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Challenges in Atom Probe Tomography Instrumentation and Reconstruction

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Atom probe tomography (APT) has been incorporated into a wide variety of materials research applications over the course of the past twenty years as the installed base of atom probes has increased from single digits to over one hundred [1]. Despite this increase, and the corresponding technology advances, there are still challenges to further adoption. This abstract discusses some of the key challenges of yield and reconstruction and some of the avenues CAMECA® is exploring to overcome them.

A primary challenge of APT is the survivability of many scientifically interesting samples [2] and, given a successful analysis of the sample, an imperfect reconstruction due to a dependence on an assumed apex shape [3] that may complicate the interpretation of the data. Historical experience has suggested general evidence that higher energy photons improve yield [4]. Deep-UV laser systems have been investigated by several groups [5, 6], including CAMECA, and have shown some promise in continuing this trend [7].

A two-pronged approach is being explored to improve the accuracy of APT reconstruction. First, it is possible to reduce the complexity in the apex shape by heating the specimen more uniformly to minimize asymmetry in evaporation and minimize the deviation from the assumption of a constant radius. This can be done through the application of multiple thermally-coincident laser beams illuminating the sample [8,9] Second, an advanced electrostatic configuration can be used to capture the entire evaporated surface which provides a boundary condition in the reconstruction [10].

With these improvements, the specimen apex shape should be closer to the single-radius value assumed by the reconstruction, but some deviation may remain. Further improvement must come from advancements in the reconstruction algorithm. Here, we describe a new model for reconstruction which incorporates an electrostatic model to project ions along realistic flight paths from realistic apex shapes [11]. Figure 1a shows the reconstruction of a silicon/oxide/silicon structure (right) based on a projection from a spherical apex shape (shown as a series of arcs on the left), while 1b shows the reconstruction of the same dataset (right) based on modeled ion trajectories from a series of non-spherical, and variable apex shapes (left). This model can incorporate apex shapes determined from correlative microscopy techniques, simulations, or shapes derived from the data itself (e.g., feature recognition or density evaluation). Combining this new reconstruction model with more uniform evaporation, a larger field-of-view, and a higher survivability has the potential to further expand the range of addressable applications for atom probe tomography and continue the growth seen over the past twenty years.

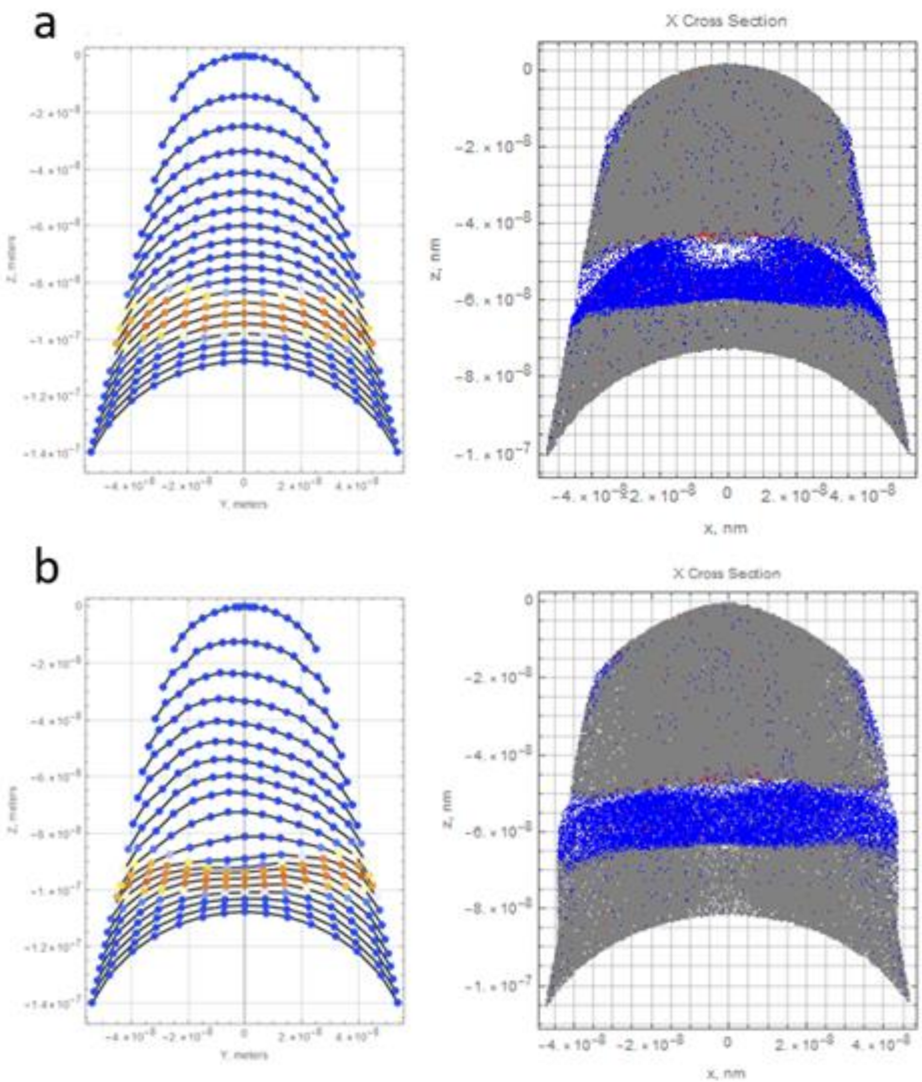

Figure 1. A series of spherical apex shapes (a) representing the traditional reconstruction methodology and the resulting reconstruction through a silicon (grey) / oxide (blue) / silicon multilayer. A series non-spherical apex shapes (b) derived via a density calculation and the resulting reconstruction through the same multilayer dataset. The yellow and orange dots in the left images correspond to volumes with higher oxide concentration representing the oxide layer.

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