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High-performance perovskite hybrids for printable optoelectronics

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In the last 5 years, methylammonium lead halide or MALH perovskites (e.g., $CH_3NH_3PbA_{3-x}B_x$, where A and B are I, Cl or Br) have shown tremendous potential for low-cost optoelectronic device integration, including light-emitting diodes, solar cells and photodetectors. For example, the power-conversion efficiencies from organometallic halide perovskite solar cells have increased from 3.8% in 2009 to 22.1% in 2016. This spectacular progress is largely attributed to improved processing and longer charge-carrier lifetimes, directly related to increased material quality. While significant progress was made, many key parameters including compatibility, interface engineering, surface treatment and processability remain essential to achieving the best device performances. These fundamental challenges prevent integration into commercial-grade devices. For one, relatively low carrier mobilities still prevent large-area devices with performances competing with state-of-the-art technologies. Several groups began exploring hybrid perovskite films in the last 3 years. In the last year, we have made major progress towards viable MALH devices (1) by dramatically enhancing structure and properties through solvent engineering, (2) enhancing conductivities by several orders of magnitude using MALH hybrids, (3) extending their operation to the near-infrared and (4) significantly improving their stability and lifetime by doping with SCN. Preliminary results shown in Fig.1 are greatly encouraging and suggest that the carefully-controlled processing capability allowed by the Ceradrop inkjet printer can yield high-quality MALH films. This is a major step towards the integration of MALH perovskites within commercial printable photovoltaic devices, LEDs and sensors.

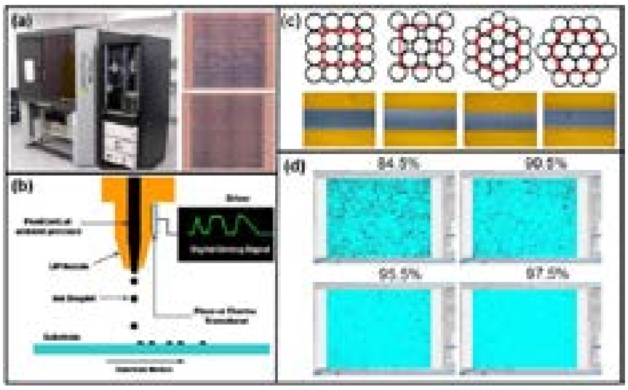

Figure: *(a) Commercial research-grade inkjet printer. (b) Unique control of the nozzle speed, temperature and drive signal can help optimize the jetting process.*

(c) The splat pattern and the overlap ratio also have dramatic consequences on the printed features' quality.

(d) Fully-converted CH3NH3PbI3-xClx (also called MAPbI3-xClx or MALH) nanocrystalline perovskite films printed with the printer. The control of the jetting helps optimizing the coverage and quality.

Biography

Sylvain G. Cloutier received the outstanding Ph.D. thesis award in 2006 from the Division of Engineering at Brown University, where he studied the optoelectronic properties of nanoengineered materials. As an assistant professor of Electrical and Computer Engineering at the University of Delaware, he received the DARPA Young Faculty Award for his work on the use of Nano-engineered materials for lasers. In 2011, he joined ÉTS as professor of Electrical Engineering, where he leads the Canada Research Chair on Hybrid Optoelectronic Materials and Devices and explores new hybrid materials and heterostructures for optoelectronic device integration. He published more than 80 contributions cited over 1400 times and obtained 3 patents. In 2014, he was elected to the College of the Royal Society of Canada. At ÉTS, he is also the director of research, partnerships and faculty affairs.

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