Production of functional nanoparticles and their characteristic phenomena

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The functional nanoparticles, such as NiTi, WO_3, MoO_3, Al_2O_3, were produced by gas evaporation method, and their behavior in high temperature field or size effect was revealed by TEM observation or IR spectroscopy.

$Sb_{50}Se_{50}$ amorphous thin film was crystallized by electron beam irradiation of 10 A/cm^2 or heating at 200℃. The overgrowth of re-orientated crystal with more stable orientation was also observed by further beam irradiation.

The austenite phase of NiTi shape memory alloy nanoparticle was predominantly produced by flash gas evaporation method. The high resolution TEM observation revealed that the austenite phase and R-phase, which is intermediate phase between martensite and austenite phase, co-existed in one single crystal particle. It turned out that the R-phase did not transform to austenite phase even at 450℃ in nanoparticle.

Lowering of anisotropy of [metal-O_6] octahedron due to size decrement was found from the study of various sized ReO_3-type oxide nanoparticles. The WO_3 nanoparticle changed its structure from triclinic to cubic less than 10 nm. The IR spectra of MoO_3 nanoparticles were discussed based on simple harmonic oscillator model, and the lowering of anisotropy of MoO6 octahedron on needle MoO_3 nanoparticle was indicated by comparing with IR spectrum of bulk MoO_3.

The delta-Al_2O_3 nanoparticle was directly produced from gas phase. The IR spectral change by heating in air indicated that the transformation temperature from delta- to theta- and alpha-phase were 800-900℃ and 1300-1400℃. Furthermore, the production and their characteristic spectra of Al_2O_3 polymorphs nanoparticles opened new laboratory analogies in astrophysical field.

The hibonite ($CaAl_{12}O_{19}$) phase, which was major phase among CaO-Al_2O_3 compounds found in meteorite, was produced by solid-solid reaction between Al_2O_3 nanoparticle and CaO film. On the other hand, the $CaAl_2O_4$ phase was produced by the reaction between Al film and CaO nanoparticles. Solid-solid reaction with different combination alters the products in this system.

CaO nanoparticle or Ca thin film was immediately hydrated by exposing into air. The $Ca(OH)_2$phase was easily formed at their surfaces. The change of IR transmittance of Ca thin film revealed that the Ca thin film was completely hydrated in 700 seconds. The hydroxylation of CaO particle were slower than that of Ca thin film and, he 50 nm sized CaO particles were hydrated about 50% in a day. The $Ca(OH)_2$ was easily decomposed to H_2O and CaO by irradiation of electron beam, and the CaO crystallites were formed in the film or the particle. Oxidation, hydration and decomposition process of Ca and CaO have been opened the new view points of nano-dusts.