Extended Abstracts of the 2010 International Conference on Solid State Devices and Materials, Tokyo, 2010, pp451-452

Facile Fabrication of Two-dimensional Assemblies of Gold Nanoparticles by Using Solvent evaporation method

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1. Introduction

Surface plasmons are collective oscillation of free electrons in metal nanoparticles and structures and lead to an enhanced local electric fields at the metal/medium interface region by resonating with light containing specific wavelength (localized surface Plasmon: LSPR)[1,2].

This phenomenon will open up the development of uniquely-sensitive spectroscopic sensing, novel high performance photonic devices and so on. In fact, the occurrence of enhanced Raman signal of photofunctional molecules by local electric fields has received a lot of attention for the development of “one molecule sensing”[3].

Also, Yamada et al. have reported that the photocurrent of organic dye molecules modified on the gold or silver nanoparticle films was dramatically enhanced within the surface plasmon resonance wavelength[4-7].

To utilize this local electric field, we should focus on a special plasmon mode induced at the joint area between metal nanoparticles. This mode leads to greatly enhanced local fields, to give the development of further high-perfarmance deveices. Therefore, the primary importance is skillful design and tailor-made fabrication of fine metal nanostructures. The typical fabrication method of these nanostructures is photolithography. However, this method is not good for cost performance and furthermore unsuitable for the fabrication over vast areas.

In this study, we suggest that the phase transfer of plasmonic gold nanoparticles (diameter: >10 nm) from aqueous to organic solution and rapid and facile fabrication method of two-dimensional assemblies of gold nanoparticles from the transferred solution with high density by solvent evaporation method.

2. Experimental Section

The colloidal aqueous solution of gold nanoparticles was prepared by the reduction of $HAuCl_4$ with citric acid as described previously, and the mean diameter was 14 ± 1 nm[8].

The fabrication scheme of gold nanoparticles assembly is shown in Fig.1. Typically, toluene solvent (5 ml) was added to aqueous solution of gold nanoparticles (30 ml) and then the toluene solution of 0.1 M octadecylamine (30 μl) was added to this solution, followed by stirring vigorously. After a few minutes, the color of the aqueous solution was changed from wine red derived from the optical absorption of surface plasmon resonance of gold nanoparticle to clear and colorless. Meanwhile, the color of toluene solution

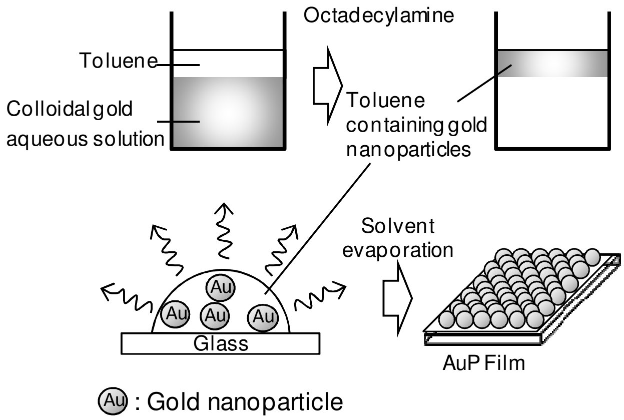

Fig. 1 The scheme of the fabrication method of the AuP film.

was changed from clear to deep wine red. This suggests that the gold nanoparticles contained in water phase were transferred to toluene phase without any aggregation (Fig. 2). Next, 100 μl of the prepared colloidal toluene solution of gold nanoparticles was casted on the surface of the glass slide and then dried at room temperature, to give the two-dimensionally gold nanoparticle assembly film (AuP film).

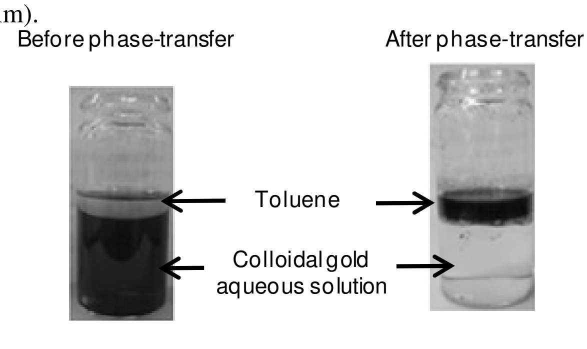

Fig. 2 The photographs of phasetransfer of gold nanoparticles.

3. Results and discussion

The obtained AuP film showed light blue, suggesting that the coupling of surface plasmon resonance was induced by the aggregation of gold nanoparticles.

To evaluate detailed optical information of AuP film, the

UV-visible absorption spectrum of the AuP film was measured (Fig. 3). The absorption spectrum exhibited clear peak around 590 nm ascribed to the plasmon oscillation of interparticle plasmon coupling.

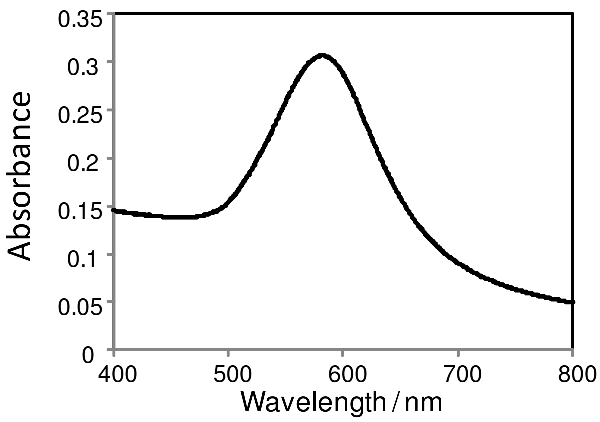

Fig. 3 The absorption spectrum of AuP film.

The SEM photograph of AuP film is shown in Fig. 4. The photograph showed that Gold nanoparticles were assembled two-dimensionally with high- density. Also, the subtle void was existed in the AuP film.

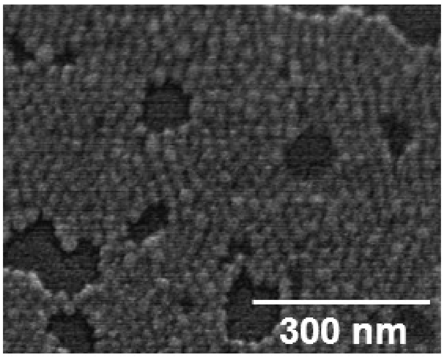

Fig. 4 SEM image of AuP film

4. Conclusions

We have established a novel approach for the rapid and facile preparation of the two-dimensional assemblies of gold nanoparticles. The detailed structures of the assemblies were confirmed by absorption spectra and SEM. These results suggest that the assemblies formed fine high-density.

Now we comfirm the plasmonic properties of AuP film by evaluating the effects on the optical properties of organic dye molecules.

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