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High-Pressure/High-Temperature Studies of the Low-Z materials - Beryllium

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Experiment Report
for Online Submission

1. Report Title

High-Pressure/High-Temperature Studies of the Low-Z materials - Beryllium

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3. Body (about one A4 page)
- Purpose of the experiment and summary of the result
- Experimental method and key experimental data
- Conclusion, examination and reference list

The high-pressure/temperature phase diagrams of materials are largely unexplored. Combined laser heating/x-ray diffraction capabilities applied to diamond anvil cell experiment provide unique opportunities to study materials over a broad range of temperature (several 1000 K's) and pressure (several 100 GPa's). Of particular interest are high temperature phase transitions including solid-solid and melting transitions in geophysically and technologically important systems. Data derived from these experiments serve to extend our scientific understanding of materials and evaluate theoretical predictions. Using the laser heating (LH) and angle dispersive x-ray diffration (ADXD) capabilities at BL10XU at SPring-8, we have studied several materials at high-pressure/temperature. This report will summarize results of our studies of solid-solid and melting transitions of beryllium at high pressures and high temperatures.

The phase diagram of beryllium is largely unexplored, and the limited data that is available relies on indirect means to establish phase lines and phase transitions (see figure 1)[1]. At ambient pressure an hcp-bcc phase transition has been observed at 1523 K with a subsequent melt transition at 1551 K. Using electrical conductivity, Francois and Contre[2] inferred that the hcp-bcc phase line had a negative slope with pressure. It should be noted that this was established using indirect evidence, and the bcc phase was not definitively identified using, for example, x-ray diffraction. Many subsequent studies have searched for the extension of this phase line, but have failed to find the hcp-bcc transition at room temperature up to pressures approaching 200 GPa[1]. The goal of our studies at BL10XU/SPring-8 was to identify stronger evidence for this hcp-bcc phase line, extend the pressure range and measure the lattice parameters at high pressure.

Laser-heated angle-dispersive x-ray diffraction studies of beryllium at high pressures are challenging. The low x-ray scattering efficiency of beryllium, a low- Z material, requires the high-performance of SPring-8, a 3rd generation synchrotron source. We used LLNL designed diamond anvil cells (DAC) to contain and pressurize the beryllium samples. We imbedded the sample in MgO and NaCl, in order to thermally insulate the sample from the diamond anvils and achieve efficient heating. Using the laser-heating system at BL10XU we were able to perform simultaneous x-ray diffraction/laser-heating experiments and heat our samples to temperatures exceeding 2000K, as determined by pyrometry, at pressures of up to ~40GPa. Below ~2000 K we measured ADXD patterns consistent with hcp beryllium. Images of a sample before and after heating are shown in figure 2. Careful examination of the images reveals perforations in the sample after laser heating. We ascribe this to movement of the sample once the sample and/or the insulator/hydrostatic medium melted. Thus, it is difficult to determine melting as the lack of an x-ray pattern may not be due to melting, but instead movement of the sample out of the x-ray beam path.

An interesting result of our work is the lack of any evidence of the bcc phase. Our work calls into question the existence of a bcc phase in beryllium at high-pressure/temperature. Further experiments and analysis of our data will permit the construction of a complete pVT equation of state for beryllium, and extraction of the Gruneisen parameter thermal expansion coefficient.

This work was performed under the auspices of the U.S. Department of Energy by University of California, Lawrence Livermore National Laboratory under Contact W-7405-ENG-48.

References

1. Evans, W.J., et al., *X-ray diffraction and Raman studies of beryllium: Static and elastic properties at high pressures.* Physical Review B, 2005. **72**(9).
2. Francois, M. and M. Contre. *Contribution to the Study of the Pressure-Temperature Diagram of Pure Beryllium*. in *Conference Internationale sur la Metallurgie du Beryllium*. 1965. Grenoble: Universite de France, Paris.

4. Attachment (JPG, PNG, GIF)

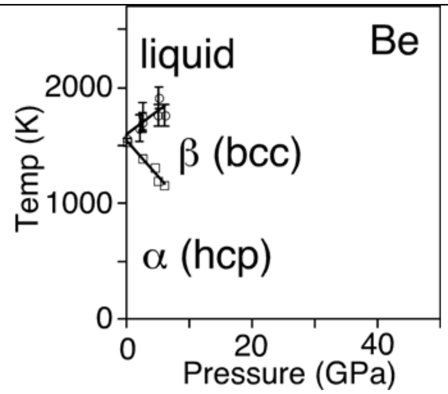

Fig 1. Phase diagram of beryllium. Adapted from [1]

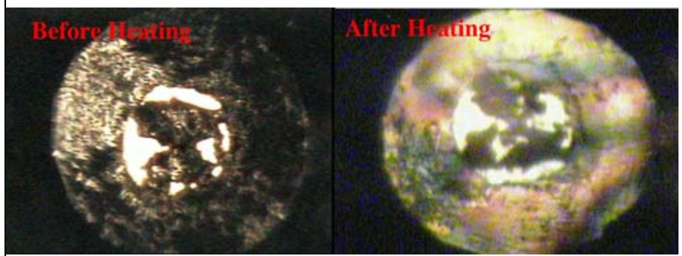

Fig 2. Images of Beryllium sample before and after laser heating. Note perforations and holes in the after image.

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5. Publication Schedule

Type of Publication*: Referred Journal	Journal/Conference title:	Expected Date of Publication**: 6 months

*Refereed Journals, Review Articles, Proceedings, Books, Awards, Patent, Others, Invited Talks, Other oral

**Expected date of publication: within 3 months, 6 months, 1 year, 2 years, or more

If you are not sure when you will to publish your results, specify the reason and provide the publication schedule.

We are still in the process of analyzing our results. We expect to submit a manuscript of our work within the next 6 months.

6. Comments and Suggestions