INTERSTELLAR MATTER IMPLANTED IN PRESOLAR SIC GRAINS. T. Henkel[1], A. King[1] and I. Lyon[1], [1]School of Earth, Atmospheric and Environmental Sciences, The University of Manchester, Oxford Road, Manchester, M13 9PL, UK (torsten.henkel@manchester.ac.uk, ian.lyon@manchester.ac.uk).

Introduction: Presolar silicon carbide grains are stardust from various stellar sources including Red Giants, AGB-stars, Supernovae, and Novae and are therefore ideal to study all different kinds of stars in detail with high precision in the laboratory [1]. These grains are identified by their isotope ratios which differ significantly from solar values so that they can only be explained as direct condensates from their stellar sources. Recently, some studies [2-5] have shown evidence for implantation of interstellar material in the outer layers of these grains. This is evident from depth profiles of Li and B [2,3] and noble gas measurements of size separated samples [4,5]. The implantation depths seem to be a few hundred nanometers suggesting supernovae shockwaves through interstellar gas clouds could have been the source for implantation for Li and B [3]. We analyzed four presolar silicon carbide grains from the KJG-fraction which have been extracted from the Murchison meteorite [6] to carry out systematic depth profiling (see also accompanying abstract [7]). We especially looked for evidence of implanted material in the outer layer in the major and minor elements trying to improve our data on implantation depths for better estimates of implantation energies.

Methods: The grains have been analyzed using our self-built time-of-flight secondary ion mass spectrometer IDLE [8,9] in a "delayed extraction" mode. In this mode the extraction voltage is switched on after the primary ion pulse hit the surface. The advantage is that longer primary ion pulses can be used leading to better lateral resolution and higher count rates. The drawback is that only a narrower region of the mass spectrum will show high mass resolution (m/dm ~3000 in a mass range from 20 to 40 amu) to resolve interferences from hydrides and oxides. The samples have been analyzed in a scanning mode rastering the primary ion beam over the sample with a field-of-view of 5 to 10 micrometers with 64 by 64 pixels. The whole raw data was recorded for offline analysis during which spectra can be restored from any region of interest excluding interferences from other areas than the grain itself. Elemental abundances have been calculated using relative sensitivity factors determined from very homogeneous standards [8,9].

Results: Two of the grains (STL2-M0 and STL2-D-grain1) have been depth profiled almost all the way through so that the last analysis is close to the other end of the grain which faced the gold foil on which the grains have been deposited. The other two grains (STL-D-grain2 and KJG-grain6) have been sputtered less than a quarter of their size and further analyses will be undertaken.

Grain STL2-M0. This grain shows depth profiles with a dip in the center for Li, B, Na, Mg, Al, and K. The elemental abundances in the center of the grains are around a factor of two lower than in an outer layer for Mg, Al and K. Na showed a depletion by a factor of around three and Li and B by a factor of four. There was no significant depletion for Ca, Ti, and Cr measurable in this grain.

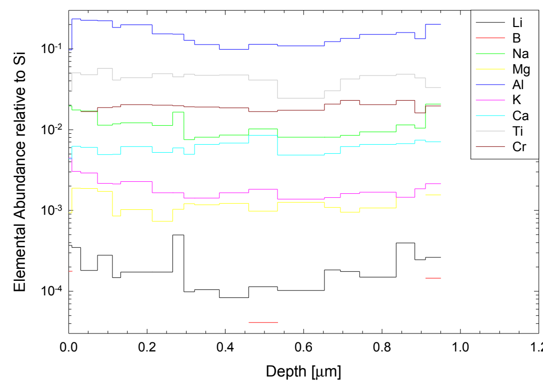

Figure 1: Depth profiles for grain STL2-M0. The width of the step corresponds to the sputtered depth of that particular measurement.

Grain STL2-D-grain1. This grain shows a more complex structure with very high abundances of almost all elements at the very surface of the grain which seem to be surface contamination as it disappears after the first measurement. Underneath this layer is another layer of around 50nm with a very high Li and Mg abundances accompanied by higher abundances for K and Cr when compared to the third layer from roughly 50 to 200nm into the grain where Al and Na show their highest abundances. Mg is depleted in this layer compared to the core and the outer layer. B shows the highest abundance in the inner parts below 50nm and is depleted in the outer layer.

Grain KJG-grain6. The reached sputter depth for this grain is around 225nm at this time and further measurements will be undertaken to record a complete depth profile of the grain. The grain is quite unusual because of a very high Al abundance within the so far analyzed part. A discontinuity at around 50nm depth correlates with the recording of an SEM-image for which the grain was taken out of the IDLE instrument.

Grain STL2-D-grain2. Similar to the previous grain, more analyses needs to be done and will be presented at the conference.

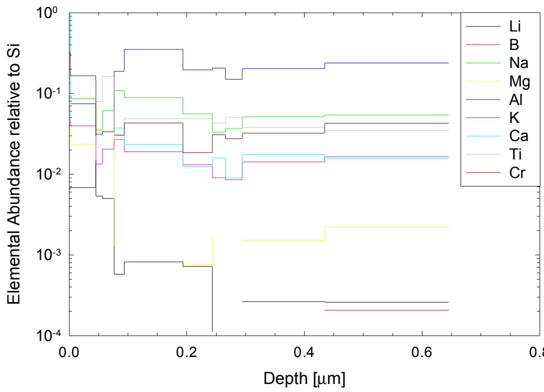

Figure 2: Depth profiles for grain STL2-D-grain1.

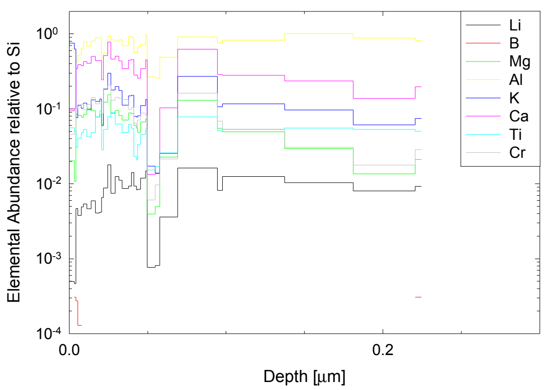

Figure 3: Depth profiles for grain KJG-grain6.

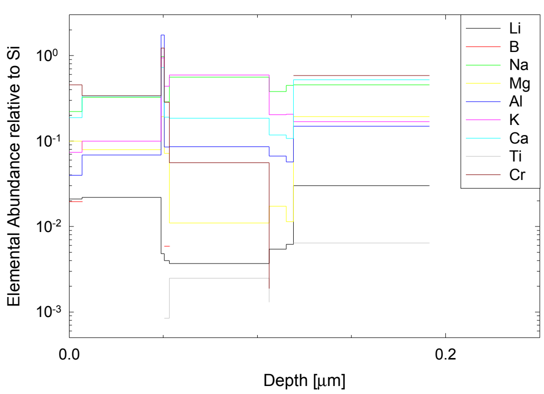

Figure 4: Depth profiles for grain STL-D-grain2.

Discussion: High minor and trace element abundance in the outer layer will contribute a spuriously large signal of those elements during sputtering (see discussion in [7]). In such a situation the maximum width of the outer layer can be estimated with a simple model assuming the core abundance of this element is zero.

The estimations from the abundance ratios between the outer layer (first measurements) and the core (middle measurement) for grain STL2-M0 leads to widths of the outer layer between 140 and 300nm with a grain size of 2µm. This agrees with estimated implantation depths from previously measured grains [3] although the differences in abundance between the outer layer and the core are much smaller. This can be understood when taking into account the smaller size of this grain.

Grain STL2-D-grain1 seems to have a very thin contamination layer which was sputtered away during the first measurement. It must have been smaller than a few nanometers and is probably from redeposition of sputtered material from other analyzed, nearby grains. The second layer and third layer are more puzzling with the second one especially enriched in Li and Mg and the third one especially enriched in Na and Al. These layers might present two different implantation events with different energies happening at different times and/or places so that different elements have been implanted.

These newly determined depth profiles corroborate our previous results showing implantation of interstellar material into stellar dust opening a new possibility to study the interstellar medium.

One still has to bear in mind that the grains from this study are from an acid extraction process which might have removed or altered the outer layer of the grain [10]. The surface from which the depth profile starts might therefore not be the very surface of the grain. To address the aspects of this issue, detailed depth-profiling analyses of gentle separated grains [11] are planned for comparison with these results.

References: [1] Bernatowicz T. J. and Zinner E. K. (1997) *Astrophysical implications of the laboratory study of presolar materials*, AIP. [2] Lyon I. et al. (2006) *LPS XXXVII*, #1750. [3] Lyon I. C. et al. (2007) *Meteoritics & Planet. Sci.,* in print. [4] Verchovsky A. B., Wright I. P. and Pillinger C. (2004) *APJ, 607,* 611-619. [5] Verchovsky A. B. et al. (2001) *Nucl. Phys. A, 688,* 106c-109c. [6] Amari, S., Lewis R.S., and Anders E. (1994) *Geochimica et Cosmochimica Acta, 58,* 459-470. [7] King A. et al., submitted LPSC XXXVIII [8] Henkel T. et al. (2006) *Applied Surface Sci., 252,*. 7117-7119. [9] Henkel T. et al. (2006) *Review of Sci. Inst., submitted*. [10] Henkel T. et al. (2006) *Meteoritics and Planet. Sci., submitted*. [11] Tizard J., Lyon I. and Henkel T. (2005) *Meteoritics & Planet. Sci., 40,* 335-342.

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