Simultaneous Voltage and Laser Pulsing in Atom Probe Tomography

D.J. Larson, T.J. Prosa, D.A. Reinhard, R.M. Ulfig, M. Holman and D. Lenz

CAMECA Instruments Inc., 5470 Nobel Drive, Madison, WI USA 53711

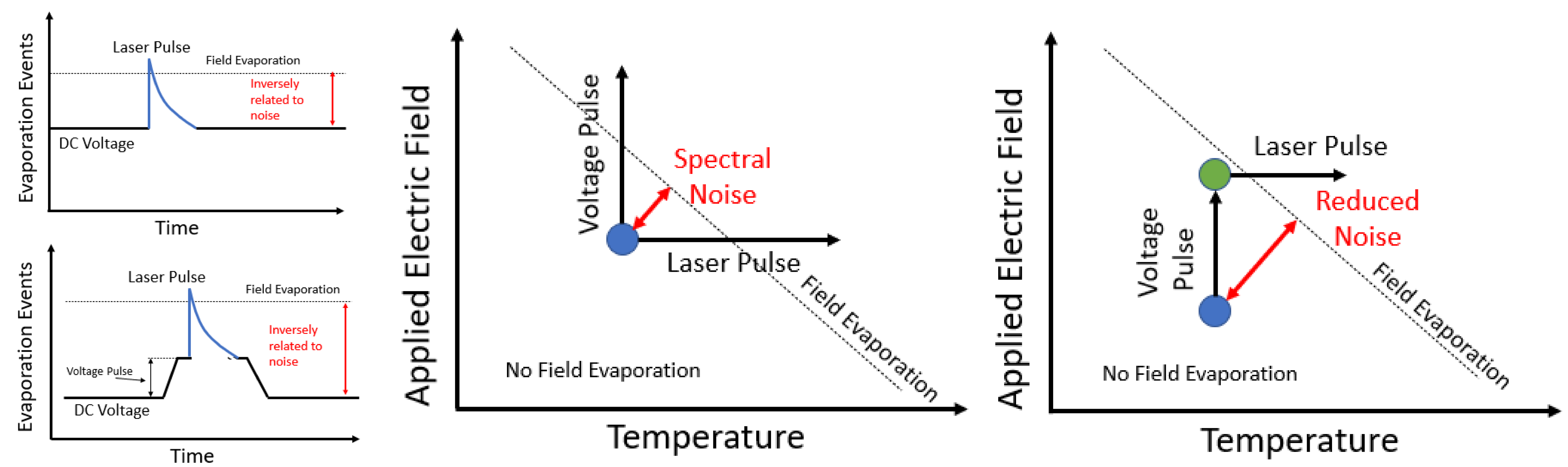
CAMECA SCIENCE & METROLOGY SOLUTIONS / AMETEK

INTRODUCTION

Concurrent voltage and laser pulsing in atom probe tomography (APT) has recently been proposed [1] and explored [2]. Advantages of such a pulsing scheme include reduction in background, potential improvement in composition determination for challenging materials (i.e, GaN) [3, 4], and the capability to filter background using kinetic energy discrimination [1]. This work presents preliminary experimental data on the application of concurrent voltage and laser pulsing to a variety of materials.

BACKGROUND AND CONCEPT

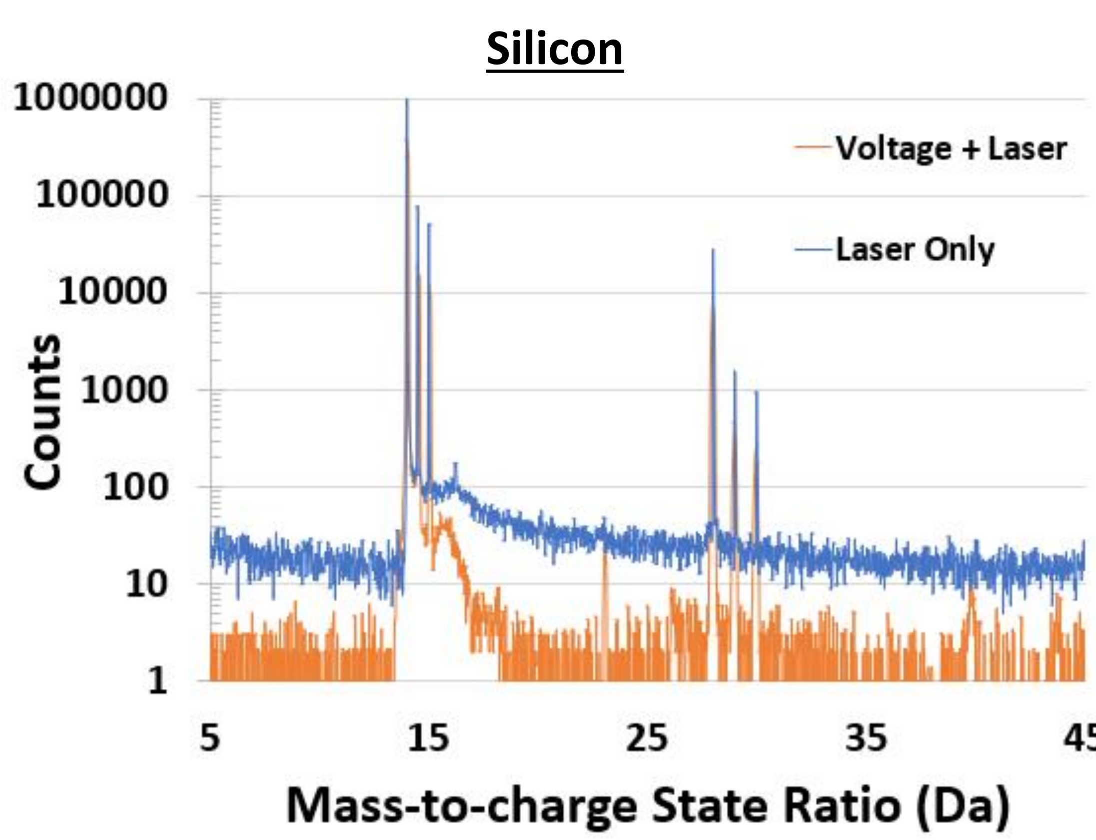
In APT, a voltage or laser pulse is applied onto a DC standing voltage and, in either case, the background noise is generally inversely related to the magnitude of the pulse (red arrow). Schematically shown at right, the application of concurrent voltage and laser pulses theoretically decreases background by reducing the probability for field evaporation between pulsing events, when the specimen is being held at a constant DC voltage (blue point middle figure). In this mode, the specimen is held at the blue point during most of the analysis time. A voltage pulse increases the applied evaporation field and moves the specimen from the blue point to the green point (far right). While the voltage pulse is still applied, the specimen temperature is increased by using a laser pulse, which then moves the specimen from the green point to the right and crosses the field evaporation threshold. Background noise is inversely related to the red arrows and is thus reduced in the combined pulsing mode.

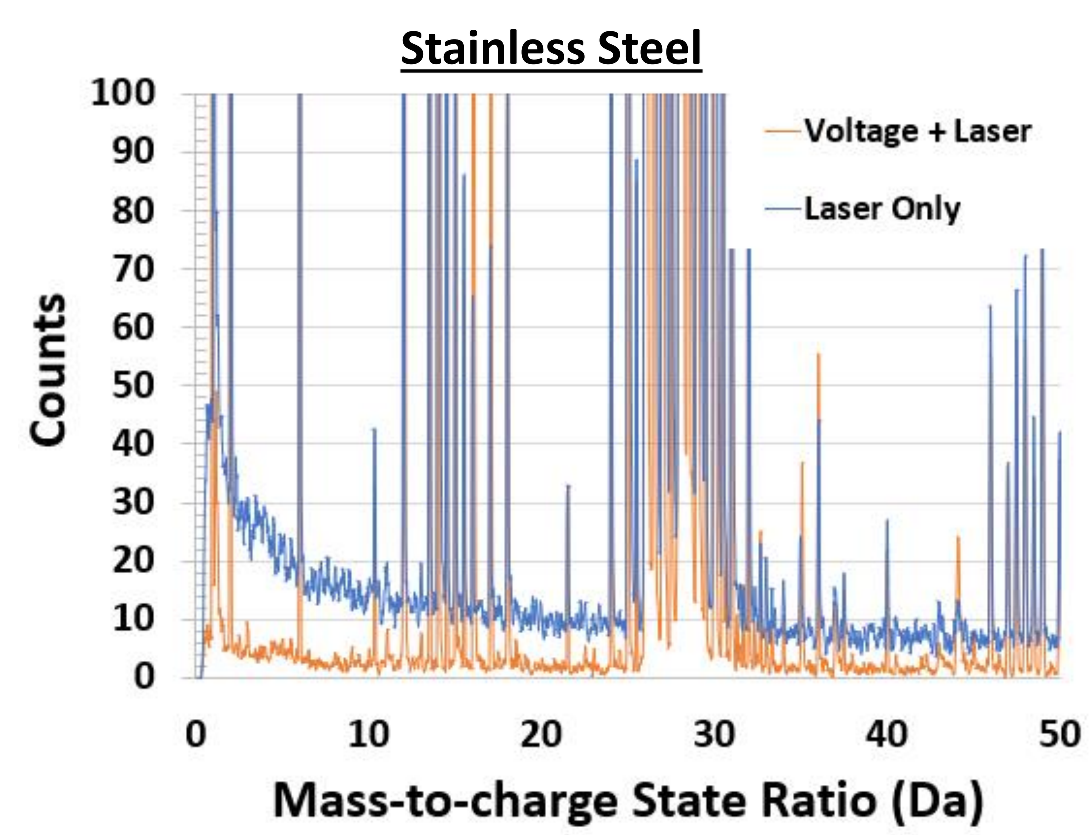


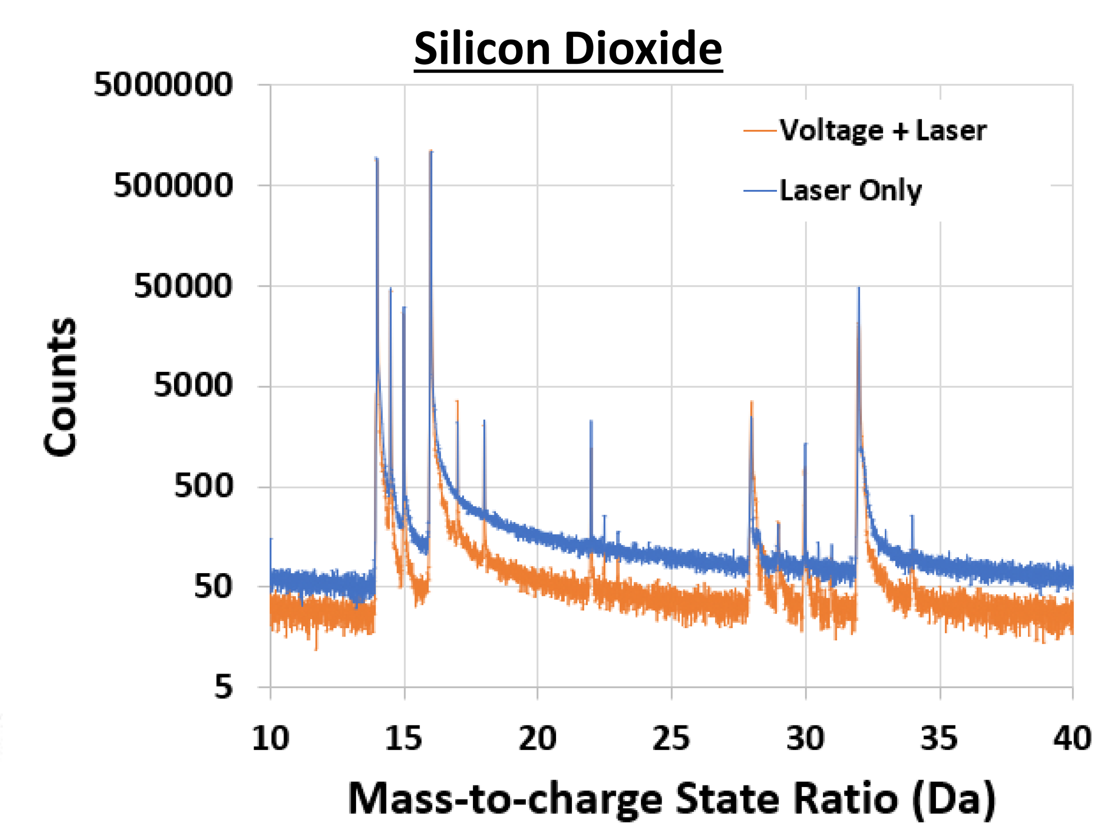
SIGNAL TO NOISE RATIO (SNR) IMPROVEMENT

Spectral examples produced by concurrent voltage plus laser pulsing is presented at right for silicon (2M ions), stainless steel (2M ions) and silicon dioxide (10M ions). To make fair comparisons, the data collection parameters were normalized for detection rate and charge state ratio and each comparison is binned equally. The table below summarizes the SNR improvements for the various materials (all materials investigated showed reduced background with increasing voltage pulse fraction up to ~30%)

Material	PF%	SNR improvement
Bulk SiO2	22	2
Stainless Steel	30	4
Al	25	5
Silicon	30	>10







CONCLUSIONS

- We show APT spectral signal-to-noise improves for a variety of materials, including aluminum (~8X), a stainless steel (~4X), silicon (~15X), and silicon dioxide (~2X)
- The best combination of laser amplitude, standing voltage, and voltage pulse amplitude will depend on material properties such as individual evaporation fields, electrical conductivity, thermal diffusivity, and experimental conditions such as base temperature

REFERENCES

[1] T. F. Kelly, Micro. Microanal. 17 (2011) 1.
[2] L. Zhao et al., Micro. Microanal. 23 (2017) 221.
[3] D. R. Diercks et al., J. Phys. Chem. C 110 (2015) 20623.
[4] R. A. Morris et al., J. Vac. Sci. Tech. B 36 (2018) 03F130.