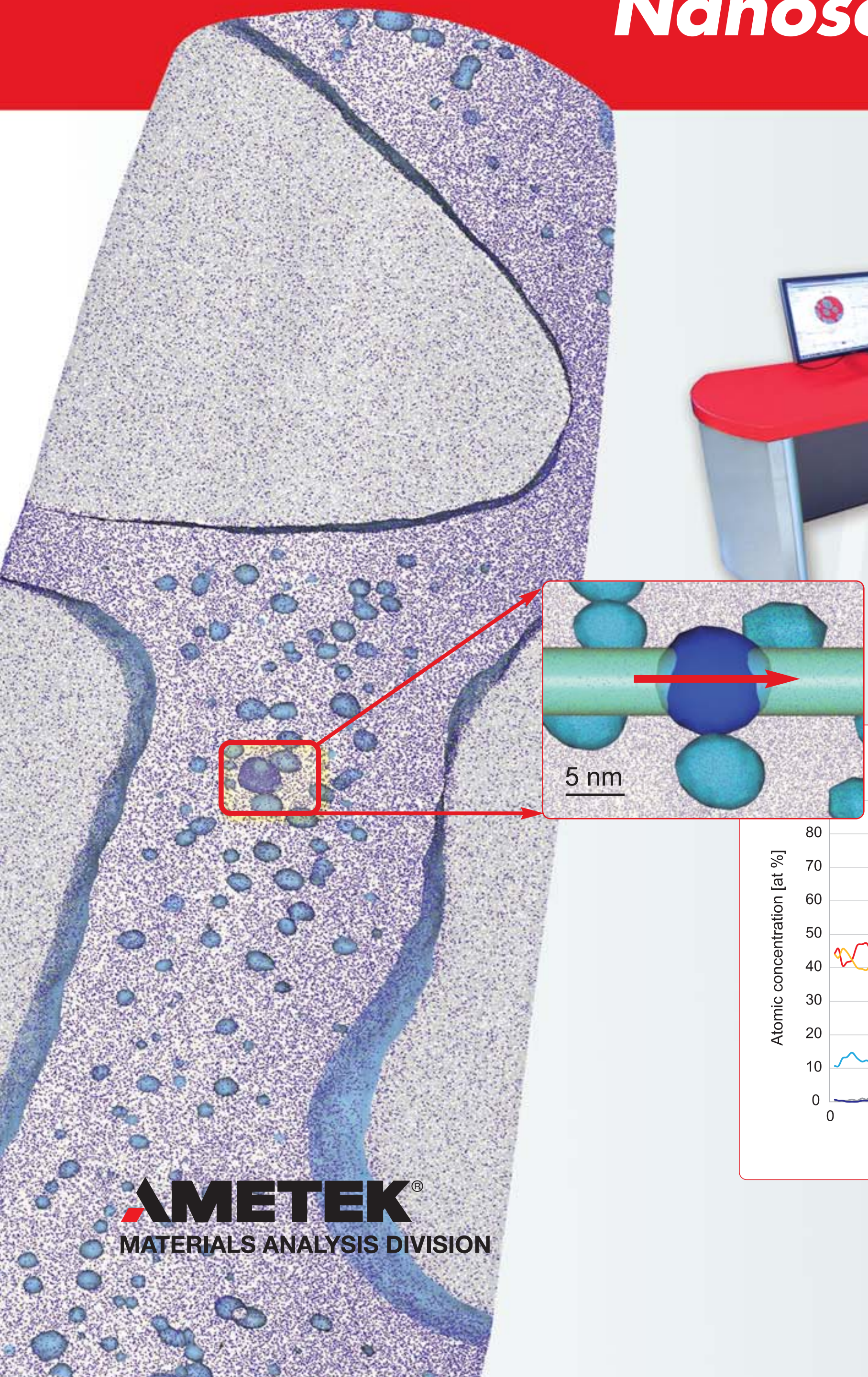
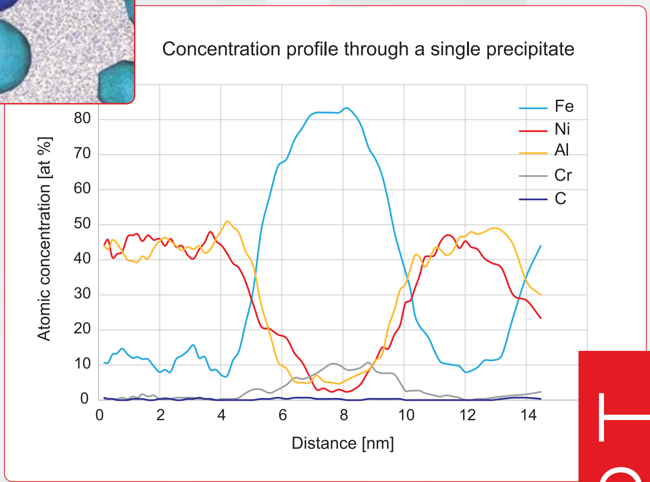
CAMECA®
SCIENCE & METROLOGY SOLUTIONS

LEAP® 5000

3D Atom Probe

Fast, High-Sensitivity 3D Imaging & Analysis with Nanoscale Resolution





APT

AMETEK®
MATERIALS ANALYSIS DIVISION

The LEAP 5000 is CAMECA's newest, cutting-edge 3D atom probe model, available in three basic configurations: LEAP 5000 R / XR & XS.

Local **E**lectrode **A**tom **P**robe (LEAP) microscopes allow scientists and engineers to analyze materials in three dimensions with near-atomic resolution, offering key insights into how a material's nanostructure affects its functional properties. Information acquired by **LEAP** microscopes allows researchers to link phenomena that occur on the nano-scale to properties at the macro-scale.

LEAP Product Family

CAMECA offers the LEAP 5000 family of instruments in three basic configurations, utilizing a common platform. The LEAP 5000 R is optimized for metals analysis whereas both the LEAP 5000 XR and LEAP 5000 XS add ultra small spot UV laser pulsing capability to address the full range of LEAP applications.

LEAP 5000 R

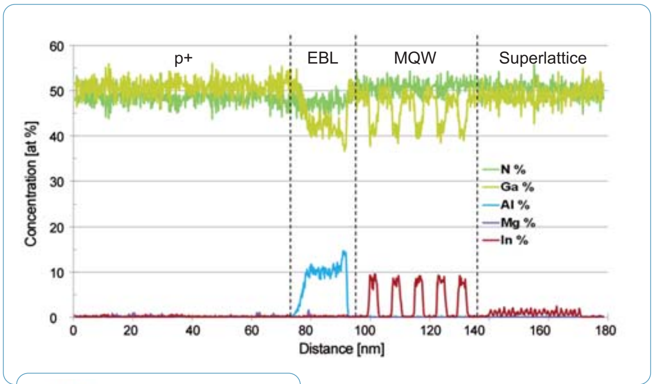
The LEAP 5000 R offers major advantages in quantitative performance across all metallurgical applications. These new capabilities include enhanced detection sensitivities (50% of all atoms detected - *40% more atoms per nm^3*), improved compositional accuracy and precision and increased specimen throughput. The LEAP 5000 R is the most powerful voltage mode atom probe ever produced.

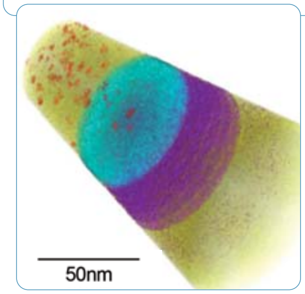
LEAP 5000 XR

The LEAP 5000 XR adds laser mode capability and extends the advantages in quantitative performance to the full range of LEAP applications. In addition to the improved detection sensitivity, data quality and specimen throughput, the advanced laser pulsing module enables increased yield with complex, fragile materials to enable new applications and make the LEAP 5000 XR the most versatile atom probe ever produced.

LEAP 5000 XS

The LEAP 5000 XS is configured to provide the ultimate performance for laser mode applications where data quality and specimen throughput are paramount. It achieves the largest analysis volumes, the highest available detection efficiency (80% of all atoms detected) and the shortest analysis time. The LEAP 5000 XS offers the ultimate in both sensitivity and productivity.





LEAP data of an OSRAM white LED including a composition profile from the p$^+$ Mg doped region, through the Al-rich electron blocking layer into the active region containing a multi quantum well, and a 21 period indium superlattice.

A.D. Giddings et al., Microscopy Today 22/5 (2014) p.12.

LEAP Applications

Metals and Advanced Materials

- Steels
- Light alloys
- Superalloys
- High entropy alloys
- Bulk metallic glasses
- Oxides and ceramics
- Nuclear structural materials
- Carbon-based materials (carbides & diamond)
- Energy capture & storage materials
- Advanced magnetic materials
- Advanced glasses
- Geochemistry
- Biominerals

Semiconductor and Microelectronics

- Silicides
- High-k dielectrics
- Advanced metallization
- Channel engineering (Si/SiGe[B])
- Compound semiconductors
- 3D device structures
- Optoelectronics

Metals & advanced materials research

Proven Results For

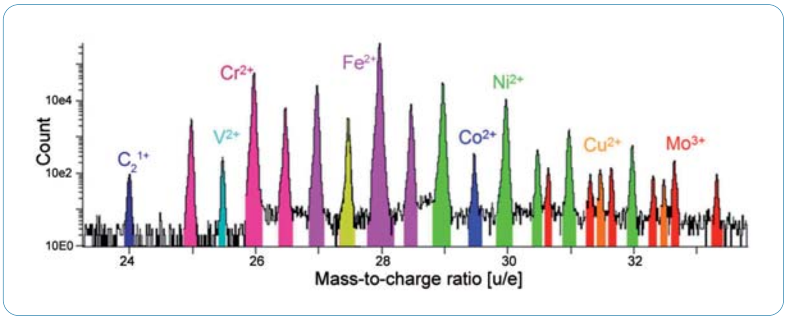
- *Steels*
- *Nanowires*
- *Aluminum alloys*
- *Nickel-based alloys*
- *Zirconium-based alloys*
- *Superalloys*
- *Coatings*
- *Precipitates and clusters*
- *Grain and phase boundaries*
- *Precipitate-hardened materials*

Metals and Advanced Materials Research

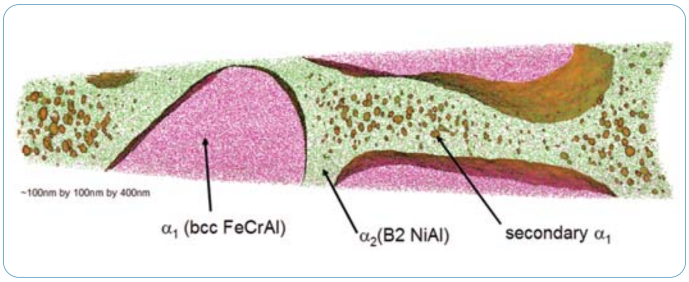
The LEAP system enables material analysis in three dimensions with atomic resolution, offering key insights relating properties (strength, heat transfer, irradiation damage, carrier lifetime, etc.) to underlying nanostructural factors. The LEAP's high mass resolution enables it to differentiate between elements and their isotopes.

Compositional Analysis

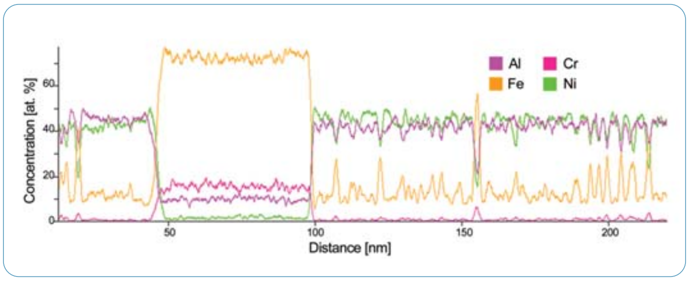
CAMECA's cluster analysis algorithms allow researchers to determine elemental concentrations within precipitates and clusters as small as ten atoms across. CAMECA's IVAS integrated visualization and analysis software enables user-defined isoconcentration levels to limit analysis to within specified boundaries.



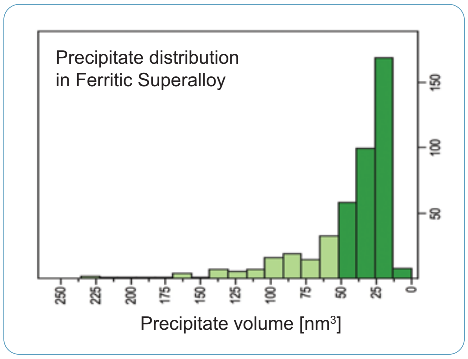
High mass resolution enables LEAP to differentiate between elements and their isotopes.



Grain boundaries and precipitate concentration.



Concentration profiles taken through different phases. Any desired region of interest may be selected for further analysis.



Statistical precipitate distribution by volume.

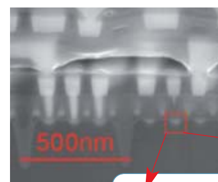
Analysis of semiconductor devices

3D Quantitative Metrology

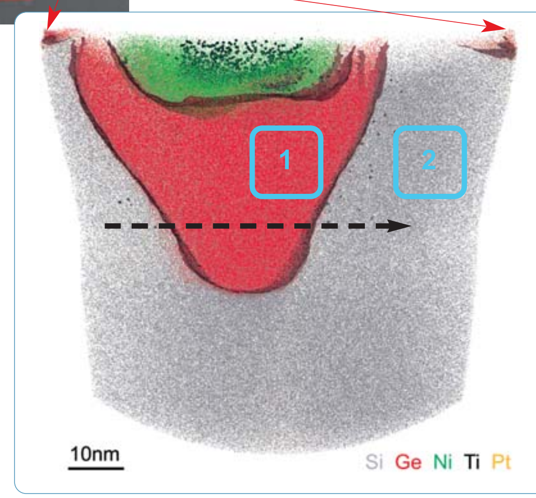
Scaling next-generation electronics for ever-greater performance requires innovative design beyond merely shrinking the size of today's circuitry. Semiconductor researchers must incorporate new materials (SiGe, doped nickel silicides, high-k dielectrics) into new 3D transistor geometries (e.g., finFETs). LEAP analysis provides key data used for design, quality control, and failure analysis of these next-generation devices.

Analysis of Device Interfaces with LEAP

Prior to the development of the LEAP, there was an unmet need for accurate characterization of buried interfaces in three dimensions. For example, in order to develop and ramp next generation device structures (e.g. finFETs) and materials (high-k dielectrics, contacts and high mobility channels) characterization of local and interface composition is critical. Other analytical techniques cannot provide the required 3D interface measurements. LEAP microscopes complement existing measurement techniques (such as TEM and SIMS tools) by providing 3D compositional characterization at nanoscale resolution.

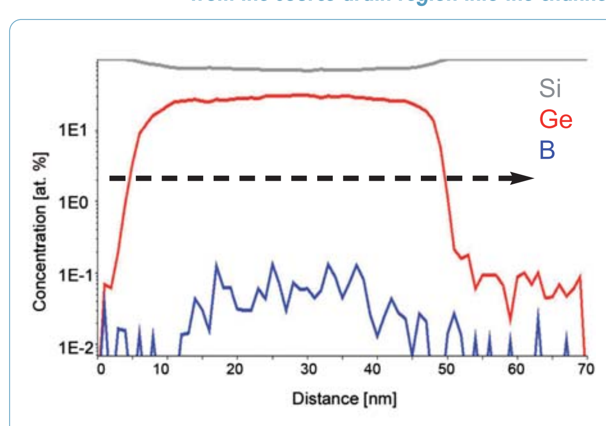


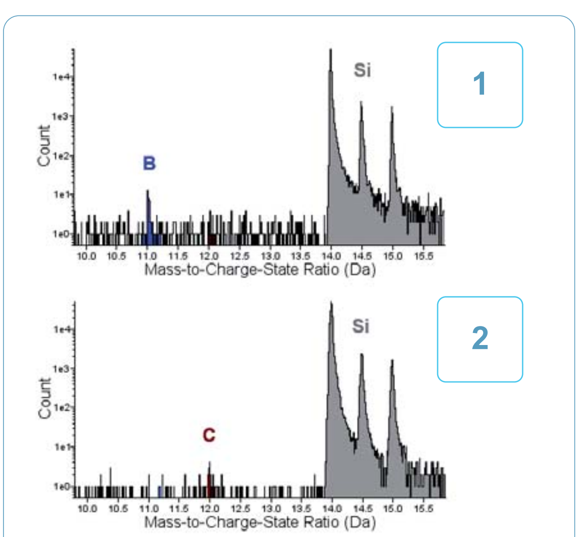
*FIB/SEM was used to select individual devices for liftout and LEAP analysis. 10nm slice of 3D data from a AMD Radeon R7 GPU.**



The 3D analysis of the source-drain region reveals Titanium and Platinum doping in the Nickel Silicide to SiGe contact. The arrow denotes a region of quantitative analysis through the S/D region, into the channel (see below).

One-dimensional concentration profile from the source drain region into the channel.





Mass spectra from regions 1 and 2 in the above image demonstrating the detection and quantification of boron at 50ppm in region 1, but no boron above the detection limit in region 2, the device channel, but rather the presence of carbon.

* D. Lawrence et al., Proc. 40th ISTFA (2014) p. 19.

Quantification on the atomic scale

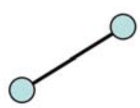
Transforming 3D data into quantitative information

CAMECA's proprietary Integrated Visualization and Analysis Software (IVAS™) provides powerful analysis features to extract 1D, 2D, and 3D quantitative information collected on any LEAP microscope.

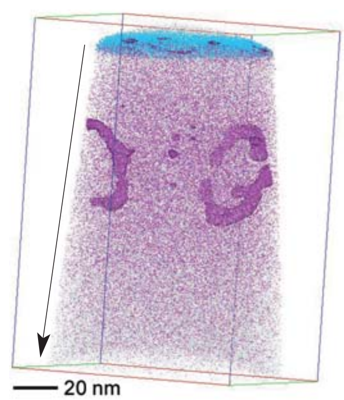
IVAS key features include:

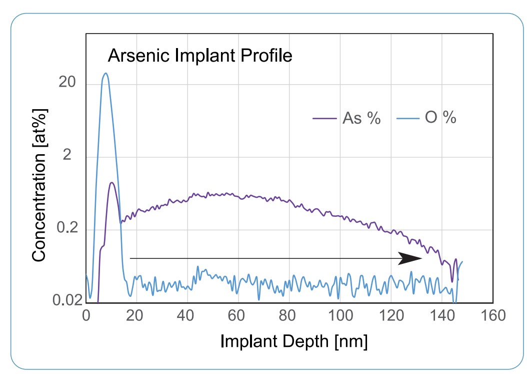
- *Easy to use integrated reconstruction and analysis in the same platform*
- *Optimized for Windows operating systems*
- *Powerful multi-threaded computational analysis*
- *Data can be imported or exported into standard formats*
- *Advanced tools for cluster searching*
- *Region of interest data simulation tool*
- *Integrated molecular ion and peak overlap decomposition*
- *1D, 2D, or 3D chemical and roughness analysis around buried interfaces*

1-Dimensional Analysis

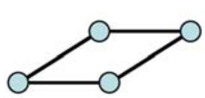


Example: Arsenic implant profile after rapid anneal and oxide growth.

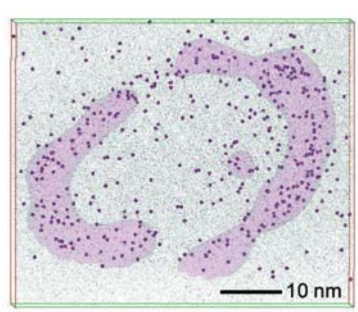


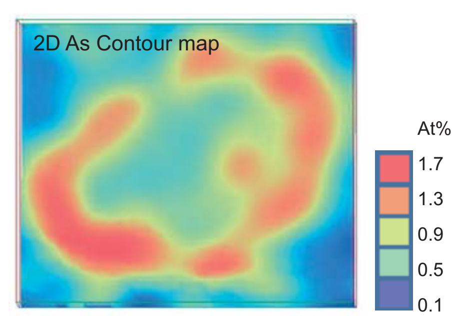


2-Dimensional Analysis

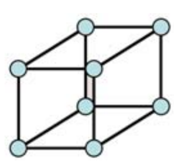


Example: A 2D contour plot of a defect ring structure decorated with Arsenic atoms.

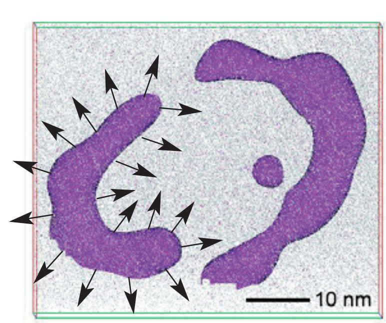


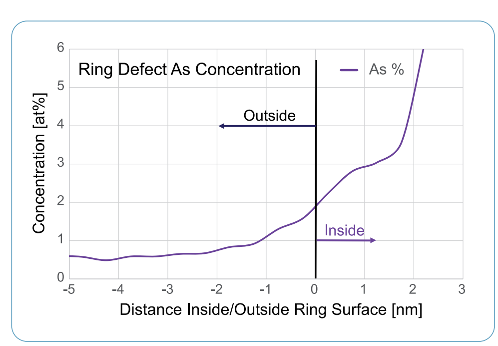


3-Dimensional Analysis



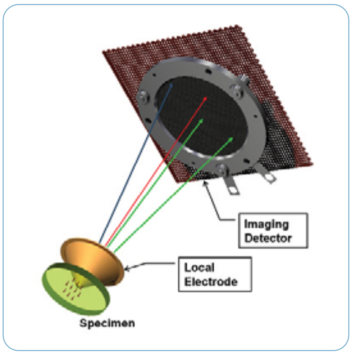
Example: Proximity histogram analysis calculates concentration gradients away from a specified 3D iso-concentration surface.



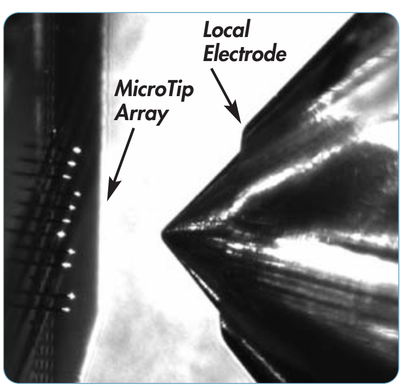


K. Thompson et al., Science 317 (2017) p.1370.

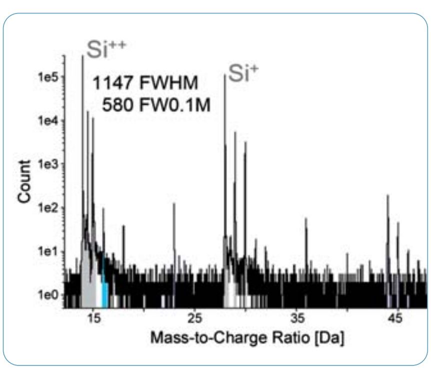
CAMECA LEAP microscopes: providing quantitative 3D compositional imaging and analysis with nanscale resolution and ppm sensitivity.



Local electrode geometry.



Local electrode with Microtip array.



Excellent signal to noise ratio enables low ppm detection sensitivity.

Introduction to Atom Probe Tomography

An atom probe produces images by field evaporating atoms from the nanoscale region of interest of a needle-shaped specimen and projecting the resultant ions onto a detector. Atoms are identified by their mass-to-charge ratio using time-of-flight mass spectrometry. The X-Y position of the ion impact on the detector and their order of arrival is also measured, thus reconstructing the original position of the atoms on the tip in a 3D image of the material, with subnanometer resolution. Many types of useful analyses are possible from the reconstructed data set: 3D visualization, 2D atom mapping, 1D depth profiling and line scanning, as well as mass spectra and compositional analysis from user-selected volumes.

Local Electrode & Ultrafast Laser

The local electrode technology revolutionizes atom probe analysis by enhancing the electric field applied to the specimen. This enlarges the field of view, enables faster data collection rates and improves the time to knowledge. The ultrafast small spot UV laser system with advanced automated focusing and alignment control algorithm capabilities, delivers improved mass resolution, enhanced reproducibility and increased yield from previously non-addressable material types. The combination of these two technologies is providing a revolution in application space for atom probe tomography.

Fast & Easy Sample Prep with Microtips™

By focusing the applied electric fields directly onto the specimen apex, the Local Electrode enables the use of microtips, arrays of multiple specimen tips that allow quick and easy transition from one specimen to the next. Microtips, designed for full compatibility with Focused Ion Beam site-specific lift-out procedures, enable multi-specimen analyses to be completed with reduced specimen preparation time and enhanced reproducibility.

A Wider Field of View

Previous generations of atom probes suffered from limited fields of view, so that researchers could only see a small window into their specimen's microstructure. The LEAP 5000-series atom probes, by contrast, achieve a large solid angle which enables analyzation of > 50% of the internal volume of the specimen to provide a field of view that can exceed 200 nm for a wide variety of materials.

Better Signal-to-Noise Ratio

Instrument sensitivity is determined by the noise level, the signal level, and the number of atoms detected. The LEAP 5000-series instruments have been designed with advanced noise-suppressing flight paths, faster pulse repetition rates, increased detection efficiencies and expanded data acquisition controls to offer the ultimate in signal-to-noise performance and to achieve better detection limits.

LEAP 5000 R/XR:
breakthrough data quality for metals & materials research

Enhanced Voltage Mode

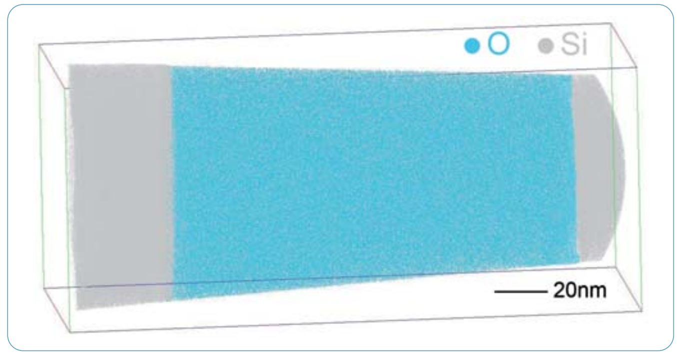
Voltage pulsing remains the mode of choice for many metallurgical applications because of the proven capability and comprehensive publication history. The **LEAP 5000 R/XR** includes a new pulser technology that delivers increased pulse amplitude, advanced pulse shaping and faster pulse repetition rates to deliver improved data quality, larger analysis volumes and increased productivity.

High Mass Resolution

The **LEAP 5000R/XR**'s patented Large Angle Reflectron design enables for excellent mass resolution to be achieved while maintaining a wide field of view. The energy compensation in voltage mode and extended ion flight times in laser mode enables elements and isotopes with nearly-identical mass-to-charge ratios to be uniquely identified, a key requirement in the analysis of metals and other advanced materials.

Key features of LEAP 5000 R/XR include:

- Local electrode technology
- High mass resolution in voltage mode
- Improved mass resolution in laser mode
- Field of view > 150nm
- Improved signal-to-noise
- Easy sample preparation with MicroTip array
- Available in voltage or voltage & laser configurations



A tightly focused UV laser enables high yield and excellent data quality, even on materials containing thick dielectric films.

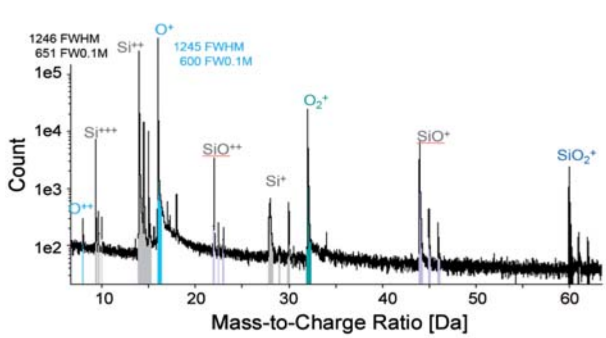
LEAP 5000 XS:
rapid time to knowledge for microelectronics process optimization

High Productivity

The **LEAP 5000 XS** combines new flight path technology with enhanced detector performance to offer improved field of view whilst achieving unprecedented detection efficiency (~80%). In addition, the straight flight path design allows data collection to be performed at very fast pulse repetition rates (1MHz) to give the largest analysis volumes in the shortest possible time.

Key features of LEAP 5000 XS include:

- Local electrode technology
- Field of view up to 250nm
- Highest data rate
- Easy sample preparation with microtip array
- High spatial resolution and sensitivity
- UV Laser Pulsing with small spot

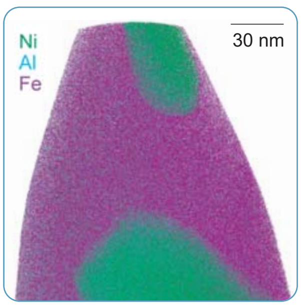


Small Spot UV Laser Maximizes Performance in both XS & XR Configurations

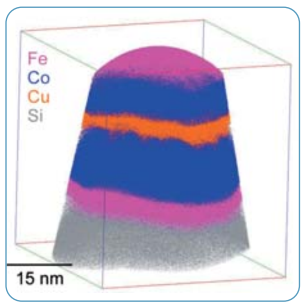
The system uses a UV laser with a tightly focused spot when in laser mode. The small UV laser spot enables exceptional mass resolution to be obtained.
The use of UV wavelength enables a wide variety of materials, including many insulators, to be analyzed with high yield.

Offering key insights into materials' nanostructures, the CAMECA LEAP 5000 3D Atom Probe opens exciting new research possibilities.

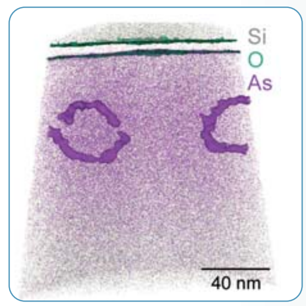
With the introduction of the Local Electrode Atom Probe (LEAP) in 2003, APT has become a standard material science method for the ultimate in 3D nanoscale compositional characterization of metals, ceramics, semiconductors, biomaterials, geological materials...



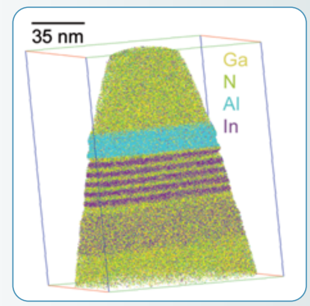
Advanced Alloys



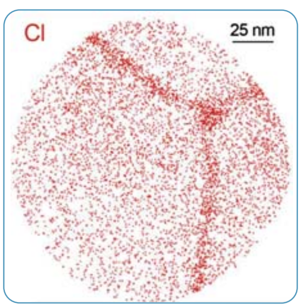
Thin Films



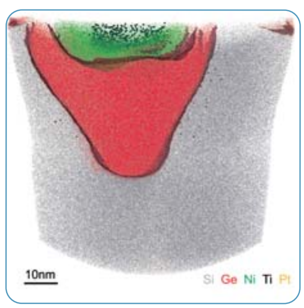
Dopant Mapping



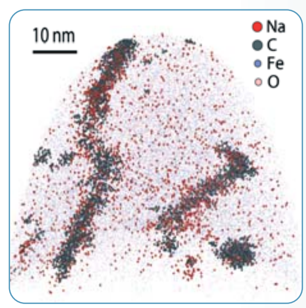
III/V LEDs



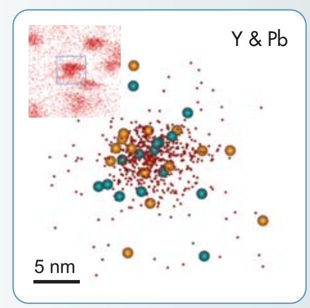
II/VI PVs



Transistors



Biominerals



Geochemistry

CAMECA is the world premier provider of microanalytical instrumentation.
We deliver cutting-edge science and metrology solutions, and offer our customers unparalleled support and maintenance service through the comprehensive AMECARE program.

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