

A Preliminary SERS-MCBJ Study on Molecular Junction on Chip

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Molecular devices and nanodevices have attracted increasing attention because of their important potentials in miniaturization of electronic devices. A critical challenge in this field is how to connect molecules or nanocrystals to the outside world. A practical way is to fabricate a pair of facing electrodes with a controllable width on the nanometer scale (nanogap) on a microchip so that it can meet the specific need to fit with target molecules or nanocrystals whose electron transport properties can be characterized in detail. Recently, we developed an electrochemical method by utilizing the potential as a feedback indicator to control the fabrication process of the nanogap [1]. MCBJ (mechanically controllable break-junction) [2-4] allows us to precisely and stably adjust the separation between the electrodes over a range from few angstroms to about nanometers with a resolution of one angstrom.

By bending the chip with a simple mechanical drive (Fig. 1. c), the gold electrodes contact was elongated until it breaks (Fig. 1. a). This setup allows us to continuously vary the gap between the two electrodes over a range of 0-2 nm with a resolution of 0.1 nm. A drop of solution contained probe molecules was placed over the gap to allow the molecules to adsorb onto the electrodes. After the solution was evaporated, the tunneling current usually increased as the two electrodes were brought to each other. We then created molecular junctions by closing and reopening the two electrodes repeatedly. The I-V curve characterization of these molecular junctions was found to resemble that reported in the literature (Fig. 1. b). Surface-enhanced Raman scattering (SERS) was further used to characterize the molecular junction using a confocal Raman microscope. We have examined several kinds of molecules. Figure 2 shows three typical SERS spectra of BDT inside the gap at the different separation. The SERS intensity

was increased considerably when the gap width was changed from about 8 Å to 4 Å. This change in SERS intensity is expected because the electromagnetic field coupling increases significantly as the gap of two Au micro-electrodes is reduced [5]. This SERS-MCBJ method shows the potential as a powerful tool for characterizing molecular devices, and to answer a question if and how a molecule is present between two probing electrodes on the molecular level.

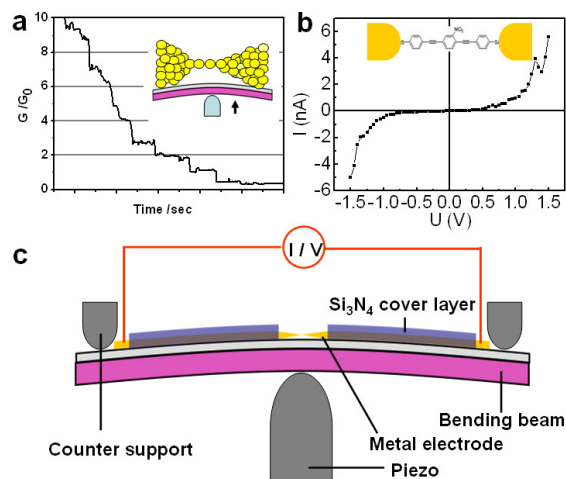


Fig. 1 (a) Contacted gold electrodes was elongated, and then separated by MCBJ setup. Trace of the conductance G as Au atom connection was observed. (b) I-V curve characterization of Au/OPE-NO₂/Au molecular junctions. (c) Schematic drawing of the MCBJ setup stress in (a).

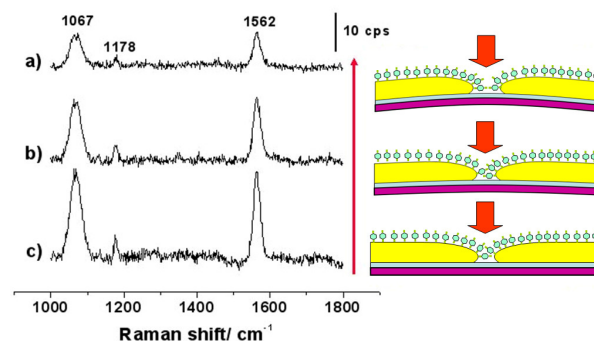


Fig. 2 SERS of 1,4-benzothiazolium in the nanogap with the process of bending the metallic electrodes pair. From a) – c) the gap width is reduced. Laser: 632.8 nm.

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