Atom probe tomography using an extreme ultraviolet pulsed light source

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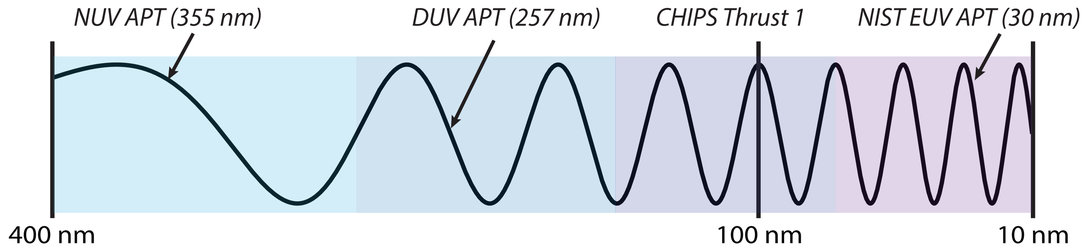
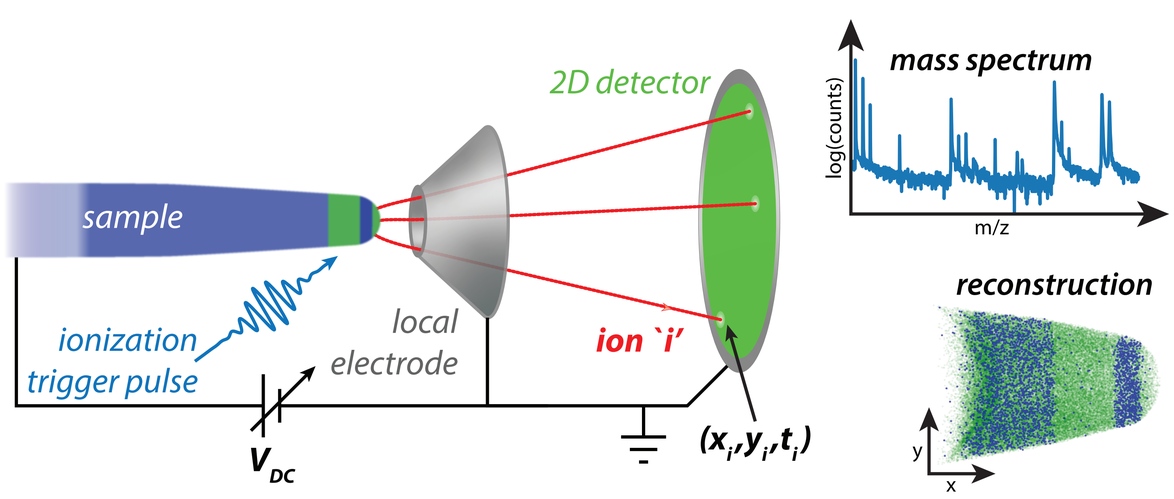
Improve atom probe tomography instrumentation, experimental methods, and understanding of apex electrostatics.
Thrust 1: Build a new atom probe instrument optimized for the specific materials of interest to the semiconductor industry.
Thrust 2: Optimize atom probe measurements on commercial tools using specimens provided by the semiconductor industry.
Thrust 3: Develop modeling tools to simulate apex electrostatics on real-world specimens of interest to the semiconductor industry.



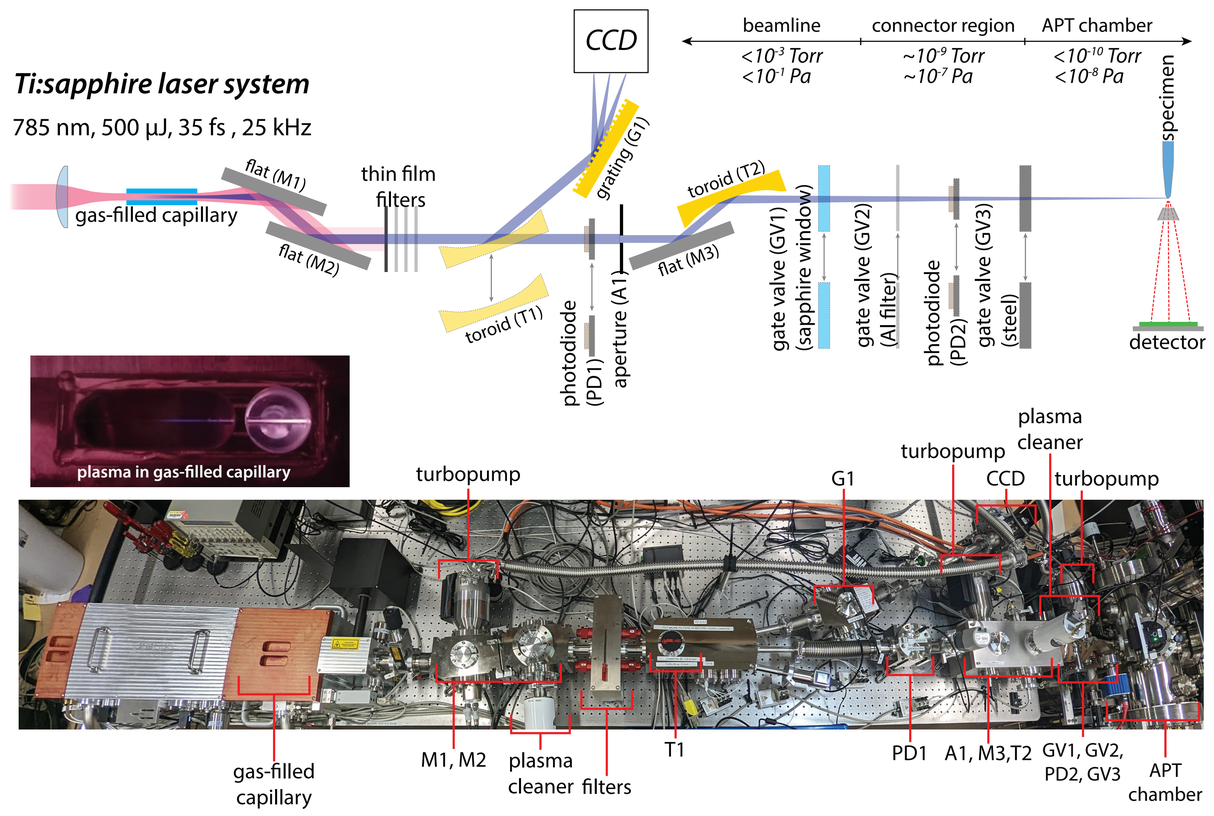
Atom probe microscopes operate in the ultraviolet region of the electromagnetic spectrum. The goal of Thrust 1 is to determine the optimal laser wavelength for the specific elements, materials, and structures of interest to the semiconductor industry.

Atom Probe Tomography



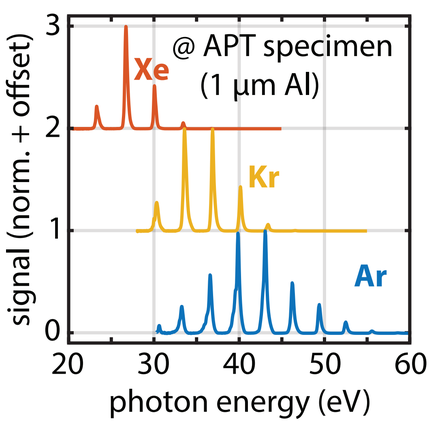
Conventional APT measurements are performed with voltage pulses or laser pulses. Typically harmonics of a Nd-based laser are used having wavelengths around 532 nm, 355 nm, 257 nm (2.3 eV, 3.5 eV, 4.8 eV). For samples containing materials with large optical band gaps these photons are not efficiently absorbed and APT measurements can be challenging.

Design of an EUV Atom Probe Microscope



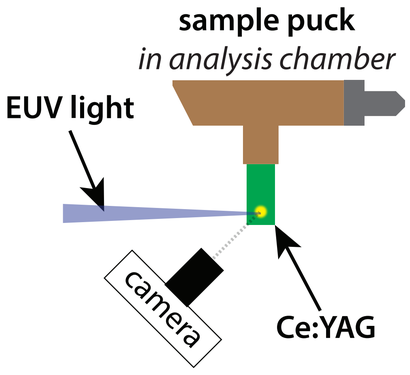
Characterization of a EUV Source for APT

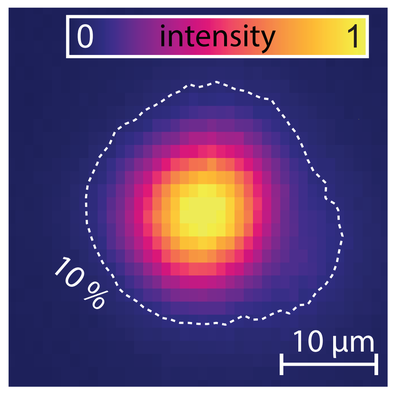
Characterizing the spectrum



EUV light requires a careful selection of optics to maximize beamline throughput. We use grazing incidence reflective optics to steer and focus the light which permit broadband reflection. We use ultrathin aluminum foils to filter the NIR light.

Measuring the beam size and shape

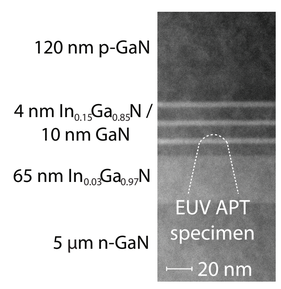


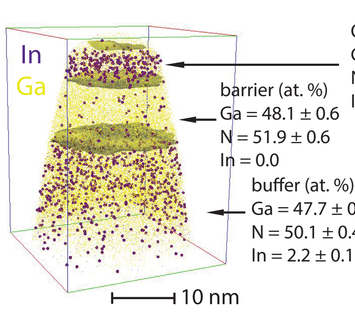


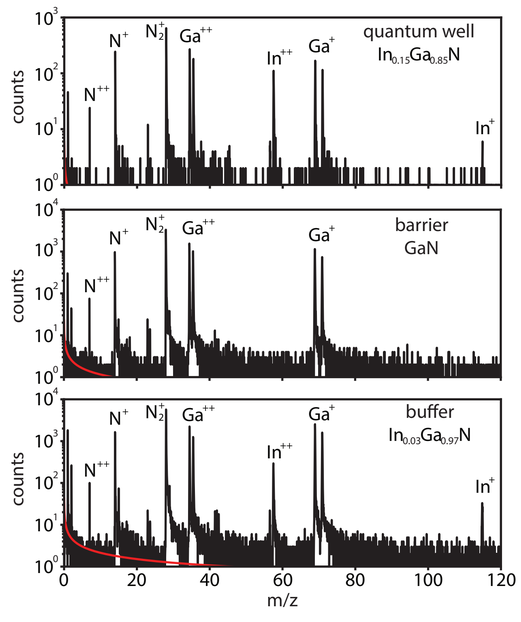
To calculate the energy or photon fluence at the sample, the spot size at the sample plane must be known.

EUV APT Data

InGaN

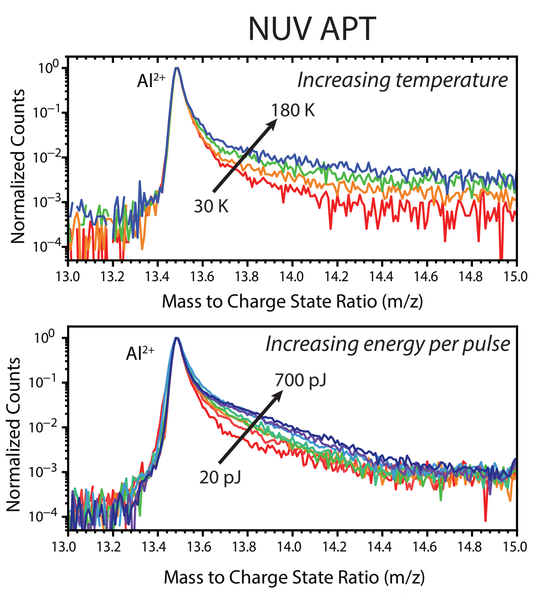


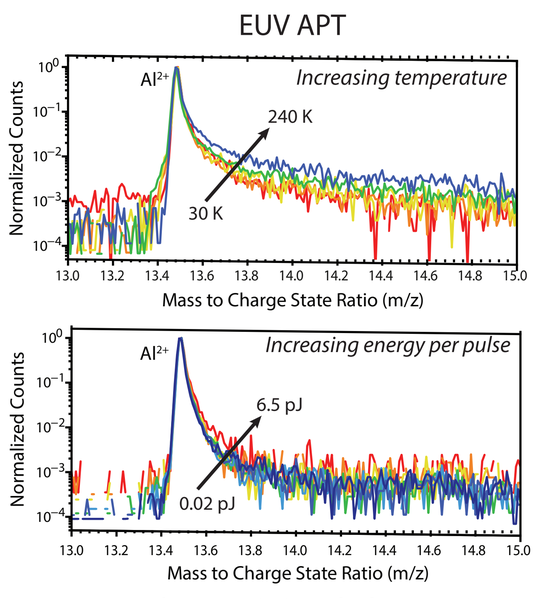




InGaN quantum well sample, mass spectra, and EUV APT reconstruction. Using EUV light we obtained the correct indium apparent composition values.

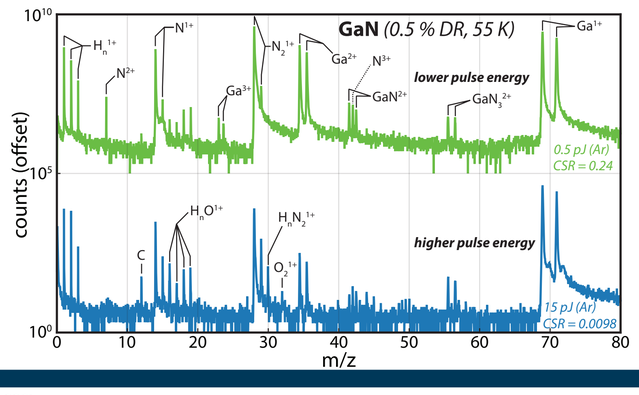
Al_2O_3

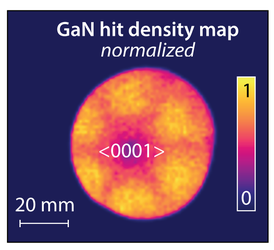


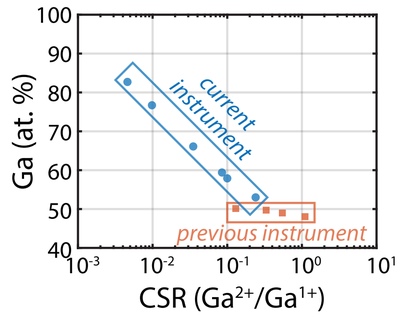


NUV and EUV mass spectra for Al_2O_3. EUV mass spectra show minimal change in peak width with increase in pulse energy while NUV data show increase in peak width.

GaN







GaN EUV APT mass spectra. Apparent compositional measurements show clear biases in gallium and nitrogen compositions, similar to NUV APT. These measurements suggest the electric field at the tip is the main cause of compositional bias in GaN.

References:
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