Estimation of density and size distributions of Wild-2 cometary dust particles based on Stardust tracks

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NASA Stardust spacecraft captured cometary dust from Comet Wild2 with the relative velocity of 6.1 km/sec. In this hypervelocity impact, silica aerogel, a material with an ultra-low density (5-50 mg/cm^3), was used as a collector for intact capture of dust particles of about 10 microns. However, the particles were disaggregated into many grains, and impact tracks with a variety of morphologies suggesting a variety of the cosmic dust were formed. It is important to understand impact track morphology and its formation process to reconstruct original cometary dust. In previous work, dust diameter and cumulative particle size distribution were estimated from the maximum width of Stardust tracks [1].

We have investigated quantitative three-dimensional structures of Stardust impact tracks with various shapes using synchrotron radiation x-ray microtomography at SPring-8 [2]. At the same time, Fe mass distributions along the tracks were obtained using XRF. We found that track morphologies near the track entrances normalized by the track entrance size are similar to each other irrespective of the whole track morphologies (type A-C), and a little amount of Fe were distributed near the track entrances. Base on these results, we proposed a track formation model that the track morphology near the entrance is strongly influenced by shock-wave propagation. In addition, we estimated the density of each cometary dust particle based on the model and by assuming the hypothesis that a track volume is proportional to the kinetic energy of a projectile. From the relation between the estimated particle size and density, mean density of cometary dust particles are estimated as 1.03+/-0.14 g/cm^3. Moreover, it is suggested that crystalline particles, such as chondrules found in cometary dust [3], account for approximately 6 vol.%. This must correspond to the proportion of high-temperature particles, which were formed at an inner region of the primordial solar system and transferred to the outer region of comet formation.

[1] Burchell *et al.* (2008) *Meteor. Plant. Sci.*, **43**, 23-40.
[2] Tsuchiyama *et al.* Submitted to *Meteor. Plant. Sci.*
[3] Nakamua *et al.* (2008) *Science*, **321**, 1664-1667.