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Charge Transport through Molecular Wires and Inorganic Nanowires

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1. Introduction

Due to the merits such as low cost, high-density, and less heat problems for using functional molecules as nanoscale building-blocks in miniaturized electronic devices, molecular electronics is currently undergoing rapid development, although poor reproducibility and low device yield still remains a challenge [1]. Extensive efforts have been made to understand charge transport in molecular layers. In this presentation, we report on the recent progress on the electronic properties of molecular systems. At the later part, some research results on the nanowire or nanotube transistor devices, as well.

2. Experiments

Charge transport through molecules was investigated with conducting atomic force microscopy (C-AFM) and with vertical structured metal-molecule-metal (M-M-M) devices. For the C-AFM experiments, alkanethiol self-assembled monolayers (SAMs) of various molecular lengths were prepared on Au substrates and their electrical properties were characterized by placing a Au-coated AFM tip in the stationary point contact on alkanethiol SAMs under a controlled tip-loading force. And for the M-M-M devices, vertical structure microscale or nanometer scale molecular electronic devices were fabricated and characterized. In addition to the molecular systems, various inorganic nanowires were synthesized and fabricated into field effect transistor (FET) devices and subsequently characterized.

3. Results and Discussion

The chain-to-chain tunneling in metal-alkanethiol-metal junctions was examined using C-AFM. The results (Fig. 2) indicate that the tilt configuration of alkanethiol SAMs enhances the intermolecular charge transfer [2]. As the molecular tilt angle increases with the tip-loading force, the chain-to-chain tunneling becomes significant, in addition to the already existing through-bond tunneling in overall transport. And, we performed a statistical analysis on the electronic transport properties of individual molecular electronic devices in via-hole structures with different lengths of alkanethiols. The introduction of the statistical consideration of determining the working molecular devices and representative devices can be a meaningful concept to understand electronic transport properties. And electrical properties of carbon nanotube (CNT) and various inorganic nanowires in FET device structures were also characterized.

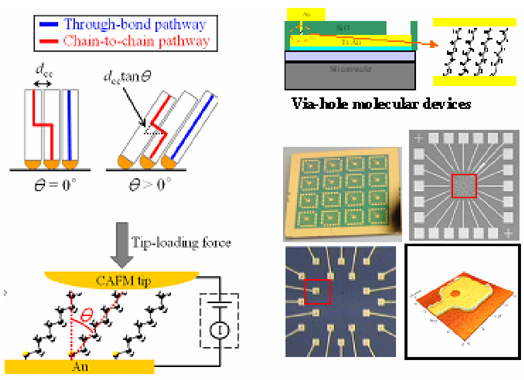

Fig. 1. Schematics for C-AFM measurement (left) and M-M-M devices (right) for studying molecular scale charge transports

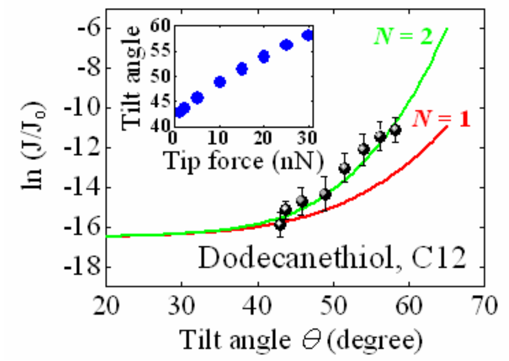

Fig. 2. Semilog plots of normalized tunneling current densities as a function of the molecular tilt angle for different length alkanethiols. Insets show the relationship of molecular tilt angle, contact separation, and tip-loading force.

For example, we have investigated the radiation effect on single walled carbon nanotube network-type FETs under high energetic proton beams that is similar to aerospace environment, and our results indicates a certain radiation-tolerance against the proton beams, which promise of space application of CNTs [3]. Also, we have studied electrical properties of variety of nanowires such as In_2O_3 [4], ZnO [5], GaN, etc, and some recent results will be explained in this presentation.

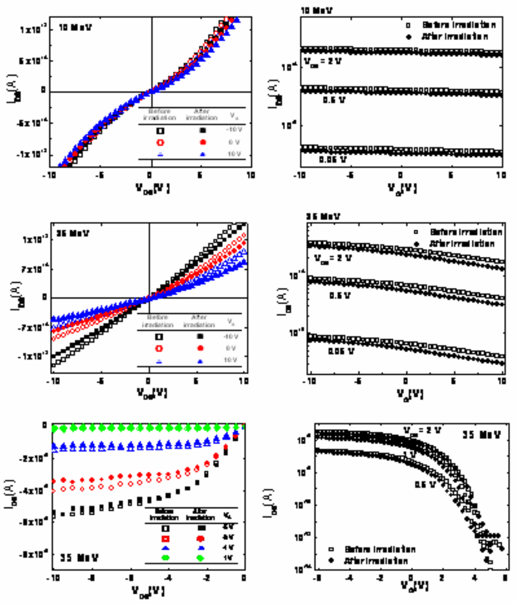

Fig. 3. Transistor data for CNT-network FETs before and after proton beam irradiation.

4. Conclusions

The detail transport properties and conduction mechanisms of molecules and inorganic nanowires will enhance the potential usage as electronic device components in future.

References

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