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Three-dimensional structures of impact tracks of cometary dust in Stardust mission

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Meteorites and cosmic dust are samples for investigating the origin and evolution of primitive materials in the early solar system. However, we cannot determine their parent bodies definitely. Moreover, they have experienced some metamorphism more or less during their atmospheric entry or on the Earth. Therefore, it is most desirable to go to the space and collect samples from their parent bodies directly (sample return). For this purpose, Stardust spacecraft of NASA captured cometary dust from Comet Wild2 with the relative velocity of 6.1km/sec. In this hypervelocity impact, silica aerogel, a material with ultra-low density (0.01 g/cm^3), was used as a collector for intact capture of the 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. Accordingly, it is important to understand impact track morphology and its formation process to reconstruct original cometary dust.

So far, simulations of impact tracks in laboratory have been done (e.g., [1]), and theoretical studies of impact track morphology have been also performed (e.g., [2]). However, the capture process is actually complicated and we do not know the physics of capture process into targets of low-density materials, such as silica aerogel, in detail. In this study, we have investigated three-dimensional structures of Stardust impact tracks using synchrotron radiation x-ray microtomography at SPring-8 to reconstruct captured particles by understanding the captured process as a final goal. Elemental distributions along the tracks were also done using XRF at the same time. The microtomography enables us to obtain quantitative 3-D track structures, which cannot be obtained from optical microscopic observation [3]. Sizes and shapes of original particles were estimated from the entrance shapes of impact tracks and their bulk Fe contents [4]. In this paper, we will report 3-D structures of bulbous tracks, which are believed to be formed by impact of fragile fine-grained particles. We will compare 3-D structures of bulbous tracks with those of carrot-shaped tracks and discuss differences of capture processes of between the two types of tracks.

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[2] Kadono. (1999) Planetary and Space Science, 47, 305
[3] Tsuchiyama et al. (2008) Meteor. Plant. Sci., in press.
[4] Iida et al. (2007) Planetary Sciences Symposium, 335