**Introduction:** Chondritic IDPs from the anhydrous chondritic porous (CP) subset are believed to be among the most primitive meteoritic materials available for laboratory investigations. Their silicate mineralogy resembles those of silicates in the interstellar medium and around some young stars [1,2]. High D/H ratios measured in some IDPs are consistent with the preservation of carbonaceous material from a presolar interstellar molecular cloud [3]. Chondritic IDPs may also contain “presolar” nano-diamonds like those found in primitive meteorites. In principle, nano-diamonds should be easy to detect in IDPs because the bulk carbon content of chondritic IDPs is typically several times higher than that of (CI) chondrites [4]. In practice, 2-5 nm diameter nanodiamonds have been difficult to unambiguously identify in IDPs because, in contrast to chondritic meteorites, the fine-grained matrices of IDPs are mineralogically heterogeneous on a scale of 2-5 nm and nano-diamonds scatter electrons weakly relative to other higher atomic-number nanophase minerals (e.g. FeNi metal and sulfides). The goal of this work is to establish the abundance of nano-diamonds in IDPs, compare their properties with those found in meteorites (e.g. size distribution and defect structures), and determine their petrographic context in IDPs (i.e. what minerals they are associated with). Answering these questions might clarify the relationship between chondritic IDPs and meteorites and provide an estimate of the relative abundance of nano-diamonds in small, primitive solar system bodies as a function of heliocentric distance.

**Methods:** Five chondritic IDPs and fragments of fine-grained matrix from two chondritic meteorites were selected for this study. The IDPs are W7027A-8D, U2-20GCA, U2-17B19, U2073B-1F, and U2073B-4C, and the meteorites are Murchison (CM) and Tagish Lake (CMI). In order to optimize the chances of detecting nano-diamonds we used an in-situ acid dissolution procedure [5]. The IDPs and several meteorite fragments were mounted in sulfur beads that were in turn embedded in epoxy and ultramicrotomed [6]. The ~100 nm thick sections were collected on carbon-film/gold-mesh TEM substrates and the sulfur was sublimed leaving the IDP or meteorite matrix slice at the center of a ~50μm hole in the epoxy. The sections were then individually characterized using analytical TEM prior to the etching procedure. Etching is done by placing the grids on a polyethylene frit which is then saturated with triple distilled concentrated HF. After a room temperature etch for an hour, the grid is rinsed (5 times) with nanopure water and dried.

We examined the etched sections using transmission electron microscopes (TEM’s). Lattice fringe images were acquired using a 400 keV JEOL 4000EX, a 200 keV analytical JEOL 2010 TEM, and a 200 keV field emission Hitachi HF2000 STEM. Grain compositions were measured (in the JEOL 2010 & HF2000) using energy-dispersive x-ray spectroscopy and electron energy loss spectroscopy (EELS).

**Results:** The simple HF etching works remarkably well for chondritic IDPs and meteorite fragments. In less than an hour all silicates and metals are removed leaving only Fe-rich sulfides and carbonaceous materials, including organic compounds [5]. Images taken before and after etching confirm that, despite contact with aqueous solutions, the spatial distribution of structure remaining within the sections is preserved at the nanometer scale.

Figure 1 is a darkfield image of residue remaining after after acid-etching a fragment of Murchison matrix. Most of the bright spots are 2-5 nm diameter nano-diamonds. Some of the larger grains are Fe,Ni sulfides. The measured nano-diamond concentration on the carbon substrate is ~3.1 x 10^{15} meter^2. Assumming the thickness of the pre-etched section was 100 nm, there are ~1.6 X 10^{23}meter^3, which translates into an abundance of ~2000 ppm nano-diamonds in the (pre-etched) thin section. The nano-diamonds are relatively uniformly distributed over the surface of the carbon support substrate, suggesting that their distribution was not highly localized in the fragment of fine-grained matrix of Murchison.

Figure 2 is a lattice-fringe image of a nano-diamond crystal in the etched Murchison thin section. The crystal is multiply-twinned with pseudo-pentagonal (or star-twin) morphology. This striking diamond growth feature is relatively common in nano-diamonds in meteorite acid residues and in CVD diamond thin-films [3]. Packets of turbostratic graphite-like fringes around the edge of the crystal suggest that the host carrier of at least some of the nano-diamonds in Murchison is carbonaceous, in accordance with previous in-situ observations of nano-diamonds in the Allende meteorite [7].

Figure 3 is a lattice-fringe image of a nano-diamond in an etched thin section of IDP U2-20GCA. The grain size and twin structures are similar to those of nano-
Nano-diamonds observed in meteorite residues [3]. In contrast to those in the Murchison residue (e.g. Fig. 1), the nano-diamonds in IDP U2-20GCA appear to be more highly localized in clumps of carbonaceous material at a concentration ~3X higher than those we observe in the Murchison thin section.

**Discussion:** Using in-situ acid-etching, lattice-fringe imaging, defect structure analysis, and energy-dispersive x-ray spectroscopy we have identified populations of face centered cubic (FCC) carbon-rich nanocrystals in ultramicrotomed thin sections of a chondritic IDP and meteorite matrix fragments. We tentatively identify these crystals as nano-diamonds. At the same time we recognize that unambiguous identification of nano-diamonds using the TEM should include electron diffraction ring patterns and, more importantly, EELS spectra showing clear evidence of sp$^3$-bonded carbon. Unfortunately, these options are presently not available for isolated (non-agglomerated) nano-diamonds resting on (sp$^2$-bonded) carbon substrates because of insufficient signal-to-noise.

Our estimate of the abundance of nanodiamonds in the Murchison thin-section (~2000 ppm) is a factor of ~5 higher than their abundance in the bulk meteorite [8]. Either the selected matrix fragment contained a locally higher concentration than the meteorite as a whole, our assumptions about the nano-diamond size distribution are inaccurate, or some of the nanocrystals we observe are not nano-diamonds. Furthermore, we have so far detected nano-diamonds in only one of five chondritic IDPs. Either they are not present in most chondritic IDPs, some of them may have been destroyed by heating and oxidation during atmospheric entry, or their abundance in chondritic IDPs is significantly lower than in chondritic meteorites. Alternatively, the carrier of nano-diamonds may be a carbonaceous phase that, like the carrier of the D/H enrichments [2], is heterogeneously distributed among chondritic IDPs.

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