FIDUCIAL MARKS FOR LOCATION OF PARTICLES IN AEROGEL. A. J. G. Jurewicz[1] , A. I. Tsapin[1], and S. M. Jones[1], [1]Jet Propulsion Laboratory/California Institute of Technology (m/s 183-501, 4800 Oak Grove Drive, Pasadena, CA 91109-8099; Amy.J.Jurewicz@jpl.nasa.gov).

Introduction: If an extraterrestrial sample is captured in aerogel as a collection of particles, it is important to be able to consistently locate individual grains when changing instruments or laboratories. We report on a feasibility study for applying fiducial marks to aerogel nondestructively so that the marks can eventually be used with optical, X-ray or other (manual or automated) location techniques.

Background: Stardust will bring back cometary and interstellar particles in aerogel in 2006. Other platforms have also brought back particles embedded in aerogel. For example, aerogel exposed to LEO on MIR are currently available, as detailed in [1]. So, extraterrestrial particles in aerogel are becoming increasingly available to the planetary materials community *at large,* and the ability to relocate individual particles for further analysis will become increasingly important.

For the ability to repeatedly identify specific particles under different conditions, fiducal marks that define an invariant coordinate system are extremely useful. Optical microscopy, X-ray tomography and other techniques can locate groups of particles, or tracks in aerogel with high precision [1,2, 3]. For large or scattered particles an entire wedge of aerogel with that particle can be then removed and, therefore, isolated [4]. However, removing individual "keystones" with particles will be impractical if the captured particles are very densely packed and will only mitigate the problem of relocating individual grains if an individual particle has broken into a cluster. So, there will be cases when multiple particles remain in a single piece of aerogel. At that point, it will be important to uniquely identify each particle using a coordinate system with an independent frame of reference that is tolerant to aerogel breakage. Corners and sides of the aerogel are tenuous markers, as they may chip during handling. Multiple internal features (e.g, a particle with associated track; unusual particle clusters; etc) might work as a basis for finding other features. However, the most straight-forward way to add a coordinate system is to apply specialized fiducial marks to aerogel surfaces. The smaller the size and the greater the number of fiducial marks, the more the precise the ability to repeatedly and reliably locate very small particles within a cluster for analysis by different instrumentation in different facilities.

We note that these marks must be applied nondestructively, must not interfere with analyses and should be visible with a variety of instrumentation, or they defeat the reason for applying them.

Technique: We applied fiducial marks to aerogel using e-beam evaporation of metals through holes in masks. E-beam evaporation allows the deposition of very thin layers of high-purity metals and is very directional, so that there would be no vapor transport to masked areas. Initial tests used Al and Si metal and physical masks that included: shapes cut into kapton film (fig. 1), wire mesh with portions of the grid sealed using carbon paint (DAG), and small holes in SiN films (fig. 2).

For ease of handling during these preliminary experiments, the test aerogel was fitted into stainless-steel jackets and sat directly on the mask in the vacuum chamber. The e-beam system was not designed to evacuate porous materials, so the back of the aerogel was covered to mitigated aerogel damage caused by extremely-abrupt decompression and to protect the vacuum pumps from accidental ingestion of aerogel.

Aluminum-test. It was hypothesized that the low melting point of Al would be unlikely to damage the aerogel while the high reflectivity of Al would make the mark easy to find. A 2000Å film was selected as a baseline since, on semiconductors, films this "thick" are low-porosity metals. The result is shown in Fig 1. In fact, 2000Å Al on aerogel was reflective in a glancing view, but was transleucent in transmitted light. It was visible both optically and by X-ray.

Silicon. Since the aerogel is SiO_2, to minimize contamination we also tested 2000Å Si-metal (Fig. 2). The silicon was more opaque than the aluminum but still transmitted light. We also used new masks with smaller openings: (1) a 100 mesh grid with some openings manually closed by painting with DAG, and (2) SiN with micron-scale holes. 20μ and 35μ marks were identified by optical microscopy, but the 20μ circle was especially difficult to find. A distinctive, non-circular geometry would alleviate that difficulty.

Conclusions and Future Options: Marks can be applied to aerogel nondestructively. In principle, blocks containing multiple particles can use fiducial marks to precisely locate (and relocate) small particle on all equipment with 3-D calibrated, precision stages.

Large fiducial marks may obscure small particles during optical inspection. However: (1) thinner coatings or (2) coatings of optically transleucent materials (e.g., Ge) may allow optical inspection of particles through the mark. Moreover, optical transleucency is not necessary if the marks are small and distinctive, or if CT or non-visual means are used to locate grains.

Using semiconductor techniques, masks can be made with small opening so that, in principle, micron-scale marks can be evaporated onto the surface of the aerogel in any shape. The lower size-limit for these marks could be <<20μ, as determined by the aerogel structure and/or mask thickness and mark geometry.

Finally, we note that other metals (e.g., Cr, Au, Pt, Mo) are routinely evaporated by e-beam and most metals (even Fe, Cu) could be used for fiducial marks if desired for a specific study.

References: [1] Horz F. et al. (1999) NASA/TM-1999-209372, 146p. [2] JurewiczA. J. G. et al. (2003) *LPS XXXIV,* Abstract #1228. [3] Flynn G. J. (2003) *LPS XXXIV,* Abstract #1814. [4] Westphal A. J. (2003) *LPS XXXIV,* Abstract #1826.

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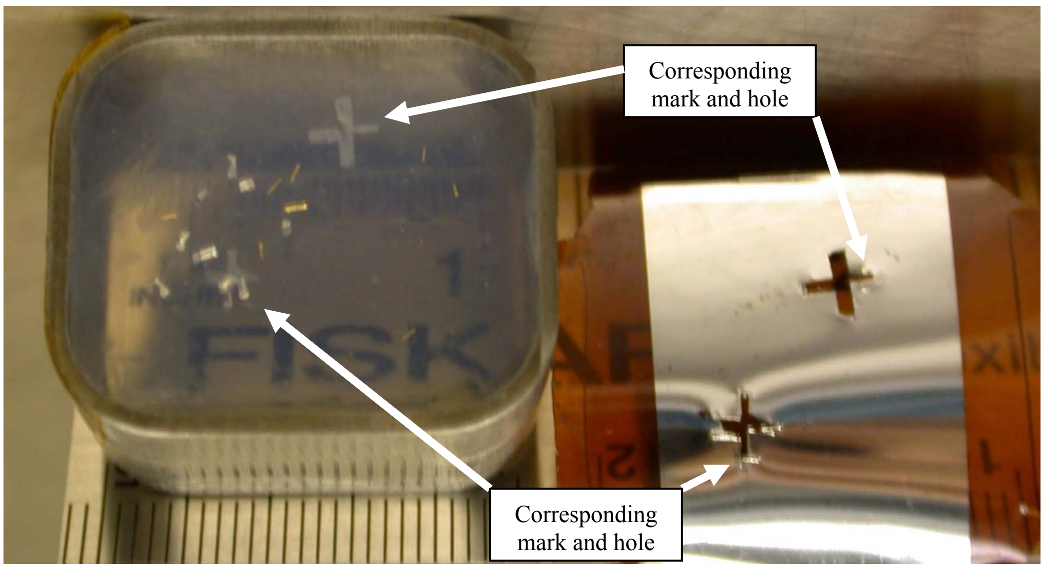

Fig 1 (above). 2000 Å Al baseline test. Right: mask manually cut from kapton film (brown where not exposed to evaporated Al) showing holes (+ shape in area of deposition). Left: aerogel in stain-less steel holder showing corresponding (+ shape) marks. Short bars are (subsurface) pieces of Al and Au wire embedded in the aerogel. Note that these wires can be seen through the lower-left Al fiducial mark.

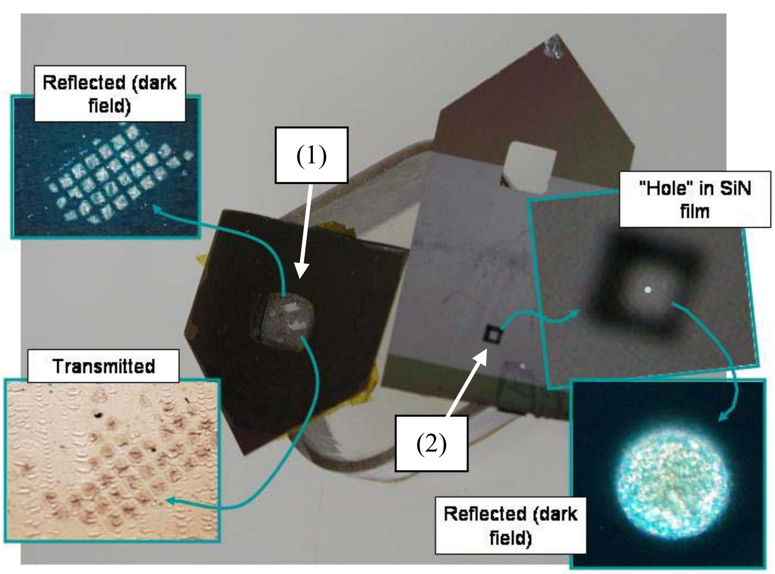

Fig 2 (left). The 2000 Å Si fiducial marks on aerogel and the two masks used to make them. (1) Mesh partially covered in DAG corresponds to a pattern of square marks (insets on left). Mesh is mounted over a square hole in a silicon wafer. (2) hole in a SiN film (enhanced in labeled inset) mounted on a Si-wafer that produced the distinct, 35μ Si-circle (lower right inset). Not shown: similar mask used to make a 20μ-diameter circle.