Relationships among morphology, microstructure, and noble gas signatures of four Itokawa grains

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Grains recovered from Itokawa preserve the processes on and near the surface of the asteroid. The textures of surface modifications observed by TEM suggest that irradiation by solar wind (SW) plays an important role for their formation. However, the rates of the surface modifications on the Itokawa grains are still unresolved. Noble gas mass spectrometry is an important tool to infer the individual history of each Itokawa grain. We investigate the relationships among morphology, surface modifications, microstructure, and noble gas isotopic signatures by SEM and TEM observation and noble gas mass spectroscopy to discuss the history of each Itokawa grains.

All the grains, except for a grain with macrosteps on its surface, have space weathered rims and solar flare tracks. A grain containing the highest amounts of SW ^{4}He and ^{20}Ne among the samples analyzed has the highest track number density. There is a positive correlation between the track density and length, which suggests that moderate heating occurred on the surface of Itokawa. The thickness of the amorphous rims of the three samples is similar regardless of their noble gas concentrations, suggestive of a steady state between sputtering and amorphization. The amounts of the accumulated ^{20}Ne suggest that the steady state accomplished ~100 years or so.

The grain with stepped surfaces shows a quite different noble gas signature; only a small amount of ^{4}He (~10^{-4} cm^3 STP/g) was released only below 200 °C, which suggests that high temperature fractions of He was completely reset by severe heating. The steps on the surfaces may have been formed through the same severe heating event that have released SW noble gases by evaporation and/or by combination of evaporation and subsequent recondensation. SW irradiation for a short period is necessary to explain the ^{4}He released below 200 °C and the absence of solar flare tracks. Such a severe heating event could have occurred in a parent body of Itokawa.