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MegaSIMS: a High Energy Secondary Ion Mass Spectrometer for the Analysis of Captured Solar Wind.

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Introduction: In September 2004 the GENESIS spacecraft returned samples of the solar wind (SW) to the Earth for analysis [1]. The SW was captured in ultra-pure target materials exposed outside the Earth's magnetosphere for ~29 months, and although the sample return capsule crashed upon reentry, sufficient collector materials survived impact to address many scientific objectives. Among the highest priorities are the analysis of the isotopic abundances of SW oxygen and nitrogen with accuracy targets of ~1‰ and 10‰, respectively. The spacecraft carried an electrostatic mirror designed to enhance the signal-to-background as well as depth of implantation of these SW elements in target materials (SiC, ^{13}C CVD diamond, diamond-like C film) chosen for their low intrinsic backgrounds and lack of native surficial oxide layers [2,3]. The concentrator also rejected ~90% of the protons, but nevertheless most of the atoms collected are H. Even with the concentrator, only small amounts, ~8 and 0.8 ng of O and N, respectively, were captured per cm^2 of target and those SW atoms are not very far removed from surface contaminants (mean implantation depth, ~500 Å). Such relatively small amounts of O and N have been measured with good precision in extraterrestrial materials, e.g. by secondary ion mass spectrometery (SIMS) in dust particles, but not in such dilute concentrations spread over a relatively large area. In order to address these analytical challenges, we have constructed a new instrument that combines the unsurpassed capabilities of SIMS for high-resolution depth-profiling of semiconductor materials (like the GENESIS collectors) with those of accelerator mass spectrometry for overcoming limitations in isotopic abudance measurements caused by molecular ion interferences. Here we report the design characteristics and preliminary performance for this new micro-analytical instrument, termed the UCLA "MegaSIMS."

Instrument Description: The MegaSIMS consists of a modified CAMECA ims 6f ion microscope coupled to a National Electrostatics Corp. (NEC) tandem accelerator through an "isotope recombinator" band-pass mass filter (Fig. 1). Negative secondary ions are generated by a mass-filtered Cs+ primary ion beam, accelerated to 10keV, and energy-analyzed before being admitted to the recombinator. The recombinator consists of two 45º sector magnets coupled by a pair of einzel lenses; a widely adjustable slit at the mass dispersion (symmetry) plane permits precise control of a range of masses to be introduced to the accelerator (Fig. 2). Negatively charged ions enter the accelerator where molecular species are quantitatively destroyed by a recirculating Ar-stripper gas in the tandem terminal (at up to +1.2 MV). The resulting positively-charged high-energy atomic ion beam is mass analyzed by a forward-geometry double-focusing mass spectrometer equipped with 5 collectors on the mass-focal plane.

A projection ion optical system (Kore Technology Ltd.), which is engaged when the second recombinator magnet is de-energized, enables real-time (ion microscope) imaging of the sample surface on a micro-channel plate, which is critical for avoiding micron-sized particulate contaminants (a potentially serious problem for oxygen). The projection system houses an ion

counter and Faraday cup for "normal" low-energy ion microprobe data acquisition. This also permits us to make good analyses of the absolute transmission of the tandem into various charge states as a function of input tuning, tandem voltage, stripper pressure, etc.

Initial Performance: We have made preliminary investigations of the ion imaging capabilities and the transmission and beam profile of the high energy mass spectrometer. The spatial resolution of an ion image, obtained on the Kore channel plate, is estimated to be better than 2 μm. One attempt to measure transmission has been performed thus far by setting the recombinator to pass only $^{28}Si^{-}$ to the accelerator. The intensity was measured by a Faraday cup inserted into the beam path just prior to the accelerator entrance and compared to the intensities detected for different charge states at the mass focus of the AMS beam line. For an accelerator terminal voltage of 0.95 MV and gas stripper pressure of 0.4 mTorr, we measured throughputs for $^{28}Si^{+}$, $^{28}Si^{2+}$, and $^{28}Si^{3+}$ to be 20%, 30%, and 10%, respectively. This distribution can be further optimized in terms of tuning both the mass spectrometer and stripping conditions. The peak shapes obtained indicate that it should be possible to achieve mass resolving powers > 300, which is consistent with design goals. Future work will concern measurement of the stabilitiy of the instrumental mass fractionation and optimization of transmission and molecular ion destruction.

References: [1] Burnett D.S. et al. (2003) *Spa. Sci. Rev.* ***105***, 509-534. [2] Nordholt J.E. et al. (2003) *Spa. Sci. Rev.* ***105***, 561-599. [3] Jurewicz A.J. et al. (2003) *Spa. Sci. Rev.* ***102***, 27-52.

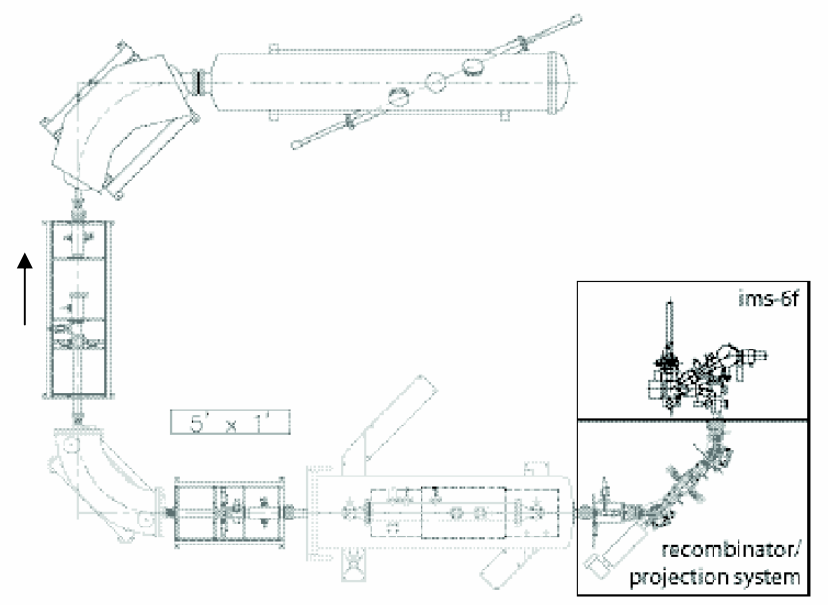

Figure 1. Layout of the UCLA MegaSIMS.