Organic-Inorganic Hybrid Semiconductor Thin Films Deposited Using Molecular-Atomic Layer Deposition (MALD) – Supplement

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Organic-Inorganic Hybrid Semiconductor Thin Films Deposited using Molecular-Atomic Layer Deposition (MALD)

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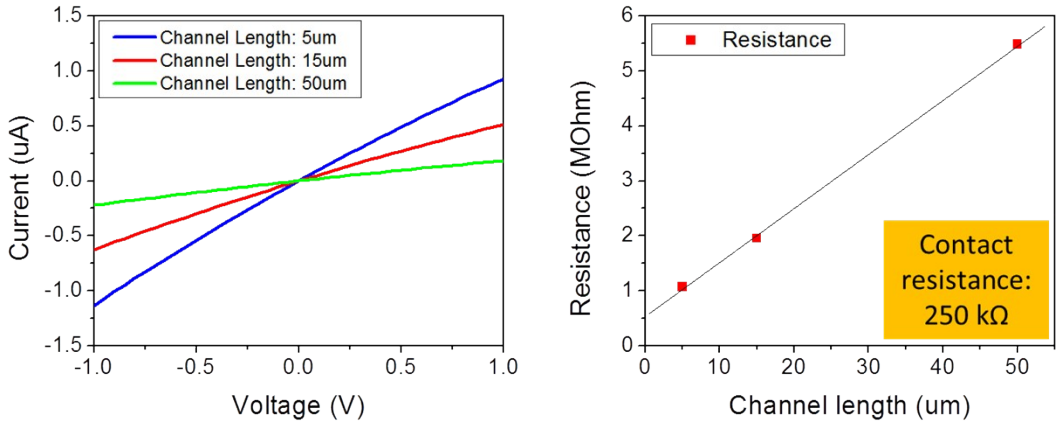
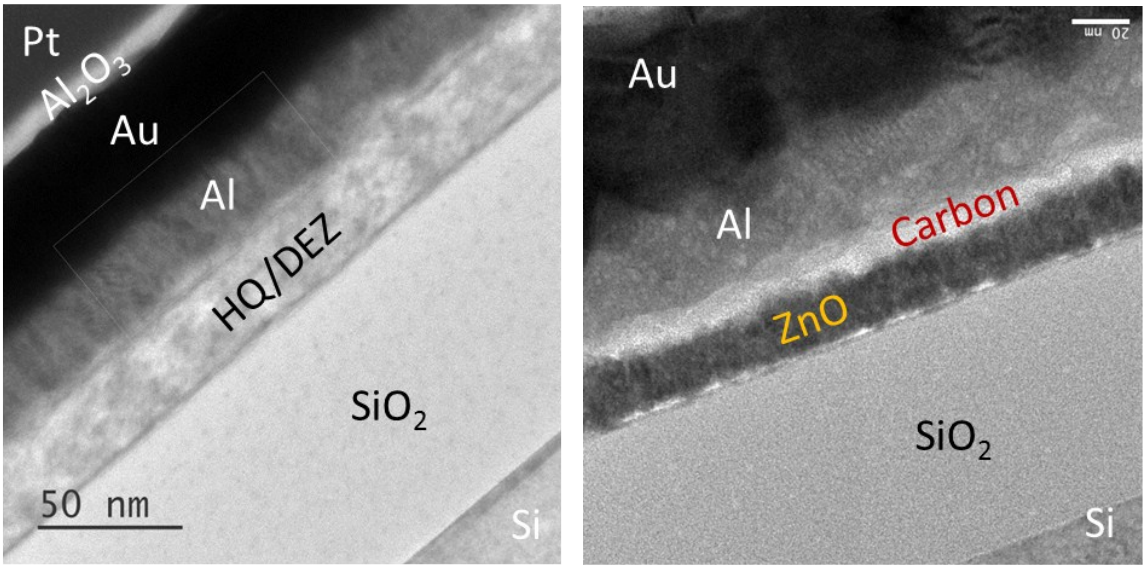
Supporting Information

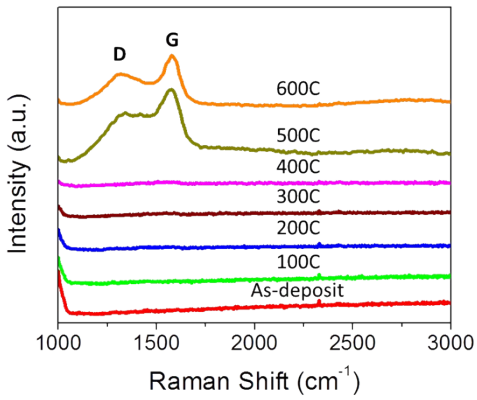
We tested the n-type metal Al/Au, as well as the p-type metal Pt/Au, and determined that Al/Au formed an Ohmic contact to the semiconductor following low temperature annealing (see S.1). In the sample annealed at 200 °C, the S-D contact on the channel switched from Schottky to Ohmic behavior. However, after annealing at 300 °C, the HQ/DEZ film lost field-effect behavior and became a conductor (data not shown) possibly because of the separation of the hybrid phase into ZnO and carbon precipitates, observed via cross-sectional TEM images of HQ/DEZ films (see S.2). However, from both Raman and XRD, nanocrystalline graphitic carbon and ZnO was not detected until annealed above 500°C. We believe that it depends on characterization technique issues. Particularly HQ/DEZ is hybrid material. TEM may result in local heating while sample preparation using FIB and TEM electronic beam as well like what happens in soft matter. Further studies are required to understand the phase separation mechanism of this material.



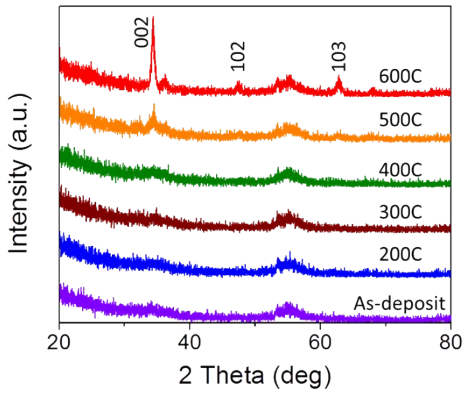
Supporting 1. Ohmic contact between Al/Au S/D to HQ/DEZ hybrid thin film annealed at 200°C for 1 hour in N_2 gas.



(a) (b)



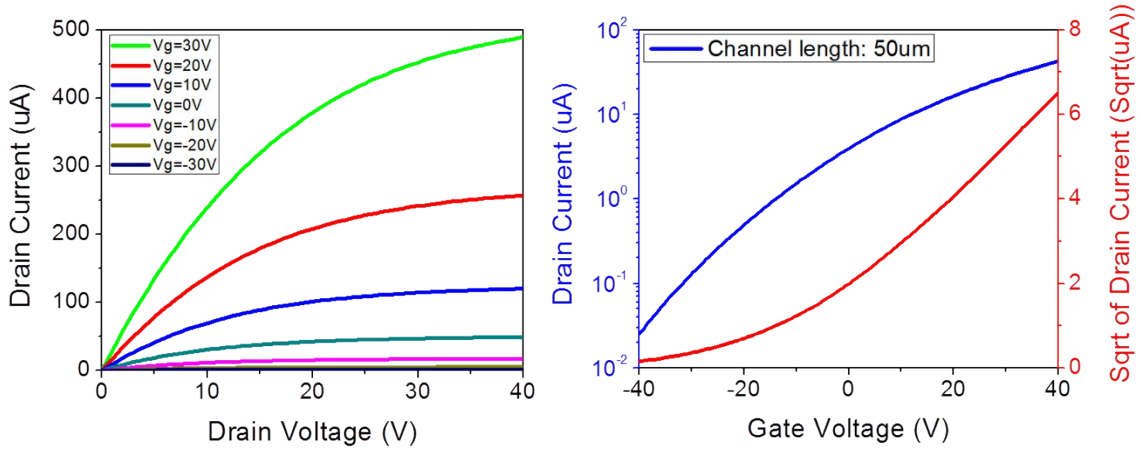
(c)



(d)

Supporting 2. Cross-sectional TEM of HQ/DEZ hybrid channel layer post annealed at (a) 200 and (b) 300 °C for 1 hour in N_2 gas. And (c) Raman, (d) XRD spectra of HQ/DEZ annealed at 200 to 600 °C.

The temperature dependence of the field-effect properties of Al_2O_3 passivated HQ/DEZ films were also performed (see S.3). The mobility decreased obviously upon increasing measurement temperature. The inverse relationship between the electron mobility and temperature may be attributed to the lattice vibration induced carrier scattering at elevated temperatures. This phenomenon suggests that band transport might be more applicable than the hopping theory commonly suggested to interpret the behavior of organic semiconductors. In addition, traps attributed to structural defects are another important factor impacting the transport of charge carriers in polycrystalline/amorphous films.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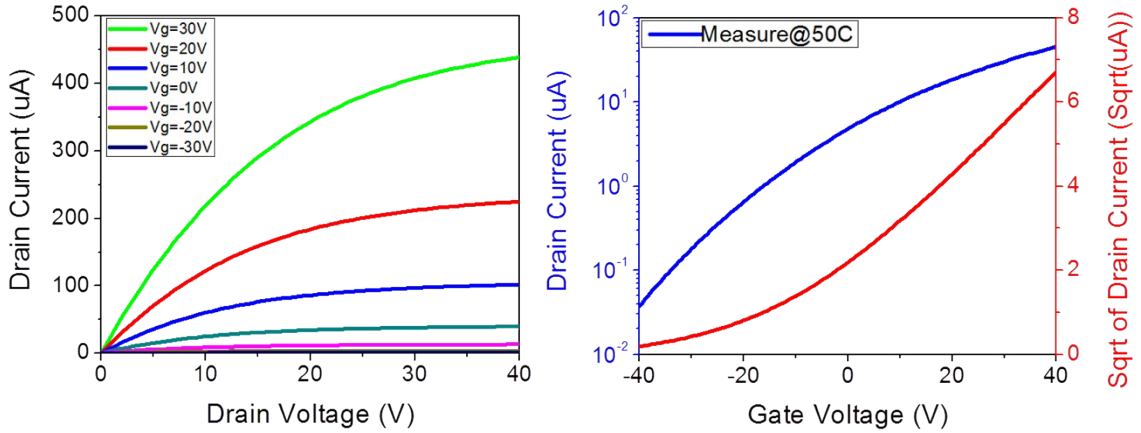
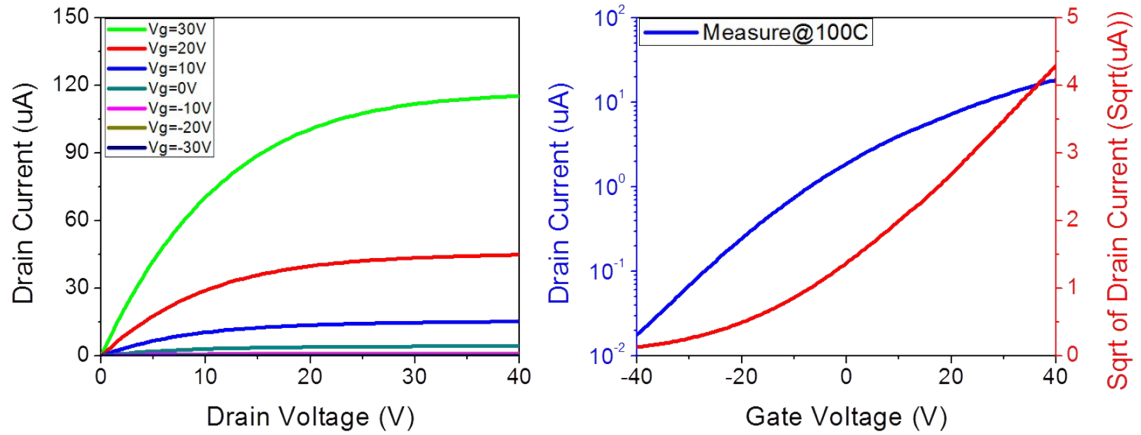
Vg=20V
Vg=10V
Vg=0V
Vg=-10V
Vg=-20V
Vg=-30V
Drain Current (uA)
Drain Voltage (V)
Channel length: 50um
Drain Current (uA)
Sqrt of Drain Current (Sqrt(uA))
Gate Voltage (V)

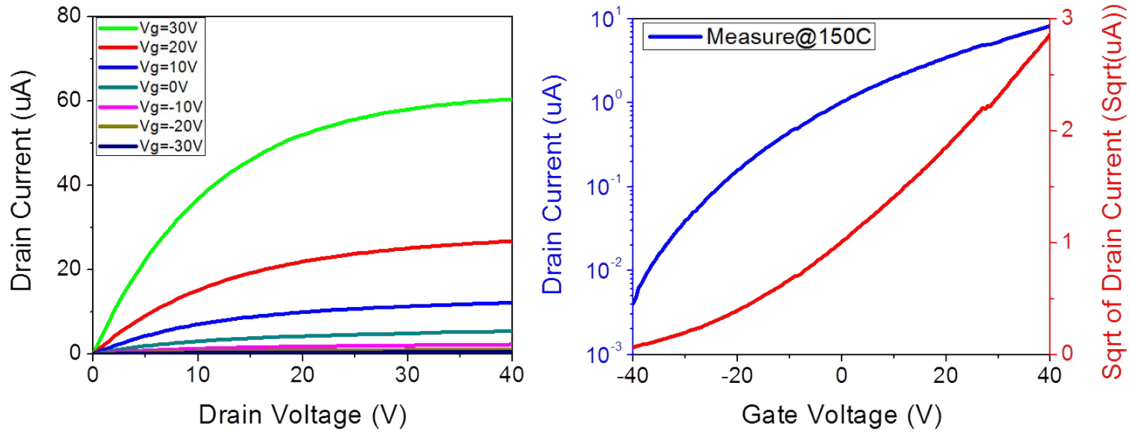
(a)


Vg=30V
Vg=20V
Vg=10V
Vg=0V
Vg=-10V
Vg=-20V
Vg=-30V
Drain Current (uA)
Drain Voltage (V)
Measure@50C
Drain Current (uA)
Sqrt of Drain Current (Sqrt(uA))
Gate Voltage (V)

(b)


Vg=30V
Vg=20V
Vg=10V
Vg=0V
Vg=-10V
Vg=-20V
Vg=-30V
Drain Current (uA)
Drain Voltage (V)
Measure@100C
Drain Current (uA)
Sqrt of Drain Current (Sqrt(uA))
Gate Voltage (V)

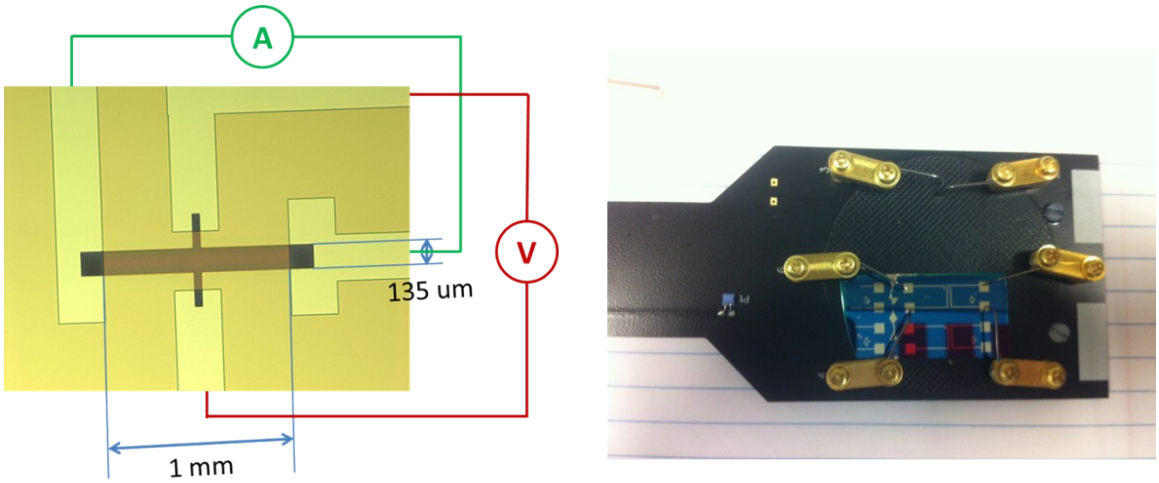
(c)



(d)

Supporting 3. TFT device performance out-put curve (left) and transfer curve (right) of HQ/DEZ hybrid thin film as channel layer at (a) room temperature, (b) 50 °C, (c) 100 °C, and (d) 150 °C.

Hall-effect measurements using Hall-bar configuration (see S.4), were performed to confirm the electron mobility using the HQ/DEZ thin film of the same thickness for TFT devices. HQ/DEZ Hall-bar was patterned using lift-off approach. All Hall-measurement was performed at room temperature.



(a) (b)

Supporting 4. (a) Hall-bar patter on photoresist after developing (before HQ/DEZ deposition), and (b) the

sample holder/prober of Hall measurement.