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Thermal Conductivities of Crystalline Organic Semiconductors[1]

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As applications for organic semiconductors grow, it is becoming increasingly important to know their thermal conductivities, k. For example, for sub-micron electronic devices, values of $k>k_0 \sim 5$ mW/cm/K are needed, while values $k<k_0$ are required for desired thermoelectric applications. Whereas it is not surprising that semiconducting polymers typically have room temperature thermal conductivities below k_0, many molecular organic crystals also have values of k below this value. We have started measurements of both the in-plane and interplane thermal diffusivities of layered crystalline organic semiconductors using frequency[2] and position dependent[3] ac-calorimetry; the thermal conductivities are then determined from the specific heats measured with differential scanning calorimetry. For rubrene, which has $k<k_0$, the interplane thermal conductivity is several times smaller than the in-plane value, although its temperature dependence indicates that the phonon mean-free path is at least a few layers.[4] On the other hand, the in-plane thermal conductivity of TIPS-pentacene,[5] is several times greater than k_0, similar to that of the quasi-one dimensional organic metal TTF-TCNQ.[6] Remarkably, its interlayer thermal conductivity is several times larger than its in-plane value,[7] perhaps due to interactions between the large (triisopropylsilylethynyl) side groups on the pentacene backbone.

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