

SOLAR WIND CALCIUM AND CHROMIUM IN GENESIS BULK SILICON COLLECTOR: SIMULTANEOUS MEASUREMENTS BY RIMS. I. V. Veryovkin,¹ C. E. Tripa,¹ A. V. Zinovev,¹ M. J. Pellin,¹ and D. S. Burnett², ¹Materials Science Division, Argonne National Laboratory, 9700 S. Cass Ave., Argonne, IL 60439 (contact: verigo@anl.gov), ²Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125.

The Genesis Discovery mission has delivered samples of the Solar Wind (SW) for analysis of isotopic and elemental compositions using the most advanced analytical techniques available in laboratories on Earth. In our lab at Argonne National Laboratory, we are performing measurements of metallic elements in the Genesis SW collectors using the Resonance Ionization Mass Spectrometry (RIMS) method, which is capable of detecting these elements at low concentrations expected to be in the range from above one part per million ($>10^{-6}$) to below one part per trillion ($<10^{-12}$). In this work, we report first results of simultaneous RIMS measurements of Ca and Cr performed on a piece from a bulk Si Genesis collector. The motivation of these experiments is two fold: (1) to compare RIMS results on Ca and Cr to previously reported SIMS data [1], and (2) to improve accuracy of comparison between RIMS data as new elemental fluencies are measured.

At LPSC 2008 we reported the following preliminary data of fluencies for SW Ca measured by RIMS: 4.79×10^{11} and 3.55×10^{11} at/cm² [2]. These numbers were about factor of three higher than the value of 1.33×10^{11} at/cm² expected after 852.83 days of SW collection. During the year 2008, we thoroughly examined our experimental procedures and introduced many changes aiming at improving reproducibility and accuracy. The key changes were: (1) development and tests of new resonance ionization (RIS) schemes permitting simultaneous measurements for two (and possibly more) elements, (2) performing RIMS sputter depth profiling on a standard reference material (SRM) and on a Genesis sample on the same day, in order to assure close to identical photo-ionization efficiencies, and (3) performing these measurements on analysis spots with identical coordinates (for both the SRM and Genesis) in order to cancel artifacts originating from changes in instrumental transmission and to eliminate many data processing steps that potentially could introduce systematic errors.

A new RIS scheme combined the same wavelength for the resonance step of Ca (422.79 nm), reported at LPSC 2008 [2], with the resonance step for Cr (360.53 nm) acting as the ionization color for both elements. This combination allowed us to perform simultaneous RIMS measurements of two elements with only two

tunable Ti-Sapphire lasers. In order to enhance the ionization transitions for both elements, we overlapped these beams with that from one non-tunable high intensity 355 nm laser (3rd harmonic of YAG). This resulted in about factor of four signal increase.

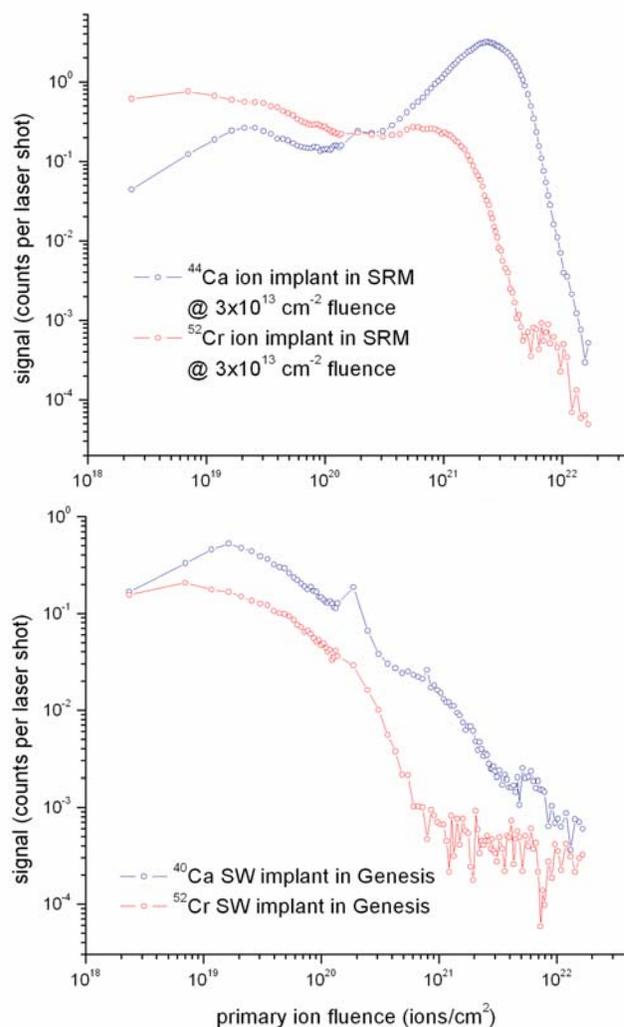


Figure 1. Sputter depth profiles of Ca and Cr measured with RIMS. Top – L52 standard (Si implanted with ⁴⁴Ca and ⁵²Cr). Bottom – Genesis bulk Si 60179.

Figure 1 displays results of background-subtracted RIMS measurements of one set of experiments. Both RIMS signal and the SIMS background were measured simultaneously in the same experiment. Limits of

depth profile integration were chosen assuming that the first peak (to the left) corresponds to surface contamination.

The advantage of the new experimental scheme is that the photo-ionization volume during one day is the same for both elements. Moreover, because of the same instrumental transmission, we can now determine elemental fluences by a direct comparison between areas under the depth profile curves for the standard and for the Genesis sample, while the range of integration is set the same for Ca and Cr, with no extra normalization steps involved. Despite the coordinates of analysis spots on these two days were very different, causing some 30% change in the instrumental transmission, the ratios between Ca and Cr fluences appeared to be about the same: 0.29 for the first set versus 0.30 for a second set. According to the reference fluence number we have for the standard, (3×10^{13} at/cm² for both Ca and Cr), we obtained the following figures for SW fluences:

experiment	⁴⁰ Ca (at/cm ²)	⁵² Cr (at/cm ²)
#1	1.19×10^{11}	4.09×10^{11}
#2	1.39×10^{11}	4.66×10^{11}

Thus, implementing the new experimental scheme resulted in a significant correction of the RIMS data for SW ⁴⁰Ca, making them agree better with those obtained by SIMS in Ref.[1]. However, the figures we obtained for ⁵²Cr appear almost a factor of ten higher than expected (2.95×10^{10} for Cr after 852.83 days of SW collection). In order to better understand this discrepancy for Cr, we have to verify the Cr fluence in the standard by separate measurements and to re-evaluate sources of possible Cr contamination in the vacuum chamber of our RIMS instrument that could cause high blank values for this element. Another possible explanation for this discrepancy can be insufficient discrimination between the surface contamination and the ultra-shallow SW implant. To address this problem, we are presently implementing a new high current ion source to enable more efficient surface cleaning with ultra-low energy Ar⁺ ion beam (100-500 eV). This low energy ion mill can work in combination with the presently used in our instrument 10-15 keV analytical ion gun in a dual beam depth profiling regime. We expect that this way of operation will significantly enhance our ability to distinguish between surface contamination and SW implants.

Moreover, once the ion mill is operational, it will be possible to use it in combination with the laser desorption analytical probe, which should improve precision of RIMS measurements at low concentrations.

References: [1] Burnett, D. S. et al. (2006) LPSC XXXVII #1843 [2] Veryovkin I. V. et al. (2008) LPSC XXXIX, #2396

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