UV absorption control of SWNT films by modulation of perpendicular $\pi$ plasmon excitation

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Abstract:
Recently, we have found that the remarkable UV absorption of SWNTs that had been conventionally explained as $\pi$ plasmon excitation is actually composed of two distinct components at $\sim 4.5$ and $\sim 5.2$ eV and that these peaks exhibit different dependencies on incident light polarization [1]. We have discussed the origins of these UV absorptions and concluded that the former ($\sim 4.5$ eV) is $\pi \rightarrow \pi^*$ interband transition excited by polarized light parallel to SWNT axis whereas the latter ($\sim 5.2$ eV) is $\pi$ plasmon excited by perpendicularly polarized light [1]. Such a consideration implies that only the latter ($\sim 5.2$ eV) can be controlled by a modulation of chemical potential of SWNTs, for the collective plasmon excitation is a Fermi-surface related phenomenon. In order to confirm our conclusion above, we performed an electro-chemical experiment using our vertically aligned SWNT film grown on a quartz substrate [2] that is set in acetonitrile dissolved with 0.1 M LiClO$_4$ as an electrolyte. Figure 1 shows optical absorption spectra measured with the voltage changing 0 → +800 mV (left) and subsequently +800 → 0 mV (right panel). In our system, +800 mV is an upper limit for ensuring the reversibility against the separation of the electrolyte. In addition to known inter-subband absorption below 3 eV, the simultaneous change of UV absorption around 5.1 eV is clearly observed. This result not only provides a direct evidence to above discussion (i.e. $\sim 5.2$ eV peak is plasmon while that at $\sim 4.5$ eV is not), but also shows a way of controlling UV absorption of SWNTs, which would be more efficiently fulfilled if a dry-processed gate electrode is used to achieve an applied voltage of as high as several volts.


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Fig. 1. Optical absorption spectra of a VA-SWNT film measured in acetonitrile with 0.1 M LiClO$_4$. The applied voltage is varied as 0 → +800 mV (left) and subsequently +800 → 0 mV (right panel).