29a-D2-5

Synthesis of Rh/Pd/Pt trimetallic alloy nanoparticles through femtosecond laser irradiation of solution

IMRAM, Tohoku University,

°Md. Samiul Islam Sarker, Takahiro Nakamura, Yuliati Herbani, and Shunichi Sato

E-mail: samiul@mail.tagen.tohoku.ac.jp

Pure metal and alloy nanoparticles (NPs) have attracted much attention mostly due to the significant scientific and industrial interests. Especially, studies on alloy or core-shell NPs are of great importance because the optical and catalytic properties usually depend on the composition of NPs. We have successfully demonstrated the fabrication of solid solution Rh–Pd and Rh–Pt binary alloy NPs with controllable compositions using femtosecond laser irradiation in an aqueous solution of metal ion mixture. As we explained earlier, reduction of metal ions could take place throughout the photo decomposition of water molecules due to a high intensity optical field. This method is not only one of green routes to the synthesis of pure metal and/or alloy nanoparticles with no chemical reducing agents, but also possible to produce multimetallic NPs with desired compositions. In this study, we extended our approach to fabricate Rh–Pd–Pt trimetallic alloy NPs, which are well known as three-way catalysts for automobile emission control, through femtosecond laser irradiation.

Sample solutions of Rh, Pd and Pt ions with 2.5×10^{-4} M concentration were prepared. Their mixing ratios of Rh:Pd:Pt were 33:33:33, 50:25:25, 25:50:25 and 25:25:50. 3 ml of the mixed solution was kept in a quartz glass cuvette and irradiated by tightly focused laser pulses at the intensity of 2.1×10^{14} W/cm^2. Irradiation time was set to 30 minutes for all the solutions. Figure 1 shows the TEM images and XRD profiles of NPs fabricated in the mixed ion solutions. It has been confirmed that the fabricated NPs are solid-solution alloy, as the XRD peaks for (111) and (200) planes of fcc structure are within the range of those of pure Rh, Pd and Pt. Moreover, the lattice constant calculated from the XRD peaks and from the SAED patterns are well fitted to the Vegard's law. Elemental compositions of NPs measured by EDS analysis are almost the same as the mixing ratios of the mixed ion solutions.

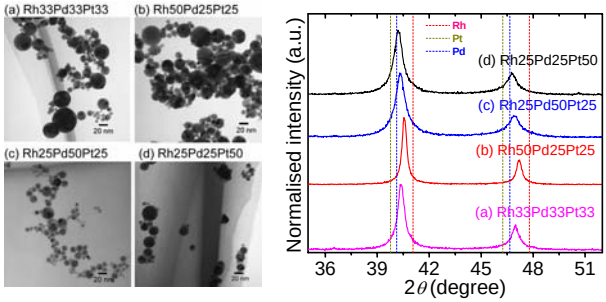

Fig. 1. TEM images of the NPs fabricated by laser irradiation of solutions with different mixing ratio of ions, (a) Rh33Pd33Pt33, (b) Rh50Pd25Pt25, (c) Rh25Pd50Pt25 and (d) Rh25Pd25Pt50 (left) and XRD patterns of the NPs (right). The dotted straight lines correspond to peak positions of pure Rh, Pd and Pt obtained from JCPDS card.