Attachment of Gold Nanoparticles on Glassy Carbon Surfaces with a Seed Mediated Growth Method

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Gold nanoparticles are promising as functional materials, because they have peculiar electric, magnetic, optical and catalytic properties different from those of bulk gold. To make the best use of these characteristics of gold nanoparticles for nano-devices, it is necessary that each nanoparticle is attached on the surface keeping moderate dispersion.

In the previous work, we succeeded in the attachment of gold nanoparticles on indium tin oxide (ITO) surfaces without using peculiar bridging reagents by applying the seed mediated growth method. Just via two-step immersion of the substrate into the seed and growth solutions, gold nanospheres and nanorods were successfully fixied on the ITO surfaces. In the present work, we applied this approach to the attachment of gold nanoparticles on glassy carbon (GC) surfaces.

As the actual procedures, at first, a plate of GC was sonicated in acetone and distilled water, and then dried. Next, it was immersed in the seed solution containing gold nanoparticles of 4 nm. Following this seeding procedure, the substrate was immersed in the growth solution, which contained gold ion and cetyltrimethylammonium bromide. The modified surfaces were evaluated using a field emission scanning electron microscope (FE-SEM).

Fig. 1 shows the GC surface prepared by immersing in the seed solution for 2 hours and the growth solution for 2 hours. It was found that the whole GC surface was modified by the dispersed gold nanoparticles, whose average size was 40-60 nm. In the expanded images, the dense coverage by gold nanoparticles was confirmed on the GC surface. Compared with the results on the ITO surfaces, it was characteristic that the formed structure was flat, small and densely dispersed, while the crystal growth was mainly observed on the ITO surfaces.

We studied the effect of the immersion time in both the seed and growth solutions on the formed nano-structures in details. As the result, for example, the FE-SEM image of Fig. 2 was obtained for the GC surface prepared by immersing in the seed solution for 30 minutes and the growth solution for 5 minutes. Apparently, the size of the formed nanoparticles was small (ca. 20 nm), and the nanoparticles located sparsely compared with the result of Fig. 1. Thus, it can be concluded that the density of gold nanoparticles on the surface was controllable by changing the immersion time in the seed and growth solutions.

On the other hand, to extend the immersion time into the growth solution caused some changes in the surface structures. After immersing in growth solution for 8 hours following 2-hours immersion in the seed solution, the size of nanoparticles became larger than those in Fig. 1 accompanying an increase of the exposure of the GC surface. Furthermore, when we increased the immersion time in the growth solution to 24 hours, we could observe the aggregation of the gold nanoparticles to form larger gold nanocrystals as shown in Fig. 3. So, the long immersion time was found to be not necessarily good to get uniformly gold nanoparticles modified GC surfaces.

In conclusion, we could successfully attach gold nanoparticles onto the GC surface directly without using particular bridging reagents by applying the seed mediated growth method, and the differences in the formed structures between the GC and ITO surfaces were revealed.

This work was supported by Kyoto Nanotechnology Cluster Project, a Grant for Regional Science and Technology Promotion from the Ministry of Education, Culture, Sports, Science and technology, Japan.

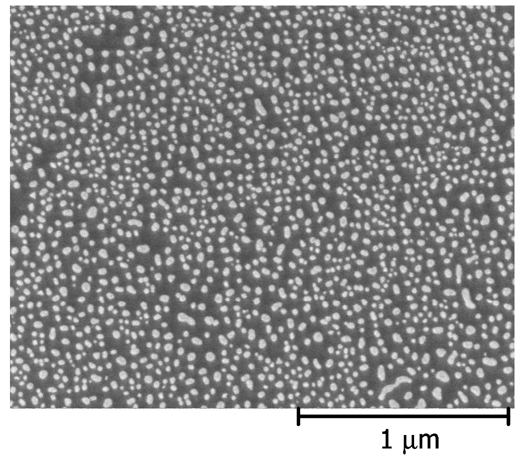

Fig. 1. FE-SEM image of the GC surface prepared by immersing in the seed solution for 2 hours and in the growth solutions for 2 hours.

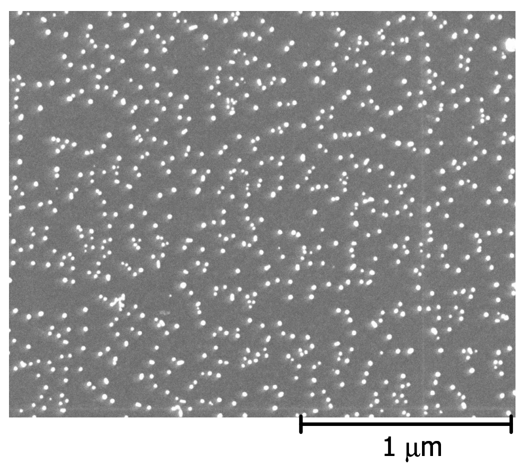

Fig. 2. FE-SEM image of the GC surface prepared by immersing in the seed solution for 30 mins and in the growth solutions for 5 mins.

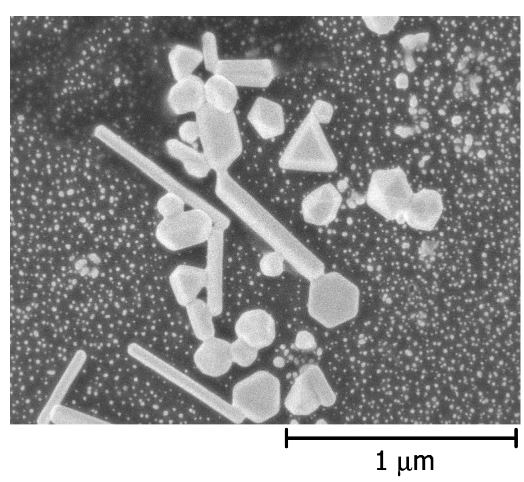

Fig. 3. FE-SEM image of the GC surface prepared by immersing in the seed solution for 2 hours and in the growth solutions for 24 hours.