In-situ High Temperature Phase Transformations in Oxide Ceramics

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Introduction

High temperature phase transformations in oxide ceramics are being studied *in-situ*, in air, using a thermal-image furnace in conjunction with synchrotron radiation. The emphasis is on oxide materials exhibiting polymorphic phase transformations of a ferroelastic nature, at elevated temperatures (up to 2000ºC).

Understanding the mechanisms of crystal structure changes in true ferroelastic phase transformation in selected materials is expected to aid in designing multifunctional, or tough high temperature composites, large force actuators and shape memory ceramics.

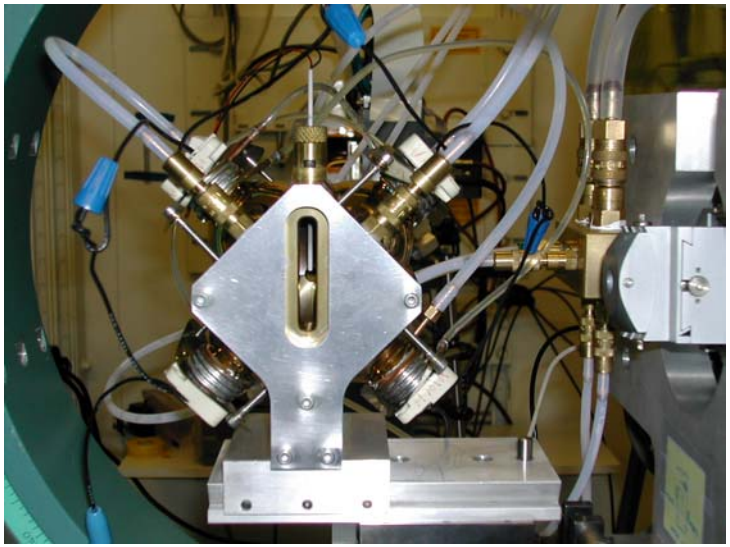

Fig. 1. The quadrupole lamp furnace used for *in-situ* high temperature XRD studies at the synchrotron source.

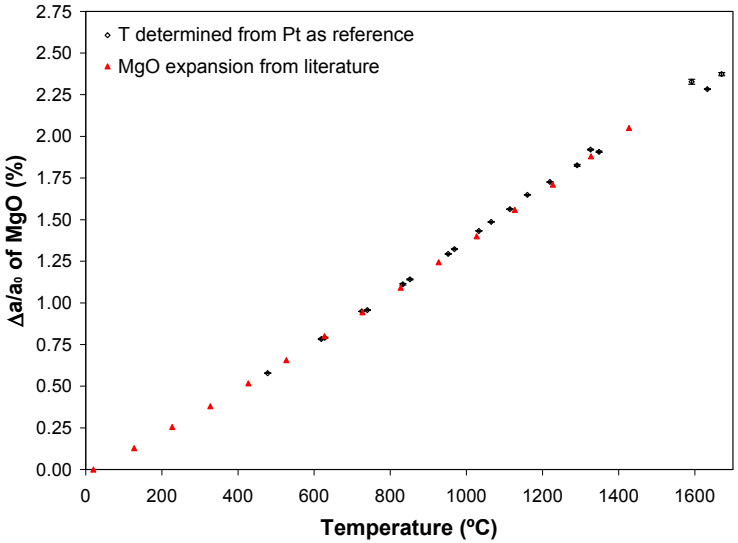

Fig. 2. Comparison of the thermal expansion of MgO, as determined experimentally using the reflection mode set-up for *in-situ* high temperature XRD, for experimental validation.

Accomplishments:

- Experimental verification of reflection mode setup for *in situ* high temperature XRD studies
- Successful synthesis of rare earth vanadates (a magneto-ferroelastic) and phosphates for transformation studies
- Extensive experimental studies on Ta_2O_5 and HfO_2-Ta_2O_5 are currently underway
- The PI was elected to the World Academy of Ceramics and several invited and contributed presentations were made at national and international forums

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Education:

The technique developed in this research project for conducting high-temperature XRD studies and its application for studying rare earth titanate systems have been presented at the 2004 Denver X-Ray Conference. This work was also presented as invited lectures at the National Workshop on Sample Environments for Neutron Scattering Experiments (SENSE), (invited plenary lecture), at the American Crystallography Society Annual Meeting; the Condensed Matter Physics Seminar, in the Department of Physics, Brookhaven National Laboratory; and the inaugural workshop for the opening of the Korean Basic Science Institute, High Voltage Electron Microscopy Facility, Korea.

Outreach:

Jeff Noga and Michael Mulholland are two undergraduate students supported by the REU program. Both have successfully learnt the science of synthesis and characterization of ceramic powders. A few results from their 14-week REU program are presented in Figure 3. Our Ph.D. student is Ms Ann Randolph.

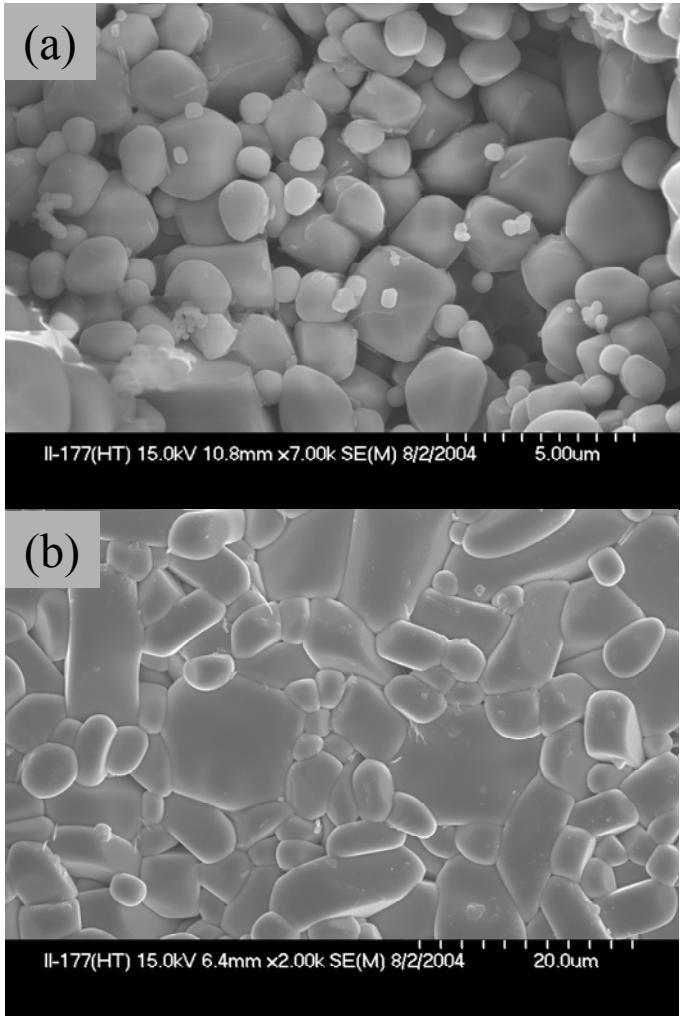

Figure 3. SEM micrographs of $DyVO_4$ samples (a) powders synthesized by the PEG method and (b) dense pellets after sintering at 1500ºC for 10 hrs