Fast Nanoscale Imaging of Live Cells Using an Adaptive Hopping Probe Ion Conductance Microscope

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Abstract (in 12 Pt Arial Font)

Scanning probe microscopy techniques can obtain images of cell topography at nanoscale resolution by dragging a physical probe near, or directly on, the cell membrane. Vertically-protruding cell extensions can cause the probe to break and/or lead to cell damage. Hopping probe ion conductance microscopy (HPICM) deals with complex surfaces by retracting the nanoprobe away from the sample before moving to a new X-Y coordinate. This strategy, however, significantly increases the imaging time and leads to motion artifacts when a live cell moves or exhibits nanoscale surface changes during imaging. To increase the imaging speed of our HPICM setup we performed several hardware and software modifications. First, we replaced the Z-scanner for one with 10X higher resonant frequency (~18kHz) to allow for faster retraction and approach movements. Second, we added an external proportional-integral-derivative controller to decrease the reaction time of the Z scanner (down to ~50µs). Third, we implemented an “adaptive” approach that significantly increased the speed of imaging and also reduced the noise floor by half. Our improved HPICM setup has a Z resolution of ~5nm, an X-Y resolution of ~10nm, and 3-4 times faster imaging speed. This new setup has allowed us to image live cells with complex topography, such as the sensory cells of the inner ear (which have stereocilia that protrude up to ~3µm in height and are only ~100-400µm in diameter) without causing any cell damage, even after several hours of continuous time-lapse imaging.

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Biography of Presenter (in 12 Pt Ariel Font)

Dr. Vélez-Ortega is an assistant research professor in the Department of Physiology at the University of Kentucky, studying molecular mechanisms of inner ear mechanosensitivity and noise-induced hearing loss for almost a decade. She has a B.S. in Biomedical Engineering, a M.S. in Biology, and a Ph.D. in Physiology. Dr. Vélez-Ortega’s research is currently funded by the National Institutes of Health and the Hearing Health Foundation.