Noble Metal Recovering by Electroless Displacement Deposition on Silicon powder

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Noble metal is not only precious but also crucial for industries, such as electronics, catalyst, automotive, and electrolysis. Recycling of noble metal from scrap electronics and industrial waste is important for saving natural resources and environment. In the conventional recycling process, the scraps and waste are dissolved in aqueous solution and refined chemically. For recovering from low concentration waste solution, ion-exchange resin or electrolysis is used. We have been studying electroless displacement deposition of noble metal nanoparticles on silicon (Si) substrates (1) for efficient solar cell production (2) and metal film formation (3). This deposition is a local galvanic reaction expressed by followings.

Deposition of metal: $M^{n+} \rightarrow M + nh^{+}$

Dissolution of Si in an hydrofluoric acid (HF) solution:

$$Si + 4HF_2^{-} + 2h^{+} \rightarrow SiF_6^{2-} + 2HF + H_2$$

or

$$Si + 6F^{-} + 4h^{+} \rightarrow SiF_6^{2-}$$

In this study, the electroless displacement deposition on Si is applied for recovering noble metal from aqueous solutions. Efficient recovering is expected by the large electrochemical potential difference between noble metal deposition and Si dissolution. Figure 1 shows outline of the recovering process. The first step of the process is addition of HF and Si powder into an aqueous solution of noble metal ions. Noble metal particles and deposited on Si powder. The second step of the process is addition of oxidizing agent, such as nitric acid into the solution. Only Si is dissolved into the solution, and only noble metal particles remain in the solid-state. Features of this process are simplicity of process, high efficiency of recovering noble metal, and availability of using waste Si powder and HF provided by electronics industries.

An aqueous HF solution and Si powder were added to 0.5 mmol dm^{-3} H_2PtCl_6 solution, corresponding to 98 mg dm^{-3} of Pt. After stirring the solution for 10 min, the concentration of Pt in liquid phase was 0.028 mg dm^{-3}. Pure Pt particles were obtained by adding nitric acid to the solution and filtering, as shown in Fig. 2.

Figure 3 shows recovery ratio of metal from mixture solution of metal salts, such as H_2PtCl_6, $HAuCl_4$, $PdCl_2$, $CuCl_2$, $NiSO_4$, $CoSO_4$, and $FeSO_4$. The recovery ratio was determined by measurement of change in metal ion concentration of the solution with ICP photoemission spectroscopy. Au and Pd were 100% recovered in ten min. Pt was reached 100% in forty min. On the other hand, no concentration change was obtained for Ni, Co, and Fe. The energy band structure of silicon exerts this selectivity of noble metals and Cu. All eight noble metals, Ag, Au, Pt, Pd, Rh, Os, Ru, and Ir, were successfully recovered by this process.

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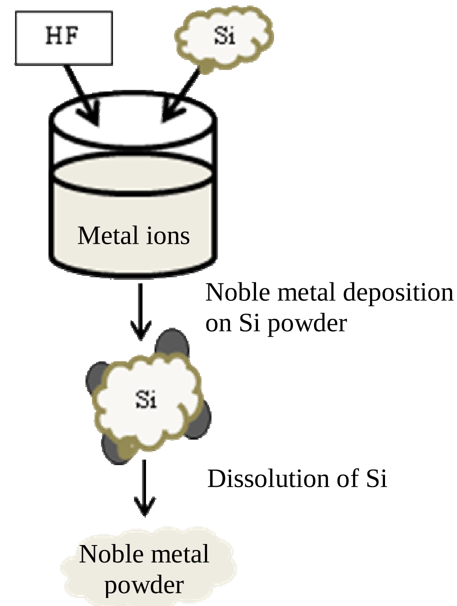

Fig. 1 Outline of the recovering process.

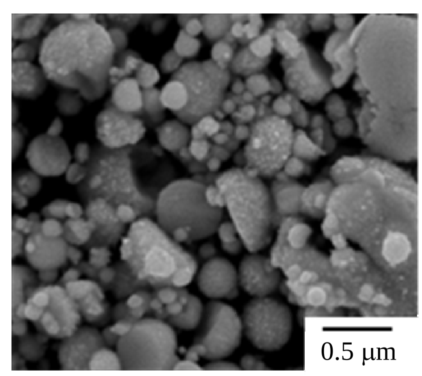

Fig. 2 SEM image of pure Pt particles.

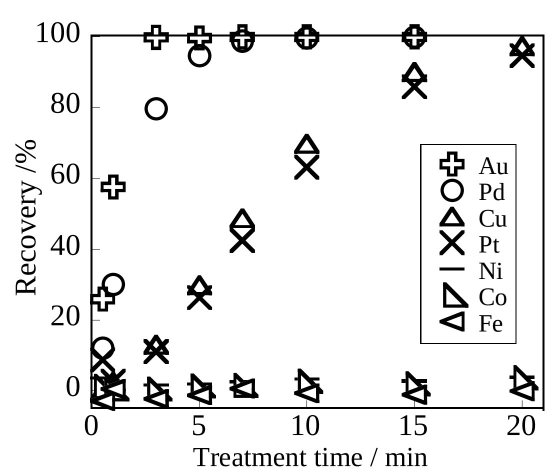

Fig. 3 Recovery ratio of metal from mixture solution.