A new thermal ionization mass spectrometer (TIMS)

J. Schwieters
D. Tuttas
B. Windel

Finnigan MAT GmbH, Barkhausenstr. 2, 28197 Bremen, Germany

TIMS is a well established technique capable of extremely high precision and accuracy in the determination of isotope ratios, but a number of interesting problems remain elusively just beyond the ability of current instruments (e.g. the putative terrestrial ^{142}Nd anomaly). While precision and accuracy of TIMS instruments have improved over the years, it is not generally appreciated that the instrumental advances of the last ten+ years (moveable Faraday collectors, negative ion technique, positive and negative ion counting, ultrahigh abundance sensitivity using retardation lenses) have been implemented on instrumental platforms which date back to the single collector instruments of the 1970s. To address currently identified research needs as well as a number of anticipated future needs in geo- and cosmochemistry, Finnigan MAT has developed a completely new TIMS which is built on an all new platform which offers improved analytical performance (precision and accuracy), significant new analytical capabilities, and enhanced reliability and ease of operation. The ion optics of the ion source and the mass analyser have been recalculated using proprietary state of the art simulation programs, and all optical elements have been completely redesigned to increase transmission, eliminate image errors, and to significantly increase the mass dispersion. Wherever possible, optical fiber links have been used to make the electronics more robust against noise. This concept has been adopted from the the Finnigan MAT *ELEMENT*, a high performance ICP-MS instrument.

The accelerating voltage is kept at the 10-kV of its MAT 26x predecessors (262, 261, 260) but the use of a larger magnet leads to a larger geometry and a wider dispersion (81 cm). The variable collector array of the new instrument has been completely redesigned from that of the MAT 262. The multicollector array has eight independently moveable platforms, each of which can hold either a Faraday cup or a Channeltron ion counter. Additionally, there is a fixed center channel where the ion beam can be switched between a Faraday cup and an ion counter. For applications which require ultra high abundance sensitivity, the proven RPQ-retardation lens can be installed in front of the ion counter. The maximum signal on the Faraday cups has been increased to 50 V and the new electronics have reduced noise, thus allowing access to an enhanced dynamic range. The design of the new Faraday collectors significantly reduces emission of secondary ions and electrons, and increases the lifetime of the cups. The Faraday cups can be readily exchanged by the user in the field (plug-in cups), thus eliminating all concerns about cup aging: changes in collector efficiency that occur as a result of use. The ability to perform field exchanges of the collectors means that the collector array can be now be defined by the user to accommodate changing experimental needs, with a choice among arrays of all Faraday cups, mixed Faraday cups and ion counters, and multiple ion counters (MIC), in either positive or negative ion modes.

The new laminated magnet which allows rapid scans and jumps enables a new mode of operation, dynamic measurement of isotope ratios using a single electron multiplier. The accessible relative mass range has been increased to 15%, to allow static multicollection of ^{6}Li-^{7}Li, ^{10}B-^{11}B, ^{40}Ca-^{46}Ca, U-Pu, and ^{238}U-^{208}Pb.

Precision attainable with multidynamic ion collection schemes has up to now been limited by incomplete cancellation of cup factors due to compromises in cup positioning; the new instrument includes 'zoom optics', which allow multidynamic analysis without any compromise in peak overlap and peak flatness. One of the significant factors limiting the precision attainable with currently available TIMS instrumentation is the electronic gain calibration error of the current amplifiers. The all-new electronics incorporate a new concept for electronic gain calibration which eliminates inter-amplifier bias. This feature is the key to higher external precision. Several elaborate diagnostic tools are used to monitor the performance of the current amplifiers and the Faraday cups.

This is the first change to the *bauplan* of TIMS instruments since 1978. The new instrument has a redesigned sample carousel, a new source design, a new laminated electromagnet, new optics including quadrupole lenses for zoom optics, a new multi-collector design, new electronics, and all new software based on the Windows NT platform. It is expected that this new instrument will allow significant improvements to precision and accuracy attainable during TIMS analysis. The redesigned source has already yielded significant improvement in sensitivity during double filament analysis. Isotopic analysis of very small sample amounts can be performed with either dynamic collection on a single ion counter or static multiple ion counting (MIC). The improved control over filament heating in the low temperature range (650–850°C) should enable breakthroughs in negative ion TIMS

References

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