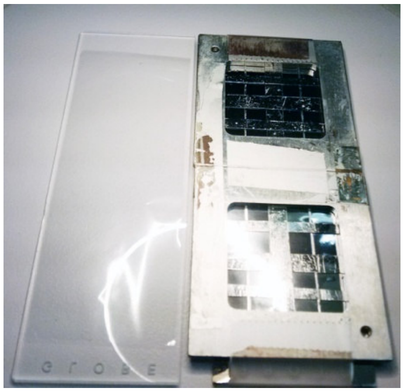
Technical notes: fabrication of ultra-flexible thin-film TES-ADT OFETs on plastic sheets.

02/13/2013

The procedure described below is performed in ambient air at room temperature, that is, in a non-clean room environment, without any use of glove boxes, high-vacuum evaporation of organic semiconductors, solvent-vapor or high-temperature annealing, and it does not require silicon wafers.

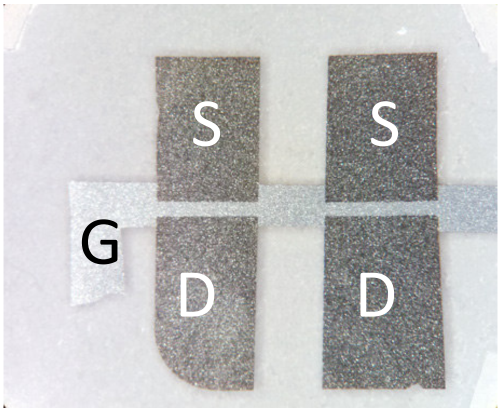
1. Preparing Mylar substrates and masking. Cut a piece of 2.5 µm-thick Mylar® film of appropriate shape and size. We use a commercially available Mylar purchased at Chemplex.Inc (CAT #3012). Place the Mylar film on a clean glass slide and add a shadow mask (place the shadow mask on top of the Mylar film and fix it in place). We use small pieces of scotch tape. Caution: to avoid Mylar film sticking to the Scotch tape holding the mask, the size of Mylar film should be slightly smaller than that of the shadow mask.



2. Thermal evaporation of Source and Drain contacts. Use a thermal evaporator to deposit 35 nm-thick silver (Ag) source and drain contacts.

3. Thermal evaporation of the Gate electrode. After depositing the Source and Drain contacts, deposit silver Gate electrode (35 nm-thick) on the opposite side of Mylar. The gate shadow mask must be aligned correctly to completely overlap the area between the contacts (the channel area).

4. Using a solid support for further handling. Attach the Mylar film with pre-deposited S, D and G electrodes to a glass slide using small pieces of Scotch tape (attach it to the glass by the four corners of Mylar). Make sure the S and D contacts are facing up.



5. Preparing a TES-ADT solution. Make an 8%-wt solution of TES-ADT in toluene. Weight 3.52 mg of crystalline TES-ADT powder using a high-precision balance and put it in a clean small bottle. Add 50 μl Toluene (0.866 g/ml) using micropipette (Molecular Bioproduct ART (Aerosol Resistant) or BIO-CERT high-purity plastic micropipette tips). Toluene must be of a high purity (we use 99.8 % toluene purchased from Fisher scientific, CAS# 108-88-3). Wait for 5 - 10 min at room temperature in order to fully dissolve TES-ADT in toluene (gently shaking the bottle might help). Before the solution preparation, the bottle must be pre-washed 3 times with a high–purity acetone and 3 times with a high-purity isopropanol, followed by a blow dry with a nitrogen gun.

6. UV-ozone treatment of the plastic substrate. In order to make the substrate's surface more hydrophilic (which seems to be necessary in the case of TES-ADT to achieve good film forming properties), treat the sample in a UV-ozone chamber for 3 min (we use UVOCS.inc machine in Prof. E. Andrei's lab).

7. Drop casting and crystallization of TES-ADT. Drop about 1 μl of TES-ADT solution on the Mylar film between the S & D contacts and cover the entire sample with a small box or opaque dish to block off ambient light. After each use, tightly seal the bottle with TES-ADT solution using a Teflon or Parafilm tape and wrap it in aluminum foil (to protect the contents from light), then put the bottle in a desiccator. Check the growing TES-ADT film under a microscope. If the solution did not spread well, the duration of UV-Ozone treatment has to be increased next time in order to make the surface of Mylar and silver more hydrophilic. Observe crystallization of TES-ADT under a microscope. In a good sample, nucleation and growth of purple domains in a pinkish amorphous film must be clearly seen. Refer to a movie "real-time crystallization of TES-ADT on Mylar" (http://www.youtube.com/watch?v=ArX6tfFklVY) for an example of good crystallization.

8. Removing the peripheral film material. The crystallized TES-ADT layer has to be trimmed by removing the film outside of a selected channel area. This will ensure accurate channel length and width reading (with a well defined W/L ratio) as shown in the photo on the right. Gently wipe off TES-ADT from Mylar surface using a toothpick soaked in toluene, leaving only a rectangular piece of film in the middle. Selecting an area with a good morphology and crystallinity helps achieving a good device performance.

9. Device wiring. Attach thin gold wires to the silver Source, Drain and Gate electrodes using a silver paint. Let the paint dry in the dark. The device is ready for wiring to your measurement setup. Contacting the device with external pins of a probe station instead of using wires is also possible.

Illumination of organic powders, solutions and films must be minimized during the entire procedure. Organic semiconductor materials (solutions and powders) and devices must be stored in air-tight opaque bottles/containers placed in a desiccator protected from light. Details on device fabrication and characterization can be found at:

H. T. Yi, M. M. Payne, J. E. Anthony and V. Podzorov, "Ultra-flexible solution-processed OFETs", ***Nature Comm.***, DOI: 10.1038/ncomms2263 (2012).