Organic Optoelectronic Devices Printed by the Molecular Jet Printer

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Using a micro-fabricated silicon printhead, we developed a novel printing technique, molecular jet printing (MoJet) [1-2] that allows direct patterning of small molecular weight organics and metals by additive deposition at high resolution. Today’s dominant method for patterning vacuum-deposited semiconducting molecular organics uses a thin metal stencil as a shadow mask through which material evaporates. Once the metal stencil is fabricated, it cannot be reconfigured to define arbitrary patterns or be scaled up with substrate size. In contrast, the MoJet printing technique utilizes a silicon printhead that integrates a moving micro-shutter with a micro-aperture. The shutter can be opened or closed with a DC control signal. Evaporated organic molecules can either pass through the aperture to reach the substrate when no bias is applied or be obstructed by the shutter when the control signal is above 30 V DC. This reconfigurable printhead together with a moving stage allows arbitrary patterning capability and scalability of the MoJet printer to larger substrate sizes.

We demonstrate that active organic devices such as organic LEDs and organic FETs (see graphics below) can be fabricated directly using the MoJet printer. The MoJet printing is a solvent-free process (in contrast to inkjet printing) that combines the high quality of thermally evaporated thin films with the high precision and scalability enabled by MEMS technology. The MoJet printed organic electronic devices have the same performance characteristics as those defined by the shadow-mask patterning method, but the size of the substrate plate can now be expanded beyond GEN 2/3. As such, the MoJet printer surpasses the capability of the metal-stencil shadow mask and has the potential to become the next generation patterning tool for making organic optoelectronic devices.

Figure 1: (a) Layer structure of printed OLED array. The green electroluminescent layer (EL) is directly printed with the MoJet printer. (b) EL micrograph of active OLED array at 7.5V applied voltage. The image is taken through a 470-nm low-pass filter to reveal that green pixel patterned by the MoJet. The pixel size is 30 µm, equivalent to 800 dpi resolution.

Figure 2: (a) Structure of the printed Pentacene transistor. Pentacene layer is printed down first and silver contacts are printed sequentially. (b) Micrograph of a single-printed OFET on silicon oxide. (c) The I-V characteristics of one of the transistors. The gate voltage Vg is varied from 0 to –60V in 10V steps.

REFERENCES