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Meeting-report

# A High Kinetic Energy Atom Probe Design to Improve Instrument Performances in Voltage Pulse Mode

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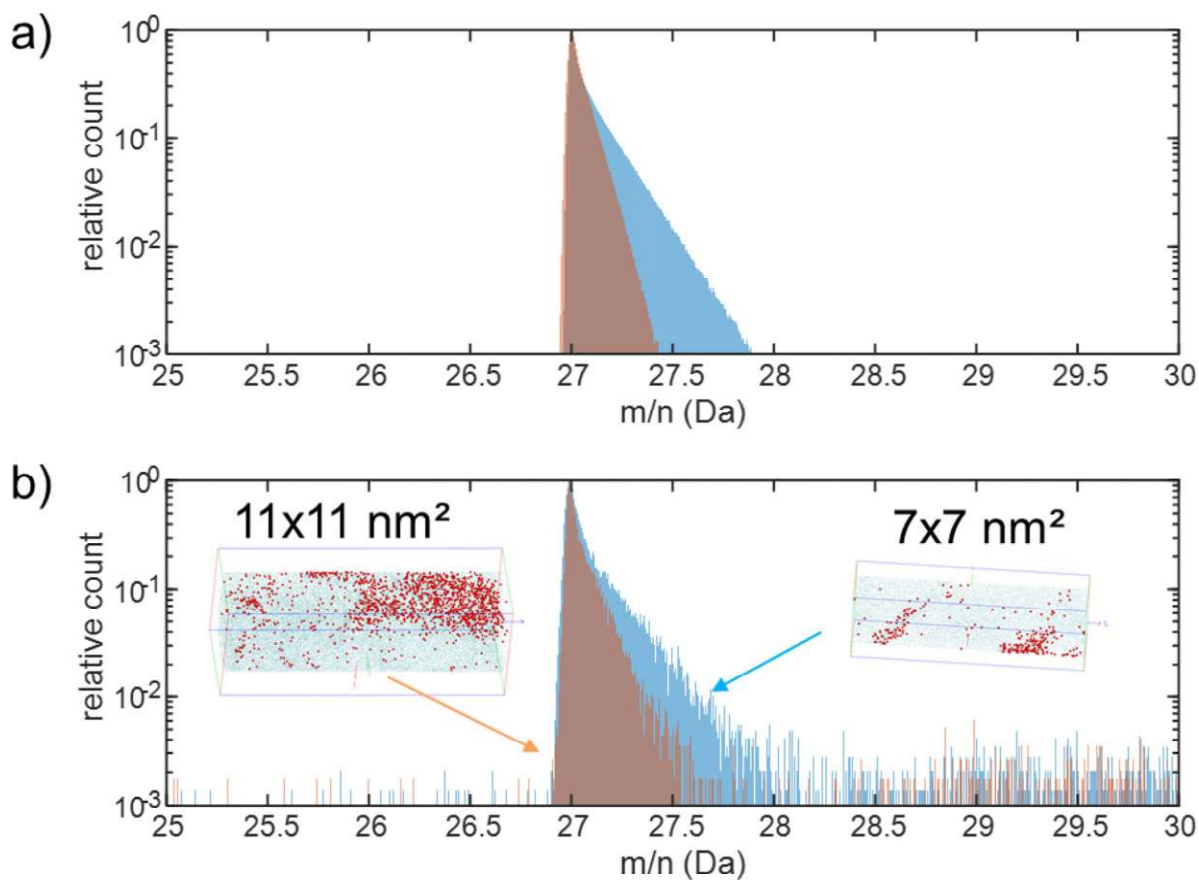
Atom probe tomography (APT) has emerged as a powerful technique for three-dimensional elemental mapping with near-atomic resolution in research laboratories. Over the past two decades, significant advancements in APT have been realized through innovations in hardware configurations, leading to simplified techniques and enhanced data acquisition rates. These developments are closely tied to the evolution of detectors and notable improvements in mass spectrometer performance [1-3].

Enhancing mass resolution in voltage pulse APT necessitates the utilization of energy compensation devices, commonly referred to as *reflectron*. Modern APT instruments are typically equipped with the latest version of these devices, referred as large-angle reflectrons, enabling a mass resolution (MR) in the range of  $\sim 150$  FW1%M albeit with a compromise in detection efficiency and a slight degradation in spatial resolution due to the presence of meshes. The detection efficiency in the latest generation of APT instruments is around 50%, compared to 80% in straight flight path instruments [3,4].

To address these challenges, alternative methods to increase MR have been proposed, such as post-acceleration using adapted electrodes facing the sample. Elevating the final energy of ions offers numerous advantages, particularly in improving MR at a low cost and expanding the probed field of view on the sample [5]. However, the original design of counter-electrodes, to which high voltage was applied, imposed a technical limitation on the final acceleration ( $\sim 20$  kV) [6].

In this paper, we propose an alternative design called the High Kinetic Energy Atom Probe (HiKEAP), capable of adding an acceleration voltage of up to 30 kV, corresponding to ion kinetic energies of 30 keV to  $\sim 150$  keV depending on of their charge state. Note that the HiKEAP is designed to increase the ion's initial energy without the need for a mesh in its configuration.

Electrodynamic simulations were employed to calculate the potential performance metrics, including field of view, MR (in voltage pulse mode), and maximum pulse repetition rate (PRR), and were compared with preliminary results from the setup. As depicted in Figure 1, post-acceleration significantly enhances MR at the base of the mass peak (X2, FW1%M from 50 to 100) while doubling the field of view. Although time-of-flight (TOF) is slightly reduced with post-acceleration, full width at half maximum (FWHM) remains comparable between both configurations. Note also the significant increase in field of view, resulting from the ion compression in post-acceleration mode. A side aspect is the reduction of maximum TOF to  $\sim 5000$  ns with an extended flight path of 55 cm, enabling a high pulse repetition rate ( $>100$  kHz). Another advantage of this approach is that the total ion energy remains consistently above 20 keV, allowing for the evaluation of alternative detector technologies, such as pixelated avalanche detectors, Timepix detectors, and CF-MCP detectors, potentially replacing simple MCP-DLD detectors and providing the ability to employ kinetic energy discrimination [7-9].



**Figure 1.** a) Simulated and b) experimental mass spectrum of a material composed of Al ( $m/n=27$ ) for a configuration with no post acceleration (blue histogram) and the HiKEAP prototype (orange histogram) in VP mode (20% PF) in blue, and at  $V_{DC}=5\text{kV}$ , post-acceleration is set to 20 kV, total energy kinetic energy of ions is about 26 keV.

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