Charge Carrier Dynamics in Transition Metal Dichalcogenide Nanosheet Films Obtained from Liquid Phase Exfoliation

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Semiconducting transition metal dichalcogenides (TMDs) are important optoelectronic materials thanks to their intense light–matter interaction and wide selection of fabrication techniques, with potential applications in light harvesting and sensing. Crucially, these applications depend on the lifetimes and recombination dynamics of photogenerated charge carriers, which have primarily been studied in monolayers obtained from labour-intensive mechanical exfoliation or costly chemical vapour deposition. On the other hand, liquid phase exfoliation presents a high throughput and cost-effective method to produce dispersions of mono- and few-layer nanosheets. This approach allows for easy scalability and enables the subsequent processing and formation of macroscopic films directly from the liquid phase. Here, we use transient absorption spectroscopy, spatiotemporally resolved pump–probe microscopy, and two-dimensional electronic spectroscopy to study the charge carrier dynamics in tiled nanosheet films of MoS_2 and WS_2, both in single-material form and as a heterojunction of both materials, deposited from the liquid phase using an adaptation of the Langmuir–Schaefer technique. We find an efficient photogeneration of charge carriers with unusually long lifetimes of several nanoseconds, which we ascribe to stabilisation at nanosheet edges. These findings provide scope for photocatalytic and photodetector applications, where long-lived charge carriers are crucial, and suggest design strategies for photovoltaic devices.