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Self Assembly in Advanced Manufacturing

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Advanced manufacturing techniques are convenient tools for translating dispersed colloids and molecules into larger patterns and structures. Thus, can be viewed as a creative platform for materials chemistry and self-assembly, one that merges confined reactions, microfluidics, and intermolecular forces with broad length scales for the emergence of intermolecular control and self-organization in large areas.

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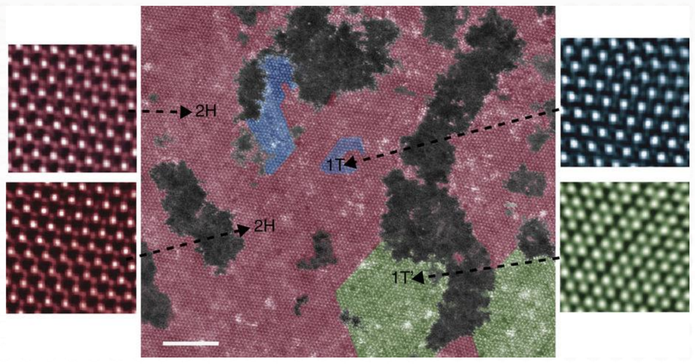
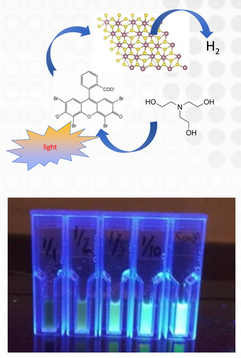
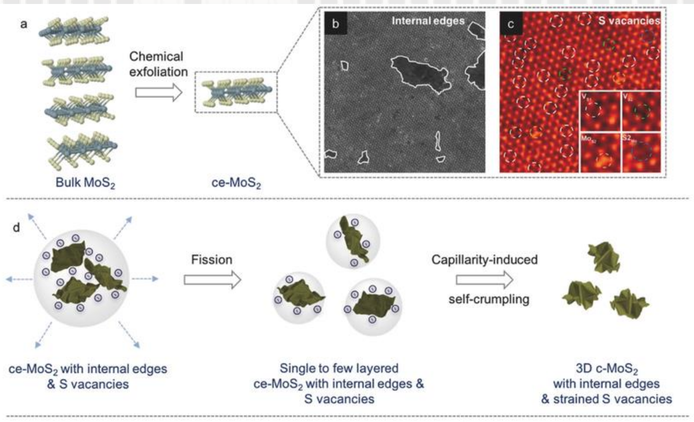
Self-Assembly and Droplet Templating

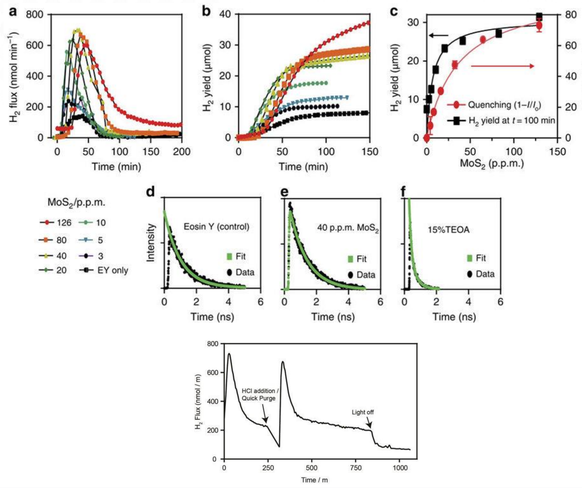


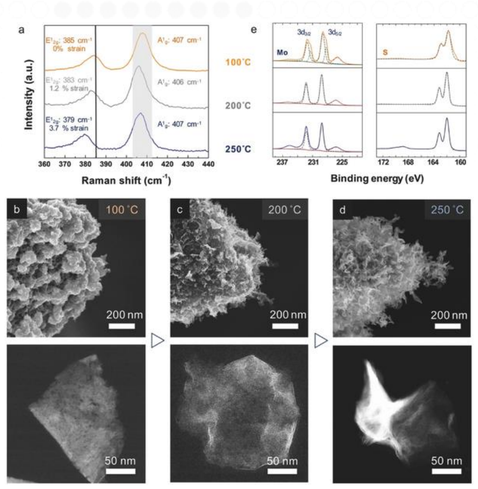


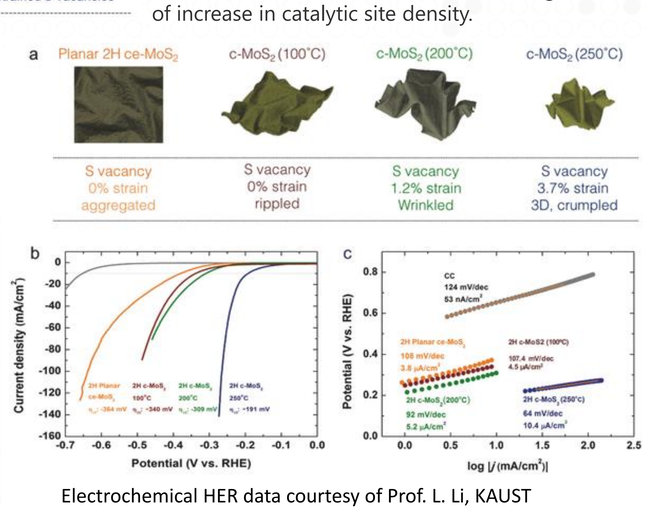


Surface tension and hydrodynamics can be designed to control wetting and patterning; further, each droplet is a reactor, capable of templating colloids and molecules inside. Shown on left, edges and atomic defects of (a) MoS_2 characterized by (b) TEM and (c) HAADF. (d) Charged, MoS_2 droplets undergo stages of (i) electrostatically induced separation, (ii) fission, and (iii) capillarity-induced crumpling into 3D MoS_2 structures. This brings about a high degree of strain in individual MoS_2 sheets, bringing about a semiconductor to metal transition in folded creases. The strained creases form the basis of the conductive molecular wire-network that electronically connect the catalytically dormant defects to enable orders of magnitude of increase in catalytic site density.

Solution self-assembly strategies applied to "ink" formulation. Exfoliated MoS_2 assembled with eosin Y to form charge transfer pathways between colloid and molecule. On Right: (**a**) Real time H_2 flux at incremental MoS_2 concentrations. Diminished reactions are indicative of proton exhaustion, and can be restarted with acid addition. (**b**) Corresponding cumulative H_2 yield (For **a** and **b** note key bottom left). (**c**) Incremental concentration of MoS_2 and correlative overlay of cumulative H_2 yield (black) with fluorescence quenching of dye (red) in solution. (**d**) fluorescence decay of eosin Y, (**e**) reaction saturated with eosin Y and MoS_2 showing similar decay, indicative of static-quenching and ground-state complex, and (**f**) collisional quenching between TEOA and eosin Y, resulting in second order decay and attenuated lifetime. The same strategy can be applied to other colloids, an example being transparent, thermally insulating coatings we are developing for ARPA-E.



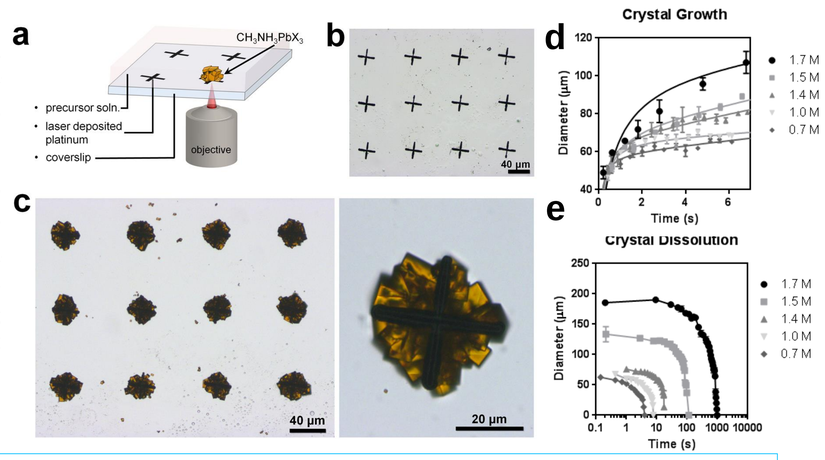




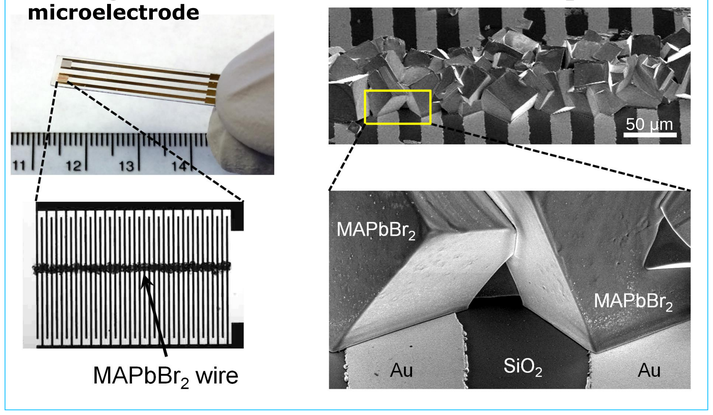
Electrochemical HER data courtesy of Prof. L. Li, KAUST

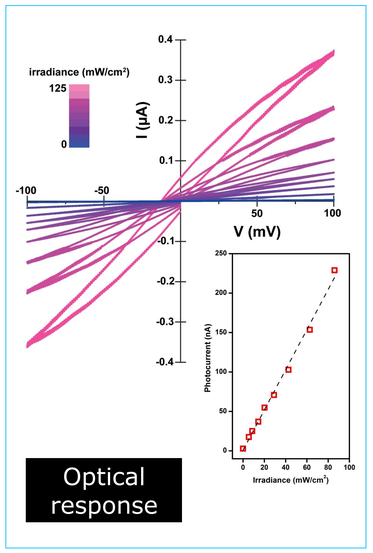
Laser-Directed Writing of Perovskite Crystals

Laser directed perovskite crystallization, as enabled by localized heating. (a) Schematic of the experiment. Platinum crosses are patterned onto glass and immersed in precursor solution. The backside of the Pt metal is heated to induce $MAPbBr_3$ crystallization. (b) Laser patterned platinum crosses. (c) An array of $MAPbBr_3$ crystals following laser heating. This site-specific heating enabled a detailed understanding of the dependence of crystal growth (d) and dissolution rates (e) on precursor concentration.

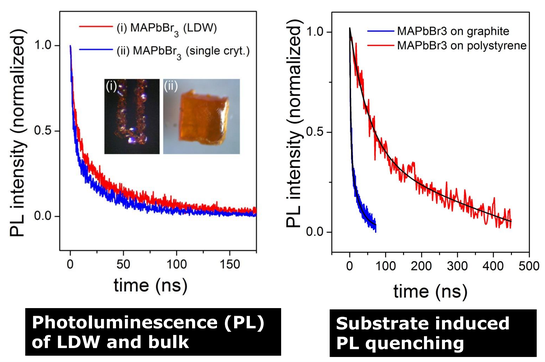


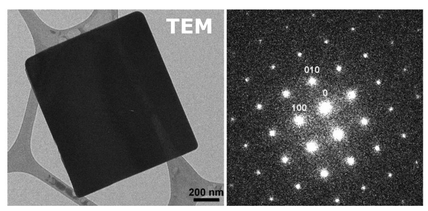
Microfabricated photodetector employing a LDW perovskite wire

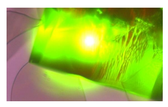




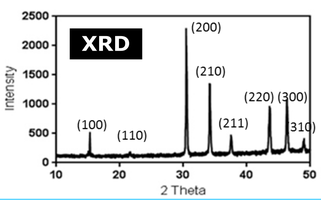
Characterization of LDW perovskite materials

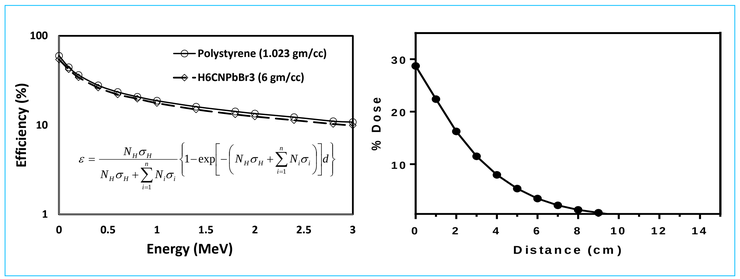






Two photon induced PL in LDW perovskite
(ex 750 nm; em ~550 nm)





Relevant Publications.
1. Chou, et al. 10.1038/ncomms9311
2. Chen, et al. 10.1002/adma.201703863
3. Chou, et al. 10.1021/acs.jpclett.6b01557

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