DECONVOLUTING TOFSIMS DEPTH PROFILES OF PRESOLAR SIC-GRAINS. T. Henkel[1], A. Sattaur[1] and I. C. Lyon[1], [1]The University of Manchester, School of Earth, Atmospheric and Environmental Sciences, Oxford Road, Manchester, M13 9PL, UK (e-mail: torsten.henkel@manchester.ac.uk).

Introduction: The origin and formation of presolar SiC grains is studied using their isotopic and trace elemental compositions. The analysis of isotopic ratios is used to determine their stellar origin and test stellar models [e.g.1,2] whereas elemental abundances help to understand condensation conditions [3].

Over recent years it has become clear that presolar grains can be affected by the harsh acid treatment used during the extraction from their host meteorites [4,5]. They also show signs of implanted material from Supernova shockwaves. Verchovsky et al. explained measured noble gas isotope ratios with shockwave implantation in the interstellar medium [6]. Lyon et al. found elevated concentrations of Li and B in the outer layers of some grains which were interpreted as Supernova shockwave implantation [7].

For a better understanding of the processes which affect the grains during their travel from their stellar origin to their incorporation into our Solar System, it is necessary to gain a complete analysis of the three-dimensional distributions of all elements and isotopes within the grain. A step towards this goal are analyses undertaken by King et al. [8] who used a time-of-flight secondary ion mass spectrometer (TOFSIMS) to gain full mass spectra for each layer sputtered away.

TOFSIMS has the advantage of recording complete mass spectra with sub-micrometre spatial resolution. Each measurement only consumes a few atomic layers resulting in depth resolutions of several nanometers. Even though the spatial resolution is not quite good enough to resolve the grain interior, the very high depth resolution allows the deconvolution of the interior structure.

Fast ion sputtering is a preferential process and the sputter rate not only depends on the material which is sputtered but also on the angle of incidence between the ion beam and the sample surface. The first is not problematic as the grains consist of mainly SiC throughout so sputter rates do not change during analysis. However, the three-dimensional nature of the grains results in changing angle of incidents and therefore changes in the sputter rates from the centre to the rim of the grains which means depth profiles are not flat sections through the grains.

To understand the depth profiles of presolar SiC grains and be able to interpret the measured depth profiles we ran simulations of the sputtering process for an individual grains of various shapes and sizes.

Experimental: The simulation consists of a virtual SiC grain which is made up of several spheres to build an irregular shape. Two trace elements with Gaussian distributions with a given width and depth below the surface were included in the model to simulate implantation. Their depth profiles were recorded whilst the grain was sputtered away. The simulation takes into account the different angles of the primary and secondary ion beams and does not count secondary ions which are blocked by the grain itself.

Setting the depth of the implantation layer to zero and the width to its minimum simulates surface contamination on the grain. Variations for the depth and width of the implanted elements simulate different average velocities and different velocity distributions respectively.

Results: Figure 1 shows a comparison of shallow and deeply implanted profiles together with a surface profile. The latter is exaggerated for easier plotting and comparison.

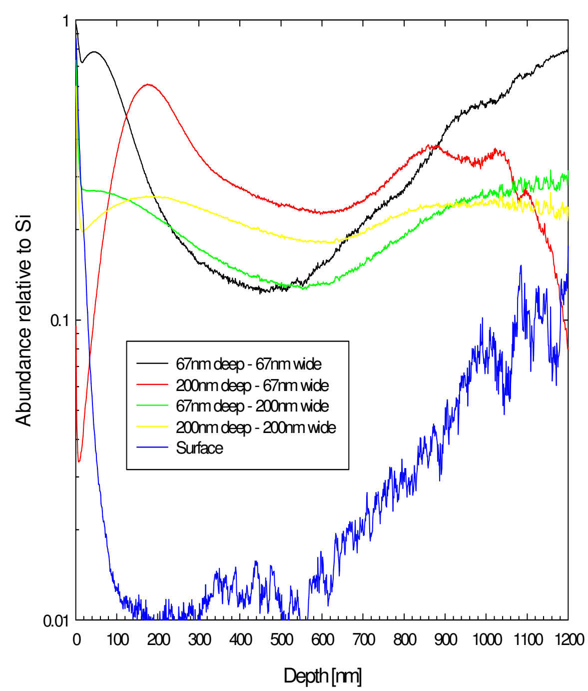

Figure 1 Comparison of implanted and surface profiles from the sputter simulation.

The depth profile for surface contamination is very asymmetrical as would be expected. Around half the surface of the grain is exposed to the incident beam which means most of the surface contamination is sputtered away at the very beginning of any measurement resulting in very high abundances which quickly drops. Further sputtering slowly exposes the backside of the grain leading to a slow increase in surface contamination abundances.

Deeper implanted material shows a much shallower profile depending on the implantation width and depth. In general, the wider the distribution the more symmetrical and shallower the profile. Narrow distributions lead to asymmetrical profiles which decrease quicker in the first half than the increase in the second half. This effect can be explained similarly to the surface contamination profile because the "front" part of the implanted material is reached at similar times whereas part of the "back" half is already gone by the time the ion beam is sputtering through the centre. Shallow implantation results in U-shaped depth profiles which changes into more M-shaped profiles for deeper implantation

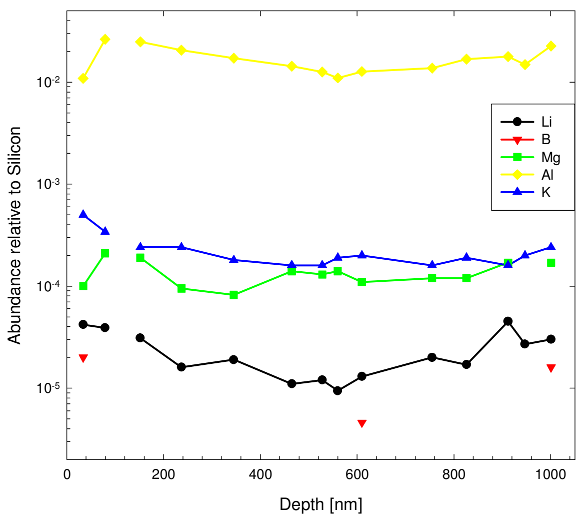

Figure 2 Depth profiles for Li, B, Mg, Al and K for grain KJG-M-1 from King et al.[8].

Figures 2 and 3 show depth profiles for selected elements from two grains from King et al. [8]. The first grain in figure 2 show a shallow and symmetrical depth profile as would be expected from a wider implantation distribution. The second grain in figure 3 possibly shows a narrow distribution. The grain was not completely sputtered away during analysis and therefore the depth profile does not show the typical increase towards the end.

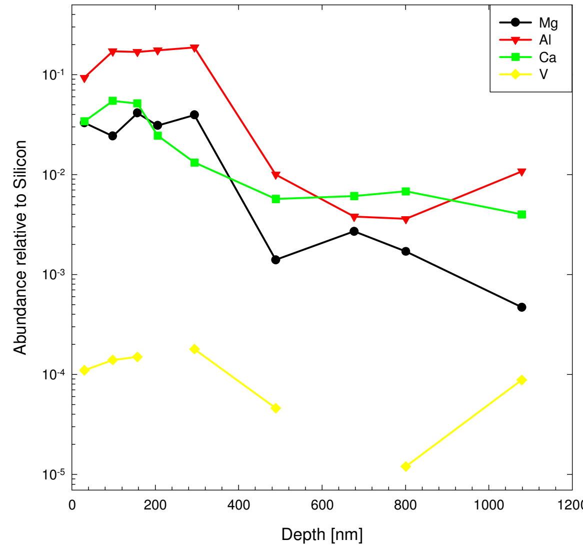

Figure 3 Depth profiles for Mg, Al, Ca and V for grain MM2-Delta-2 from King et al. [8].

Discussion: Interpretation of depth profiles is made more complicated by the fact that shockwaves in the interstellar medium (ISM) not only implant material into stellar grains but also sputter the outer layers of these grains. It is therefore difficult if not impossible to decide if a U-shaped profile is due to a shallow implantation depth or if the lower outer parts have been sputtered away in the ISM and an original M-shaped profile turned into an U-shaped profile. A helpful hint would be an asymmetrical profile which could be used to judge the width of the original distribution but extimates for the shockwave speed will usually be lower limits.

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