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Benefits of a Full Field of View in Atom Probe Tomography

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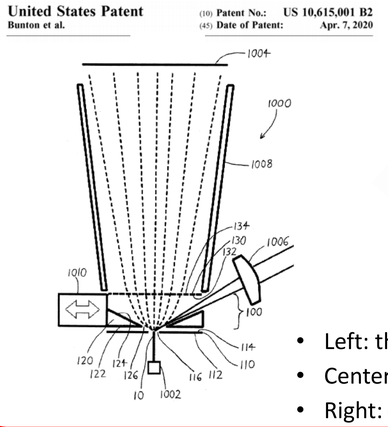
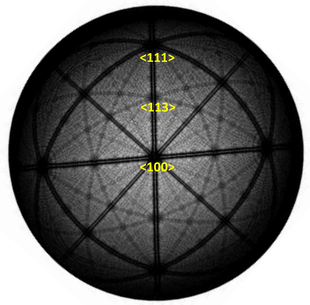
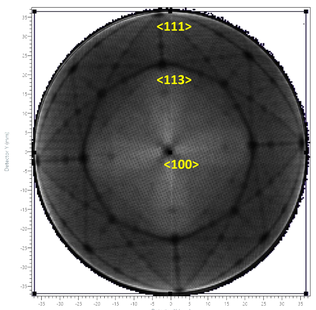
INTRODUCTION

The analytical performance of atom probe tomography (APT) is determined by, among other things, the field of view (FOV) and mass resolving power (MRP). The FOV sets the lateral analyzable length scale while the MRP influences the quantification of the mass spectrum. It is highly desirable for both to be as large as possible, but historically, these two metrics are inherently at odds with each other. From a design perspective, the challenge is due to (in part) the high spread in flight-time variations (different flight paths) across the FOV of a large detector. Some efforts to overcome this difficulty employ reflectron energy compensating based solutions [1] while others use a straight flight path design [2, 3]. This work presents some recent examples of data collected with the new CAMECA Invizo 6000® showing the benefits of this innovative new system [3] to provide unprecedented FOV with high MRP.

FULL FIELD OF VIEW CONCEPT



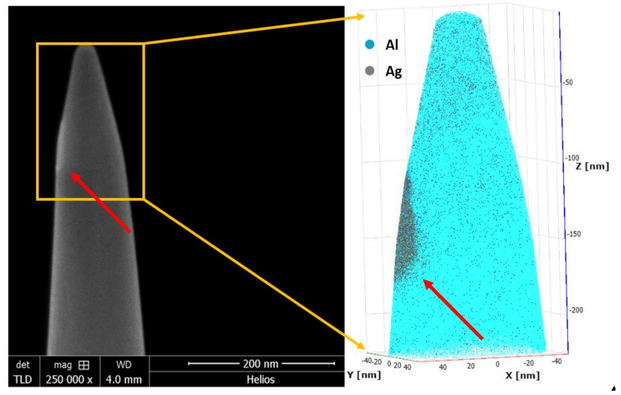




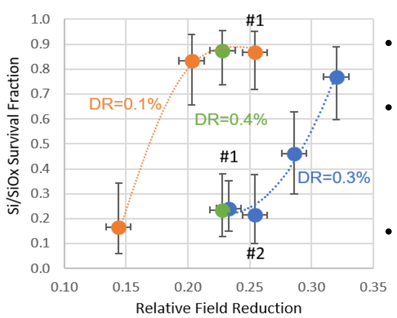
- Left: the patented concept for achieving wider field of view in APT
- Center: a simulated FOV of this design
- Right: experimental aluminum data demonstrating an angular FOV of ~114 degrees

REGION OF INTEREST TARGETING

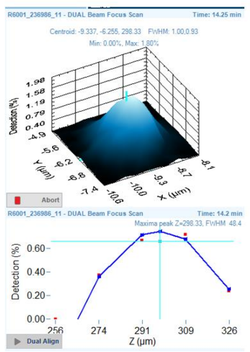
- Focused ion beam (FIB) preparation is necessary for many APT samples and can be an expensive bottleneck
- Typically, regions of interest (ROI) must be within the central 50% of a 50-100 nm wide specimen
- The full FOV design of the Invizo increases the analyzable portion of the specimen to ~90% or more (depending on the specimen geometry)
- Higher targeting success rate ➔ fewer specimens needed ➔ less FIB time
- In the example to the right, a feature clearly identified on the extreme edge of the specimen (red arrow) can be correlated to a silver-enriched feature at the edge of the FOV, this would not have been captured in a typical LEAP FOV



INSTRUMENT CONTROL AND SAMPLE SURVIVABILITY

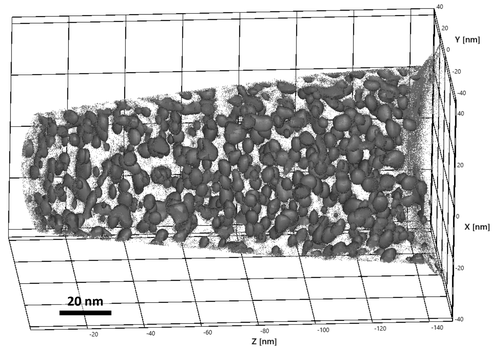


- Lower detection rates are associated with higher sample survivability (left) [4]
- Laser-specimen alignment relies on analyzing the detection rate as a function of laser position (right); higher detection rates provide higher signal-to-noise
- The wider FOV of the Invizo 6000 results in a lower ion flux from the sample at a given detection rate which reduces stress on the specimen and improves yield



INCREASED SIZE OF REGION OF INTEREST

- A larger FOV directly provides larger analyzable volumes
- Larger features, and more features, can be captured and analyzed within the FOV
- A clear example of this is in the case of a precipitate analysis (right), for equivalent depths, the Invizo 6000 contains ~2X the volume compared to a LEAP and thus would have ~2X the precipitates
- This provides better statistics for understanding the composition, orientation, and shape of the precipitates in each data set



CONCLUSIONS

- In atom probe design there has always been a tradeoff between mass resolving power and XY field of view; CAMECA's Invizo 6000 substantially increases the FOV while maintaining the high MRP of the established LEAP 5000 product line
- The larger FOV provides a number of benefits including 1) lower ion flux rates from the specimen at a given detection rate providing lower stress on the specimen, 2) larger data sets which produce higher data quality and capability to analyze larger features of interest, and 3) easier site-specific specimen preparation

REFERENCES

[1] P. Panayi, "Reflectron", United States Patent 8,134,119, March 13, 2012.
[2] A. Bostel et al, "High Resolution Wide Angle Tomographic Probe", United States Patent 8,074,292, 2011.
[3] J. H. Bunton and M. S. Van Dyke, "Wide Field of View Atom Probe", United States Patent 10,615,001, 2020.
[4] T. J. Prosa et al., Microsc. Microanal. 25 (2019) 425.