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IMS 7f / 7f-GEO

UNIVERSAL MAGNETIC SECTOR SIMS

The CAMECA **IMS 7f** is a magnetic sector SIMS with top performances in trace element depth profiling and secondary ion microscopy.
Its unique stigmatic optical system allows both direct ion microscopy and scanning microprobe mode.
The High Mass Resolution capability permits true elemental analysis by eliminating the numerous interfering ions ($^{56}Fe/^{28}Si_2$, $^{31}P/^{30}SiH$, $^{32}S/^{16}O_2$...). The HMR capability ensures the instrument's long life, especially in fields (semiconductors) where materials and thus analytical problems (i.e., mass interferences) change rapidly.
The magnetic sector analyzer allows to work with a high DC extraction field; accordingly, analyzer transmission is higher by two orders of magnitude than with quadrupole analyzers. High transmission is absolutely necessary for performing analyses or profiles on small areas (ex: 100 μm test pads in semiconductor, or μm size particle analysis), while maintaining excellent detection limits (down to the ppb level).
High Mass Resolution, High Transmission and Stigmatic Optics allow the CAMECA IMS 7f to show benchmark results and application together with the highest sample throughput (sputter rates up to μm/min).

The **IMS 7f-GEO** (see photo above) is a version specialized for **high precision**/ **high throughput** measurements in geological samples, i.e. REE elements or stable isotopes (H, C, O, S...). The key features of this new instrument are a sub-permil isotope ratio reproducibility, a new detection composed of one EM and a dual FC, a fast electro-magnetic peak switching and a full set of dedicated softwares.

Compared to previous CAMECA IMS instruments, the IMS 7f offers:

Dramatic improvements for shallow profiles: the impact energy can be reduced to very low level (300 eV), with independent control of the impact angle by the continuous variation of extraction voltage and primary energy. High speed of erosion (2 nm/min with 500 eV O_2^+, 45° on silicon) can be maintained at low energy with the new accel/decel optics for the duoplasmatron. A high sensitivity is now maintained at low energy even for heavy ions (cesium clusters, noble metals...) thanks to the new electron multiplier post-acceleration.

A new eucentric rotating stage reduces rugosity even on profiles from small dimension crater, at any position on the sample holder.

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An important new feature of the IMS 7f is its new PC-Windows automation system, which increases the analysis throughput by allowing unattended, chained operation. Analyses can be run in a completely automatic mode with an excellent repeatability over hours and days. In addition, all aperture and slit movement are now motorized and computer controlled in standard. This ensures best reproducibility and allows an easier use of the instrument through memorized settings and recipes.

Ultra High Vacuum is obtained thanks to a combination of Titanium sublimation with ion or turbo-molecular pumping. UHV technology ensures excellent detection limits for light elements (H, N, C, O, ...) and becomes an important point for ultra-shallow profiling when the sputter rate is reduced at low energy.

The improved IMS 7f electron flood gun provides a unique self-compensation mode that makes it possible to measure depth profiles on complex insulating structures and isotope ratios in minerals with an accuracy at the permil level.

A synopsis of the instrument is available on request.

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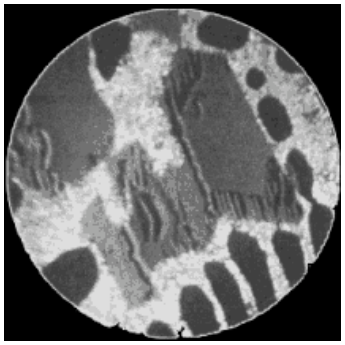
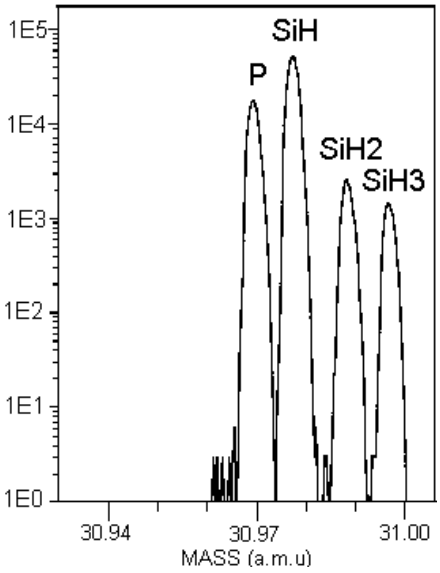
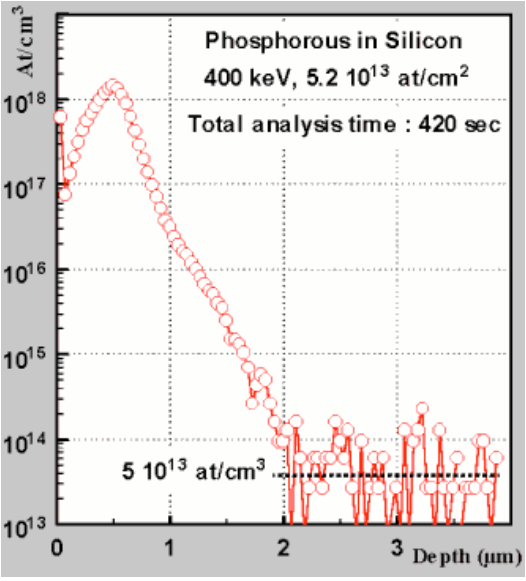
IMS 7f HIGHLIGHTS



Lateral resolution of direct ion microscopy images, in contrast to microprobe imaging only used on all other instruments, is independent of the primary beam diameter. This makes *extremely short acquisition times* possible with large primary ion beam.
An example of direct secondary ion image showing the distribution of Silicon in an Aluminum matrix. This image can be visualized on a fluorescent screen, or digitally integrated with a Resistive Anode Encoder (RAE). Field of view: diam. 250 mm.

The CAMECA IMS 7f optical system allows a mass resolution up to 25 000 (at 10% definition, equivalent at least to 50 000 FWHM as quoted for TOF-SIMS). This ensures clear, unambiguous analyses, by removing most mass interferences. The quality of the analyser design ensures the highest abundance sensitivity and sharp peak shape with minimum background and tail. The double focusing analyser and its adjustable energy slit allow also to use energy filtering of the secondary ions to reduce contribution from different species at the same nominal mass (ex: reduce a molecular or organic interference on an elemental peak). This crucial capability for elemental analysis is not available from Reflectron TOF analysers contributing to peak tails and background noise.





In this example, the High Mass Resolution of the magnetic sector analyzer makes it possible to perform a depth profile of Phosphorus in Silicon by discriminating between the Silicon 30 hydrides ions ^{30}SiH and the Phosphorus ions ^{31}P, both at mass 31. This allows an extremely low P detection limit, even in amorphous silicon. A quadrupole analyser with its low mas resolution will give a Phosphorous detection limit *several orders of magnitude* poorer.
Also note the speed of analysis, guaranteeing the highest sample throughput available.
With a (DC) magnetic sector analyser, the faster the profile, the better the sensitivity or detection limits: each data point signal is integrated over a larger depth (volume). In contrary with a (pulsed) Time Of Flight analyser, the faster the profile the poorer the sensitivity: most of the material is sputtered away by the sputter gun and lost for the analysis ion gun. This explains the poor results obtained on deep profiles with TOF analysers.

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Matrix	Element	Detection limit (10^{13}at/cm3)	Detection limit (ppb)
Si	H	7000	1400
	B	3	0.6
	C	3000	600
	N	50	10
	O	6000	1200
	F	500	100
	Al	10	2
	P	5	1
	Cr	2	0.4
	Fe	50	10
	Ni	30	6
	Cu	80	16
	As	5	1
	Ag	50	10
	Pb	10	2
GaAs	Si	50	20
	Zn	200	80
InP	Zn	270	60
	Si	780	180
	Fe	440	100
	S	610	140

IMS 7f Elemental detection limits in DEPTH PROFILING mode.

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The combination of high transmission, optical gating, high mass resolution and ultra high vacuum ensure the obtention of benchmark detection limits together with a high sample throughput (no need to leave the sample degas in load-lock as usual with quad-SIMS).

Element	Detection limit (at/cm2)	Det. limit (ppm)
Li	1E7	0.01ppm
B	1E9	1
Na	1E8	0.1
Mg	5E9	0.5
Al	5E8	0.5
K	1E8	0.1
Ca	5E8	0.5
Ti	1E9	1
V	1E8	0.1
Cr	5E8	0.5
Fe	8E8	0.8
Cu	1E10	10
Pb	3E9	3
...		

SURFACE analysis of inorganic trace elements on silicon.

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The method, ASTM F1617 approved, is based on a Low Energy Sputter (3keV impact), high mass resolution, O2+ primaries & Oxygen flooding. High transmission at high mass resolution, energy bandwidth control and fast magnet switching ensure fast and reproducible data. In addition this fast depth profiling method ensures the correct contamination dosage by integrating the signal over a few tens nm depth, not achieved by VPD-ICPMS or TOF-SIMS. The detection limit is at the ppm level for most elements.
Data taken from Charles Evans & Associates application note.

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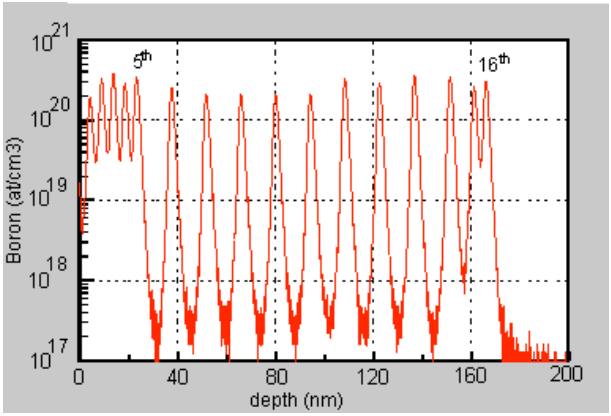

Boron delta structure. SEMATECH round-robin, SIMS XII, Brussels, sept. 99.
500 eV impact energy, O_2^+ at 44° incidence angle and oxygen flooding.

The IMS 7f upgraded with "accel/ decel" on the duoplasmatron source, allows state-of-art ultra-shallow profiling.

No visible rugosity is detected, and depth resolution is maintained at benchmark level:

- decay length (1/e) 5th layer: 0.7 nm/ 16th layer: 0.7 nm
- FWHM 5th layer: 1.8 nm/ 16th layer 1.8 nm

The position of the first layer (4.14 nm) is correct, and does not show the error and artifact obtained with normal incidence/ no flooding condition (too small value). In addition, the use of 45° angle together with gas flooding offers higher sputter rate compared to normal incidence condition, leading to a much higher sample throughput.

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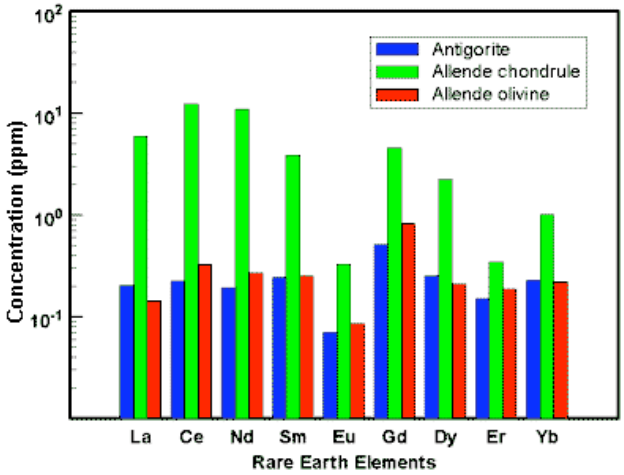

Measurement of Rare Earth Elements at trace level in geological samples.

The IMS 7f allows reproducible quantitative measurement of REE despite the low concentration level (sub-ppm for most), numerous mass interferences (removed by energy offset + filtering) and insulating nature of the samples (use of O- primary ions, metallic coating and/or charge compensation).