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Bringing Standardized Processes to Atom-Probe Tomography – Part 1: Establishing Standardized Terminology

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There is rarely a unique answer to a materials analysis question. Even with analysis by an individual technique, the approach used to address the question can shape the answer, and there are often several valid approaches. The results depend upon the specifics of the approach, which can include such variables as the specimen preparation, analysis methodology, data acquisition and analysis tools, and error analysis. This approach-specific aspect of scientific analyses can undermine confidence in analytical methods when the results of various approaches conflict, and can cause problems from wasted resources to unacceptable materials failures. Establishing consistent methods that deliver reproducible results with quantifiable errors can often improve the reliability of the method and the interpretation of multiple sets of data. In the rapidly maturing field of atom-probe tomography (APT), such standard approaches are needed.

While an obvious concept, standardization of method requires careful consideration of the entire APT field and its applications. Following preliminary efforts [1], the International Field Emission Society (IFES) has elected a Standards Committee, whose membership is listed above, which is tasked to determine the needed steps to establish APT as an accepted metrology technique. Specific tasks include developing protocols or standards for: (i) terminology and nomenclature, (ii) protocols for test methodologies, (iii) protocols for metrology and instrumentation, (iv) specifications for standard reference materials, (v) protocols for modeling and simulations, and (vi) science-based health, safety, and environmental practices.

The Standards Committee is currently working on defining terminology related to APT with the goal being the inclusion of terms into a document published by the International Organization for Standards (ISO). Many terms common to other techniques and disciplines have already been defined [2], and will be considered for adoption in the context of atom-probe tomography. A preliminary list of terms can be found in Table 1 below.

[1] R.M. Ulfig, T.F. Kelly, and B. Gault, *Microsc. Microanal.* 15 (Suppl. 2) (2009) 260.
[2] Surface Chemical Analysis – Vocabulary – Part 1: General Terms and Terms for the Spectroscopies, *ISO/CD* 18115-1, International Organization for Standards, 2008.

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TABLE 1. : Initial list of terms for which a standard terminology is being developed in conjunction with [2].

	TERMS		TERMS		TERMS
Techniques	*Field ion microscopy (FIM)*		Laser spot size		Ion pile up
	e-FIM		Laser incidence		Multiple hit
	Field emission microscopy (FEM)		Laser polarization, wavelength, pulse duration		Sequence of evaporation/detection
	Atom probe tomography (APT)		Local electrode	**Specimen**	Pole
	Field desorption mass spectrometry (FDMS)		Pulse fraction		Radius
Field evaporation	DC evaporation		Repetition rate		Radius of curvature
	Energy deficit, Ion energy		Specimen		Surface
	Evaporation field		Specimen-to-electrode distance		Shank angle
	Evaporation flux/rate		Specimen-to-detector distance		Field of view
	Evaporation duration		Specimen temperature	**Reconstruction**	Field factor
	Field evaporation		Vacuum		Image compression factor
	Molecular evaporation	**Spectrometry**	Background		Local magnification
	Post ionization		Composition		Magnification (angular, …)
	Preferential evaporation/retention		Concentration		Point density
	Reduction in field		Count		Projection (stereographic, …)
	Surface migration		Detection rate		Spatial resolution
	Specimen surface		Energy compensation		Trajectory aberrations
	Critical surface		Error		Cluster
	Electrical surface		Evaporation rate	**Data Mining**	Cluster identification
	Temperature		Flight path (length)		Concentration
Instruments	1DAP		Ion		Concentration profile
	PoSAP		Ion energy		Contingency table
	OAP		Mass (mass-to-charge state ratio)		Delocalization
	TAP		Mass range		Error
	3DAP		Mass resolving power		Fourier transform
	EC AP		Mass compensation		Isoconcentration surface Isodensity surface
	LEAP		Noise		Voxelization
	Einzel lens		Sensitivity Signal-to-noise ratio		Proximity histogram
	Poschenrieder lens		Time-of-flight		Data file
	Reflectron lens		Units		Raw
	DC voltage	**ion detection**	Desorption map		Reconstructed
	Effective pulse fraction/field reduction		Detection rate/flux		Peak width
	Energy compensation		Detection limit		Roughness
	Laser dose, fluence, intensity		Detection efficiency		Spatial Distribution Maps
	Laser pulse energy				