Very high spatial resolution isotope and elemental imaging of pre-solar SiC grains: topographic and imaging artefacts that may lead to apparent, but spurious, heterogeneity within grains.

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Introduction: Over 17,000 presolar SiC grains have been studied to date [1] but very few have been studied with very high spatial resolution analysis to determine whether there is isotopic or elemental heterogeneity within the grains. In this study we analysed 55 SiC grains separated by the acid-residue technique of Amari et al., [2] and 64 discovered in-situ in polished sections of the meteorites Acfer094 and GRA95229.

The grains ranging in size from ~100nm to 1.5µm were analysed using the University of Manchester's NanoSIMS 50L for $^{12,13}C$, $^{12}C^{14}N$, $^{12}C^{15}N$ and $^{28,29,30}Si$, all analysed as negative secondary ions formed by a Cs^+ primary ion beam of ~0.5pA using aperture D1-5 to give a primary ion beam spot size ~100nm. Extensive analysis was performed on each one to depth profile and image isotopic and elemental compositions.

Results

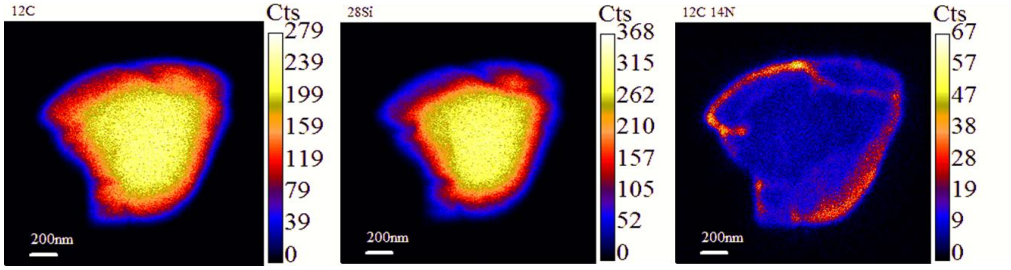

Figure 1. Acquired secondary ion images of a mainstream SiC grain showing an apparent enrichment of $^{12}C^{14}N^-$ in the outer layers of the grain.

A highly heterogeneous distribution of secondary ion species, especially of CN^- was noted in numerous analysed grains which raises the question of whether such distributions are real or an artefact. Secondary ion extraction in the NanoSIMS was modelled using the SIMION 8 ion optic programme [3] from samples with topographic relief. The modelling shows that low energy molecular secondary ions may be focusing differently within the NanoSIMS compared with higher energy atomic ions and thus potentially giving rise to apparent differences in distribution between different species. This is demonstrated by an apparent change in $^{12}C^{14}N^-$ image with deflection across the mass spectrometer entrance slit (Cy) for a SiC grain with topographic relief.

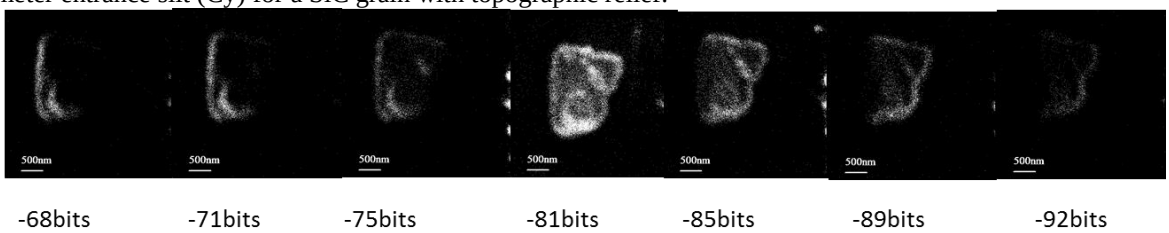

Figure 2. Changes in the acquired $^{12}C^{14}N^-$ image of a SiC grain as a function of deflector plate Cy.

Studies are underway to image other sputtered species such as C_2^- to better understand how secondary ion imaging of samples such as presolar grains may be affected by sample topography. Further SIMION modelling demonstrates that redeposition of sputtered species both by line-of-sight impact and reimplantation of sputtered species of the opposite polarity to the sample voltage may also lead to artefacts that distort the true elemental and isotopic distributions within samples with topographic relief.

Conclusion. The apparent distribution of sputtered secondary ion species during secondary ion mass spectrometry from samples with topographic relief may result from artefacts in the way that secondary species are sputtered rather than representing the true distribution of species within the sample.

References: [1] Hynes K. M. and Gyngard F. 2009. Abstract #1198. 40th Lunar & Planetary Science Conference. [2] Amari S. et al. 1994. *Geochimica et Cosmochimica Acta* 58:459-470 [3] SIMION 8.0 Scientific Instrument Services, Inc. 1027 Old York Rd., Ringoes, NJ 08551-1054