Electron-ion Transport in ZrO_2-Y_2O_3-CeO_2 Ceramics

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Mixed conduction of oxide ions in zirconia-yttria based ceramic systems has been a field of intense study for several years. The introduction of a multivalent cation such as Ce or Ti into the zirconia-yttria solid solution lattice is one approach followed by many investigators (1-4). Electron jump between different valence states of the multivalent cation is the generally expected mechanism of mixed conduction in these systems. Many multivalent metallic dopants, for example Ce, have a tendency to segregate to the grain boundary region when incorporated into the ZrO_2-Y_2O_3 fluorite-type lattice. One would therefore expect predominant electronic conduction along the grain boundary regions of such solid solution ceramics.

In order to gain a deeper understanding of the above phenomena, we have investigated solid solutions in the ZrO_2-x%Y_2O_3 -y%CeO_2 system where x (mol%) varies from 5.8 to 8 and y (mol%) varies form 2 to 10. We have used hydrothermal synthesis to prepare nanocrystalline powders of the above materials with uniform crystallite size (10 nm) and chemistry. High-density ceramic discs of different grain sizes were prepared by sintering pressed powders; the sintering temperature and sintering time were used as variables to obtain different grain sizes. A bright field TEM image of ZrO_2-5.8%Y_2O_3-10%CeO_2 having an average grain size of 50 nm is shown in figure 1. Microanalysis of the grain boundary region shows significant Ce segregation.

Our measurements of the electronic and ionic transference numbers in the above systems do not support enhanced electronic conduction along the grain boundary. Preliminary results are presented and hypotheses for the lack of enhanced grain boundary electronic conduction proposed.

References

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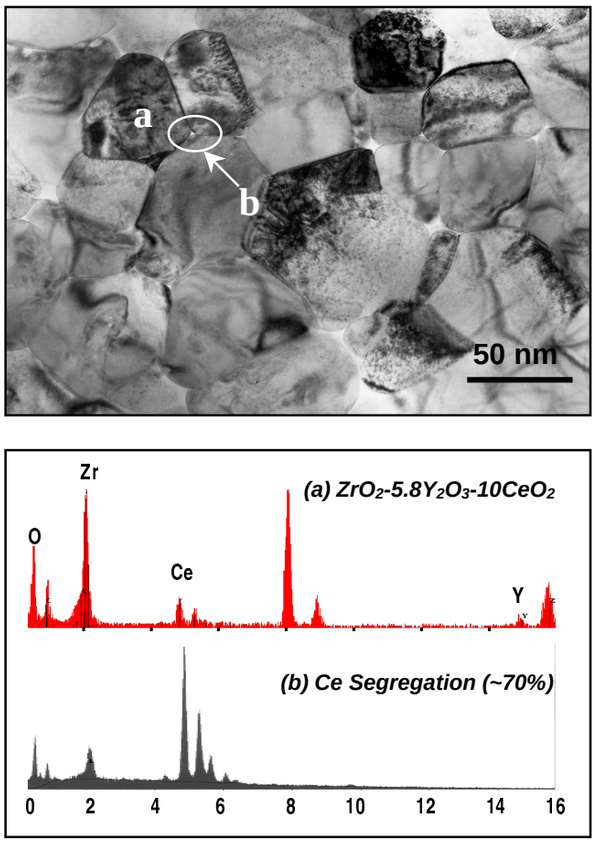

Figure 1. Bright field TEM image of nano-structured ZrO_2-5.8%Y_2O_3-10.0%CeO_2 ceramics after sintering at 1050°C for 4 hours and EDXS at a grain and a triple junction of grains as indicated.