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Ultrafast carrier dynamics in organic molecular crystals and conjugated polymers

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Organic semiconductors are being extensively studied by many research groups around the world for applications in electronic and photonic devices. For example, much work has focused on the development of organic thin film transistors based on thermally evaporated pentacene films, where the polycrystalline morphology typically results in a thermally-activated carrier mobility. On the other hand, more intrinsic bandlike transport, where the carrier mobility increases as the temperature decreases, has been observed in many organic single crystals. However, the nature of charge transport in organic molecular crystals is still not understood. Also, despite many advances in organic photonics, the nature of photocarrier generation in organic semiconductors is not completely understood and remains controversial even today. The generation of mobile charge carriers in photoexcited organic materials occurs over femtosecond to picosecond time scales, and so ultrafast pump-probe experiments are essential in order to improve our understanding of fundamental processes in these materials. Recently, time-resolved terahertz pulse spectroscopy has been used to directly probe transient photoconductivity in pentacene and functionalized pentacene thin films and single crystals [1,2], revealing photogeneration of mobile charge carriers over sub-picosecond time scales as well as bandlike carrier transport in both single crystal and thin film samples [1]. This talk will provide an overview of ultrafast carrier dynamics in organic semiconductors, and will emphasize how time-resolved terahertz pulse spectroscopy can be used to help understand the nature of photoexcitations and carrier transport in organic materials. (This work was supported by NSERC, CFI, CIPI, the Killam Trust, and ONR. Collaborators for this work are listed in Ref. 1.) [1] O. Ostroverkhova, D. G. Cooke, S. Shcherbyna, R. F. Egerton, F. A. Hegmann, R. R. Tykwinski, and J. E. Anthony, Phys. Rev. B., in press. [2] V. K. Thorsmølle, R. D. Averitt, X. Chi, D. J. Hilton, D. L. Smith, A. P. Ramirez, and A. J. Taylor, Appl. Phys. Lett. 84, 891 (2004).