A Search for presolar grains in the Murchison meteorite. B. Liebig and M. C. Liu, Institute of Astronomy and Astrophysics, Academia Sinica, No. 1, Sec. 4, Roosevelt Rd., Taipei 10617, Taiwan (bernd@asiaa.sinica.edu.tw).

Introduction: Presolar grains are condensates from the outflows or envelopes of evolved stars and thus preserve records of nuclear processes in their parent stars. Those grains survived the destructive processes in the interstellar medium and the early solar system before they were finally incorporated into primitive meteorites. They can be identified based on their isotopic compositions that largely deviate from the average solar ratios. Previous studies of presolar grains involved chemical dissolution of a bulk rock and isotope measurements of insoluble residues [1]. With NanoSIMS, it has become possible to look for presolar grains in situ, and this technique has led to new discoveries, such as presolar silicates from supernovae and AGB stars [2].

Here, we report the first results of the NanoSIMS 50L recently established at Academia Sinica. A search for presolar grains was conducted on a sample of the Murchison meteorite in order to find silicon carbide, graphite or oxide grains large enough for subsequent analysis of spallogenic products, such as Li-Be-B, to constrain the interstellar residence time of such particles.

Methodology: A 1 cm × 1 cm slab of the Murchison meteorite was pressed into an indium-filled aluminium disk. After polishing, the sample was coated with carbon and investigated in a field-emission SEM (JEOL JXA8500F) to obtain topographic information and identity of major phases. A Cameca NanoSIMS 50L was used to record isotope images of carbon ($^{12}C^-$, $^{13}C^-$), nitrogen ($^{12}C^{14}N^-$, $^{12}C^{15}N^-$), oxygen ($^{16}O^-$, $^{17}O^-$, $^{18}O^-$) and silicon ($^{28}Si^-$, $^{29}Si^-$, $^{30}Si^-$), as well as aluminium oxide ($^{27}Al^{16}O^-$). For this purpose, the carbon coating was removed by an intense Cs^+ beam of 100 pA in two strips 14 µm × 320 µm each, and 20 µm apart. The cleaned surface area was then investigated using a primary of 1.6 pA with a spatial resolution of 120 nm.

In a first experiment, the entire area was scanned in squares 10 µm by 10 µm while recording the signals of the carbon, nitrogen and silicon isotopes. By using the L'image analysis program (written by L. Nittler), grains with anomalous isotope ratios, i.e. isotope ratios deviating by more than four times the standard deviation (4σ) from their respective terrestrial or solar standard value, were identified and confirmed by subsequent measurements in a 3 µm × 3 µm square. In the second part of the experiment, the isotopic composition of oxygen was recorded for the previously identified grains, which were localised by their $^{12}C^-$, $^{12}C^{14}N^-$ and $^{28}Si^-$ signals.

Results: A total of 54 grains with anomalous isotopic composition were found in an area of 6300 µm^2. Three of these grains were identified as presolar SiC grains, due to their isotope ratio $^{12}C/^{28}Si$ close to 1. Those grains are characterised by light nitrogen ($^{14}N/^{15}N > 400$) (Figure 1). The isotope ratio $^{12}C/^{13}C$ is below the solar value of 89 for two grains, whereas one grain exhibits isotopically light carbon. We, therefore, suggest that these grains belong to the mainstream silicon carbide group, probably originating from an AGB or red giant star [3]. This assumption is supported by measurements of the silicon isotopes, which reveal slight excesses of both ^{29}Si and ^{30}Si up to 100 ‰ (figure 2). Subsequent measurements of the oxygen isotopes, shown in figure 3, found $^{17}O/^{16}O$ and $^{18}O/^{16}O$ ratios to be close to the solar value within the measuring error (1σ).

Two additional groups of grains were found, as in-

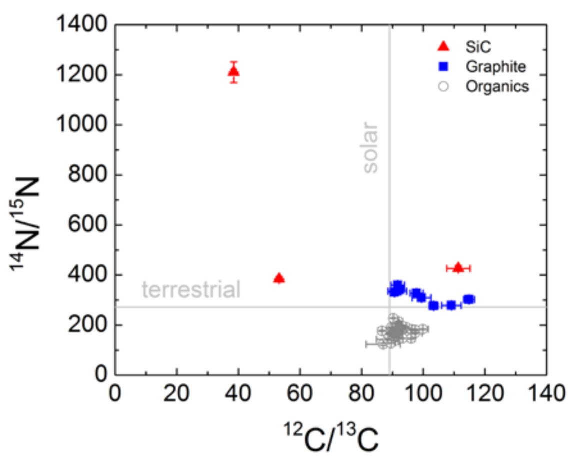

Figure 1: Nitrogen isotope ratio plotted over carbn isotope ratio.

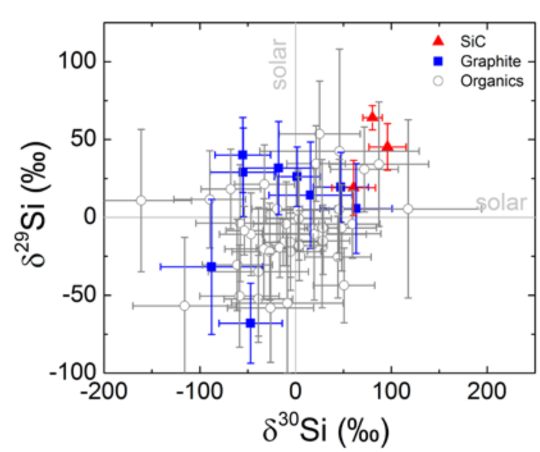

Figure 2: Silicon isotopic composition of identified grains.

dicated in figure 1. One of the groups is characterised by $^{14}N/^{15}N$ ratios lower than the terrestrial value of 272, but normal carbon isotopic composition (grey symbols). The silicon intensity of these grains was generally an order of magnitude lower than the carbon signal. Combining the chemical compositions with isotopic ratios, we inferred that these grains might consist of extraterrestrial organic material [5], but additional investigations are necessary to confirm this assumption.

The second group contains nine grains with nitrogen ratios close to or above the terrestrial value (blue symbols). They are isotopically light in carbon and only show a negligible silicon intensity. It is likely that these are graphite grains, which will also require confirmation by additional measurements. Both groups of grains show nearly normal silicon isotope ratios with large errors (1σ) due to the low silicon countrates. No abnormal isotope ratios could be recognised for oxygen, except for one grain that is characeterised by an excess of ^{17}O and near-solar ^{18}O composition. Due to its high $^{27}Al^{16}O$ and low ^{28}Si signal, the grain was identified as a group I oxide grain, which probably originated from an AGB or red giant star [6].

The average diameter of the grains identified is about 0.4 µm. With even the largest grain being smaller than 1 µm, spallogenic products could not be measured.

The matrix-normalised abundance of SiC grains observed within the area of observation was calculated to be 95 ppm, which is more than five times higher than reported for IOM (insoluable organic matter) [7] and noble gas analysis [8]. This might be attributed to the poor statistics with only three grains found, one of which being much larger (diameter ~0.7µm) than the other two (diameter ~0.2 µm). If this large grain is excluded from the statistics, the abundance drops to 20 ppm, which is much closer to what the previous studies inferred [7, 8]. Abundances for other groups of grains cannot be given at this time, as the density of these grains has yet to be determined.

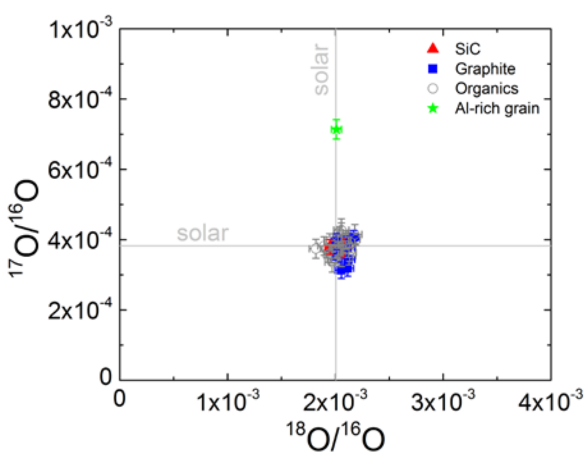

Figure 3: Oxygen isotopic composition of identified grains.

Summary: In the current study, 54 grains with anomalous isotopic compositions of carbon, nitrogen, silicon and oxygen were identified. Three of these could be identified as mainstream SiC grains and one as a group I oxide grain which probably originated from an AGB or red giant star. Future studies will include the determination of the structure of the graphite and extraterrestrial organic candidate grains, the measurement of extinct radionuclides, such as ^{26}Al, and a continuous search for large grains that allow us to study other n-rich stable isotopes and spallogenic products.

References: [1] Bernatowicz, T. et al. (1987) *Nature* 330, 728-730. [2] Messenger, S. et al. (2003) *Science* 300, 105-108. [3] Hoppe, P. et al. (1994) ApJ 430, 870-890 [4] Hynes, K. M. and Gyngard, F. (2009) *LPSC XXXX*, #1198. [5] Nakamura-Messenger, K. et al. (2006) *Science* 314, 1439-1442 [6] Nittler, L. et al. (1997) *ApJ* 483, 475-495. [7] Davidson, J. et al. (2009) *LPSC XXXX*, #1853. [8] Huss, G. R. et al. (2003) *GCA* 67, 4823-4848.