In-plane time-of-flight photoconductivity of two-dimensional materials and their composites with organic semiconductors

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Photoconductivity of two-dimensional materials (2DM) is highly sensitive to the environment due to enormous ratio of their surface to thickness [1]. Photoconductivity measurements of 2DM thereby promise superior performance in sensing applications compared to bulk materials [2]. Frequently, submicron-size flakes of 2DM are obtained using various methods, which have potential of large-scale production. More, blending them with organic semiconductors (OS) introduces new material functionalities [3]. In order to fully understand charge transport in thin layers of 2D flakes, electronic properties of the microscopic environment at the interfaces between individual flakes and/or between a flake and an OS molecule must be considered in addition to the inter-flake charge transport [4]. These interconnecting segments drastically change the overall charge transport characteristics, as was thoroughly studied in graphene/organic semiconductor composites.
Here we present recent results of in-plane time-of-flight photoconductivity (TOFPC) measurements of thin films of MXene (Ti_2C_3) flakes and of quasi-two-dimensional conjugated polymers. Due to high sensitivity of TOFPC, we were able to distinguish the samples exhibiting nondispersive, or dispersive transport of photoexcited charge carriers. In the case of samples exhibiting non-dispersive charge transport, charge carrier mobility as high as 200 cm^2/Vs was detected. This surprisingly high mobility is atypical for spin-coated thin films comprising interconnected 2DM nanoparticles. In fact, by using unique TOFPC method, we can discover high-mobility pathways, which can be formed in an interconnected network of these materials. More, by tuning the excitation photon energy, TOFPC can be used to explore transport of hot charge carriers through non-equilibrium states, which exists at higher energy levels.

References

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Figures

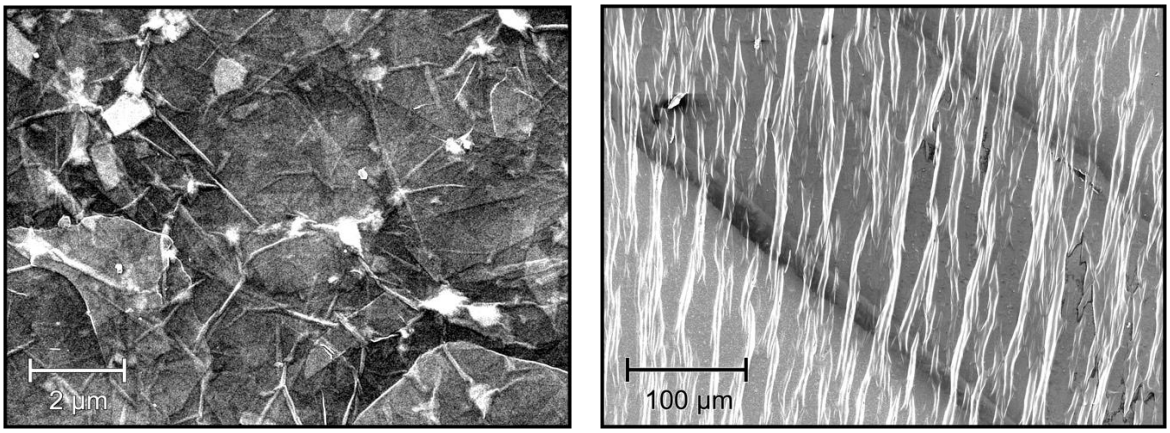

Figure 1: Time-of-flight photoconductivity measurements were performed on thin-films of interconnecting MXene flakes (left) and on thin-films of quasi-two-dimensional conjugated polymers (right). Scanning electron imaging reveals the microscopic morphology characterized by grain boundaries and wrinkles.