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Selective deposition of gold nanoparticles on the oxide surface of Si nanowire

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1. Introduction

Gold Nanoparticles have been developed for biological applications, including drug delivery, and detection technology[1]. On the other hand, silicon nanowires (SiNWs) have attracted attention as prospective candidate for nanobiosensing[2]and nanoelectronics. In this paper, self-assembled monolayers (SAMs) are used to functionalize both the surface of SiNWs and gold nanoparticles with molecules. Deposition of monolayer with gold nanoparticles on the surface SiNWs by SAMs process allows easy, efficient, and selective immobilization of bio-molecules on gold nanoparticles, which is found very useful for biosensor applications.

2. Experimental

Solution of 100 ml of 2.2 mM sodium citrate($C_6H_5Na_3O_7$) as a reductant was heated to boil and 40 ml of 0.815 mM hydrogenterachlorauic acid($HAuCl_4{\cdot}3H2O$) was added by rapidly mixing. The resulting gold nanoparticles solution had a mean gold nanoparticles size of around 15 nm. Figure 1 demonstrated the feature size distribution of Au nanoparticles with described method.

Samples with SiNWs, details of SiNWs fabrication with scanning probe lithography has been reported previously[3], were immersed in a N-(2-aminoethyl)-3-amino-propyltrimethoxysilane(AEAPTMS) solution for 5 min after samples cleaning. Then the samples were dried with N_2 and baked at 120 °C for 30 min with hotplate. The amino-functional silane formed on the SiNWs surface. After silanation modification, samples were immersed in citrate gold nanoparticles solution for 1 h. After immersion, the samples were rinsed with DI water and dried with N_2. This process led to the deposition of a monolayer of gold nanoparticles which repelled each other due to the formation of negative citrate ions on the surface of the Au particles[4].

3. Results and discussion

Figure 2 shows the schematic diagram of deposition monolayer gold nanoparticles on the surface of SiNW. It is well known that the SiO_2 surface is terminated by hydroxyl groups and the amino group will be functionalize on SiO_2 by immersion SiNW in AEAPTMS solution [5]. The amino groups on the AEAPTMS molecules were used to immobilize gold particles onto the SiNW due to the specific affinity of the amino group to the negative citrate ions on the surface of gold nanoparticles. On the region of H-terminated silicon surface, the hydrophobic nature reject the conjugation of AEAPTMS with amino group. Consequently, no Au nanoparticle was immobilize on the region of H-terminated silicon surface. Fig 3 shows the SEM images of gold colloidal particles deposited on Si/SiO_2 selectively. Nano-oxide patterns were prepared with scan probe lithography on silicon wafer. Then, samples were dipped into the gold nanoparticles solution. Fig 4 shows the AFM topographic image of gold colloidal particles deposited on SPL-oxide patterns of SiNW.

4. Conclusion

In this paper, SAMs of Au nanopartilces with negative charge on the surface was demonstrated. We have also demonstrated a selective deposition of monolayer of gold nanoparticles on the surface of SiO_2 on SiNWs. We believe that the Au nanoparticles on the SiNWs can served as gates for both electronics and biosensing applications.

Acknowledgements

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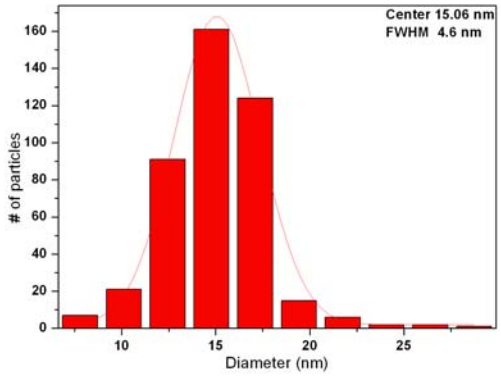

Fig1. Distribution of feature size of Au nanoparticles.

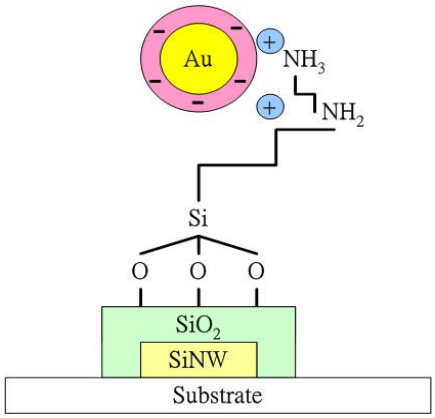

Fig2. The mechanism of deposition monolayer gold colloidal particles on SiNW surface.

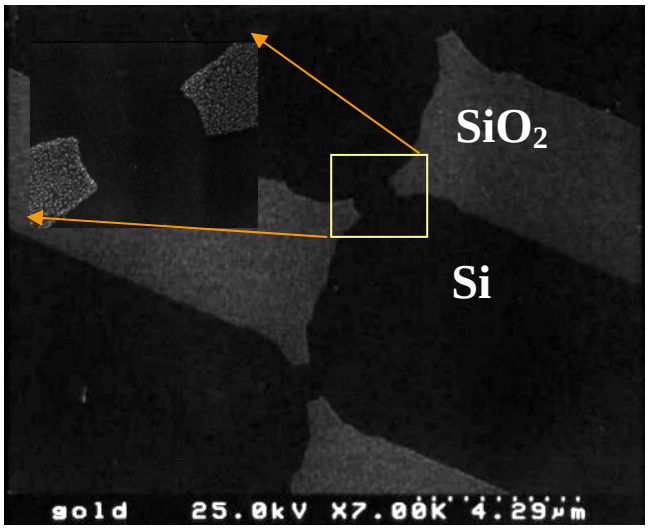

Fig3. SEM images of gold colloidal nanoparticles deposited on SiO_2 selectively.

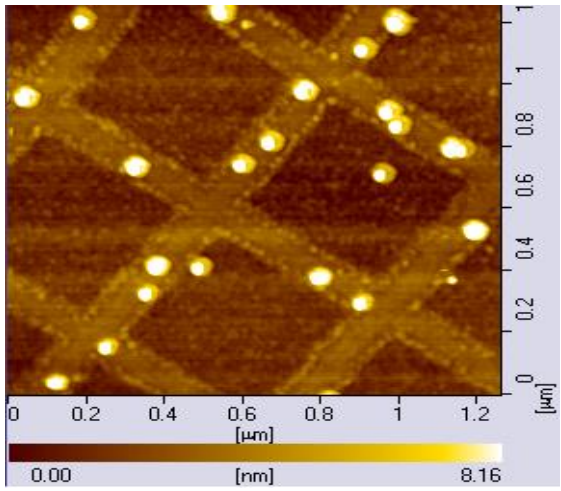

Fig4. The AFM topographic image of gold colloidal particles deposited on SPL-oxide patterns.