

TRANSMISSION ELECTRON MICROSCOPY OF THE BONANZA SUPERNOVA SiC GRAIN.

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Introduction: SiC is the most well studied phase of presolar grains [1]. Isotope compositions of thousands [2], and the crystal structure of hundreds [3], of individual grains have been measured. Although synthetic SiC occurs in > 100 polytypes, the crystal structures observed for presolar SiCs have been limited to the two lowest temperature forms (2h and 3c), their intergrowths, and a few grains too disordered to assign a structure. The Bonanza SiC grain is an unusually large grain of type X, ~ 30 μm , from the LS+LU size separate of the Murchison meteorite L series residue [4]. Bonanza's exceptional size has allowed measurement of the isotope composition of multiple elements, including Si, C, N, Al-Mg, Ca, Ti, Fe and Ni [5]. All of the isotope composition data indicate that the grain originated in the ejecta of a Type II supernova. However, the large size, and the complex microstructure, consisting of multiple crystallites visible in SEM images, suggest that Bonanza formed under different condensation conditions than other SiC X grains studied to date. We have initiated a transmission electron microscopy (TEM) study to obtain more detailed information about the crystallography of Bonanza, and thus constrain the possible condensation conditions.

Methods: We prepared three sections of Bonanza with the FEI Nova 600 focused ion beam-scanning electron microscope at the Naval Research Laboratory (NRL) for TEM analysis. The first section was prepared as an ex situ lift out, supported on a carbon film coated TEM grid. The remaining sections were prepared as in situ lift-out sections and attached to Cu Omniprobe TEM grids. TEM studies, including high-resolution TEM, selected area diffraction, bright-field and dark-field STEM imaging, were performed with the JEOL 2200FS scanning TEM at NRL. Elemental composition measurements were obtained with the Thermo Noran System Six energy dispersive spectroscopy system attached to the JEOL 2200FS.

Results: Each of the three sections analyzed contained multiple SiC crystallites, i.e. > 10 grains of sub- μm to μm size, as well as multiple compositionally distinct subgrains. Although the identification of the polytype of each crystallite is on-going, the present data demonstrate a complex mixture of 2h, 3c, 15r, and 1- and 2- dimensionally disordered domains. The spatial relationships between crystallites indicate co-crystallization, rather than agglomeration of separately condensed grains. Incorporated subgrains include Ti, Fe, Fe-Ni, Al-Mg and S-rich phases.

Conclusions: The TEM data show that Bonanza has greater structural complexity than previously analyzed presolar SiCs, consistent with early Raman measurements [4]. We speculate that this complexity derives from initiation of the crystallization at a higher than typical temperature. The incorporated subgrains may also play a role in nucleating or stabilizing specific polytypes.

References: [1] Davis A. M., 2011. *PNAS* 108:19142-19146. [2] Hynes K. M. and Gyngard F. 2009. *LPS XL, Abstract#* 1198. [3] Daulton T. L. et al. 2003. *GCA* 67:4743-4767. [4] Wopenka B. et al., 2010. *LPS XLI*, Abstract #1390. [5] Zinner E. et al., 2011. *LPS XLII*, Abstract #1070.