ISOTOPIC AND STRUCTURAL INVESTIGATION OF PRESOLAR SiC GRAINS OF SUPERNOVA ORIGIN. J. Kodolányi[1], P. Hoppe[1], C. Vollmer[2] and M. Müller[3], [1]Max Planck Institute for Chemistry, Hahn-Meitner-Weg 1, 55128 Mainz, Germany (j.kodolanyi@mpic.de), [2]University of Münster, Institute for Mineralogy, Corrensstr. 24, 48149 Münster, Germany, [3]Max Planck Institute for Polymer Research, Ackermannweg 10, 55128 Mainz, Germany.

Introduction: Isotopically anomalous SiC grains were among the first phases identified as presolar in primitive Solar System materials (see [1] for a historical review). The wealth of knowledge collected in the past three decades about and from the isotope composition of presolar SiC grains has been complemented by research on the grains' internal structure and chemical composition [e.g., 2,3]. Nevertheless, there have been few studies on SiC which linked isotopy with structural information [e.g., 4]. Such attempts are especially important in the research of supernova (SN) derived SiC grains because such grains were suggested to carry the isotopic signatures of different zones of their parent stars [e.g., 5], and may record a busy history of chemical fractionation, grain condensation and grain growth in SN ejecta. Previous attempts to obtain structural data on presolar SiC grains of SN origin are scarce [4,6] and in only two instances has an attempt been made to obtain meaningful isotope data on SiC grains of SN origin after a TEM investigation [6]. The aim of our study is to further improve our understanding of SiC condensation and growth in SN ejecta, by linking structural and isotope data on SN derived SiC grains.

Procedure and analytical methods: We have been searching for SN grains in an SiC grain separate of the Murchison meteorite produced in our lab. The grain separate is suspended in a water-isopropanol mixture. SiC grain mounts for the analysis of individual grains were produced by dropping 6-7 µl of this liquid on Au foils mounted on Al stubs. Based on their isotope composition there are two types of presolar SiC which condensed in SN ejecta: X and C (sometimes also referred to as U) grains (e.g., [1,7]). To find such grains on the mounts, we measured the C and Si isotope composition of thousands of individual SiC grains with the NanoSIMS 50 of the Max Planck Institute for Chemistry (1 pA Cs^+ primary beam of ~100 nm diameter). First pre-selected areas of the grain mounts were mapped to find ^{28}Si hot-spots (which are thought to correspond to SiC grains). Then the C and Si isotope composition of the ^{28}Si hot spots was measured individually. The procedure from mapping to individual C and Si isotope analysis is fully automated and run by an in-house software. We used an artificial SiC standard with known Si and C isotope composition to quantify the results of individual isotope analyses and to check whether all ^{28}Si hot spots are indeed SiC.

Three of the SN grains identified so far were subjected to further isotope analysis. In case of one grain, suspected to be of type C, we obtained N and S isotope compositions by measuring $^{12}C^{14}N^-$, $^{12}C^{15}N^-$, $^{28}Si^-$, $^{32}S^-$ and $^{34}S^-$ simultaneously (beam conditions same as for mapping). In case of the other two grains, N and Si isotope compositions were measured (analyzed ions: $^{12}C^{14}N^-$, $^{12}C^{15}N^-$, $^{28}Si^-$, $^{29}Si^-$ and $^{30}Si^-$; again, beam conditions were the same as those of mapping). For the quantification of N and S isotope measurements we used the same standard as for the C and Si isotope measurements (the standard had been doped with N and contains sufficient S contamination to correct for instrumental mass fractionation of ^{32}S and ^{34}S).

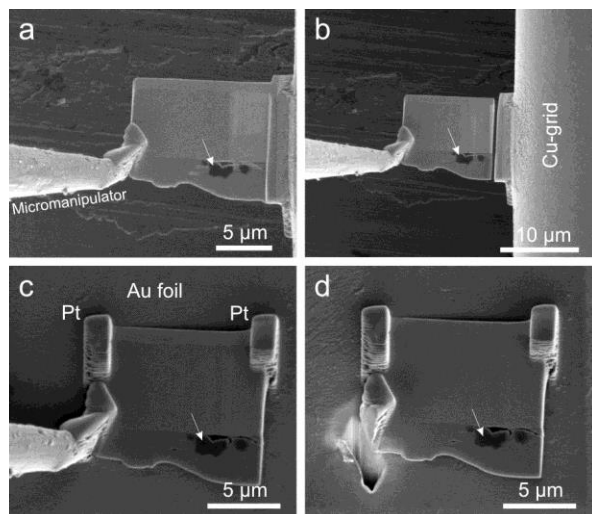

Figure 1. Re-mounting of the electron transparent slice of an SiC grain (white arrows in a-d) on an Au foil. First a micromanipulator is attached to the slice (a). After cut off the Cu grid (b), the slice is placed on the foil and fixed with Pt-patches ("Pt" in c). The micromanipulator is then detached from the slice (d). The SiC grain depicted is a test grain which most likely formed in the winds of an AGB star.

For structural analysis with TEM we select large (d > ~1 µm) SiC grains. Although this size restriction may make sampling of the SiC population less representative, large grains may have more internal structural and chemical features and are easier to separate from the Au foil for TEM analysis. Electron-transparent slices of such grains were prepared by a 0.050–20 nA focused Ga^+ ion beam (FIB) and mounted on a Cu grid with a micromanipulator, as has been done by [6]. The slices can be detached from the Cu grid after TEM analysis and re-mounted on Au foils (Fig. 1) if further isotope analyses are needed (slices on Cu grids cannot be analyzed in the NanoSIMS because the much faster sputtering rate of Au and Pt relative to that of SiC may cause the SiC grain to get lost already before analysis).

Progress and First Results: So far we have identified 31 SiC grains of likely SN origin. All but one have depletions in the heavy Si isotopes when compared to Solar System compositions (Fig. 2) and variable $^{12}C/^{13}C$ ratios. These grains can thus be classified as X grains. One of the SiC grains has an ~1.75 times larger $^{29}Si/^{28}Si$ ratio than the Solar System value and a moderately high $^{30}Si/^{28}Si$ ratio (~1.2 solar). This grain is also characterized by isotopically light C ($^{12}C/^{13}C$ = 132 ± 5) and S ($\delta^{34}S = -255 \pm 61$ ‰; $\delta^{34}S = 1000 \times [((^{34}S/^{32}S)_{grain}/(^{34}S/^{32}S)_{terrestrial})-1]$), and isotopically heavy N ($^{14}N/^{15}N$ = 15.4 ± 0.2). These isotope compositions resemble those of SiC grains of type C although most C grains show larger enrichments in ^{30}Si [7].

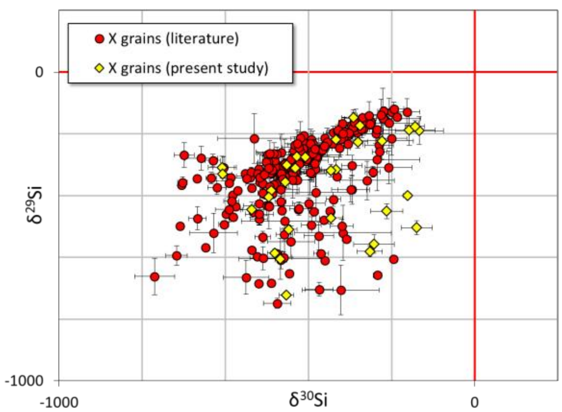

Figure 2. Si isotope composition of presolar SiC grains of type X from the literature [4,5,7-10] with the composition of X grains identified so far in our study. $\delta^{x}Si = 1000 \times [((^{x}Si/^{28}Si)_{grain}/(^{x}Si/^{28}S)_{Solar\ System})-1]$. The red lines represent the Solar System composition.

Only two of the identified SN grains are larger than 1 µm in diameter. One of these grains, 6_6_7-1, was successfully separated from the Au foil with the FIB and mounted on a Cu grid but unfortunately it broke off the Cu grid during transport before TEM analysis. The other grain, 9_GB_1_1-1 will be separated soon. This grain appears to have N rich but Si poor material attached to it. Some of the N-rich material has similar N (and Si) isotope composition as the SiC X grain so it is unlikely to be terrestrial contamination (Fig. 3).

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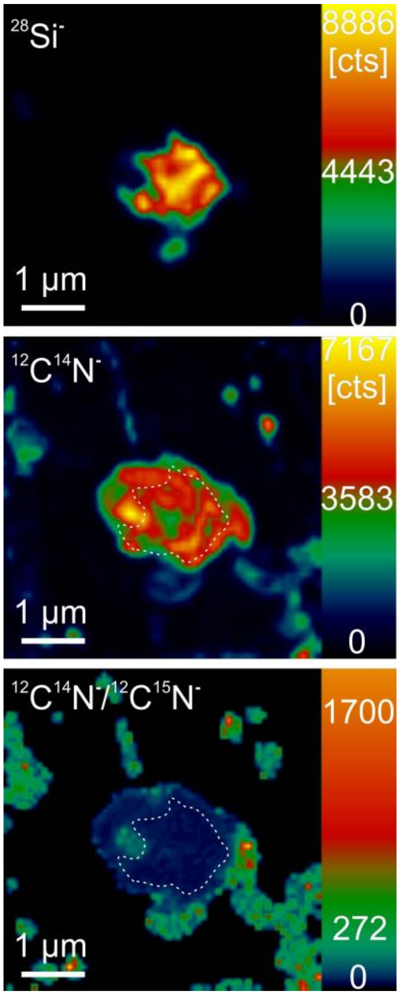

Figure 3. NanoSIMS ion– and ion-ratio maps of SiC X grain 9_GB_1_1-1. The SiC is characterized by high $^{28}Si^{-}$ intensity. The outline of the SiC is shown by short dashed curves in the two bottom panels. See text for possible interpretation.

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