Rectification effect of PTCDI-C7 on transparent ITO thin films

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Perylene-core organic molecules have been proven to be indispensable and promising candidate of n-type organic semiconductor for organic electronic application in recent years.[1-3] To date, many studies are devoted to investigate its versatile electronic properties for the fabrication of optoelectronic or field effect based organic devices.[1,4] N,N'-diheptyl-3,4,9,10-perylenetetracarboxylic diimide (PTCDI-C7) has previously demonstrated as a photoconductive material in the nanoionic solid-state device so called photoassisted atomic switch.[3] In this work, we focused on the intrinsic photoconductivity properties of PTCDI-C7 thin organic layer self-assembled on a modified transparent conducting oxide of Indium Tin Oxide (ITO). A rectangular structure with the unit cell a = 5.17 Å and b = 4.35 Å were successfully observed at room temperature (Figure a). This finding indicates that PTCDI-C7 formed a dimer governed by the hydrogen bonding between the molecules. Using scanning tunneling spectroscopy (STS), we monitored the variation of local electronic properties of PTCDI-C7 (Figure b) as a function of power density lights. Rectification behavior was observed in the I-V characteristics and it becomes more pronounced as the molecule was irradiated using higher power density at the same tunneling gap junction. We addressed the origin of rectification is due to the Highest Occupied Molecular Orbital (HOMO) level buried in the ITO gap state (inset Figure b). Moreover, a large Rectification Ratio (RR) of 10 nm-thick PTCDI-C7 after light irradiation with the value of 232 was extracted. We suggest that STS technique is a powerful tool to differentiate the changes of local electronic properties of a photoconductive organic molecule even in the weak physisorbed configuration at room temperature.

References

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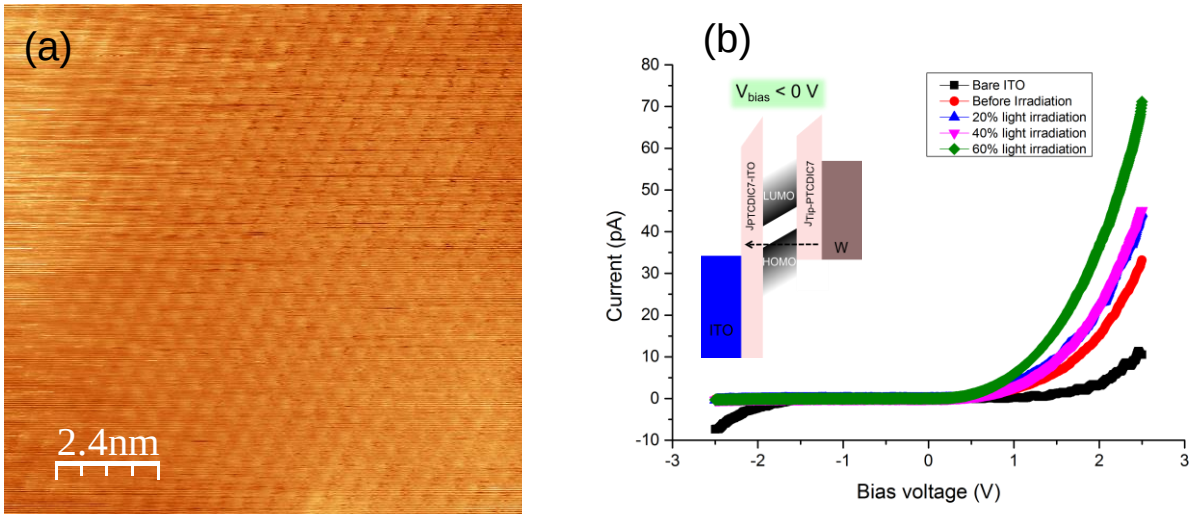

Figure. Topography and Spectroscopy of 10 nm-thick PTCDI-C7 single molecules on ITO measured at room temperature. (a) Constant current STM image showing a square structure. Scan size is 11.8 x 11.8 nm^2 (I_t = 30 pA; V_{sample}=5V). (b) I-V spectra to show the effect of irradiated light to the local electronic properties of PTCDI-C7 on ITO. STS measurements were carried out at the same tunneling setpoint for all acquisition data (500pA; 5V setpoint). Inset shows schematically a layout of relative position of Fermi level of ITO substrate, tungsten and the energy gap of PTCDI-C7 bulk state at negatively biased voltage.