NANOSCALE SOLAR CELLS

⟷ Erik Garnett

We specialize in the synthesis, characterization and integration of nanomaterials into solar cells, LEDs and light-driven chemical reactors. We also develop advanced instrumentation with unique capabilities worldwide to interrogate the properties, efficiency limits and losses of our novel energy conversion materials and device architectures. Our group members have very diverse backgrounds – from synthetic chemistry to optics and materials engineering – and we also actively scout women and underrepresented minorities (so far 38% of those hired have been women and 48% foreigners with 20 different nationalities represented). Our driving mission is to accelerate the clean energy transition to help mitigate the effects of climate change.

Highlights

- Co-development with EDAX and Amsterdam Scientific Instruments of a direct electron detector for electron backscatter diffraction (EBSD) with a 6000x improvement in signal compared to state-of-the-art [1], which allowed for nanoscale crystallographic mapping of beam-sensitive halide perovskite films [2].
- Demonstrated that tuning the excitation wavelength can lead to completely different reaction mechanisms and products in plasmonic nanoreactors [3]
- Simulated that antennas made from a non-standard plasmonic metals with high electron-phonon coupling and low thermal conductivity can provide unprecedented thermal gradients in space and time (>10K/nm and >500K/ps) [4]
- Demonstrated material learning in mixed halide perovskite films for self-optimized directional emission [5]

Plans

We will develop in operando EBSD to study degradation of halide perovskite films under light and electrical bias. We will use the extreme thermal gradients and wavelength programmable reactions offered by light-driven chemistry to improve CO_2 reduction. Finally, we will expand our efforts on material learning to make a device that can efficiently collimate and focus diffuse light to very high intensity.

Key research items

1. *World's first commercial direct electron detector for EBSD* (EDAX Clarity, https://www.edax.com/news-events/amolf)
2. G.W.P Adhyaksa, S Brittman, H Abolins, A Lof, X Li, J.D Keelor, Y Luo, T Duevski, R.M.A Heeren, S.R Ellis, D.P Fenning and E.C Garnett, *Understanding detrimental and beneficial grain boundary effects in halide perovskites*, Adv. Mater. 30, 1804792 (2018)
3. E. Oksenberg, I. Shlesinger, A. Xomalis, A. Baldi, J.J. Baumberg, A.F. Koenderink and E.C. Garnett, *Energy-resolved plasmonic chemistry in individual nanoreactors*, Nature Nanotechnology 16, 1378 (2021)
4. S.H.C. Askes and E.C. Garnett, *Ultrafast Thermal Imprinting of Plasmonic Hotspots*, Adv. Mater. 33, 2105192 (2021)
5. J.S. van der Burgt, F. Scalerandi, J.J. de Boer, S.A. Rigter and E.C. Garnett, *Perovskite Plasticity: Exploiting Instability for Self-Optimized Performance*, Adv. Funct. Mater. 32, 2203771 (2022)

Material learning in mixed halide perovskite thin films demonstrated by a nanophotonic lens focusing a training stimulus (collimated excitation) to a point where the high intensity nucleates local emitters, which are self-aligned to the focal point and therefore direct emission back to (mimic) the source.