Novel high-mobility n-type small molecule for solution-based transistors: a charge transport study

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We present detailed temperature-dependent charge-transport studies of a novel small molecule n-type semiconductor. Via a solution process we are able to deposit thin films that are only few molecular layers thick with large crystal grains on the order of 500x200µm². Field-effect transistors in bottom-gate top-contact architecture are realized on a SAM-covered Al_2O_3 dielectric with gold top contacts. Electrical characterizations performed in vacuum environment show superior performance as shown **Fig. 1A** with a maximum mobility of up to μ_{lin}=4.3 cm²/Vs and an ON/OFF current ratio of 10^5. No contact limitation can be observed from the output characteristics (**Fig 1b**).

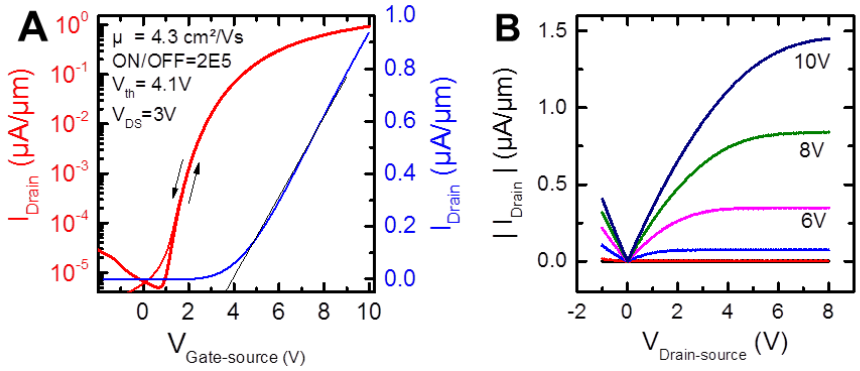

Fig. 1. A) Transfer and B) output characteristic of a device at room temperature. The transfer characteristic is shown in linear regime at V_{DS} = 3V.

As shown in **Fig. 2** charge transport is thermally activated below 260K, with a thickness-dependent activation energy of 16-21 meV that is increasing for thinner films. Above 280 K the mobility continues to increase only for the 9 nm thick films (**Fig 2A**) at carrier densities of 6E12 1/cm² or below. For a carrier density of 8E12 1/cm² however we find, that the mobility decreases with increasing temperature. For the 3 nm thick layer (**Fig 2B**), the trend of decreasing mobility with increasing temperature extends across a larger charge carrier density and also becomes stronger with increasing density. Our observations for both the 3 nm and the 9 nm can be explained, if one considers that for higher charge carrier densities (and concomitantly larger electric gate fields) the charge carriers are confined more towards the semiconductor/dielectric interface where charge transport is possibly more dominated by lattice vibrations or lattice imperfections. This effect is more pronounced for the thin layers, since here charge carriers do not have the possibility to divert to upper layers to avoid scattering.

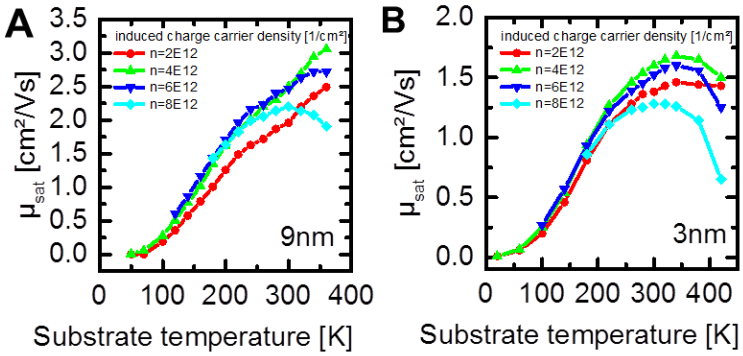

Fig. 2. Temperature dependence of mobility for different charge carrier densities of A) a 9nm thick and B) a 3nm thick sample. All evaluations are conducted in the saturation regime at V_{DS} = 8 V.