PRELIMINARY EVALUATION OF THE SECONDARY ION/ACCELERATOR MASS SPECTROMETER, MEGASIMS.

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Introduction: The GENESIS Discovery Mission [1] seeks to measure the average elemental and isotopic composition of the solar system to a precision and accuracy sufficient to address important questions in planetary science. In September, 2004, the GENESIS sample return capsule (SRC) returned to Earth with its payload of solar wind samples, captured in ultra-pure target materials. Due to an assembly error, the parachute on the sample return capsule never opened, causing the capsule to impact Earth at terminal velocity, ~300 km/h. Most of the target materials were broken and all of the science materials suffered some degree of surface contamination. Fortunately, however, both of the SiC concentrator targets, one of which we will request for oxygen and nitrogen analysis, returned fully intact [2].

The UCLA MegaSIMS (shown in Figure 1) consists of a secondary ion mass spectrometer (SIMS) front end coupled to an accelerator mass spectrometer (AMS) through a band-pass mass filter (recombinator). This instrument has been designed specifically to tackle the unique analytical challenges posed by the Genesis samples: dilute elemental concentrations, limited sample material, and close proximity of likely surface contamination to the implanted solar wind ions. The design criteria and overall instrument description were described in McKeegan et al., 2004 [3].

Construction and testing of MegaSIMS has progressed rapidly over the past year. We took delivery of the first major piece of equipment, the Cameca IMS-6f front-end in March, 2004. The National Electrostatics Corp. (NEC) AMS back-end was installed in May, 2004. The projection system, which replicates the ion-imaging capabilities of a full IMS-6f, was built to our design by Kore Technology Ltd. (UK) and delivered in August, 2004. The last major part of the instrument, the recombinator, was delivered by NEC in September, 2004. By the first week of November, we had confirmed the ion-imaging capability of the Kore projection system, and before the end of 2004, we had successfully detected an ion beam in the AMS detector chamber.

We describe here some of the preliminary tests we have made on the instrument, using the ^{28}Si beam from a Si wafer sample, and map out our plan for characterizing and calibrating the instrument in preparation for the analysis of one of the Genesis SiC concentrator samples.

Performance of MegaSIMS: Thus far, we have made preliminary analyses of the imaging performance of the projection system, the transmission through the AMS system, and the beam profile at the high-energy mass focal plane.

The imaging system consists of the IMS-6f, recombinator, and Kore projection system. A 25 µm pitch copper grid pressed into an aluminum substrate was used to confirm the direct imaging capability of ion microscope. Figure 2 shows the ion image obtained by the imaging system. We estimate the spatial resolution of the system to be better than 2 µm.

The transmission of the AMS system was evaluated using a silicon wafer sample. The operational vacuum pressure was 1×10^{-8} Torr in low- and high-energy section. Si^- ions were generated by sputtering the sample with 20 keV Cs^+ ions. The primary-ion beam position was located at the center of the optical gate by monitoring the $^{28}Si^-$ ion image. For this measurement, the recombinator was set up to only pass m = 28 amu, singly charged negative ions at E = 10 keV into the accelerator.

We measured the transmission by comparing ion current just before the accelerator to the current
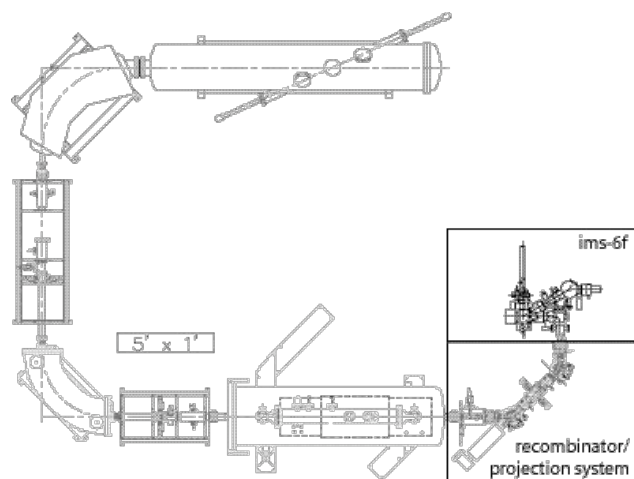

Fig. 1: layout of MegaSIMS. The Cameca IMS-6f and recombinator/projection system are indicated in the drawing; the remainder of the instrument is the AMS system.

detected at end of the AMS beamline. We adjusted the primary Cs^+ beam so that -1 nA of $^{28}Si^-$ entered the accelerator. The accelerator terminal voltage was set to 0.95 MeV and the gas stripper pressure was adjusted to 0.4 mTorr. For each of the final charge states, q = +1, +2 and +3, we adjusted the accelerator-entrance Einzel lens and the accelerator-exit quadrupole triplet to maximize the current at the mass focal plane. Under these preliminarily optimized conditions, we find the throughputs for $^{28}Si^+$, $^{28}Si^{2+}$, and $^{28}Si^{3+}$ to be 20, 30, and 10%, respectively.

The mass spectrum around m=28 amu (Figure 3) was obtained under the same analytical conditions as described above. The estimated peak width at 10% height (ΔM) is ~0.3 amu, giving a mass resolution ($M/\Delta M$) of ~100 under these conditions. Because the mass resolution is determined by the diameter of the detector, we determined the beam shape by differentiating the mass spectrum curve. Figure 4 shows the beam shape in mass dispersion space. The estimated peak width at 10% height is ~0.1 amu, giving a mass resolution of ~300 under these conditions. Note that these measurements have been made with the instrument tuned for maximum transmission, not optimal mass resolution.

Future Trends: Thus far, we have confirmed the proper alignment and working-order of the major devices making up MegaSIMS and we have made some preliminary measurements on ^{28}Si. Some work still remains before we are able to request GENESIS samples for analysis. In the first quarter of 2005, we will test the mass filtering and beam recombination capabilities of the recombinator. In conjunction with the detectors located in the projection system, we will be able to measure mass fractionation effects of the AMS system. After those tests are complete, we will measure the accelerator's efficiency to eliminate OH from the analytical beam (as a function of stripper pressure) and calibrate the instrument with an isotopically spiked SiC/O multilayered standard designed to mimic the GENESIS concentrator samples.

References: [1] Burnett D.S. et al., (2003) *Spa. Sci. Rev.* 105: 509-534. [2] Wiens R. C. et al., (2004) *EOS Trans. Am. Geophys. U.* 85: 497-498. [3] McKeegan et al., (2004) LPSC 35 : #2000.
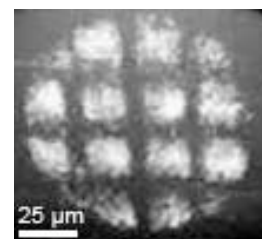

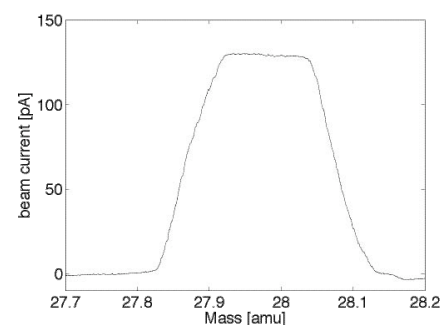Fig 2: Ion-microscope image obtained on a channel-plate detector at the low-energy image projection plane.
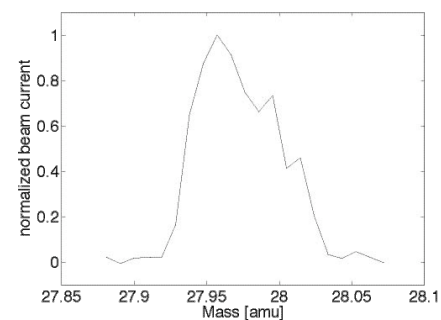

Fig 3: Mass spectrum at m=28 amu.

Fig 4: Beam shape of 1 MeV $^{28}Si^+$ ion beam calculated from the edge profiles of the mass spectrum in Fig 3.