Collision Formation of Ilmenite Nanoparticles with High-Temperature and High-Pressure Phase by Super High-Speed Ball-Milling

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Abstract (Arial 10)

Ilmenite with high-temperature and high-pressure phase was formed by the collision shock between steel balls induced by high-energy ball-milling with centrifugation of 150 G. The structural features were characterized by the analytical measurements based on the X-ray diffraction of synchrotron radiation and ultrahigh-resolution transmission electron microscopy. Fe-rich ilmenite, orthorhombic Fe_2TiO_4, could be formed by mechanochemical reaction between trigonal $FeTiO_3$ as a starting material and steel balls as a collision medium.

In order to investigate the formation process of ilmenite with high-temperature and high-pressure phase, the differences in the d spacings were evaluated of trigonal $FeTiO_3$ as-milled at 50, 100, 150 G, as shown in the synchrotron radiation X-ray diffraction patterns of Fig. 1. The collision energy, i.e., centrifugation force of 50 G, induced the remarkable decrease in the relative peak intensity and the increase in full width at half maximum. The collision energy of 100 G contributes to the formation amount of iron from steel balls and pot. In the case of 150 G, the diffraction peaks of (104) and (110) were significantly shifted to the direction of lower d spacing. Figure 2 shows the XRD patterns of $FeTiO_3$. The diffraction patterns obtained by Gaussian deconvolution indicated the best agreement with the first peak of trigonal $FeTiO_3$ as well as the first and second peaks of orthorhombic Fe_2TiO_4.

Our finding allows us to infer that such intense planetary collisions induced by high-energy ball-milling contribute to mass production of high-temperature and high-pressure phase.

References

[1] D.N.Hamane et al., Am. Mineral. 97 (2012) 568-572.

Figures

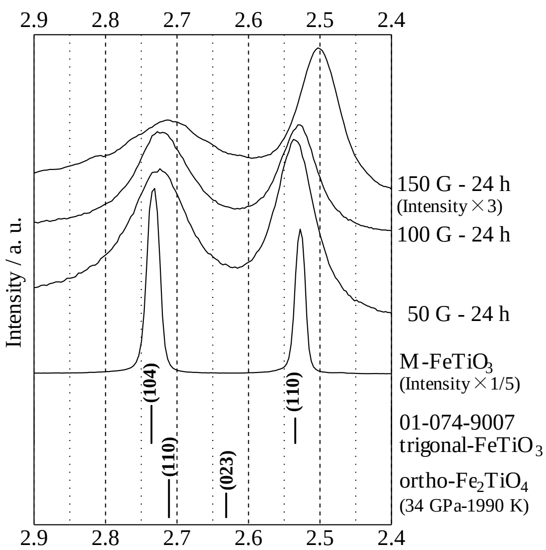

Fig.1 XRD patterns of $FeTiO_3$ nanoparticles as milled at collision energy of 50, 100, 150 G for 24 h. Bar graphs are based on the database of XRD patterns: number is extracted from ICSD; Fe_2TiO_4 from ref.1.

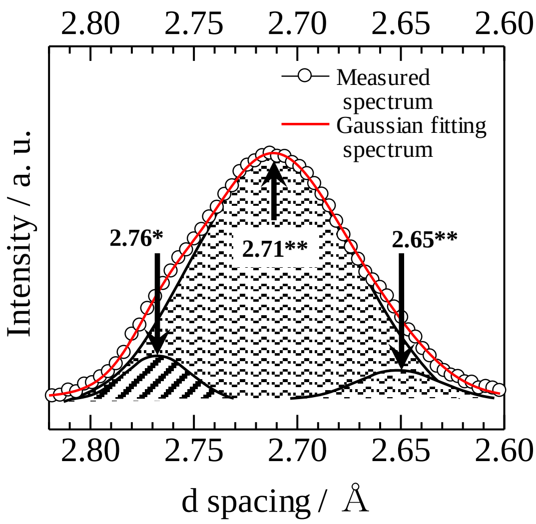

Fig.2 XRD patterns of $FeTiO_3$ nanoparticles as milled at collision energy of 150 G for 24 h. The d spacing* corresponds to d spacing of trigonal ilmenite and d spacings** to d spacing of Fe_2TiO_4* from ref.1.