Thermal and Neutron Diffraction Studies on Hydrogen Absorption/Desorption Processes in Metal Nanoparticles

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The nanometer-sized metals attract much attention since their physical and chemical properties are substantially different from those of bulk metals. We have studied thermal [1], structural [2] and dynamical [3] properties of nanoparticles of Pd hydride, which is the most popular and classical metal hydride. Following this work, we are now investigating the nanoparticles of Ru, PdPt and PdRu alloys and their hydrides by means of calorimetric and neutron powder diffraction (NPD) techniques. The enthalpy of hydrogen absorption, which is measured with our custom-built adiabatic calorimeter, provides important information on thermodynamic stability of hydride states. NPD is a very powerful method to observe H and D atoms in metals since their scattering cross sections are comparable with those of metals. A high intensity total scattering instrument NOVA at J-PARC was used for this experiment.

Bulk Ru has a hcp structure and does not absorb hydrogen, while its nanoparticles, which take both hcp and fcc structures depending on synthesis procedures, absorb hydrogen [4]. PdRu alloy nanoparticles also absorb hydrogen depending on its composition [5]. The phase-separated nanoparticles of Pd-core and Pt-shell are mixed to be solid solution alloy by repeating hydrogen absorption/desorption processes at 373 K [6]. In these systems, the positions of hydrogen atoms were determined by the Rietveld analysis.