PROGRESS TOWARD LOW-ENERGY GENESIS SIMULANTS. K. R. Kuhlman[1], A. J. G. Jurewicz[2], A. Grimberg[3], V. Heber[3], K. Sridharan[4], [1]Planetary Science Institute, 1700 East Fort Lowell Blvd., Suite 106, Tucson, AZ 85719, kim@psi.edu, [2]Arizona State University, Tempe, AZ, jurewicz@gps.caltech.edu ,[3]Institute of Isotope Geochemistry and Mineral Resources, ETH Zentrum CH 8092 Zürich, Switzerland, grimberg@erdw.ethz.ch, [4]Department of Engineering Physics, University of Wisconsin, 1500 Engineering Drive, Madison, WI 53706, kumar@engr.wisc.edu

Introduction: A suite of all of the Genesis array materials as well as flight-like silicon carbide, gold foil, and hardware constituents have been procured for implant in order to validate existing sample preparation and analysis techniques without destroying the precious Genesis samples. Linear particle accelerators cannot efficiently perform low energy implantations of light elements such as those found in the solar wind. These accelerators also require focusing using magnetic fields that can cause the ions to be implanted non-normal to the surface. In contrast, Plasma Source Ion Implantation (PSII) will gaseous light-elements (1keV/amu $\leq$10keV) at approximately solar wind energies, ~1 kV/q/amu [2], and low fluences normal to the surface of the stimulant. He has been implanted successfully at 4keV. Our current efforts are to extend the ability of PSII to implant low fluences accurately for elements where 1keV/amu is 20keV or greater. At these higher energies, generating a low fluence at a single energy requires modulation of the ramp-up of energy in the plasma. Isotopically-pure gases of ^{3}He and ^{15}N have been purchased, and non-atmospheric isotopic ratios of other gases can also be used for implant. Currently, the implants are being used to support the Genesis Early Science Return effort, but these reference materials will eventually be made available to general researchers through allocation by Genesis Curation.

Implanted Solar Wind Depth Profiles: Solar wind ions have ranges in materials on the order of 10 to a few hundred nanometers. In the case of $^{4}He^{+}$ in minerals, the mean range is about 25 nm [1]. While secondary ion mass spectroscopy (SIMS) and step-wise heating provide valuable data on total elemental abundances and isotopic ratios, depth profiles are needed to characterize elemental and isotopic fractionations, a scientific goal of Genesis. Depth profiles at the scale of tens of nanometers are extremely difficult to measure at present and are typically simulated using the code, the Stopping and Range of Ions in Matter (SRIM) [1]. Radiation damage and diffusion effects complicate the interpretation of depth profile.

Solar Wind Simulation Using Plasma Source Ion Implantation: In order to validate existing sample preparation and analysis techniques without destroying the precious Genesis samples, it is desirable to test these techniques using samples that have been fabricated in the laboratory. Linear particle accelerators cannot efficiently perform low energy implantations of light elements such as those found in the solar wind. These accelerators also require focusing using magnetic fields that can cause the ions to be implanted non-normal to the surface. PSII is capable of implanting these elements at solar wind energies, approximately 1 keV/amu, and normal to the materials surface [2].

Plasma source ion implantation (PSII) is a non-line of sight technique for the surface modification of materials [3]. The target -- in this case a large silicon wafer with polished wafered samples secured to the top surface using carbon tape or carbon paint -- is placed in a 1 m^3 chamber which is evacuated to a base pressure of about 10^{-6} torr. Gas of the species to be implanted (e.g. ^{3}He, ^{4}He, $^{14}N_2$, $^{15}N_2$, $^{16}O_2$ etc.) is allowed to flow through the chamber at a pressure of several millitorr. A plasma is generated using tungsten filaments to ionize the gas by energetic primary electron impact.

A series of negative high voltage pulses are applied to the target, and the resulting electric field accelerates the ions in the plasma to high energies normal to the surface of the target (Figure 1) [4]. In the case of a wafer, significant asymmetries can occur at the edges where the electric field is changing rapidly. In previous work, the samples were placed away from the edges of the large wafer in order to achieve a uniform implantation.

In the current work, edge effects have been seen around the edge of the substrate wafer (Figure 2), and step are being taken to quantify the implantation gradients across this substrate. Control of the implanted fluence has been complicated for implantation energies at and above about 20 keV due to the time required to ramp up the pulse generator to the higher voltages required. New methods for achieving the ramp-up in a considerably shorter time are currently being developed.

Benefits to the Genesis Community: The main benefit of using PSII to fabricate Genesis sample simulants is that the samples will be very similar to those to be returned by the Genesis mission in 2004. These samples are needed by investigators to validate and improve sample preparation and analysis techniques such as secondary ion mass spectroscopy (SIMS), gas source mass spectrometry (GSMS), resonance ionization mass spectrometry (RIMS), and radiochemical neutron activation analysis (RNAA) [7]. A catalog of materials implanted to date and those planned will be presented at this conference.

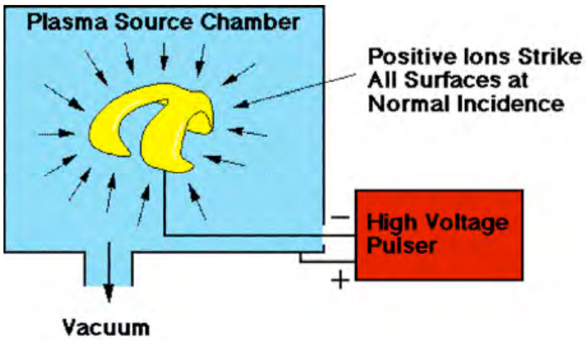

Figure 1. Schematic diagram of the Plasma Source Ion Implantation (PSII) process (showing the implantation of an artificial knee component) [4].

Acknowledgements: This work was sponsored by the NASA Office of Space Science Sample Return Laboratory Instrument and Data Analysis Program and was carried out in part at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration. Additional work was carried out at the University of Wisconsin.

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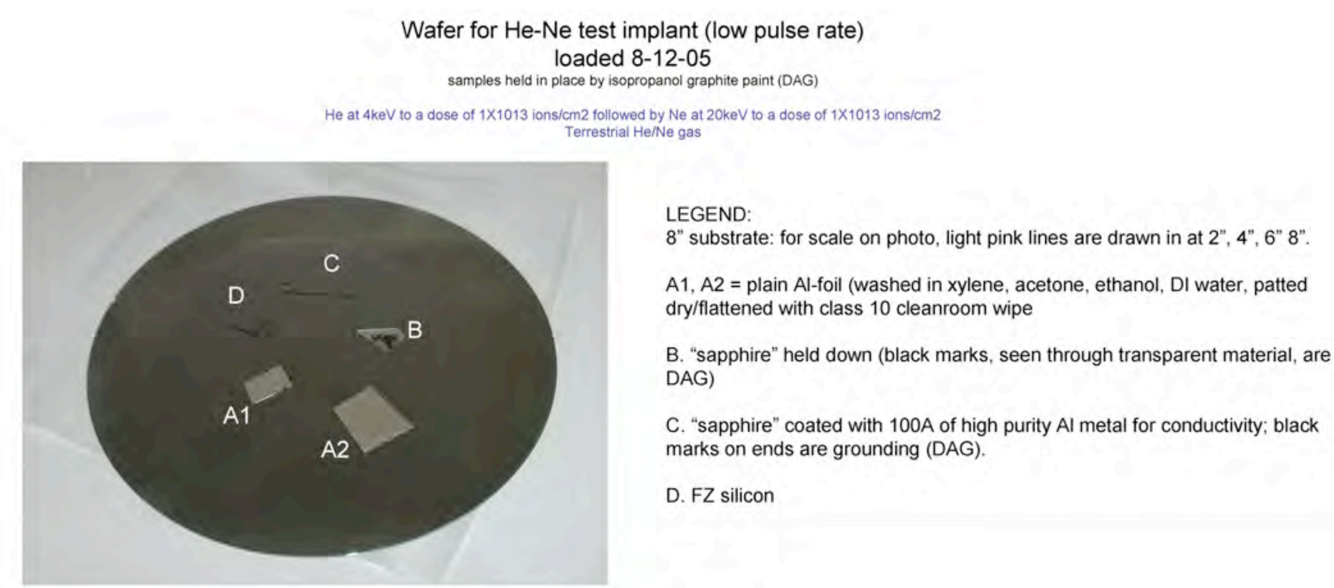

Figure 2. Example substrate wafer holding 5 samples of Genesis material that have been implanted with ^{4}He and ^{20}Ne.