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Employing 'Liquid Gap' Transistors to Examine the Mobility-Carrier Density Relation in Polymer and Single Crystal Organic Semiconductors[1]

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It is generally known that the carrier mobility in organic semiconductors can depend on carrier density, but the precise relationship hinges on the degree of structural order and the dielectric polarizability at the organic/dielectric interface. We have fabricated both single crystal and polymer transistors using the PDMS stamp approach pioneered by Podzorov and Rogers [1], where we have replaced the usual 'air gap' in these structures with liquids having different dielectric constants. This structure allows us to examine transport in single crystals and polymer semiconductors as a function of tunable dielectric constant and also charge density. We find striking differences in transport behavior for organic single crystals versus polymer semiconductor films using these liquid dielectric transistors. For organic single crystals such as rubrene, the carrier mobility does not seem to be a function of charge density but does strongly depend on the liquid dielectric constant, in keeping with previous results reported by Morpurgo [2] on the effects of dielectric polarizability. For polymer semiconductors, the effect of charge density is overwhelming; there is a strong increase in charge mobility with increasing carrier concentration, following a power law. These results are already largely known, but the 'liquid gap' transistors provide a convenient testbed for examining these effects side-by-side for different materials in the same device. We will describe the device fabrication and the nature of our results, as well as discuss the origins of the very different behavior for single crystals versus polymer semiconductor films.
1) Sundar, V.C., *et al. Science* **303** (2004) 1643. 2) Hulea, I. N., *et al. Nature Mater.* **5** (2006) 982.

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