Emission of precipitation deposited PbS quantum dots on polyethylene terephthalate

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The demand for innovative, cost effective, and more efficient optoelectronic devices has brought about a growing interest in nano-scaled hybrid materials, i.e., the combination of inorganic and organic materials. In particular, the combination of PbS quantum dots (QDs) with PET (=polyethylene terephthalate) is technologically appealing because it enables engineering of light-weight, non-brittle hosts for bright tunable light emitters that can be adjusted to match, the important information transmission wavelengths in the near infrared (e.g. 1300 to 1550 nm). Unlike spun cast hybrid materials of polymers and nanoparticles, we employed a novel deposition process utilizing a centrifuge for the deposition of PbS quantum dots (diameter 4.7 nm) on PET substrates. The QD films formed did not flake off during bending and the film integrity was not disturbed with the application of an adhesive tape test.

Using green laser excitation and a Fourier transform infrared (FTIR) spectrometer to collect the photoluminescence, we studied the emission of the PbS quantum dots, capped with oleic acid ligands, in the temperature range of 5 K - 300 K. The effects of using different solvents for the sample preparation were studied, as well as comparisons to results on other substrates such as glass and GaAs. Notably, the thermal characteristic of the emission linewidth of the Gaussian-like emission spectra does not follow the expected thermal broadening, which, commonly, exhibits a broader emission spectrum at ambient temperatures with respect to that observed at low temperatures. Instead, the PbS/PET sample maintains a nearly stable, temperature independent, linewidth. Since we do not observe such behavior with PbS QDs on glass or GaAs, we conclude that this observation is related to the PET substrate's unique characteristics. It is possible that colloidal PbS QDs on PET substrates are subject to photo-induced changes under light irradiation that alter the established bond linkages at the PET surface during the precipitation process. Due to the strong adhesion of the QD/oleic acid films, we conjecture that the binding forces result from covalent or hydrogen bonding, which appear to be altered under laser irradiation. The comparison of the QD film emission strength, based on the required laser intensity, with well known light emitters such as the commercially used semiconductor GaAs was also performed. The PbS/PET samples produced surprisingly strong emission at room temperature which shows the potential for flexible inorganic light emitter applications.