Multi-wavelength Stimulated Emission from Semiconductor Nanocrystals

Wet-chemically synthesized semiconductor nanocrystals (NCs), also known as colloidal quantum dots, are mesoscopic semiconductor particles whose physical dimensions lie in between those of bulk solids and individual molecules. As a result, these nano-sized particles exhibit strong quantum confined properties such as variations in their band-gap energies as a function of their size. In other words, a small semiconductor NC may emit blue wavelengths while its larger counterpart would emit at red wavelengths. Owing to their size-dependent emission wavelengths and other salient properties such as ease of fabrication and flexible surface chemistry, semiconductor NCs are desirable as optical gain media and a number of efforts have been made to fabricate semiconductor NC laser devices. However, the thresholds of these devices have typically been high due to intrinsic limitations of the NC materials used. We overcome this problem by using tetrapod-shaped semiconductors, as illustrated in **Figure 1**, where the centre core of the tetrapod is CdSe and the arms are CdS. We found that by a judicious tuning of the tetrapod dimensions, stimulated emission from the CdSe core (red wavelength) and CdS arms (blue wavelength) may be achieved at very low room temperature pump thresholds of ~ 70 μJ cm^{-2}, which is amongst the lowest reported for such systems. We find surprisingly that at higher pump intensities, stimulated emission from a higher excited state of the CdSe core occurs as shown in **Figure 2**, adding a third possible wavelength of emission. Taken together, such semiconductor nanostructures represent a new class of low threshold, solution-processable optical gain media capable of simultaneously emitting at multiple wavelengths over a large spectral range from a single active layer.

This work has been accepted in *Advanced Materials* and is currently in press.

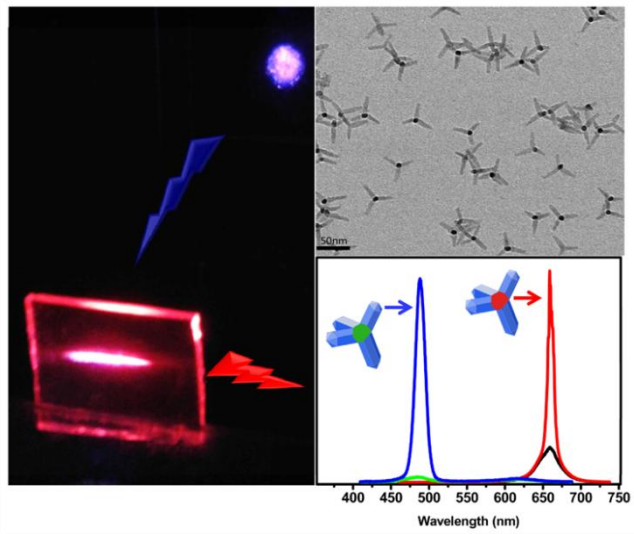

Figure 1. Picture of nanotetrapod film showing stimulated emission. *Upper right*: Transmission electron microscope image of CdSe seeded CdS tetrapods. *Lower right*: Stimulated emission from the arms and core of the tetrapods.

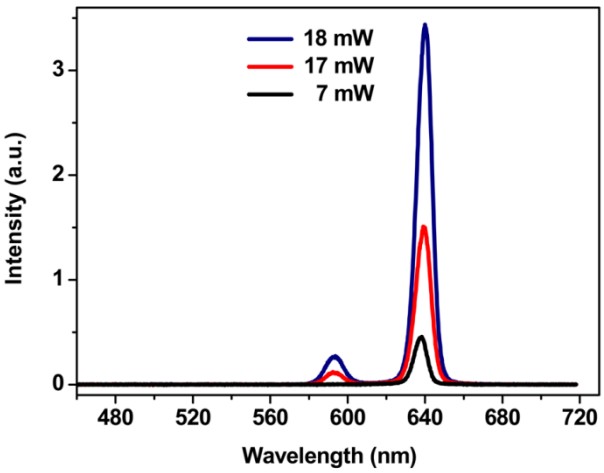

Figure 2. Spectra showing stimulated emission from ground and higher excited states of the CdSe core in the tetrapod.