Electronic transport through tetracene single crystals

- A. Morpurgo (Delft University)

The experimental investigation of the electronic properties of organic semiconductors is often hampered by material defects, such as structural faults or chemical impurities. In most cases it is the defects that determine the measured behavior these materials, which makes the study of the intrinsic properties of organic semiconductors extremely hard. For electronic transport measurements this situation is well-illustrated by the behavior of the measured charge carrier mobility as a function of temperature, which almost invariably shows a thermally activated behavior whereas from time of flight measurements it is known that the mobility should increase with lowering temperature.

In order to investigate experimentally the intrinsic transport properties of organic semiconductors

we have started to perform experiments on single crystals of different organic molecules. Here we report our work on tetracene. We first discuss the space charge limited current measurements performed as a function of temperature. We find that for the best samples the mobility at room temperature is close to 1 cm^2/Vs and that for transport both in the direction perpendicular and in that parallel to the *a-b* plane the mobility increases as the temperature is lowered. Below approximately T ~ 170 K the mobility suddenly drops as a consequence of a structural phase transition that is known to occur in tetracene around that temperature.

We have also investigated the *I-V* characteristics parallel to the *a-b* plane, in samples with contact separation in the micron range. The temperature dependence of the current in the ohmic regime shows that no Schottky barrier is present at the Gold contact/tetracene interface. The experiments also indicate that a substantial transfer of charge through this interface occurs in order to align the Fermi level in the Gold and in tetracene. We interpret our results in terms of a simple model based on the self-consistent solution of Poisson equation. This model captures the most relevant features observed in the experiments.

Using the same crystals characterized by means of space charge limited current we successfully fabricated single-crystal field effect transistors. The best mobility obtained so far in a FET geometry is ~ 0.1 cm^2/Vs, lower than that observed by means of space charge limited current spectroscopy and comparable to the best existing thin film transistors based on tetracene. This is probably due to the technique used to fabricate the FET devices. The results obtained in the study of space charge limited current suggest that further improvements of the FET fabrication technology will result also in FETs where the carrier mobility increases with lowering temperature.