Yttrium carbide in nanotubes

SIR — Filling the hollow core of carbon nanoclusters with foreign material has added a new aspect to the promise of this family of novel materials. Lead has been inserted into nanotubes by capillary suction through open ends[1], and microcrystals of LaC_2 have been encapsulated into polyhedral cages[2,3]. We have now used the general approach in refs 2 and 3 to place yttrium carbide into nanotubes.

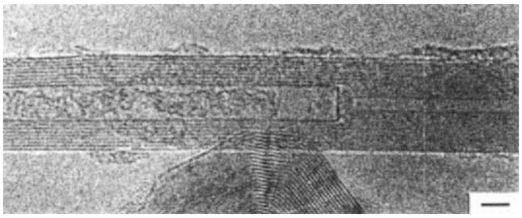

FIG. 1 High-resolution transmission electron-microscope image of a nanotube with two different sizes of inner cores. Only the larger core is partially filled; the smaller one is empty. Scale bar, 3 nm.

We prepared samples in a computer-controlled reaction chamber[4]. The composite graphite anode had a centre hole packed with paste of yttrium oxide powder mixed with isopropanol. Both materials were removed in a 550-torr helium arc discharge sustained by 28 V at 70 amps d.c. The material deposited at the cathode was ground into powder for examination by a transmission electron microscope and an X-ray diffractometer.

Figure 1 shows an electron-microscope image of a 10-nm diameter tube contained in the deposit, filled with material in the larger of two internal cavities. The irregular appearance of this material does not necessarily mean that it is amorphous, as lattice images depend on the direction of the electron beam. Apparently, the process conditions promote deposition of the enclosed material in the larger cavity, but prohibit it in the smaller. The inserted material does not wet the internal cavity surface completely. Filling extends for 100 nm along the length of the tube without overlapping the edges of the innermost tube. This would not happen by chance for material deposited on the outside of the tube. The tube tips remain closed, and show no sign of damage.

Electron energy-loss spectroscopy places the electron beam of nanometer size entirely on the filling material. The M edge of yttrium and the K edge of carbon is observed with no oxygen signal detected (Fig. 2). Yttrium metal peaks are absent in X-ray powder-diffraction patterns. Both results suggest that the nanotubes are filled with yttrium carbide crystals, and contain no yttrium metal or yttrium oxide.

Low-magnification micrographs show that about 20% of the nanotubes and 50% of the nanoparticles are filled. The fraction apparently depends on particle shape and dimension, indicating an influence of the internal topography of the cavity. Inclusion in the large diameter cavity but not in the smaller establishes size and shape as factors influencing the ease of filling. Control of the inclusion through variation of the processing parameters will be a critical factor in developing technological applications.

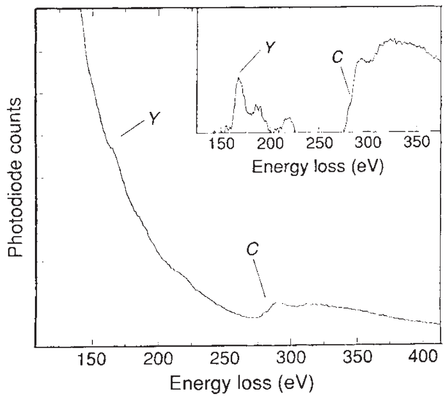

FIG. 2 Electron energy-loss spectra of a nanotube filled with foreign material. Spectrum after removing the background is shown in the inset.

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Chicxulub – K/T melt complexities

SIR — Kring and Boynton[1] attempted to strengthen the link between the Chicxulub structure and the Cretaceous/Tertiary (K/T) boundary by comparing their reconstructed Chicxulub Y6N17 groundmass compositions with typical igneous fractionation trends and impact glasses from the K/T boundary in Haiti. They argue that Y6N17 could not be easily produced by volcanism, and was probably formed by the same impact event as the Haiti glasses.

They reconstructed their Y6N17 compositions from averages of microprobe data and modal analyses of three groundmass minerals, including albite (see figure), asserting that this technique allowed them to avoid the contaminating effects of xenoliths and secondary mineralization that pervade the sample. Regardless of its origin, however, a silicate liquid crystallizing augitic pyroxene in equilibrium with plagioclase of andesine composition would not co-crystallize albite. Typically, albite of this purity results from secondary alteration processes such as hydrothermal metasomatism or authigenic growth during burial diagenesis. In hydrothermally altered igneous rock[2,3], pseudomorphic replacement of calcic plagioclase by albite is common, often in cases where relict primary textures are preserved. Corresponding changes in whole rock major-element chemistry (for example SiO_2, CaO) can cause substantial shifts away from cotectic compositions. Data in Table 1 (of ref. 1) reveal that about 27% of Kring and Boynton's average Y6N17 groundmass is albite. Consequently, it is possible that alteration is responsible, at least in part, for these unusual groundmass compositions. Whether impact melting is necessary or sufficient to produce these non-cotectic compositions remains to be demonstrated.

Kring and Boynton also state that their Fig. 1*b* (ref. 1) shows a "coherent mixing trend" defined by slight variations in their reconstructed groundmass compositions (A, B, C and D), and suggest further that the Y6N17 groundmass lies along the same mixing trend as that previously noted[4] for the Haiti glasses. The notion that the Haiti glass compositions can be modelled as a mixing line[4] is based on a published range of glass compositions that is much larger than that[5] used in ref. 1. When additional data[6] reflecting this more extensive range are considered, a simple collinear relationship between the Y6N17 groundmass and the Haiti glasses is not observed (part *a* in the figure). In addition, if a mixing relationship exists between the groundmass trend and the Haiti glass trend, it would be evident in any depiction of this projection scheme[7]. However, when these data are projected from olivine (part *b* in the figure) rather than plagioclase, it is readily apparent that the "coherent (groundmass) mixing trend" (ref. 1) is oblique to the Haiti glass trend.

Is it possible that the groundmass "trend" noted by Kring and Boynton is