CAMECA®
SCIENCE & METROLOGY SOLUTIONS



ACTINIS™
SIMS FOR RADIOACTIVE MATERIALS

Shielded SIMS Analyzer for Nuclear Research & Industry

AMETEK®
MATERIALS ANALYSIS DIVISION

Preparing the future of nuclear energy with a unique, high performance research instrument.



As the world transitions to clean energy, nuclear remains one of the largest sources of low carbon electricity - but the challenges are plenty and innovation is needed in order to ensure power plant safety, optimize the nuclear fuel cycle, and find effective solutions for waste management.

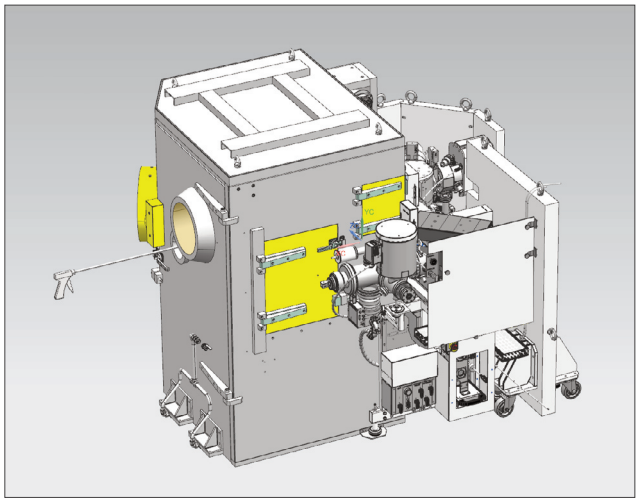
More than ever, nuclear scientists and engineers rely on high performance microanalytical instruments that allow them to characterize nuclear fuel, to investigate the effect of radiation on structural materials, and to optimize nuclear reactor operation. In particular, dynamic Secondary Ion Mass Spectrometers (SIMS) are known to be extremely useful for a wide range of nuclear science applications, but the investigation of highly radioactive materials, such as irradiated nuclear fuel, requires specifically designed equipment.

ACTINIS™ is CAMECA's new magnetic sector SIMS dedicated to high precision elemental and isotopic analyses of highly radioactive samples.

A high performance shielded SIMS analyzer for nuclear research & industry

Benchmark SIMS performance

ACTINIS is derived from the field-proven CAMECA IMS 7f system. Offering high mass resolution and high transmission, it delivers high sensitivity depth profiling and isotope ratio measurements as well as element and isotope mapping at sub-micron lateral resolution.



Optimum safety with state-of-the-art shielding

ACTINIS must be integrated in a set of biological protections in order to protect operators from contamination and irradiation effects during the transfer and analysis of the radioactive samples.

Building on 40+ years experience developing and servicing shielded microanalytical instruments for key players in nuclear research and industry, CAMECA has designed a robust instrument shielding package: mechanical drawings and detailed specifications for the biological protections are provided before installation, allowing the customers to equip their lab with the necessary protections.

Including a glove box with manipulator for Alpha protection and lead-walled cell for Gamma protection, the shielding package enables ACTINIS to analyze samples with an activity (dose rate) of up to 2 Gy/h measured at 5 cm from the sample.

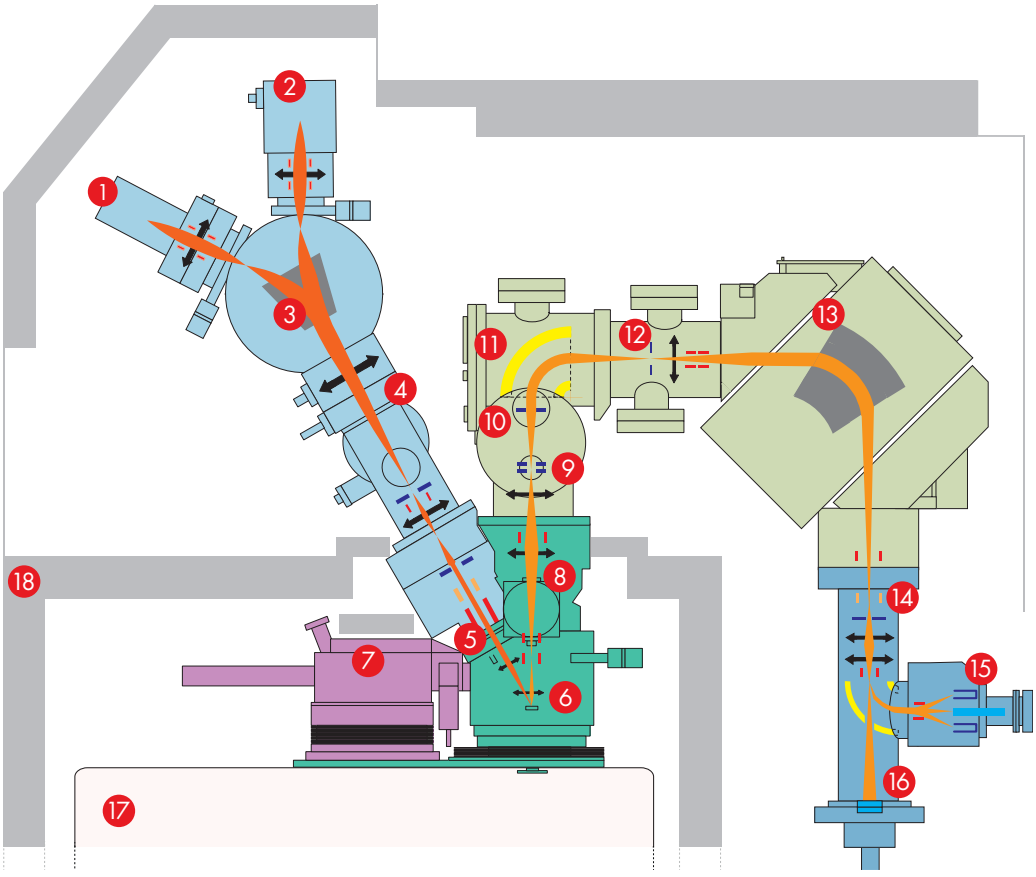
Best-in-class SIMS technology enabling the characterization of highly radioactive materials with unequalled sensitivity.

ACTINIS retains the best features of the IMS 7f / 7f-GEO models

- Combination of Duoplasmatron and Cesium primary ion sources ensuring optimum sensitivity to electropositive and electronegative species
- Computer controlled high precision sample stage
- Normal incidence electron gun for analysis of insulating samples
- Secondary ion-optical collection system:
  - High electrical field for optimized transmission
  - Beam centering for excellent reproducibility
  - Optical gating for high dynamic range depth profiling
- Double focusing mass spectrometer:
  - Electrostatic analyzer for energy focusing
  - Laminated magnet with fast peak switching
- High precision detection system:
  - One Electron Multiplier (EM)
  - Two Faraday Cups (FCs) with state-of-the-art electrometry (low noise and stable baseline)
- Direct ion imaging for instrument tuning
- Scanning ion imaging for mapping of small to large areas with high lateral resolution.

Full automation & ease of use

ACTINIS offers a high automation level and includes specific adaptations to minimize manual operations such as a full-security sample introduction system. Specific tools were developed and ion optical devices were modified to enable maintenance inside the shielding.

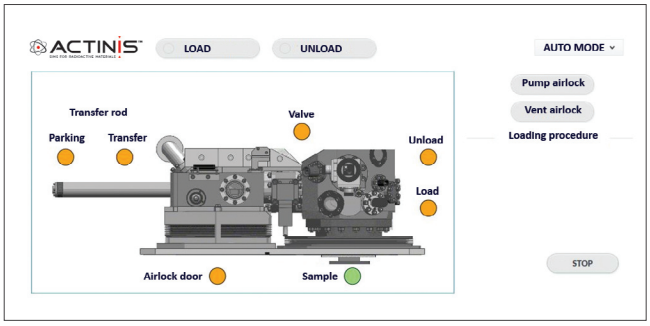


1. Microbeam cesium ion source
2. Duoplasmatron ion source
3. Primary beam mass filter
4. Primary ion optical system
5. Primary Faraday Cup
   Motor driven primary column aperture
6. Sample and analysis chamber
7. Airlock and full-security sample introduction system
8. Normal incidence Electron Gun
9. Motor driven contrast aperture and entrance slit
10. Motor driven field aperture
11. Electrostatic analyzer
12. Motor driven energy slit
13. Fast laminated magnet
14. Motor driven exit slit
15. Electron Multiplier and FC detectors (FC1 & FC2)
16. Ion image detector
17. Glove box
18. Shielding

The tool of choice for nuclear fuel cycle optimization, pre and post irradiation examination, nuclear waste management, and more.

Customized sample introduction system for safe specimen handling

The new motorized sample introduction system is specifically designed to accomodate highly radioactive samples. Specimen transfer from the 1-position entry airlock into the analysis chamber is fully automated. A manual control system allows the samples introduced into the instrument to be extracted in all situations. Sample holders are adapted to enable handling by the manipulator system inside the glove box.



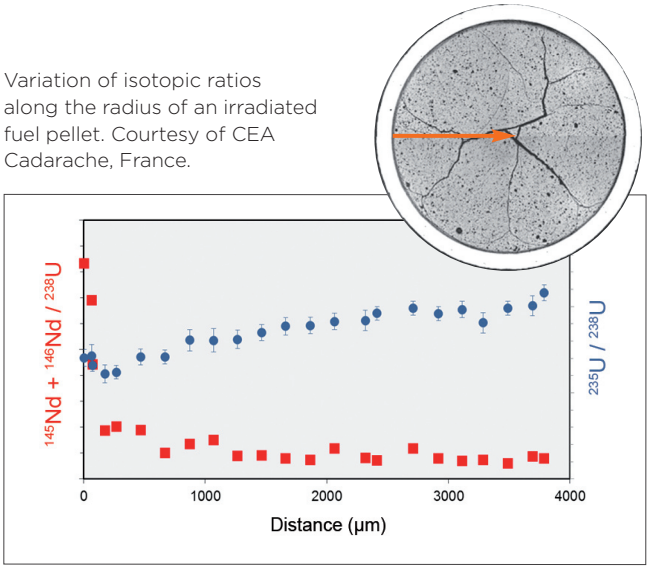
Dedicated software controlling the transfer of samples between the airlock and the specimen chamber. Hardware and visual securities ensure correct execution of loading/unloading sequences.

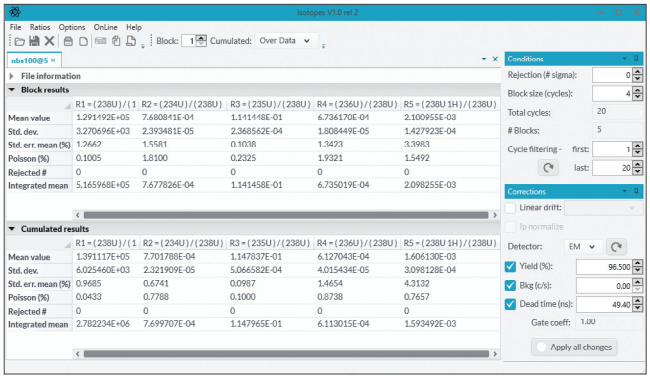
Comprehensive SIMS software package

ACTINIS includes all software capabilities for easy instrument setup and efficient operation already available in the previous IMS 7f model:

- PC automation system including three screens and a dedicated keypad for instrument control
- Complete load-save of instrumental settings (sources, electron gun, primary and secondary optical system...) and analysis recipes
- Data acquisition software with automated controls (beam centering, mass calibration...) for optimized reproducibility
- Multitasking system providing simultaneous data acquisition and data reduction
- Automated, unattended chain analysis
- WinCurve: High volume data processing capabilities (depth profiling, mass spectra...), real-time visualization of SIMS data, batch processing for improved productivity
- WinImage: Powerful image visualization and processing functions in a user-friendly interface
- WinIsotopes: Dedicated to isotope ratio and statistics computation. Adjustment of detector parameters and other data reduction features. Real-time isotope ratio computation during data acquisition.

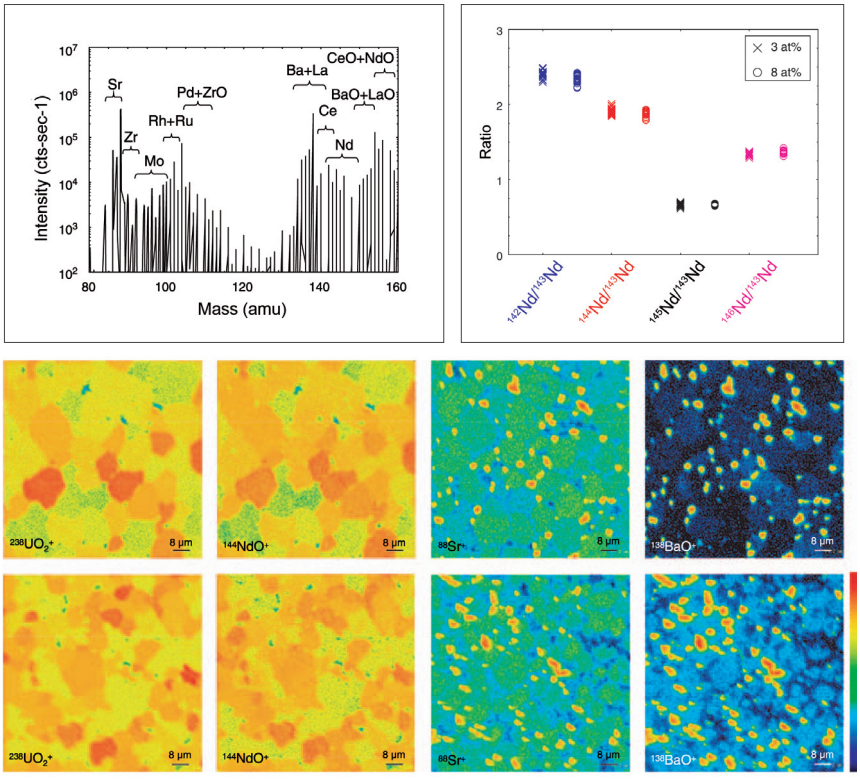
Variation of isotopic ratios along the radius of an irradiated fuel pellet. Courtesy of CEA Cadarache, France.





WinIsotopes: user-friendly isotope ratio processing software.

Easy-to-use, fast and robust, ACTINIS™ delivers elemental and isotopic data ranging from low mass (H) to high mass species (Pu and above).



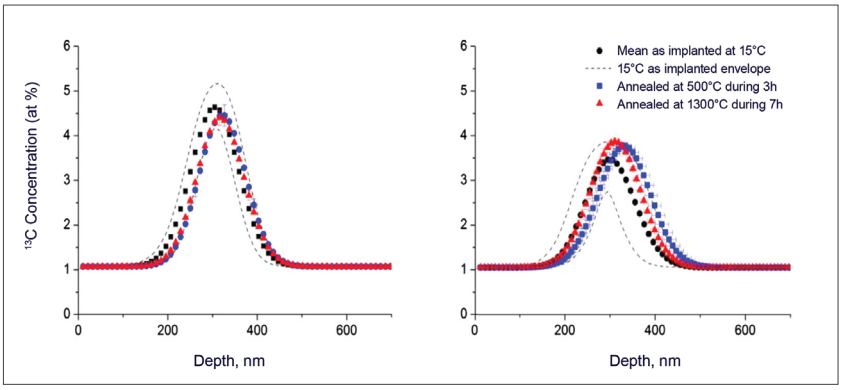
Optimizing the fuel cycle

Combining mass spectra, isotopic ratios and scanning ion imaging, our shielded ion microprobe produces comprehensive analyses of complex radioactive materials.

Two samples, simulating burn-ups of 3 and 8 at%, were obtained by doping non-irradiated UO_2 with a known concentration of elements representing fission products.

Mass spectra on the 3 at% sample (top left), isotope measurements for four Nd ion ratios (top right), ion maps on the 3 at% samples (bottom top row), and 8 at% samples (bottom low row).

Data from: S. Portier et al. Microchim Acta 161 (2008).



Study of temperature effects in nuclear graphite

SIMS enables the investigation of ^{13}C distribution at micrometer lateral scale. Despite the scatter, which is most probably linked to reordering effects, the comparison of the profile areas does not reveal any notable ^{13}C release. The extrapolation of these results to the behavior of ^{14}C shows that reactor temperatures (200–500°C) do not induce any ^{14}C release.

Data from: G. Silbermann et al. Nuclear Instruments and Methods in Physics Research B 332 (2014).

Managing radioactive waste from dismantled reactors

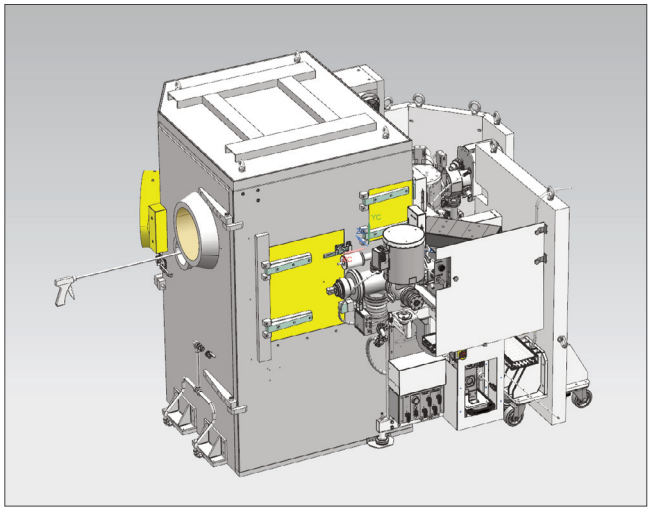
Dismantling old nuclear reactors generates irradiated graphite waste that will need to be properly disposed. ^{14}C being one of the main radioactive dose contributor, it is mandatory to get an accurate estimation of ^{14}C for safe waste management.

In this study, SIMS is used to characterize virgin nuclear graphite implanted with ^{13}C in order to elucidate the effects of temperature and irradiation that mainly influence ^{14}C behavior in graphite during reactor operation.

ACTINIS™

SIMS FOR RADIOACTIVE MATERIALS

High Performance Shielded Ion Microprobe for the Analysis of Radioactive Samples.



Inspired from the Greek ἀκτίς (ray), ACTINIS™ also refers to actinides, chemical elements of particular importance in nuclear applications.

Specification overview

Mass range	1 to 360 a.m.u at 5 kV sample HV
Mass resolving power (MRP)	> 20 000 (10% definition, FWTM)
Transmission	> 20% at high MRP (4000 FWTM)
Abundance sensitivity	< 5 x 10^{-9} at M±1 (M=^{28}Si)
Depth profiling detection limit	< 10^{14} atom/cm^3
Isotope ratio precision	< 0.2% in EM/EM mode < 0.2% in FC/FC mode
Scanning ion imaging	Field of view up to 500 x 500 µm^2 Lateral resolution down to 1 µm
Maximum sample size	1 inch diameter ½ inch in thickness

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AMETEK MATERIALS ANALYSIS DIVISION

WORLD PREMIER PROVIDER OF SCIENCE & METROLOGY SOLUTIONS FOR ELEMENTAL & ISOTOPIC MICROANALYSIS, WE DELIVER CUTTING-EDGE SCIENCE AND METROLOGY SOLUTIONS, AND OFFER OUR CUSTOMERS UNPARALLELED SUPPORT & MAINTENANCE SERVICE THROUGH THE COMPREHENSIVE AMECARE PERFORMANCE SERVICES PROGRAM.