PRESOLAR HE AND NE IN SINGLE CIRCUMSTELLAR SIC GRAINS EXTRACTED FROM THE MURCHISON AND MURRAY METEORITES. Ph. R. Heck[1], K. K. Marhas[2], H. Baur[1], P. Hoppe[2] and R. Wieler[1], [1]Isotope Geology, NO C61, ETH, CH-8092 Zürich, Switzerland, heck@erdw.ethz.ch, [2]Max-Planck-Institute for Chemistry, Cosmochemistry Department, D-55020 Mainz, Germany (kkmarhas/hoppe@mpch-mainz.mpg.de).

Introduction: Noble gases like He and Ne can be incorporated into circumstellar dust grains by different processes. Murchison SiC single grain analyses done by Nichols et al. [1,2] revealed that only about 4% of the grains (~1.5 to 4 µm diameter) contained detectable amounts of the nucleosynthetic Ne-G component (formerly known as Ne-E(H)), which was always accompanied by ^{4}He. The authors suggested, however, that other grains might also contain nucleosynthetic He and Ne, but below their detection limits of (10-40)$\cdot 10^{-13}$ and 6 to 18$\cdot 10^{-15}$ cm^3 STP, respectively (ref. 2 and R. H. Nichols, pers. comm.).

Here we present new He and Ne analyses on single SiC grains from the Murchison and Murray carbonaceous chondrites, with detection limits of ~3$\cdot 10^{-13}$ cm^3 STP for ^{4}He, and 2$\cdot 10^{-15}$ cm^3 STP for ^{22}Ne. These values are lower th~an those attained by Nichols et al. some 15 years ago by factors of up to 13 (^{4}He) and ~3 to 9 (^{22}Ne). Our major goal was to investigate whether this increase in sensitivity would lead to an increase in the fraction of SiC grains, which unequivocally contain nucleosynthetic noble gases. Additionally, we classified the grains according to their Si, C and N isotopic compositions [3]. We also investigated correlations of these isotopes with the light noble gases.

Samples and Experimental: We have analyzed 111 presolar SiC grains from the carbonaceous chondrites Murchison and Murray in the size range of 0.6 to 6.3 µm and 0.6 to 3.6 µm, respectively. The use of the ultra-high sensitivity mass spectrometer equipped with a compressor source at ETH Zürich [4] allows the detection limit to be improved as given below compared to previous analyses [2]. For the first time helium and neon from single submicron-sized presolar grains has been detected.

SiC was extracted from Murchison using a dissolution procedure described by Ott & Merchel [5] and from Murray as described by Amari et al. [6]. The grains were transferred to ultra-clean Au foils in an isopropanol/water suspension. Subsequently, SiC grains were identified by SEM/EDX. Si-, C- and N-isotopes were measured in selected grains at MPI for Chemistry, Mainz, using a Cameca NanoSIMS 50 ion microprobe following the procedures as outlined in [7]. Nitrogen isotopes have not been measured in the Murray grains, to preserve more material for noble gas analyses. He and Ne isotopes were measured either prior to (Murchison) or after (Murray) the NanoSIMS analyses. Gases were released by melting grains with an IR-laser in continuous wave mode in ultra-high vacuum. All stable He and Ne isotopes were measured. Blank and background corrections were carried out by continuously monitoring signals prior to and after gas inlet. Apart from blank and memory, ^{20}Ne and ^{22}Ne signals were also corrected for interferences ($H_2{}^{18}O$, $^{40}Ar^{++}$, $CO_2{}^{++}$) and ^{22}Ne was subsequently corrected for an atmospheric contribution assuming all ^{20}Ne to be of atmospheric origin.

Results: *Murchison SiC.* 17% of 65 analyzed grains contain ^{4}He and ^{22}Ne gas excess above our detection limit. These grains have ^{4}He/^{22}Ne-ratios of 25-689 with an arithmetic mean of 168. 12% of the Murchison SiC grains contain ^{4}He only, without detectable ^{22}Ne, while 8% of the grains contain ^{22}Ne but no ^{4}He above the detection limit (see Fig. 1). NanoSIMS analyses were carried out on noble gas-rich Murchison grains. Si- and C-isotopic compositions indicate that one of them (SiC096) is an X grain (^{12}C/^{13}C = 101, δ^{29}Si = -346‰, δ^{30}Si = -274‰), although in this particular case we cannot exclude that the ^{22}Ne and ^{4}He excesses stem from other SiC grains close-by. SiC070 and probably also SiC136 are type A/B grains (^{12}C/^{13}C = 3.4 and 9.9, respectively) . Among the studied grains, SiC070 is richest in ^{4}He and ^{22}Ne. SiC136 contains ^{4}He only. The remaining gas-rich grains are mainstream grains. There is only a weak positive correlation between grain size and gas excess.

Murray SiC. ~17% of 46 analyzed samples contain detectable ^{4}He and ^{22}Ne. ^{4}He/^{22}Ne-ratios are in the range of 54-364 with an arithmetic mean of 144. 13% of the grains contain ^{4}He but no detectable ^{22}Ne and 7% contain ^{22}Ne without measurable ^{4}He (see Fig. 2). Mainstream SiC210 is the most gas rich grain in both ^{4}He and ^{22}Ne. Two Murray grains studied by NanoSIMS were exceptional, but neither of them contains detectable He or Ne: SiC254 is an X grain as indicated by the Si- and C-isotopic compositions (^{12}C/^{13}C = 89.6, δ^{29}Si = -242‰, δ^{30}Si = -6.3‰). SiC213 has by far the lowest ^{12}C/^{13}C-ratio (^{12}C/^{13}C = 13.7) among the Murray grains. Although still in the mainstream range, this value is close to the expected ratio for A/B grains. Murray SiC grains do not exhibit a correlation between noble gas excess and grain size.

Cosmogenic and nucleosynthetic ^{21}Ne was below our detection limit in all samples. No correlation of N-isotopic compositions with ^{4}He or ^{22}Ne amounts was observed. On the other hand, there is a weak positive correlation of ^{12}C/^{13}C ratios with ^{4}He gas amounts, but no such correlation with ^{22}Ne gas amounts.

Discussion and Conclusions: From both meteorites we detected in ~17% of the SiC grains ^{22}Ne accompanied by ^{4}He and another ~20% contain measurable amounts of one of these isotopes. The total fraction of gas-rich grains found here is thus about 6-8 times higher than that reported earlier [1, 2]. Most of these grains are mainstream grains thought to have condensed in the stellar winds of low-mass AGB stars [8]. At least for the grains unequivocally containing both ^{4}He and ^{22}Ne a likely trapping mechanism is gas implantation in the circumstellar environment. Some grains have ^{4}He/^{22}Ne-ratios lower than the previously studied single grains and bulk samples, but the ranges (25-689 and 54-364) overlap with the earlier results (Murchison KJG 100-500 and KJH 100-2000 [2]) and with the predicted ratios for AGB He-burning shell material.

In contrast to Nichols et al. [1, 2], we found in some of our grains only ^{4}He or ^{22}Ne, but not detectable amounts of both of these isotopes. This raises the question whether the two sets of observations disagree in this respect. The answer is: probably not. First, all of our particularly gas-rich grains unequivocally contain both isotopes. Second, if we assume for all grains for which only one isotope has been detected that the concentration of the other one has been close to the detection limit, this yields upper and lower limits for ^{4}He/^{22}Ne, respectively, which are in most cases consistent with the range observed for the more gas-rich grains. We cannot firmly exclude, however, that some of our grains have unusually high ^{4}He/^{22}Ne-ratios due to formation in stellar environments with low ^{22}Ne concentrations. Such conditions are expected for matter from more massive AGB stars with masses around 6$M_{\odot}$ where ^{22}Ne is destroyed by α-capture [9].

If the excess ^{4}He and ^{22}Ne released during the analysis of the Murchison X grain SiC096 is indeed intrinsic, implantation of the noble gases would be the preferred trapping scenario.

Our finding that about a third of all studied SiC grains in Murchison and Murray contain ^{4}He and/or ^{22}Ne above our detection limits confirms the possibility mentioned by [2] that more than just about 4% of the grains actually contain nucleosynthetic noble gases. We note, however, that in our analyses the most gas-rich ~4% of the grains (3 of Murchison, 2 of Murray) contain only about 30-60% of the total gas measured in our single grains, whereas the same fraction of grains accounted for >90% of the total ^{22}Ne and ^{4}He in the SiC separate studied by [2].

Acknowledgements: We thank S. Merchel and U. Ott for preparing the Murchison residue, J. Huth for his help with SEM and E. Gröner for technical assistance with the NanoSIMS. ETH Zürich partially funded this project.

References:

[1] Nichols R. H. et al. (1991) *Meteoritics* 26, 377-378. [2] Nichols R. H. et al. (1992) *LPS XXIII*, 989-990. [3] Hoppe P. and Ott U. (1997) in: *AIPC* 402, 27-58. [4] Baur H. (1999) *EOS Trans. AGU* 46, F1118. [5] Ott U. and Merchel S. (2000) *LPS XXXI*, Abstract #1356. [6] Amari S et al. (1994), *GCA* 58, 459-470 [7] Hoppe P. et al. (2004) *LPS XXXV*, Abstract #1302. [8] Gallino R. et al. (1990), *Nature* 348, 298-302. [9] Karakas A. I. and Lattanzio J. C. (2003) *Publ. Astron. Soc. Australia* 20, 393-400.

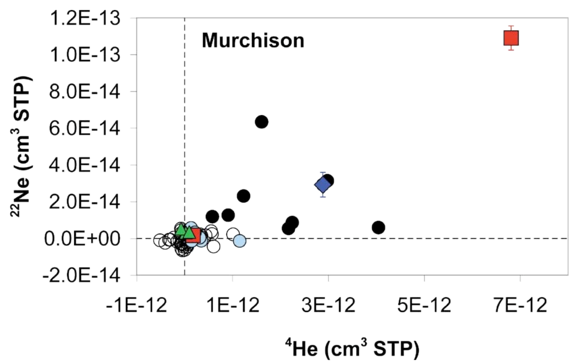

Fig. 1. ^{4}He/^{22}Ne-plot for Murchison SiC. Mainstream grains with ^{4}He and ^{22}Ne excess are indicated with filled circles. Shaded circles are ^{4}He-only grains. Triangles are ^{22}Ne-only grains. X grain SiC096 is filled diamond, A/B grains are filled rectangles. The most gas-rich grain is the type A/B grain SiC070 at the upper right. Grains with no gas excess are shown by empty circles. Only a few typical 2σ-errors are indicated.

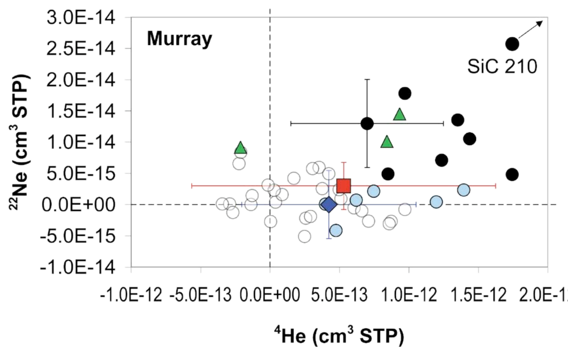

Fig. 2. ^{4}He/^{22}Ne-plot for Murray SiC. Symbols as in Figure 1. The most gas-rich grain off-scale at the upper right is SiC210 (^{4}He: 4.7 ± 1.4·10^{-12} cm^{3} STP, ^{22}Ne: 5.1±0.9·10^{-14} cm^{3} STP).