Fabrication of a nano-scale gap by selective chemical deposition

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An electrode nanogap of 45 nm has been prepared by a new method in which the initial gap of 1–2 μm obtained by conventional lithography was shortened by selective chemical deposition of copper onto the electrodes.

In recent years, fabrication of patterns on the nano-scale level, such as nanowires and nanogaps, has been drawing a great interest in the scientific community not only due to the need for ever-increasing miniaturization of microelectronics, but also because of the discovery of many novel phenomena that occur on the nano-scale. Compared with the other patterns, nano-scale gaps are more crucial to successfully make a nanodevice, such as nano-transistors or single electron tunneling junctions. However, the gaps prepared by conventional lithography are on micro-scale and can not reach the nanometer level to meet the needs of fabricating nanodevices. In order to solve this problem, researchers have recently proposed many new methods, including electron beam lithography,1 carbon nanotube masking,2 and electrodeposition,3 which have been proved to be successful in fabricating nanogaps. However, the sophistication, high cost and low yield of those methods limit their wide application. In this communication, we present a very simple and economical method to produce nanogaps by selective chemical deposition.

First, gold electrode pairs are prepared by conventional lithography with 1–2 μm gaps. In this stage, the gap between electrodes is not critical. Two self-assembled monolayers (SAMs) materials are patterned on the gold electrodes and Si electrodes is not critical. Then, the gaps at the micro-scale level can be shortened to the nano-scale by substrate. This method in which the initial gap of 1–2 μm obtained by conventional lithography was shortened by selective chemical deposition.

Next, metallic copper deposition on the top of the existing electrode pairs separated at the microscale level.

First, gold electrode pairs are prepared by conventional lithography with 1–2 μm gaps. In this stage, the gap between electrodes is not critical. Two self-assembled monolayers (SAMs) materials are patterned on the gold electrodes and Si substrate, respectively. Then, the gaps at the micro-scale level between the electrodes can be shortened to the nano-scale by selective chemical deposition of copper on the electrodes.

In conclusion, a novel method has been developed for fabricating nano-scale gaps, which is rather simple, inexpensive and advantageous. It requires only a relatively short fabrication time, a small instrumental input and can be operated in batches and so this process may be applied in the micro-electronical industry.

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Fig. 2 AFM images of gold electrode pairs before and after selective chemical deposition. (a) Electrode pairs with a 1.7 μm gap before selective chemical deposition. (b) The three-dimensional images of electrode pairs whose gap was shortened to 45 nm by selective chemical deposition. (c) Section analysis of the modified electrodes.

Notes and references