Developing TXM 3D Imaging of Stardust Using Terrestrial Samples

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The properties of non-destructive and almost contaminant-free of Transmission X-ray Microscopy (TXM) is frequently utilizied as a superior technique to characterize the interior of microscopic particles. It is also sensitive to different elements and can achieve spatial resolution as high as 60 nano-meters potentially using the 1st order zone plate. Therefore, we are developing techniques to apply this tool to examine the interior contains of the cometary dust brought back by the Stardust spacecraft from comet Wild-2. The other type of samples are the pre-solar grains included inside meteorites. In particular we would like to study the graphite which contain many TiN inclusions as nucleation seeds during the condensation of these grains from the ejecta from the AGB stars. The stardust grains are up to 15 μm in size. They will be examined by TXM after SEM-EDX but before isotopic analysis in the dust buster mass spec (SNMS). Here we report the progress in our testing using terrestrial samples.

We have selected Ti-Fe-oxide from mid-ocean ridge (provided by Prof. Shaw, Yen-Hong of NSYSU) for some prior testing. The oxide grain separates into two co-existing phases when the temperature decrease: Ilmenite ($FeTiO_3$) and Hematite (Fe_2O_3). They form alternating bands with a cat-ion contrast of 100% Fe vs. (50% Fe + 50%Ti). With the same sample imaged by SEM in the back scattered mode and by TXM with energy just below the iron's absorption edge. The backscattering is more intense for higher proton number elements. Thus the brighter bands in the SEM image are hematite because they are 100% Fe. Consistantly, the image under the TXM showed the colocallized compositions with SEM image.

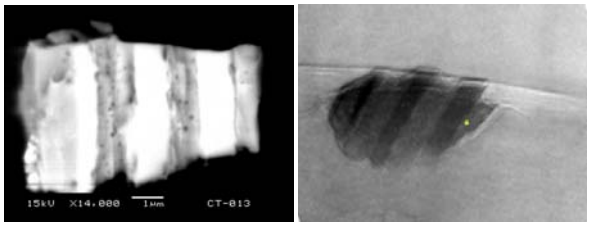

Figure 1. A mid-ocean-ridge particle imaged under SEM, the brighter bands are hematites that contained only iron oxide.
Figure 2. The same particle that is imaged under TXM, the darker bands were hematite.

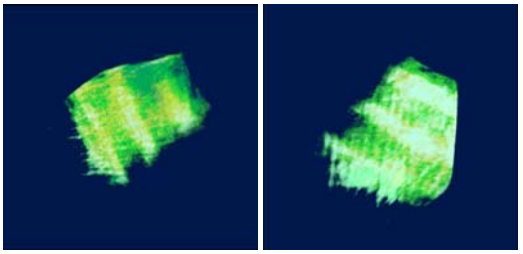

Figure 3. The 3D rendering image that is reconstructed using tomography on data taken with TXM. Many transects were taken with the azimuth angle varying from +70 degrees to -70 degrees. The darker bands are revealed as white color.

So far we have successfully tested the TXM imaging of microscopic sample grains consisting of two phases with iron content differ by a factor of 2. Our image seems to be consistent with the SEM/EDX data on the surface. The interior patterns agree with what can be inferred for these MOR samples. However, the spatial resolution obtained so far is about 3 times of that achieved previously. Thus we need longer integration or more cuts in order to raise the spatial resolution in order to detect small grains inside star dust.