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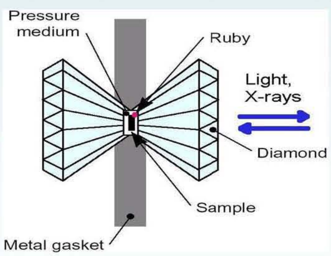
Abstract

In Diamond Anvil Cells (DACs), usually a pressure transmitting medium functions to transform the uniaxial pressure supplied by the opposing diamond anvils into uniform hydrostatic pressure acting on the sample. Conventionally, a 4-1 methanol-ethanol solution, or a 16-3-1 methanol-ethanol-water solution is used as pressure transmitting medium. However, these two solutions transform into a glass with high elastic shear strength at pressures around 12-14 GPa and no longer function as hydrostatic medium. Our goal was to determine if liquid ionic alkalihalide alkanolate complexes will provide more uniform pressure in the cell up to 20 GPa. Ruby (Cr-doped Al_2O_3) produces two Cr^{3+} fluorescence lines when exposed to sufficiently energetic radiation(457.9 nm in our case). These two fluorescence lines shift toward the IR with increasing pressure. We used the splitting of the two fluorescence lines as well as the width of the peaks in order to measure the shear strength of the alkalihalide-alkanolate as a function of pressure.

Introduction

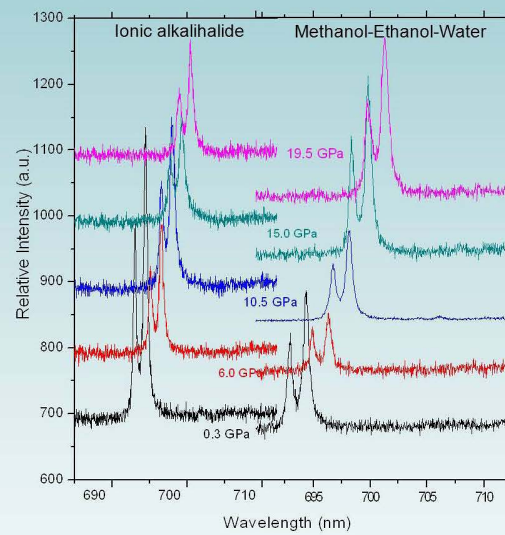
Fig. 1: Diagram of a Diamond Anvil Cell



Basic diagram of a DAC. The opposing diamond anvils provide uniaxial pressure onto the pressure medium, the sample, and the ruby. The pressure medium converts the uniaxial pressure from the anvils into uniform hydrostatic pressure. Since we were simply testing the pressure medium, no sample was inserted for our trials.

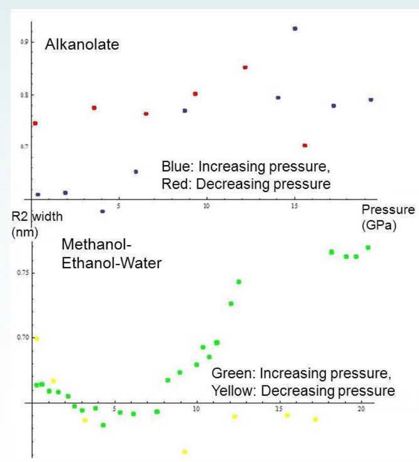
Data and Conclusions

Fig. 2: Wavelength vs. Pressure for both samples



The standard pressure medium in DACs, a 16-3-1 methanol-ethanol-water solution, begins to transition into a glass at approximately 9-14 GPa. In our case we saw a glass transition as pressure neared 10 GPa. The alkalihalide-alkanolate undergoes a glass transition at approximately 7 GPa. It is in the glass transition where the alkalihalide complex is superior to the methanol-ethanol-water solution. As pressure increases to above 15 GPa, the alkalihalide-alkanolate maintains a relatively constant R2 peak width, whereas the methanol-ethanol-water solution experiences a drastic increase in peak width (fig 3). Broader ruby fluorescence peaks imply a greater shear strain on the sample, in other words: non-hydrostatic conditions. Thus, at high pressures, the alkalihalide-alkanolate provides conditions closer to hydrostatic pressure.

Fig. 3: R2 Width vs. Pressure for both samples



While the alkalihalide-alkanolate may be superior to the standard methanol-ethanol-water pressure medium, it is not preferable to gas pressure media such as helium. While the alkalihalide-alkanolate exhibits modest shear strength after the glass-transition visible as a pressure gradient between different points in the chamber of ~1 GPa. Gas-media like helium crystallize but maintain lower shear strength to much higher pressures. The question might arise: why not always use helium as a pressure medium, since it maintains near hydrostatic conditions at higher pressures? Since helium is a gas, loading it into the DAC is a markedly more difficult task. Additionally, different media are needed for different samples, given that reactions between the media and the sample are unwanted.

Experimental Setup

Fig. 4: Experimental Setup

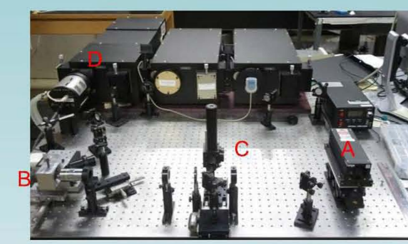


Figure 3 shows our experimental setup. A 457.9 nm laser (labeled A in the above picture) is reflected such that it travels through a focusing lens and hits the DAC (B). The excited fluorescence from the DAC travels through a collecting lens, reflects off a translatable mirror. If the mirror is in position, then the sample can be viewed in the microscope (C). Otherwise, when the mirror is moved out of position, then the light passes the microscope and travels through a condensing lens and into the spectrometer (D). We used the spectroscopy program WinSpec32 to image the peaks from the pressure media, and Origin 8 to subsequently analyze the peaks.

References

1 http://james.badro.free.fr/Java/RubyApprox.html

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3 W. Bassett, High Pres. Research, **29** (2), 163 (2009).

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