Hybridization Sensing by Electrical Enchantment with Nanoparticles in Nano-Gap

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In recent years, a variety of DNA assay techniques based on electrical detection for diagnosis of genetic and pathogenic diseases have been explored. Among those skills, the major characterizations of detection methods are to avoid the use of polymerase chain reaction for amplifying the concentration of analytic DNA and expensive optical microscope equipments to obtain emitting signals from fluorescent DNA.

In this work, we propose a nanogap device with gold nanoparticles as a base for DNA assay. We combine the shaped electron beam lithography to fabricate sub-100nm gap between two electrode pads, and the gold electrode is fabricated by lift-off process. The procedure of self-assembly of gold nanoparticles onto silicon oxide substrate is depicted in Fig. 1(a), and the electron microscope images of self-assembly of gold nanoparticles monolayer and nano-gap device are illustrated in Fig. 1(b) and 1(c), respectively. The basic concept is- a 27-mer single-strand nucleic acids modified with thiol functional groups have been anchored to gold nanoparticles surface as probe. Then we apply analytical DNA strand, named targets DNA, with fully complementary of probe DNA to hybridize. Finally, the chip surface is washed by 60°C and 70°C PBS solution to denature the hybridization double strands DNA.

The electrical behaviors of the DNA sensors were characterized by using the HP 4156A semiconductor parameter analyzer. The overall measurement in each chemical handling and thermal process was shown in Figure 2. The conductance was very low for either assembled gold nanoparticles [in Fig. 2(b)] or gold nanoparticles with single-stranded DNA [in Fig. 2(c)]. However, the conductance (10^{11} S) significantly increases with the hybridization of double-stranded DNA in Fig. 2(d). Therefore, the electrical conductance for single-stranded DNA cannot be amplified by the preassembled gold nanoparticles. In contrast, the electrical signal of doubled-stranded DNA can be amplified by the gold nanoparticles. This observation clearly indicates that single-stranded DNA is not a good conductor, in contrast to double-stranded DNA. More results of DNA identification by using different concentrations of DNA and partial complementary strand will be present in the conference.

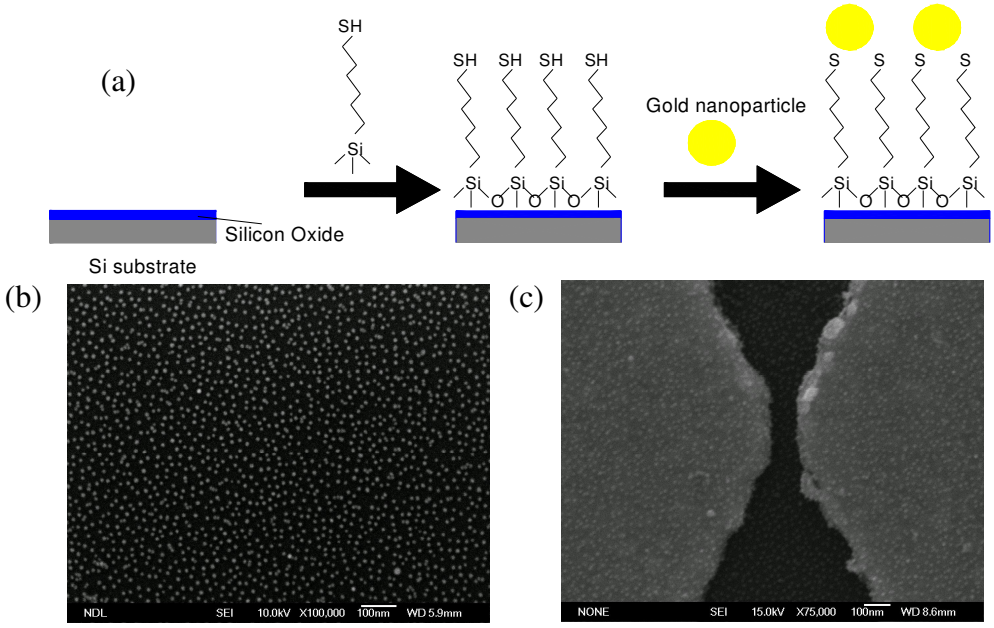

Figure 1(a). Chemical process of gold nanoparticles self-assembled onto the silicon dioxide layer, (b) the electron microscopic image of gold nanoparticles on silicon dioxide, and (c) the electron microscopic image of 10 nm gold nanoparticles in the nanogap.

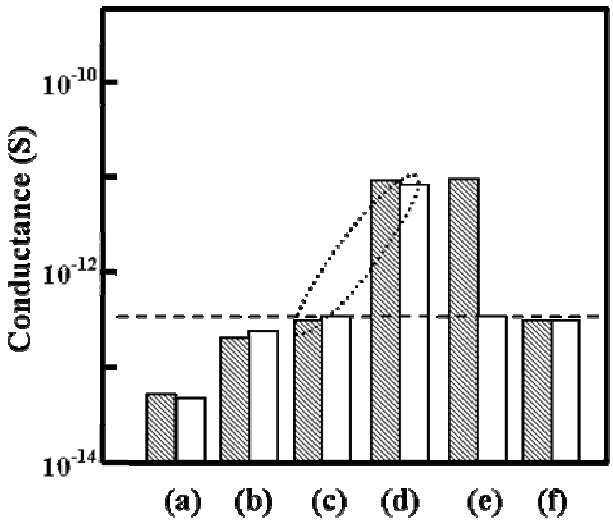

Figure 2

Figure 2. The conductance of each experiment step from (a) blank nano-gap (b) gold nanoparticles array, (c) single strand capture DNA, (d) complementary target DNA, (e) with 60°C water wash and (f) with 70°C water wash