ISOTOPIC COMPOSITION AND TRACE ELEMENT ABUNDANCES OF A PRESOLAR SIC AB GRAIN RECONSTRUCTED BY ATOM-PROBE TOMOGRAPHY.

J. B. Lewis[1], D. Isheim[2], C. Floss[1], E. Groopman[1], F. Gyngard[1], D. N. Seidman[2]. [1]Laboratory for Space Sciences, Physics Dept., Washington University, St. Louis, MO 63130, USA. Email: jblewis@go.wustl.edu. [2]Center for Atom-Probe Tomography, Dept. of Materials Science & Engineering, Northwestern University, Evanston, IL 60208, USA.

Introduction: Presolar SiC grains often contain subgrains of distinct phases, as well as sub-100 nm variations in trace element abundances [1–3]. With atom-probe tomography (APT) and its inherent sub-nm spatial resolution [4], we can characterize these features in order to understand the underlying stellar processes responsible for their presence. Below we discuss the results of APT measurements on a presolar SiC AB grain previously characterized by NanoSIMS.

Experimental: APT captures time-of-flight information from ions that are field-evaporated using laser-induced thermal pulsing at high voltage from a <100 nm radius needle-shaped sample. The resulting data can be reconstructed in three dimensions (3D) with sub-nm spatial resolution by treating the sample tip as a point projection microscope. We attached 2–3 µm diameter presolar SiC grains from the Murchison KJGN size fraction (1.5–3.0 µm; [5]) to Si microposts and sharpened them by focused ion beam milling. Eight samples were subsequently analyzed with the Local Electrode Atom Probe at Northwestern University, three of which generated statistically meaningful data. Here we focus on the results for grain KJGN6 380-5, an AB grain, with $^{12}C/^{13}C = 4.19 \pm 0.03$, $\delta^{29}Si = 73 \pm 13$ ‰, and $\delta^{30}Si = 78 \pm 12$ ‰.

Results and Discussion: With the atom-probe we detected 2.6 million ions from grain KJGN6 380-5, with strong signals from $^{28,29,30}Si$ and $^{12,13}C$. The measured C and Si isotopic compositions are consistent with the NanoSIMS results:

$$^{12}C^{+}/^{13}C^{+} = 4.16 \pm 0.06 \qquad ^{12}C^{++}/^{13}C^{++} = 3.77 \pm 0.05$$

$$\delta^{29}Si = 50 \pm 20 \text{‰}, \quad \delta^{30}Si = 120 \pm 10 \text{‰}$$

The Si/C ratio is ~1.2, suggesting minor loss of C relative to Si; this may be due to field evaporation of multiple C ions in the same laser pulse [e.g., 6].

The trace elements N, Al and Ti are relatively abundant with N = 4,460 ± 70 at. ppm, Al = 10,300 ± 200 at. ppm, and Ti = 2,700 ± 200 at. ppm; they are distributed homogeneously throughout the grain, with no evidence for discrete subgrains of AlN or TiC. A ~2 nm-wide planar band runs through the grain, compositionally indistinguishable from its surroundings, but visible in 3D elemental reconstructions of Al, N, Si, and C. This feature may represent a structural discontinuity such as a grain boundary or planar defect; however, it lacks the associated compositional variation observed by [7].

No significant O, Ca, S, V, Zr, Mo, or Ba are present in the ~40,000 nm^3 volume analyzed. For s-process elements such as Zr, Mo, and Ba, which are diagnostic of a post-AGB vs. a J-star origin [8], our detection limit lies between 10 and 100 at. ppm, too low to provide meaningful distinctions between astrophysical models of possible parent stars.

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