Gold nanoparticles (NPs) exhibit surface plasmon resonance (SPR) causing optical extinction at visible wavelength due to special physical properties based on different sizes, shapes, and environments. The synthesis of branched quantum dots could enable studies of entangled quantum states and quantum information processing within individual NPs. Metallic NPs also benefit from quantum size and shape effects. The development of Au nano-sea-urchin in aqueous solution with an environment-friendly method. They found that the gold nano-sea-urchin can induce the interaction of surface plasmon resonance (SPR) mode with substrate. The SPR peak splits and blueshifts from 630 to 440 nm and the result has potential application for enhanced-Raman scattering, optical communications, and solar cells. © 2007 American Institute of Physics. [DOI: 10.1063/1.2732823]

In this study, we investigate the synthesis and optical properties of gold nano-sea-urchin in aqueous solution with an environment-friendly method. They found that the gold nano-sea-urchin can induce the interaction of surface plasmon resonance (SPR) mode with substrate. The SPR peak splits and blueshifts from 630 to 440 nm and the result has potential application for enhanced-Raman scattering, optical communications, and solar cells. © 2007 American Institute of Physics. [DOI: 10.1063/1.2732823]
solution were added to gold colloid, and then this was irradiated for 3 h under visible light to photoinduce. The other sample was not irradiated to synthesize gold nano-seaurchin. The ITO glass substrate was immersed in Au colloid for 6 h. The morphologies of Au NPs were observed by transmission electron microscopy (TEM). The absorption of Au NPs was observed by UV-vis spectrum. The Au colloid was directly injected into a quartz tube for UV-vis analysis. The absorption coefficient of Au particles on the ITO glass substrate was measured by ellipsometry.

The size of Au NPs has recently been synthesized to about 10 nm by the chemical reduction method. Morphologies of Au NPs were observed by TEM. Au NPs synthesized with HAuCl₄(aq) and trisodium citrate(aq) were uniform and spherical, as shown in Fig. 1. Syntheses of Au NPs by using trisodium citrate can be highly reproducible and have narrow distributions. The size of the Au nano-sea-urchin is about 210 nm in diameter and 81 nm in length in Fig. 2(c).

According to the Mie theory, the SPR is related to the onset of quantum size and shape effects of Au NPs. Figure 4(a) shows that the intensity of SPR for Au NPs (540 nm) decreases during photoinduced process. Also, the SPR peak appears at 760 nm and redshifts to 970 nm as the time increases. Au NPs grow isotropically after the addition of NaCl(aq) with the photoinduced method. The SPR of unspherical Au NPs exhibits two or more bands. The redshift of the surface plasmon occurs as the particle size increases. The SPR peak of Au particles is diverged and broadened because the size increases and the shape becomes more dispersive over time. Figure 4(b) shows that the intensity of SPR for Au nano-sea-urchin (grown from Au NPs) increases without being photoinduced. The SPR peak redshifts from 540 to 560 nm as the size of Au nano-sea-urchin increases, and is thus enhanced by the Au nano-sea-urchin.
interaction of SPR with the substrate is reinforced by the gold photoinduced mechanism in a water-based solution. The gold nano-sea-urchin, which is thus an environment-friendly addition of sodium chloride to synthesize a high quantity of the substrate.

The absorption coefficient of Au nanostructure on ITO glass substrate is shown in Fig. 5. The dielectric constants of air, thanol, and ITO are 1, 1.88, and 2.89, respectively. SPR of Au NPs in the air/Au NP/ITO system has two peaks (512.1 and 598.8 nm). This is different from the absorption spectra of Au NPs in Fig. 4(a), which has only one peak at 540 nm. By adding the ethanol to the Au NP/ITO system, the SPR shows a peak at 582.7 nm. Similar results are also observed in the Au nano-sea-urchin system. The SPR of the air/Au nano-sea-urchin/ITO system has two peaks (436.8 and 607.0 nm). This also differs from the absorption spectra of Au nano-sea-urchin in Fig. 4(b), which only has one peak at 560 nm. By adding the ethanol to the Au nano-sea-urchin system, the SPR shows two peaks (488.9 and 551.3 nm). The appearance of these two peaks is due to the asymmetric dielectric environment experienced by Au NPs. For the upper interface, the gold nanostructure is in contact with air or ethanol. For the bottom interface, the gold nanostructure is in contact with the ITO glass substrate. Ethanol has a dielectric index close to that of the ITO substrate, so the splitting is reduced. This is evidence of the SPR splitting caused by the ITO substrate. Furthermore, due to the circular shape of Au NPs, the splitting of peaks is less predominant. The Au nano-sea-urchin can thus enhance the interaction of SPR mode with the substrate.

In our research, we use only trisodium citrate with the addition of sodium chloride to synthesize a high quantity of gold nano-sea-urchin, which is thus an environment-friendly technology. Moreover, we demonstrate that isotropic SPR makes the direction of Au NP growth isotropically in the photoinduced mechanism in a water-based solution. The interaction of SPR with the substrate is reinforced by the gold nano-sea-urchin. These results have potential applications for the enhanced-Raman scattering, optical communications, and solar cells.

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