Immobilization of gold nanoparticles on silicon substrates by visible light irradiation

Takashi Ichii, Kousuke Yamashiro, Kuniaki Murase, Hiroyuki Sugimura
Department of Materials Science and Engineering, Kyoto University, Japan
e-mail takashi-ichii@mtl.kyoto-u.ac.jp

Gold nanoparticles (AuNPs) have been applied for enhancement of electric field intensity because the surface plasmons are strongly localized at their surfaces. Thus, they are expected to be applied for nano optical devices such as optical waveguide and photodetector. Immobilization of AuNPs on substrates must be a key technology for their applications. Many research groups have reported the immobilization of AuNPs by using electrostatic attractive force, where the AuNPs are negatively charged and the substrates are positively charged. However, by using this technique, the AuNPs are not formed into closely-packed structures because of the electrostatic repulsion between the AuNPs. This would lead to low density of the AuNPs.

Here, we demonstrated another immobilization technique of AuNPs on silicon substrates. It is well known that surfaces of AuNPs can be modified with thiol-terminated molecules by self-assembly. On the other hand, vinyl-terminated molecules are covalently bonded to Si(111) substrates via Si-C bonds by heating or UV/visible light irradiation. In this study, the AuNPs modified with vinyl-terminated alkanethiols were immobilized on Si(111) substrates by visible light irradiation.

Experimental procedures are as follows. AuNPs (the mean particle diameter = 4.8 nm) modified with 11-mercaptoundecene (MUD) were dispersed in toluene. Hydrogen-terminated Si(111) substrates were immersed into this dispersion and visible light (400 mW cm^{-2}) was irradiated for 4 hours. Figure 1 (a) shows an FE-SEM image of the AuNPs on the Si (111) substrates immobilized by this technique. Approximately 35% of the substrate was covered by the AuNPs and the distance between the each AuNPs was 6.5 nm. Because the diameter of the AuNPs and the length of MUD were 4.8 nm and 1.5 nm, respectively, this result indicates that the AuNPs were closely packed and suggested that the MUD molecules were crossed as Fig. 1 (b) shows.

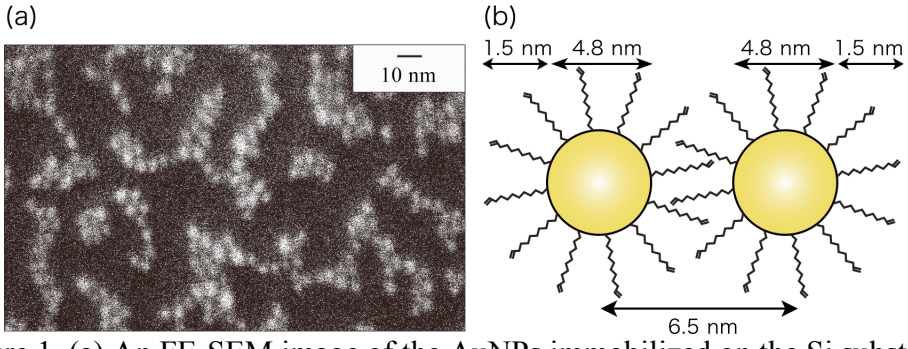

Figure 1 (a) An FE-SEM image of the AuNPs immobilized on the Si substrate.
(b) A schematic illustration of the AuNPs.