refinement is very important to improve the mechanical properties of materials. HS-PM (High Strain - Powder Metallurgy) process such as Mechanical Milling (MM) and Mechanical Alloying (MA) are quite attractive since these processes enable to obtain an nano grain structure by providing quite heavy plastic deformation. The purpose of this thesis is to make clear the mechanisms of nano grain formation in austenitic stainless steel.

Chapter 2 describes the typical experimental procedures of this research. Especially, the PREP (Plasma Rotated Electrode Processed) powder whose particle size is about 1mm was used in this research.

Chapter 3 describes the mechanism of nano grain formation in SUS304L MM powder. An ultra fine BCC grain structure was formed in the surface layer by MM treatment. Those nano grains were caused by fragmentation and spheroidization of nano layered martensite (α') which was transformed from the austenite matrix after the MM treatment.

Chapter 4 describes the nano grain formation mechanism by MM in SUS316L (γ), SUS304L (α') and Ni PREP powders with different stacking fault energies (SFE). An elongated fine grain layer was observed adjacent to the equiaxed nano grain region in all powders. However, there were different microstructural changes until reaching such a (equiaxed nano grain + nano layer) microstructure in each powder.

Chapter 5 describes the mechanism of transformation in SUS316L MM powders. SUS316L stainless steel is hard to transform to a martensite by the conventional cold deformation process since its austenite (γ) state is quite stable. Ultra-fine BCC grain whose grain size is approximately 15 nm formed in the surface region of the powder by MM treatment. The nano BCC grain formation at the powder surface was attributed to the grain boundary energy and assisted γ to. ferrite (α.) phase transformation. Otherwise, a (BCC+FCC) nano duplex structure, whose grain size was less than 100 nm, formed by MM treatment at the inner of the powder. The BCC grain formed because an increase of lattice defects and formation of the irregular grain boundaries lead to increase of the chemical free energy of austenite phase and massive like γ to α formation occurred.

Chapter 6 describes the summary and the application of nano structure. MM is able not only to make fine grain structure but also change free energy of matrix phase, and MM can induce an unusual transformation. Moreover, surface modification is possible without changing composition by nano crystallization. It was clarified that the nano crystallization is very useful for material development in future.