My research focuses on the innovative design of planar micro and nanoelectrodes using streamlined and single-step methods. Our investigation delves into the electrochemical interactions between these electrodes and solvated ions, employing optical AC-voltammetry—a specialized variant of iontronic microscopy.

Diverging from conventional lithographic fabrication methods requiring cleanroom facilities, we opt for laser ablation or origami techniques, enabling the rapid creation of micro and nanostructures within seconds. In laser ablation, high-energy laser pulses selectively remove overlapping disk-shaped regions from gold or single-layer graphene thin films, yielding sharp tips at their intersections. These sharp tips facilitate the generation of a strong electric field gradient along their surfaces.

Under the influence of an alternating electric field, solvated ions in the solution undergo redistribution, creating a local refractive index contrast. We quantify this contrast using a meticulously crafted total-internal reflection scattering microscope.\cite{zhang2023iontronics} Unlike conventional methods that rely on electrochemical analysis, our approach offers a comprehensive optical investigation employing a sensitive differential imaging technique. The interferometric scattering signal from internally reflected light carries crucial information on local refractive index changes due to ion movement. To validate our proposed contrast mechanism, we cross-reference the optical ion signal with concurrently measured electrical currents using a potentiostat.

Additionally, the inclusion of sharp corners and tips on the electrodes enables the trapping of nanoparticles, augmenting their concentration within the field of view. Alternatively, we leverage bendable conductive indium tin oxide (ITO) thin films on Polyethylene terephthalate (PET) to fabricate origami nanoelectrodes, facilitating reversible particle trapping. Before the electric field (Figure 3-a), particles show Brownian motion, while during its application, they localize at the nanocrack (Figure 3-b); upon deactivation, they are promptly released (Figure 3-c). Through these straightforward fabrication methods in conjunction with Iontronic microscopy, our research opens avenues to scrutinize (electro)chemical interactions around nanoparticles at the single-particle level.