Optimization of fabrication of atomic scale gold junction by electroplating using a common disinfectant

S. Woo* § , A. Umeno § , and K. Hirakawa §
*Department of Electrical engineering, University of Pittsburgh, Pittsburgh, USA
§ Department of Electrical engineering, University of Tokyo, Tokyo, Japan

Motivation:

The fabrication of the atomic scale junction and improve designs of better performed, delicate and stable molecular devices. And multiples of the conductance quantum of 2e2/h can be observed.

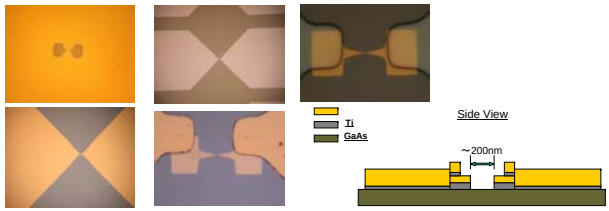
e= elementary charge = 1.6X10-19C
h= Plank's constant 6.63X10-34 Js

Introduction:

Control of the size of gold electrodes is possible by depositing/etching gold atoms through electrochemical reactions. We have investigated the optimum condition which could create quantum point contacts between the nodes of electrode pairs by changing fabrication conditions such as the concentration of gold electrolyte, bias voltage of electrochemical reactions, and the spacing of initial gap between gold electrodes. Gold was dissolved in iodine tincture, a well-known disinfectant and the gold-dissolved solution has been used as electrolyte for depositing gold onto a pair of electrodes. The conductance quantum of ($2e2 / h$) has been observed at room temperature (e: the elementary charge, h: the Plank constant) in the evolution of conductance across the electrode pair. This shows that the spacing of gold electrodes can be tuned in an atomistic scale, which we believe suitable for interfacing single molecules to macroscopic electronic circuitry.

Fabrication of Electrodes :

1. E-beam Lithography to create ~200nm gap.
2. Deposit Ti & Au (~ 100nm) using E-beam Evaporator.
3. Lift-off using Acetone
4. Photolithography to make pads for wire bonding.
5. Deposit Ti & Au using the same machine.
6. Lift-off using Acetone.

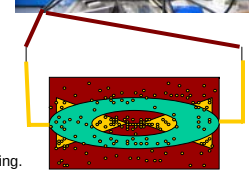


Electrochemical deposition:

- Preparing electrolyte:

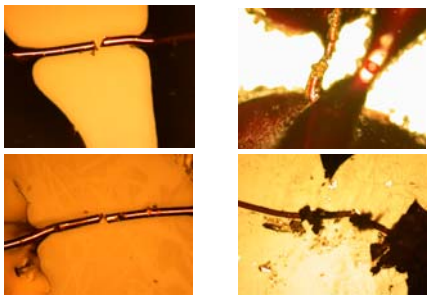
  Common disinfectant, iodine tincture, is used for dissolving Au. We approximately adjusted the amount of Au using Au foils of 1um thick and 10mm X 10mm big. Using ultrasonic, we made a homogeneous mixture of Au and iodine tincture.

- Sample preparation:
  - Place a sample on a plastic dish and wire bonding on pads.
  - cover area with epoxy glue.
    Pouring some solution
  - Adjust lock-in amplifier for detecting small signal.
  - Apply bias voltage to start electroplating.



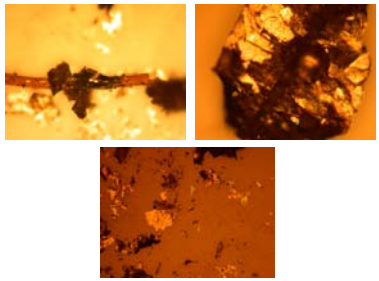
Experimental Results:

• **Microscopic Pictures for nanowires:**

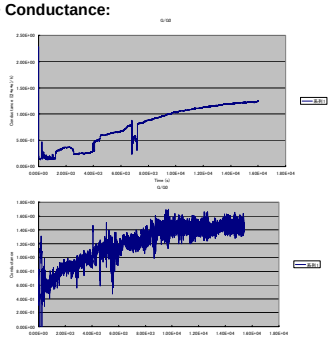


Before plating **After plating**

Plating for about 10～20hours could create crystal like solid which prevents deposition or dissolve of Au



• **Conductance:**



Summary:

Lithographically patterned or hand-cut Au electrodes are used for electroplating. And iodine tincture which is common disinfectant is used as an electrolyte. When we deposit or dissolve Au for longer time, crystal like Solid is form and covers whole electrodes. Conductance quantum was observed, but we could not get step like the conductance quantum graphs.

Future objective:

- Optimization of condition of electrochemical plating and structure of electrodes.
- Simpler setup which us DC bias voltage could be used for electroplating of Au.

Research conducted at University of Tokyo as a participant in the Rice University and NSF-PIRE sponsored NanoJapan 2007 program.