Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

Table S1. List of types of nanoparticles used in the study

	ZnO	$BaTiO_3$	CuO	SnO_2	TiO_2	Fe_2O_3 (spherical shape)	Fe_2O_3 (rhombohedral shape)
d_{xrd} [nm]	20	20	29 (tenorite)	19	28 (anatase)	55	52
synthesis*)	CP	HT	CP	CP	CP	HT	HT
note	0.03 at% Ga doped	pseudo cubic structure	tenorite with minor cuprite	cassiterite	anatase with minor rutile	hematite	hematite

*) CP: commercial powder, HT: hydrothermal synthesis

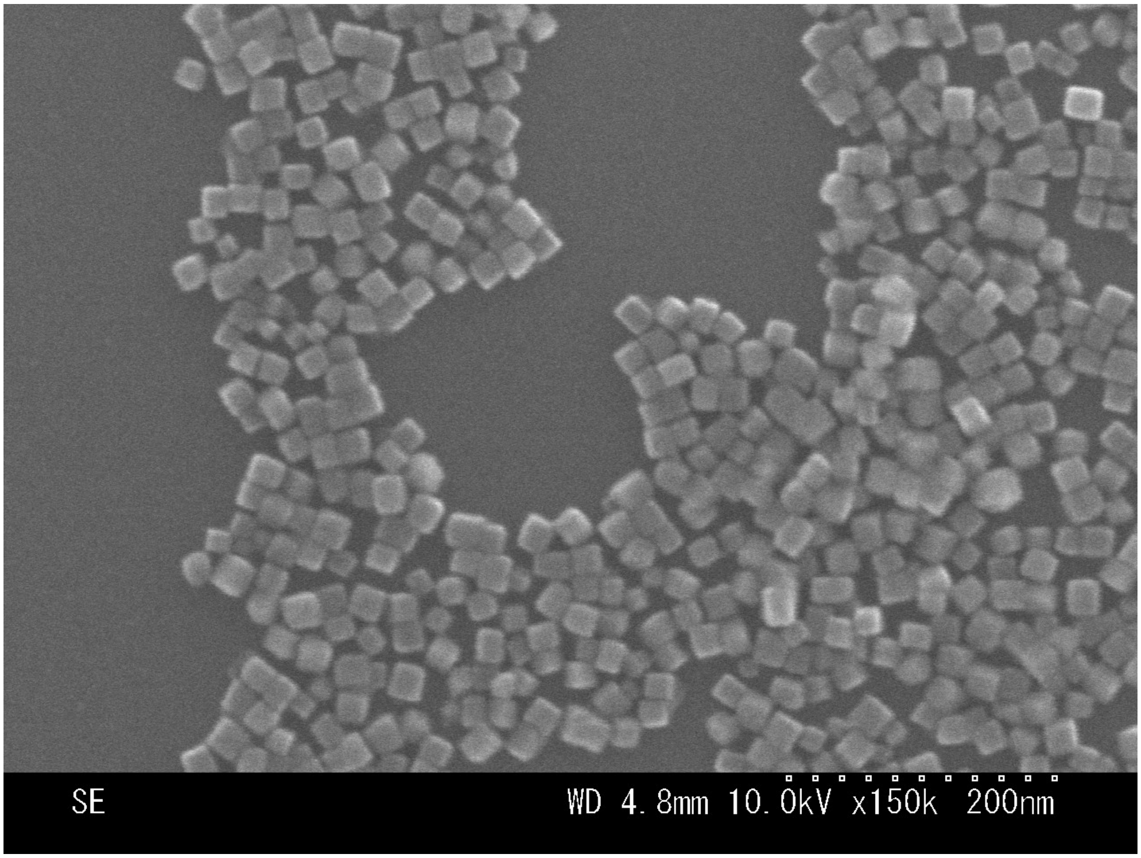


Figure S1. SEM image of $BaTiO_3$ NPs with cubic shape.

Pressure sintering of ZnO microcrystals as control

A ZnO powder with microsized (*i.e.*, 1 μm) crystals (3N grade, Koujundo Chemical Laboratory Co., Ltd.) was densified under a pressure of 500 MPa. The heating/cooling rate used was 50°C/min, and the temperature was kept at 300°C for 5 min. The density of the resultant product was 85% of the theoretical density; in comparison, sintered ZnO nanoparticles exhibited a density of more than 95%.

The density of the microcrystals was higher than the close-packing density. Thus, it is likely that the densification occurred because of yield deformation. According to Helle *et al.*, the relationship between the yield stress (ρ_{yield}) and the density is as follows:

$$\rho_{yield} = \left(\frac{(1-\rho_0)P}{1.3\sigma_y} + \rho_0{}^3 \right)^{1/3}$$

where σ_y is the yield stress and ρ_0 is the density in the absence of pressure (P).[13] The equation is valid for $\rho_{\mathrm{yield}}<0.9$. The trend observed is shown in Fig. S2.

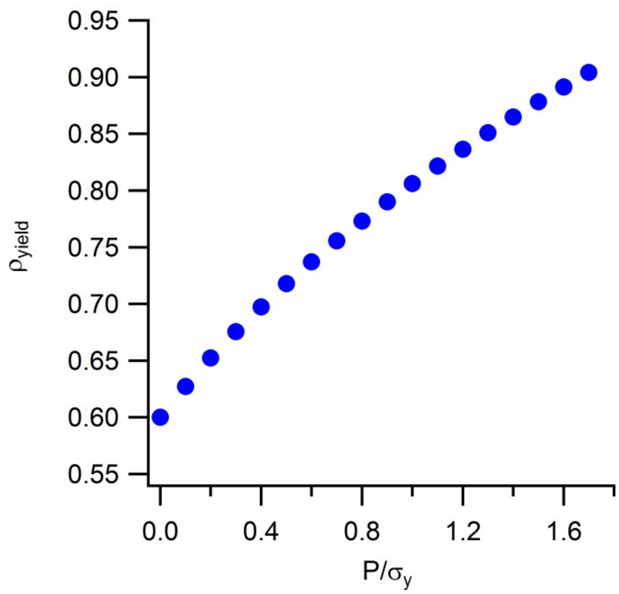
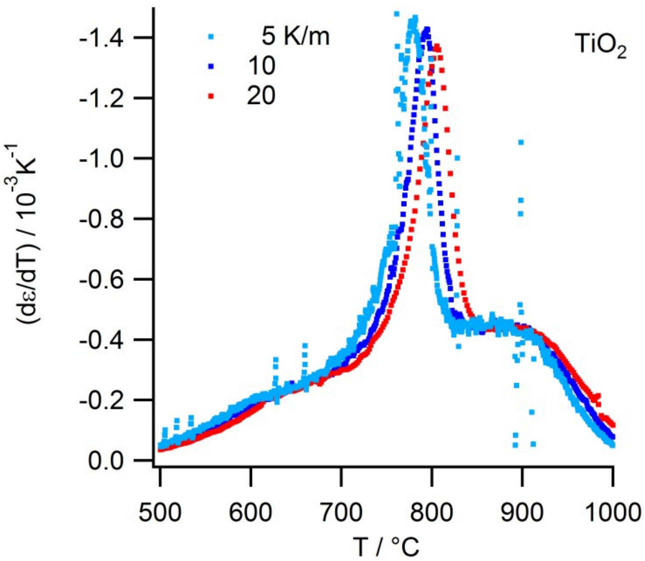


Figure S2. Densification by yield deformation.

From the figure, it can be seen that an external pressure comparable to the yield stress results in a density of 0.85. On the other hand, the yield stress of ZnO at 300°C had been determined to be of the order of 100 MPa [14]. Hence, an applied pressure of 500 MPa is enough to explain the phenomenon of densification by yield stress.

Peak shift of shrinkage rate against various heating rates of NPs above the temperature of LTD mode



The figure shows the peak of shrinkage rate for nano-TiO_2 at relatively high temperature. Although the peak shift was not evident for LTD (See Fig.8 in the manuscript), clear peak shift against heating rate was observed similar to the nano-ZnO. This peak shift is principally caused by the activation energy of diffusion during sintering. The same phenomenon is reported in the literatures regarding nano-particle-sintering of oxides. [i-iii]

i) K. G. Ewsuk, D. T. Ellerby and C. B. DiAntonio, *J. Am. Ceram. Soc.*, 2006, **89**, 2003.

ii) M. Mazaheri, A. Simchi, M. Dourandish, and F. Golestani-Fard, *Ceramics International*, 2009, **35**, 547.

iii) Y. Kinemuchi and K. Watari, *J. Euro. Ceram. Soc.*, 2008, **28**, 2019.