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MoS_2/Carbon Nanotube Core–Shell Nanocomposites for Enhanced Nonlinear Optical Performance

Over the last decade, tube-like carbon nanotubes (CNTs) have been widely investigated as a versatile third-order nonlinear optical (NLO) material in a range of applications, such as optical limiting (OL) for laser protection and saturable absorber for ultra-short pulsed lasers owing to their low saturation intensity, fast recovery time, and wide operating bandwidth.[1-3] It has been reported that both single-walled nanotubes and multi-walled nanotubes possess ultrafast relaxation time (ca. 1 ps). [4] On the other hand, two dimensional (2D) layered transition metal dichalcogenides (TMDs) semiconducting materials, such as MoS_2 and WS_2, have also been reported to have excellent NLO performances.[5]

For the sake of developing nanomaterials with higher NLO performance, we successfully synthesized nanocomposites of few-layer MoS_2 and CNTs with core–shell structure by wrapping MoS_2 nanosheets on the surface of coaxial CNTs via a simple solvothermal method (Figure 1), and systematically investigated the third-order NLO performances by Z-scan technique over a broad temporal (ns-fs) and spectral (Vis-NIR) range. Enhanced third-order nonlinear optical performances were observed for both fs and ns laser pulses over a broad wavelength range from the visible to the near infrared, compared to those of MoS_2 and CNTs alone (Figure 2). The enhancement can be ascribed to the strong coupling effect and the photoinduced charge transfer between MoS_2 and CNTs. The versatile nonlinear properties imply a huge potential of the nanocomposites in the development of nanophotonic devices, such as mode-lockers, optical limiters, or optical switches.

References

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Figures

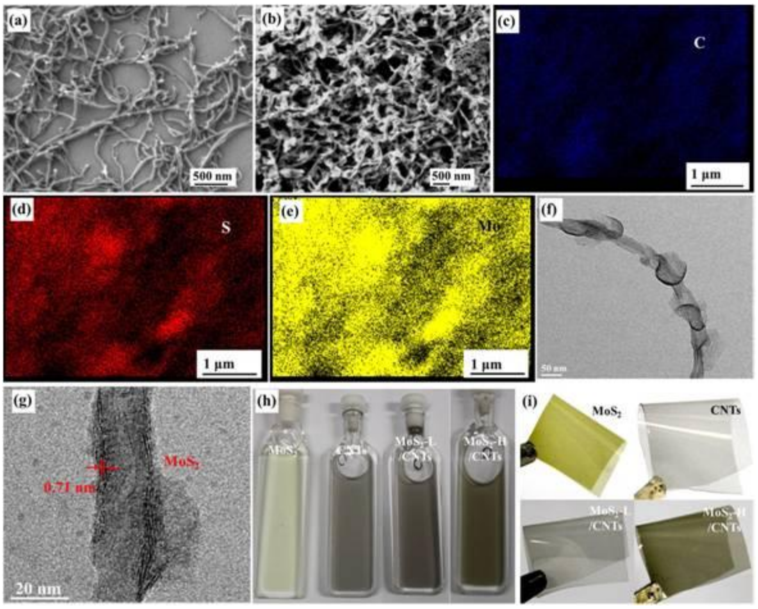

Figure 1: SEM images of a) pristine CNTs and b) the MoS2-L/CNTs. c)–e) Element mapping of C, S, and Mo. f),g) TEM images of a single CNTs wrapped by layered MoS2 nanosheets. h),i) Photographs of the samples in dispersions and PVA films.

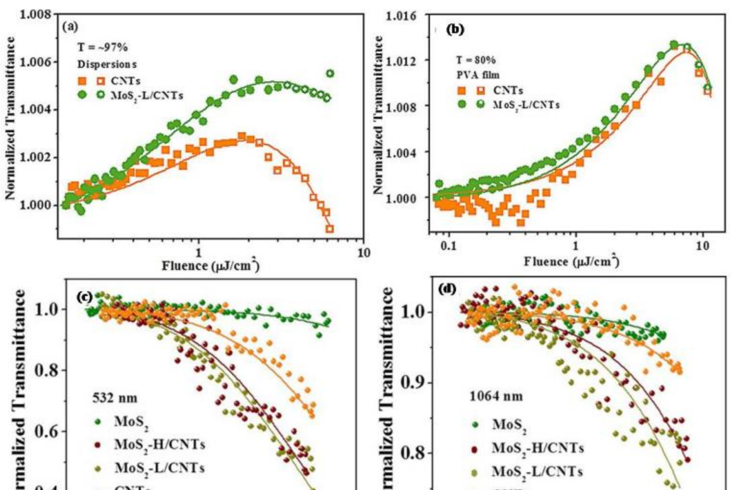

Figure 2: SEM Normalized transmission as functions of input laser fluence for pure CNTs and MoS_2/CNTs in a) high transmission dispersions, and b) PVA thin films under fs laser pulses at 1030 nm, and (c-d) MoS_2, CNTs, and MoS_2/CNTs dispersions with the transmission of about 80% for ns pulses at 532 nm and 1064 nm, respectively.