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Electronic Supplementary Information

Extraordinary High Ba^{2+} Ion Conducting Solid

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Additional Experimental Results

1. Chemical analyses

The amounts of Ba, N, and O in the $0.75(Gd_{0.4}Nd_{0.6})_2O_3$-$0.25Ba(NO_3)_2$ solid were analyzed by using the X-ray fluorescence spectrometer (for Ba) and the nitrogen / oxygen analyzer (for N and O), and the results are listed in Table S1.

In the case for Ba, its amount is constant for all samples. For the nitrogen and oxygen, although both N and O amounts in the sample at 550°C decreased a little compared with those in the mixture, considerable amount (ca. 80%) of N and O were remained in the sample. In contrast, for the sample calcined at 800°C, most of nitrogen disappeared from the sample, which supports the idea that the $Ba(NO_3)_2$ decomposed to BaO.

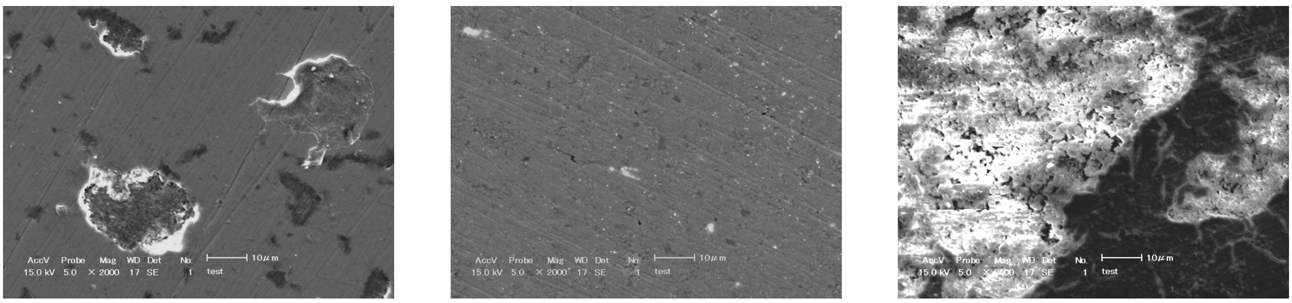
Table S1. The amounts (mass%) of Ba, N, and O in the $0.75(Gd_{0.4}Nd_{0.6})_2O_3$-$0.25Ba(NO_3)_2$ solid.

element	Mixture	Calcined at 550°C	Calcined at 800°C
Ba	15.0	14.9	14.7
N	2.15	1.77	0.40
O	18.40	14.24	12.20

2. SEM observations

The SEM photographs of the mixture of $(Gd_{0.4}Nd_{0.6})_2O_3$ and $Ba(NO_3)_2$ (molar ratio: 0.75 : 0.25) and the $0.75(Gd_{0.4}Nd_{0.6})_2O_3$-$0.25Ba(NO_3)_2$ solid calcined at 550°C, and also at 800°C are displayed in Figure S1.

For the mixture, the $Ba(NO_3)_2$ particles were clearly observed in the sample. However, such particles were not observed at all for the sample calcined at 550°C. On the other hand, large pores were recognized in the sample, which results from the decomposition of $Ba(NO_3)_2$.



(a) (b) (c)

Figure S1. SEM Photographs of the mixture of $(Gd_{0.4}Nd_{0.6})_2O_3$ and $Ba(NO_3)_2$ (molar ratio: 0.75 : 0.25) (a) and the $0.75(Gd_{0.4}Nd_{0.6})_2O_3$-$0.25Ba(NO_3)_2$ solid calcined at 550°C (b) or 800°C (c).

3. Electrical conductivity measurements

In order to make it clear that the high ion conductivity of the $0.75(Gd_{0.4}Nd_{0.6})_2O_3$-$0.25Ba(NO_3)_2$ solid is caused by the formation of solid solution of $(Gd_{0.4}Nd_{0.6})_2O_3$ and $Ba(NO_3)_2$, we measured the electrical conductivity of the sample in which $Ba(NO_3)_2$ intentionally decomposed to BaO by the calcination at 800°C. The temperature dependence of the electrical conductivity for the sample which was obtained by calcining the mixture of $(Gd_{0.4}Nd_{0.6})_2O_3$ and $Ba(NO_3)_2$ at 800°C is shown in Figure S2 with the corresponding data for the $0.75(Gd_{0.4}Nd_{0.6})_2O_3$-$0.25Ba(NO_3)_2$ solid at 550°C.

As we expected, the conductivity of the sample calcined at 800°C was considerably lower than that of the $0.75(Gd_{0.4}Nd_{0.6})_2O_3$-$0.25Ba(NO_3)_2$ solid, and the value was still lower (1 – 2 orders of magnitude) than that of pure $(Gd_{0.4}Nd_{0.6})_2O_3$ solid solution (The conducting species were not identified.). This result indicates the fact that the high conductivity can be obtained only for the sample containing $Ba(NO_3)_2$.

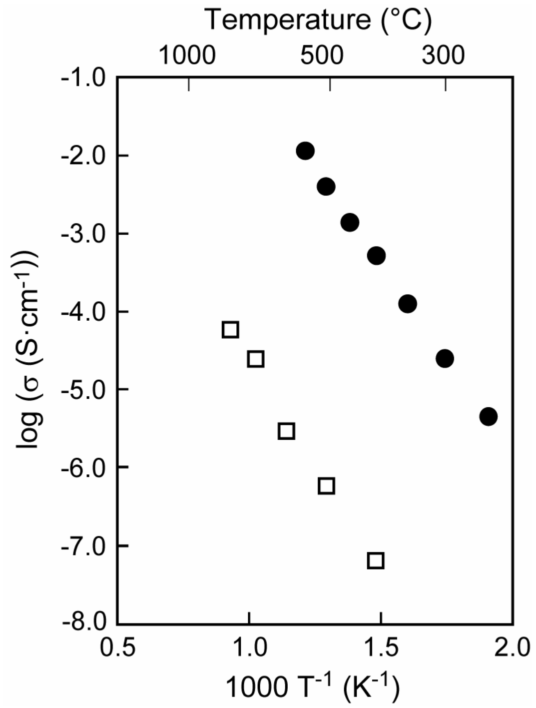


Figure S2. Temperature dependencies of the electrical conductivity for the $0.75(Gd_{0.4}Nd_{0.6})_2O_3$-$0.25Ba(NO_3)_2$ solid calcined at 550°C (●) and the $(Gd_{0.4}Nd_{0.6})_2O_3$ and $Ba(NO_3)_2$ mixture calcined at 800°C (□).