AMOLF's Light Management in New Photovoltaic Materials Program

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Nanoscale Solar Cells group (PI Erik Garnett):

1. Halide perovskite back contact and tandem solar cells (supervisor: Hongyu Sun)

Perovskite solar cells are undergoing an extremely fast development and attracting intense research attention due to their unique features such as low-cost, easy to fabricate and excellent optical/electrical performance. However, most of the state-of-art works are focusing on traditional planar solar cell designs. In this project, you will study how perovskite film performs on nanoscale patterned back contact substrates and also explore its potential for perovskite/Si tandem solar cells. The main activities of this project include synthesizing, characterizing, analyzing several different types of perovskites and further fabricating solar cells. Meanwhile many scientific equipment skills will be obtained such as SEM, XRD, probe station, spin coating, etc.

2. HfN nanoparticles for long-lived hot electrons (supervisor: Sven Askes)

Collective oscillations of conduction band electrons in metals (plasmons) have recently been shown to have improved selectivity for certain chemical reactions. Although the exact mechanism is still debated in literature, there is growing evidence that "hot electrons" – showing an energy distribution very different from the standard room temperature Fermi-Dirac distribution – play an important role. Traditional plasmonic materials (Au, Ag, Cu) have very strong electron-electron and electron-phonon interactions, leading to rapid carrier cooling to the room-temperature energy distribution (few ps timescale). HfN has been shown to have carrier cooling that is approximately 1000 times slower, which should improve the efficiency of hot carrier effects. In this project you will repeat a very recent literature report for HfN solution synthesis and characterize the plasmonic properties of the nanoparticles in solution and at the single particle level.

3. Lasers via perovskite nanocube assembly (supervisors: Jian-Yao Zheng, Harshal Agrawal)

Bottom-up fabrication strategy has emerged as one of the unique routes to realize complex nanodevices. In the *Nanoscale Solar Cell* group, we are able to synthesis, assemble and chemically weld together high-quality perovskite nanocubes various single-crystalline pre-designed patterns (Figure 1a). This project aims to fabricate ring resonator lasers by assembling the perovskite nanocubes by stamping, a technique being actively explored in our group (Figure 1b). These ring resonators will show lasing with the mode dependening on the cavity length (Figure 1c). By integrating perovskite nanocubes with different emission wavelength, we can realize multicolor lasers from the same ring cavity (Figure 1d). We can also couple two ring resonators - one providing gain, the other providing loss. Many of the fascinating aspects of parity-time symmetry can be explored in such devices, such as the "exceptional points" - conditions where a system's allowed modes coalesce into a single mode (Figure 1e).

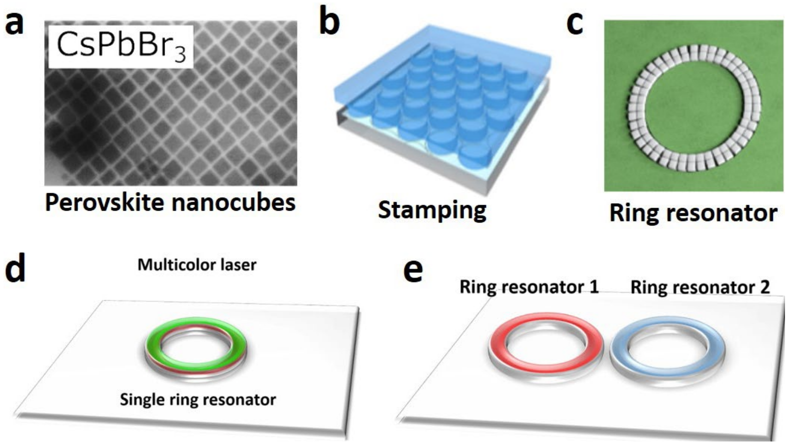

Figure 1. (a) Perovskite nanocubes synthesized in our group; (b) Sketch of the stamping technique; (c) Schematic of a ring resonator; (d) A single ring resonator with two layers of perovskite nanocubes; (e) Two coupled ring resonators.

4. Improving stability and quantum yield of 2D halide perovskites (supervisor: Biplab Patra)

2D perovskites are ideal candidate as a source of quantum confined excitons which can be very interesting for applications in luminescent solar concentrators and as well as for polariton-induced room-temperature superconductivity. Unfortunately, to date 2D perovskites are either not stable enough or not bright enough for these demanding applications. Therefore, the central goal of this project is to make stable 2D perovskites with high photoluminescence quantum yield. Both the synthesis of new 2D perovskites and the improvement of existing ones from literature, will be pursued. You will work with an experienced chemist as well as physicists to understand the formation and the stability of perovskites and measure their photoluminescence quantum yield.