doi:10.1017/S1431927621004736
Microsc. Microanal. 27 (Suppl 1), 2021

Evaporation-Field Differences with Deep-UV Atom Probe Tomography

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Pulsed-laser atom probe tomography (PLAP) has been shown to be a thermally-activated field-evaporation process [1]. The first PLAP investigations were performed in the 1970s and utilized 7 ns, 337 nm laser pulses [2]. Since the 2000s, commercially available instruments have seen a steady progression from longer wavelengths into the UV: The LAWATAP (CAMECA) eventually could switch between 1030 nm, 515 nm and 343 nm (with a prototype using 778 nm [3]), the LEAP 3000 (Imago) initially provided 535 nm and progressed to UV 355 nm for the CAMECA LEAP 4000 and 5000 (including a 400 nm prototype instrument) [4]. Recent investigations with extreme-UV suggest that new physics may come into play with photons capable of directly ionizing inner shell electrons (29.6 nm) [5]. Although there have been reports that some materials might benefit from analysis with longer wavelengths, the consensus has become that shorter wavelengths provide benefits for data quality, specimen-laser interaction, and yield [4,6,7]. In this presentation, we will discuss some preliminary results using a deep-UV (266 nm) laser system to look for novel benefits.

During the course of this investigation, multiple materials have been analyzed with deep-UV. The most dramatic effect was noted on silicon/silicon-dioxide materials and interfaces. Differences in evaporation field are known to limit specimen survivability and reconstruction accuracy because of non-uniform evaporation [8]. **Fig. 1** shows comparisons between 266 nm and 355 nm laser-pulsed APT acquisitions of similarly sized specimens made from our internal standard (Si/SiO_2-12-nm/Si) [8]. The voltage trends suggest that the relative evaporation field differences between Si and SiO_2 are dramatically reduced for 266 nm relative to 355 nm (**Fig. 1b**), and leads to much more uniformity in evaporation, especially for the transition from SiO_2 into Si (**Fig. 1c vs. 1d**). Ultimately, the smoother transition between layers leads to better, more homogeneous reconstructions (**Fig. 1e vs. 1f**) and suggests higher survivability as well. Preliminary data shows higher survivability under a greater variety of analysis conditions for this material. We note that the 266 nm data was collected with significantly higher average applied field and detection rates (DR) than reported in [8]. The 266 nm analysis was collected at 10% DR and average silicon charge-state-ratio (CSR) near 100, while 355 nm analysis was collected under modest 0.5% DR and 20 CSR conditions.

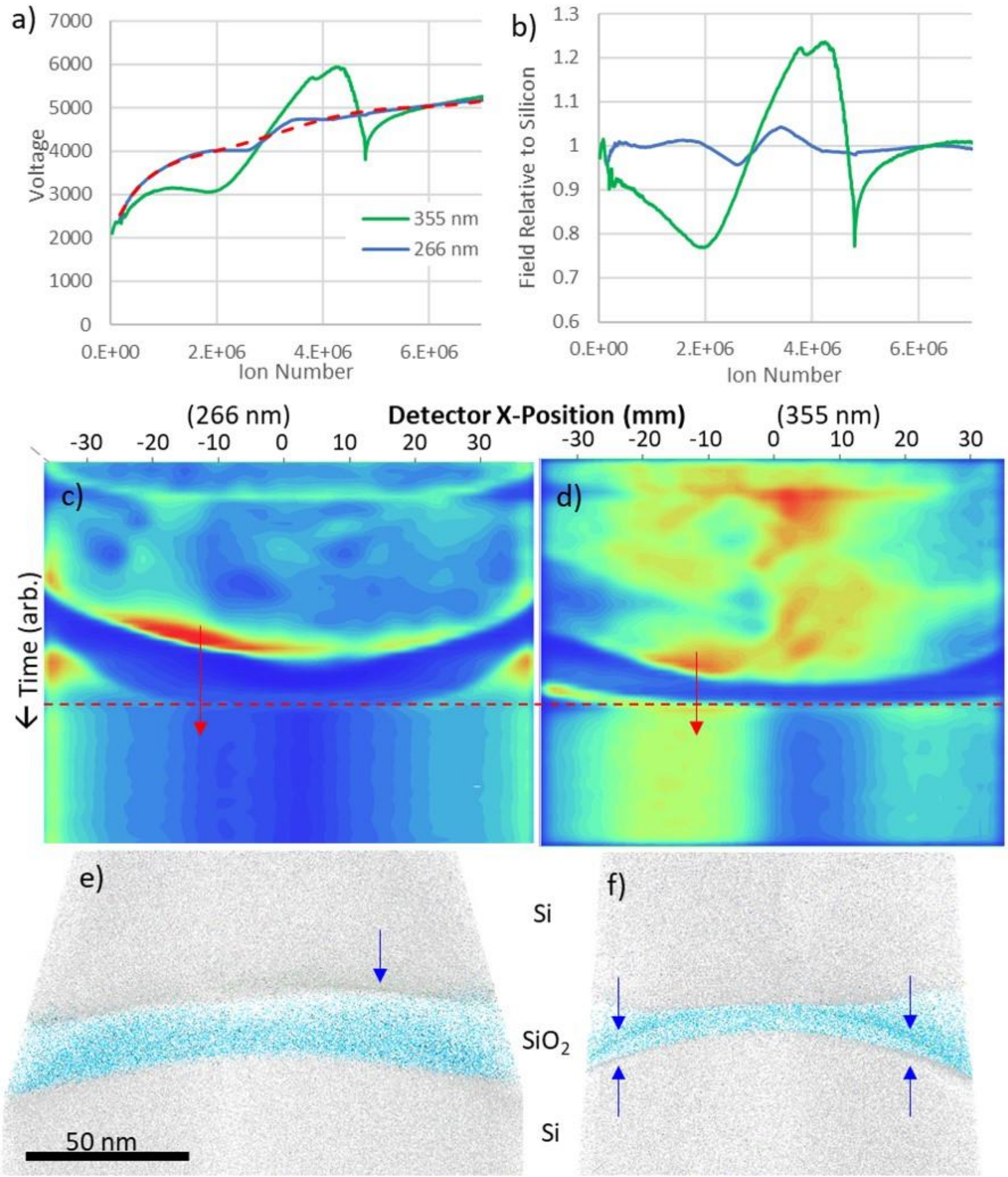

Figure 1. Figure 1. 266 nm and 355 nm PLAP comparison of a) acquisition voltage, b) relative evaporation field, c) and d) detection uniformity, e) and f) reconstruction uniformity for a standard 12-nm-oxide layer surrounded by Si [8]. a) Voltage trends are compared with an estimated average voltage trend for pure Si (red-dashed line in a) and converted into b) evaporation field relative to Si. 10-mm-thick hit-density maps (arbitrary color scale—red high density, blue low) are shown in c) and d). The red-dashed-line represents the detected ion-density at a single moment in time across the center of the detector; This moment captures the transition from SiO2 back into Si, with the high uniformity in c) resulting in more accurate reconstruction for e). Red arrows indicate regions for comparison. e) and f) show high reconstruction density aberrations (blue arrows) that have resulted from non-uniform evaporation.

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