Fast and wavelength selective photoresponse from QD/CNT hybrid

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QDs absorb lights of all wavelengths less than their own band energy, as well as emit the light according to their specific wavelength [1]. It can be used for several applications such as LED, solar cell, photodetector and so on. Even though QDs has great ability to produce charges from phonon injection, it is not easy to carry the extracted charges to the specific position in order to make the current. Therefore, carbon nanotube (CNT) as carrier transporter have been tried to use, while preserving optical characteristics of QDs [2]. There are several issues in QD/CNT hybrid structure such as dependency of CNT type (Multi-wall CNT, MWNT and single walled CNT, SWNT), linking agent between QD and CNT and the relation between wavelength of the incident light and QD size.

We firstly introduced pyridine as a linking ligand between QD and CNT. It has very short molecular length so that the interference by the light is minimized. Secondly, the difference between MWNT and SWNT as a carrier transporter has been investigated in view of the charge transfer. Finally, we measured the photo response according to the size change of QDs [3]. We fabricated FET (Filed Effect Transistor) structure of QD/CNT hybrid material by using dielectrophoresis. After taking the assembled images from SEM and fluorescence microscope, we measured photo excitation of the device by using Ar laser varying its wavelength. Pyridine molecules were used as a short, non-covalent linker allowing assemblies more efficient carrier transfer without deleteriously altering the electronic structure of NQDs and SWNTs.

Figure 1 explains how pyridine molecule combines the QD with SWNT. As the result, we demonstrate that the electron of QD occurred from photoexcitation delivered to carbon nanotube via photoluminescence measurement. In addition, QDs were firmly attached to SWNT as shown in Figure 1c. Photoexcitation studies of resulting assemblies support the efficient carrier transfer in CdSe-py-SWNTs unlike in the CdSe/ZnS-py-SWNTs.

In Figure 2, the fabricated FET device shows that the electron transfer from QD to SWNT definitely was achieved. Our observation in photocurrent, resistivity, and gate dependence characteristics along with the optical measurements suggest the efficient electron transfer from photoexcited NQDs to SWNTs.

As the result, we found that SWNT/QD hybrid structure offered rapid response as a photodetector for specific wavelength of light. In addition, we found that the size of QDs definitely determined the detectable band spectrum of the incident light. For example, the QD with 543nm emission wavelength almost could not detect the light over 600nm wavelength.

References

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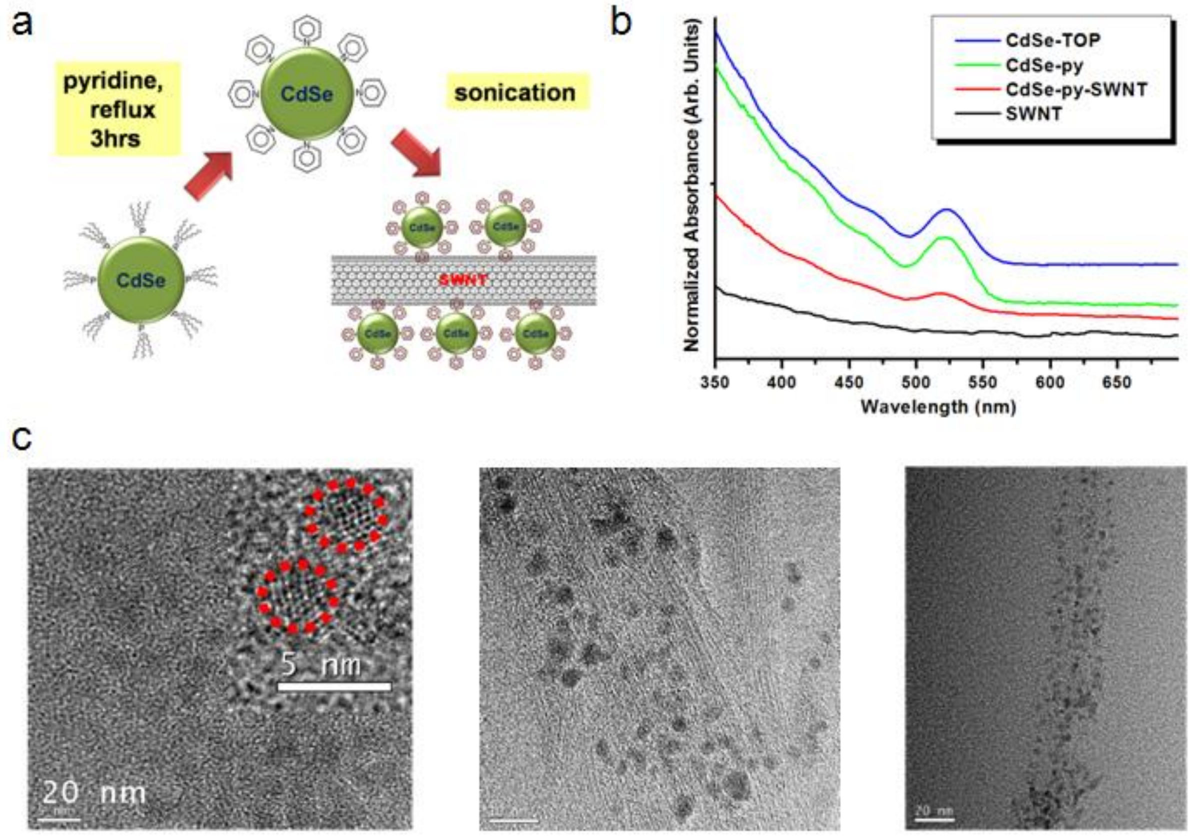

Figure 1. a) A schematic diagram illustrates the non-covalent approach used to fabricate the NQD-SWNT hybrid structures. b) UV/VIS absorption spectra show the optical transitions of synthesized CdSe particles prior to surface modification (trioctylphosphine-capped CdSe in toluene), CdSe-py, CdSe-py-SWNT hybrid nanostructure, and SWNT. The 1S transition of CdSe at 522 nm was retained throughout the process. c) TEM images show the CdSe nanocrystals (left, average size ~2.8 nm) and the hybrid CdSe-py-SWNT (middle and right)

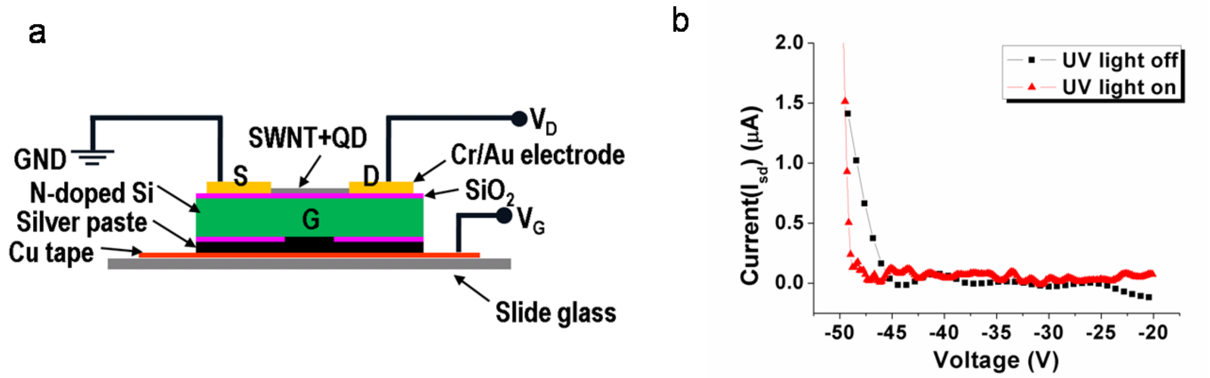

Figure 2. a) A schematic diagram shows the configuration of a CdSe-py-SWNT FET for measurements of gate dependence. b) The gate dependence curve of a CdSe-py-SWNT FET is shown with illumination on and off; λ = 365 nm, I = 1.2 mW/cm^2