PRESOLER SILICATE GRAINS IN ENSTATITE CHONDORITES S. Ebata[1], K. Nagashima[2], S. Itoh[1], S. Kobayashi[1], N. Sakamoto[1], T. J. Fagan[3], and H. Yurimoto[1], [1]Division of Earth and Planetary Sciences, Hokkaido University, Sapporo 060-0810, Japan. (ebashin@ep.sci.hokudai.ac.jp); [2]Hawai'i Institute of Geophysics and Planetology, School of Ocean and Earth Science and Technology, University of Hawai'i at Manoa, Honolulu, HI 96822, USA; [3]Department of Earth Sciences, School of Education, Waseda University, Tokyo, Japan.

Introduction: Primitive meteorites contain presolar grains that predate the formation of our solar system. Recently presolar silicate grains were identified in IDPs [1] and in primitive carbonaceous and ordinary chondrites [2-6]. In enstatite chondrites, presolar carbonaceous and oxide grains have been reported [e.g. 7-9], but no presolar silicate grains have been identified.

Here we report the first finding of presolar silicates from enstatite chondrites. We used an isotope microscope [10] to identify presolar grains in three primitive enstatite (EH3) chondrites: Yamato (Y)-691, Allan Hills (ALHA) 81189, and Sahara (SAH) 97072.

Experimental: The samples used in this study are polished thin sections of Y-691, ALHA 81189, and SAH 97072. Mineralogical and petrographical characterization of matrices was conducted using a scanning electron microscope (JEOL JSM-5310LV) equipped with energy dispersive X-ray spectrometer (Oxford LINK ISIS). After the characterization, we surveyed presolar grains by isotopography using an isotope microscope system (Cameca ims-1270 + SCAPS [10]); originally installed in TiTech and now in Hokkaido Univ. (Hokudai).

The analytical techniques for isotopography basically followed those described in elsewhere [3]. We acquired the following isotopographs for each analyzing field as a sequence of $^{12}C^-$, $^{13}C^-$, $^{12}C^-$, $^{27}Al^-$, $^{28}Si^-$, $^{16}O^-$, $^{18}O^-$, $^{16}O^-$, $^{17}O^-$, and $^{16}O^-$. Total integration time for one field was ~1 hour. In order to obtain better lateral resolution of isotopographs than the case of [3], a smaller contrast aperture (50 µm in diameter) was used in this study except for the case of C-isotopes. A larger contrast aperture (150 µm in diameter) was used for C-isotopographs in order to minimize sample consumption by sputtering with an enough precision of isotope ratio through the sequence. Lateral resolutions of the isotopographs using contrast aperture of the 50 µm and of the 150µm are 0.3-0.5 µm and ~1 µm, respectively. These analytical conditions keep the sputtering depth less than 100 nm for the sequence.

The digital image processing using a moving-average (3 x 3 pixels) was applied to simple secondary ion ratio images in order to reduce the statistical error. The selection criterion for distinguishing presolar grains and estimation of the analytical errors of the grains are the same as [3].

Results: The total analyzed areas of oxygen isotopographs are ~61,000 µm^2, ~58,000 µm^2, and ~30,000 µm^2 for Y-691, ALHA 81189, and SAH 97072, respectively. From the analyzed areas, 3 and 9 presolar silicates were identified for Y-691 and ALHA 81189, respectively (e.g. Fig. 1), whereas no presolar silicates for SAH 97072. Presolar carbonaceous grains were also identified by carbon isotopographs: 10 grains from areas of ~63,000 µm^2 for Y-691; 6 from ~61,000 µm^2 for ALHA 81189; and 2 from ~32,000 µm^2 for SAH 97072 (e.g. Fig. 2).

Matrix-normalized abundances of presolar silicate grains were calculated to be ~49, ~155 and <33 grains/mm^2 corresponding to ~4, ~14 and <3 ppm for Y-691, ALHA 81189 and SAH 97072, respectively, assuming the mean grain size to be 0.3 µm in diameter.

Matrix-normalized abundances of presolar carbonaceous grains were calculated to be ~159, ~98 and ~62 grains/mm^2 corresponding to ~14, ~9 and ~6 ppm for Y-691, ALHA 81189 and SAH 97072, respectively, assuming the mean grain size to be 0.3 µm in diameter.

Discussion: The carbonaceous presolar grains are roughly equally distributed in the three EH3 chondrites in this study. The average abundance is ~10 ppm that is consistent with the value estimated from abundances of exotic noble-gas components from acid-resistant residue of Qingzhen EH3 meteorite (10.9 ppm [7]). The smaller abundance in SAH 97072 may be due to decomposition of the presolar carbonaceous grains by thermal and/or aqueous metamorphism in the parent body.

The abundance of presolar silicates is the highest in ALHA 81189 and continues to Y-691, SAH 97072. The lowest abundance for SAH 97072 is the same as the case of carbonaceous grains. These results support that metamorphic degree is highest in SAH 97072 among the three EH3 chondrites.

The abundance of presolar silicates is much smaller in EH3 chondrites than in primitive carbonaceous chondrites [5]. The EH3 chondrites, like most type 3 carbonaceous chondrites, have undergone some parent body metamorphism. The small abundance in EH3 chondrites suggests that parts of the presolar silicate grains of EH3 chondrites have been decomposed by the mild thermal metamorphism. Other possibilities are that the EH3-matrix materials have been affected thermally during chondrule formation or diluted to a greater extent by fragmentation of chondrules. We infer that the abundance of presolar silicate grains (14 ppm) of ALHA 81189 is a minimum estimate of the original abundance for EH3 chondrite formation area in the solar nebula.

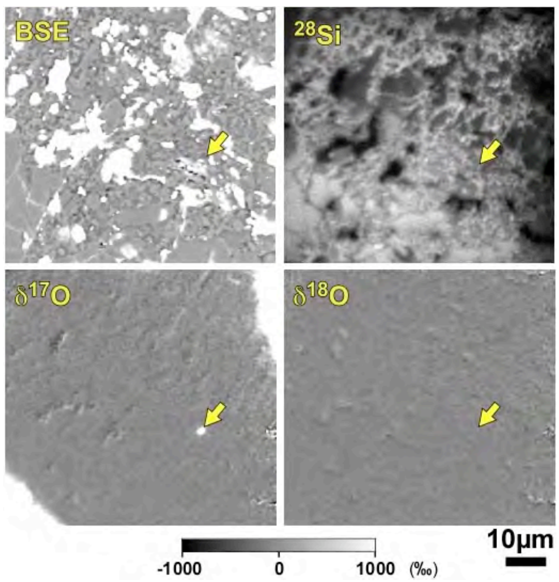

Fig. 1. Corresponding images of BSE, secondary ion ($^{28}Si^{-}$), and O-isotope ratios (δ^{17}O and δ^{18}O) from Y-691. Yellow arrows indicate locations of presolar silicate grain. White areas at upper-right and lower-left corners of δ^{17}O image show interferences of $^{16}OH^{-}$.

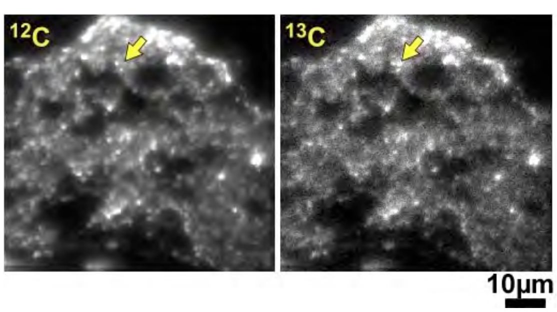

Fig. 2. Corresponding images of secondary ion ($^{12}C^{-}$ and $^{13}C^{-}$) from Y-691. Yellow arrows indicate locations of presolar carbonaceous grain.

The oxygen isotopic compositions of presolar silicates in the EH3 chondrites are shown in Fig. 3. The most grains (~ 80%) have excesses in ^{17}O with nearly normal $^{18}O/^{16}O$ ratios. These grains are categorized into group 1, which likely formed around O-rich red giant and asymptotic giant branch stars. The rest belongs to group 4, which have nearly normal $^{17}O/^{16}O$ ratios and excesses in ^{18}O. The origin of the group is considered as asymptotic giant branch stars or super novae [11].

References: [1] Messenger et al. (2003) *Science* **300**, 105-108. [2] Nguyen and Zinner (2004) *Science* **303**, 1496-1499. [3] Nagashima et al. (2004) *Nature* **428**, 921-924. [4] Mostefaoui and Hoppe (2004) *ApJ* **613**, L149-L152. [5] Kobayashi et al. (2005) *Antarct. Meteor.* **XXIX**, 30-31. [6] Tonotani et al. (2006) *LPS* **XXXVII**, this volume. [7] Huss and Lewis (1995) *GCA* **59**, 115-160. [8] Besmehn et al. (2001) *MAPS* **36**, A20. [9] Lin et al. (2002) *ApJ* **575***,* 257-263. [10] Yurimoto et al. (2003) *Appl. Surf. Sci.* **203-204**, 793. [11] Nittler et al. (1997) *ApJ* **483**, 475-495.

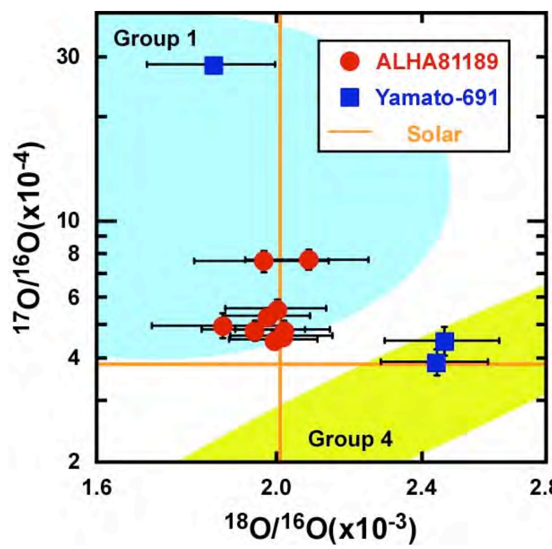

Fig. 3. O-isotopic ratios of presolar silicate grains from Y-691 and ALHA 81189. Error bars are 2σ. Ten grains belong to Group 1 and two grains belong to Group 4 defined by [11].