

Extreme Ultraviolet-Assisted Field Ion Evaporation

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Laser-assisted probe tomography (LAPT) is a powerful tool for materials characterization due to its desirable combination of high spatial resolution and analytical sensitivity. In state of the art LAPT the thermal transient from a near-UV laser ($E \approx 3.5$ eV to 3.6 eV; $\lambda \approx 343$ nm to 355 nm) provides the energy to overcome the activation barrier for field ion evaporation. This technique is generally superior to voltage pulsing, which is limited strictly to conductors, and has allowed APT to expand its capability to effectively analyze a wide-range of materials including semiconductors and insulators. However, the thermal process is not without drawbacks. For example, LAPT data quality can be degraded due to thermal tails that limit sensitivity, formation of cluster ions that may have isobaric overlap with elemental species, and undetected neutral species which can adversely influence composition measurements. This is especially true for many ionic and covalent materials and can limit the recovery of bulk stoichiometry or composition to a narrow range of experimental conditions, if at all [1,2].

Ionizing radiation in the extreme ultraviolet (EUV) region of the electromagnetic spectrum (≈ 10 eV to ≈ 100 eV; 124 nm to 12 nm) may offer a potential athermal field ionization pathway. Dependent on the particular photon energy used, EUV radiation is above the ionization potential of any naturally occurring element and photoionization cross-sections peak in the EUV band across the entire periodic table [3]. EUV is highly absorbed within the first few nm of the sample surface and may also offer a potential in situ method for imaging the evolving specimen shape in real time through simultaneous coherent diffractive imaging or related methods [4].

We will present the instrument design and initial results from a tunable EUV-APT that uses femtosecond pulsed coherent radiation from phase-matched high harmonic generation in a noble gas cell. Initial experiments using Ar gas ($E = 41.85$ eV; $\lambda = 29.6$ nm) conclusively demonstrate EUV-assisted field ion evaporation in fused quartz (amorphous SiO_2). We will compare EUV time-independent background levels, delayed evaporation tails, ${}^8\text{Si}^{n+}$, O^{n+} , and O_2^{n+} peak widths, and the relative number of SiO^{n+} and SiO_2^{n+} cluster ions to near-UV LAPT ($E = 3.49$ eV; $\lambda = 355$ nm) experiments on the same samples and specimens.

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