Photoresponse Behavior of Conjugated Polymer-Based Nano Device

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Molecular-scale device, comprising single or small number of organic molecules, has experienced extensive attention and rapid development recently. Bottom-up process using organic molecules enables us to fabricate high-dense and fine-tuned devices due to the advantages in size and design of the molecules. Conjugated polymers exhibit remarkable carrier transport and photo absorption/emission properties based on electrically conjugated polymer chain, and are thus expected to apply nano-scale electronic and photonic device components. Recently, we have synthesized a rigid π-conjugated poly(*p*-phenylene-ethynylene) derivative including thiol end groups (TA-PPE, Fig.1) [1]. By utilizing a selective chemisorption property of thiol end groups onto Au surface, it is possible to fabricate a self-assembled TA-PPE nanojunction between Au nanogap electrodes, Au/TA-PPE/Au (gap ~40 nm). We successfully observed a remarkable photocurrent switching behavior of the nanojunction [2].

Figure 2 shows the photocurrent response behavior of the nanojunction under light irradiation. With light on or off, the nanojunction exhibits switching between a low-current state in dark conditions and a high-current state in light conditions as a nanometer-scale photoswitch (the voltage between two nanoelectrodes is kept constant at 0.5 V). In the "off" state, the resistance is as high as ~10^{15} Ω. In the "on" state, the resistance is ~10^{12} Ω, the switching ratio is as high as 1000. The switching in those two states is reversible and fast. Under illumination, the photon-generated excitons are dissociated into free electrons and holes, some of them possessing sufficient energy to jump over or tunnel through the Au-S barrier, resulting in high current ("on" state) of the nanojunction. In addition, with intensity of the incident light changing, the current of the nanojunction device changed, exhibiting significant light intensity dependence. This phenomenon is understandable in terms of the changing of photon density in the incident light.

In the future, we are aiming at the fabrication of novel molecular-scale composite devices integrating the nanojunction with other optoelectrically functionalized organic/bio molecules.

[1] H. Nakashima, et al., Langmuir **21** (2005) 511.
[2] W. Hu, et al., J. Am. Chem. Soc. **127** (2005) 2804.

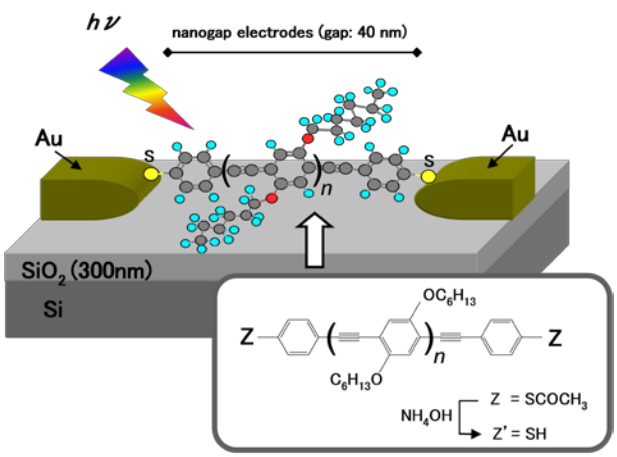

Fig. 1. Molecular structure of TA-PPE and nanodevice structure

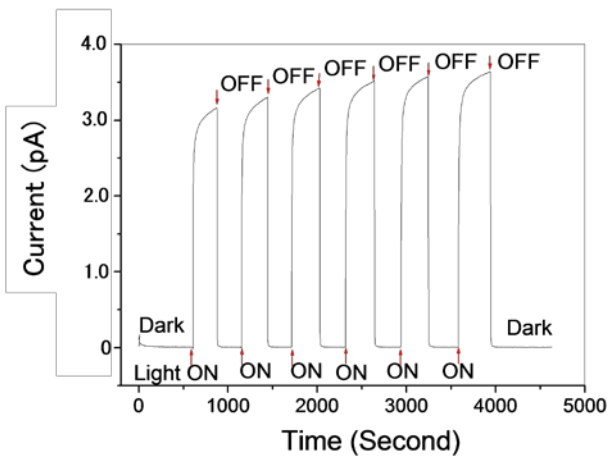

Fig. 2. Photoresponse characteristics of the nanojunction device (white light, 52 mW)