Big-data-enabled true analytical atomic-scale tomography –

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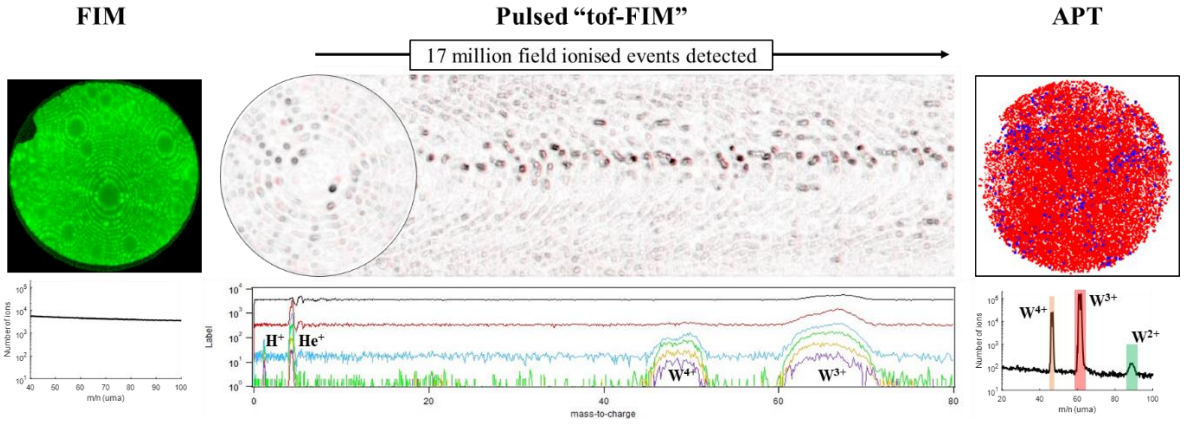
Field ion microscopy (FIM) provides a magnified image of a cryogenically-cooled, needle-like specimen subjected to a high electric field. Projected gas ions form an image in which a specimen's surface atoms can be individually observed. FIM provided the first direct observation of single atoms in 1956 using He-gas as the imaging medium and a positively-biased tungsten needle. Despite the impressive resolution, FIM is primarily a surface imaging technique. A three dimensional variant of FIM (3DFIM) stimulates incremental field evaporation of surface atoms so that a FIM image sequence can be converted into a 3D atomic reconstruction. While 3DFIM can resolve both a crystalline lattice and its structural defects (such as vacancies and dislocations), the use of existing 3DFIM techniques are largely hampered by the enormous computational costs associated with acquiring and storing large quantities of image data and subsequently performing the required feature analysis and reconstruction. Its potential has been unexploited for two other reasons. Modern FIM techniques have been spurned in preference to atom probe tomography (APT), a technique that while giving lower spatial resolution otherwise provides invaluable time-of-flight spectrometry that allows the chemical identification of atoms. Secondary to this, few modern commercial atom probes have FIM capabilities and there are only a few bespoke FIM machines.

This project will develop the computational and analytical methods necessary to support a new hybrid technique combining both FIM imaging and APT time-of-flight spectrometry.



Above. A conventional FIM experiment does not employ pulsing for time-of-flight mass spectrometry so a corresponding mass-to-charge spectrum would show only a flat imaging gas background. (Right) An APT experiment employs voltage- or laser-pulsing within a clean UHV chamber realising a clean time-of-flight chemical *analysis but without the spatial accuracy of FIM. (Middle) Between the two experimental paradigms, pulsed "tof-FIM" employs pulsing in a UHV-HV chamber, allowing for both high spatial precision and mass spectrometry.*