

High Pressure – Variable Temperature Studies on Pressure Transmitting Media

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Abstract

The pressure transmitting medium is an important element in high pressure physics. A variety of pressure transmitting media exist including Silicone fluid, Daphne Oil, 4:1 Methanol:Ethanol mixture, etc. In this experiment, the hydrostatic limits of pressure transmitting media have been observed at low temperatures and high pressures. In this case, 4:1 Methanol: Ethanol has been used.

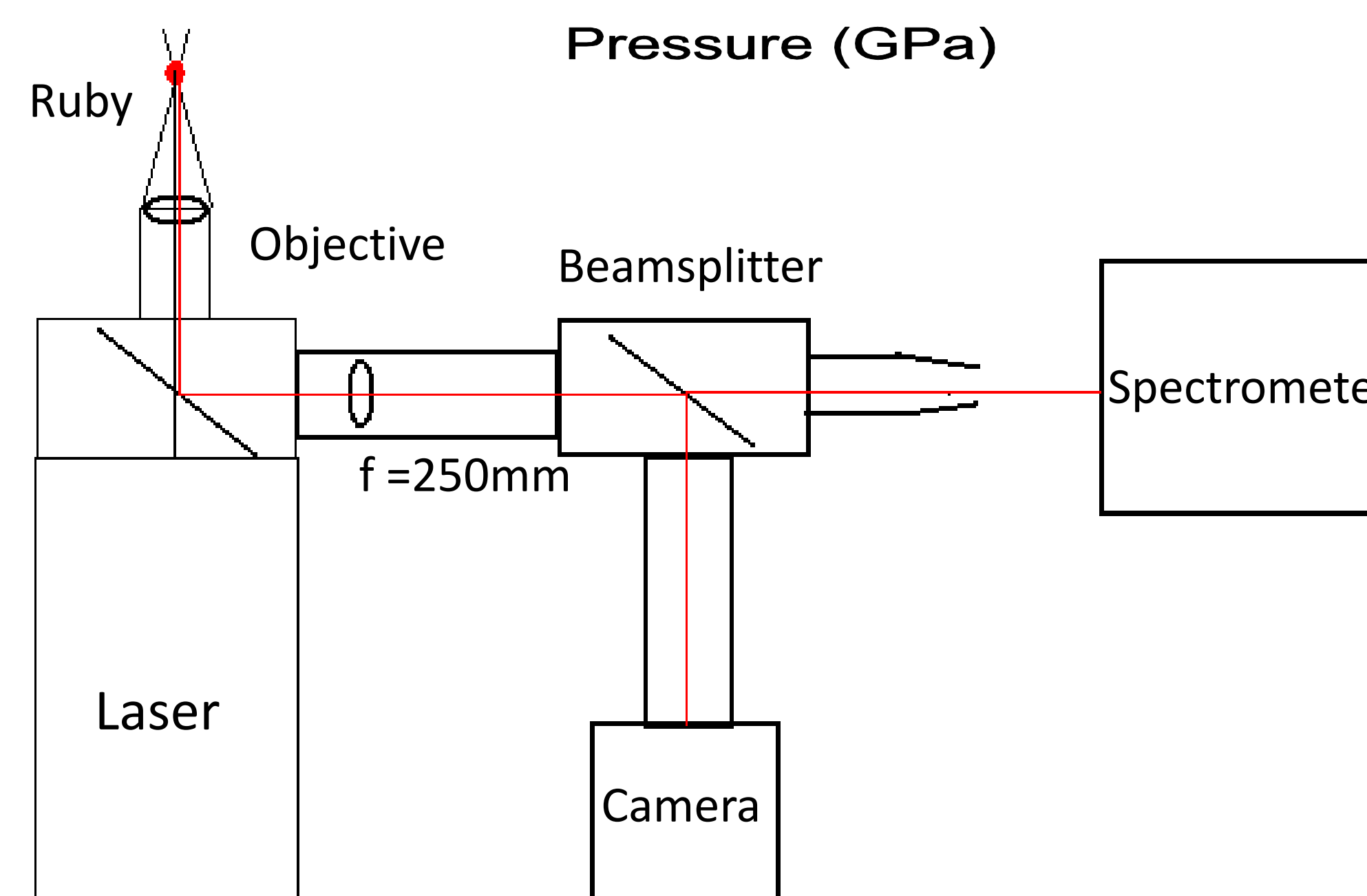
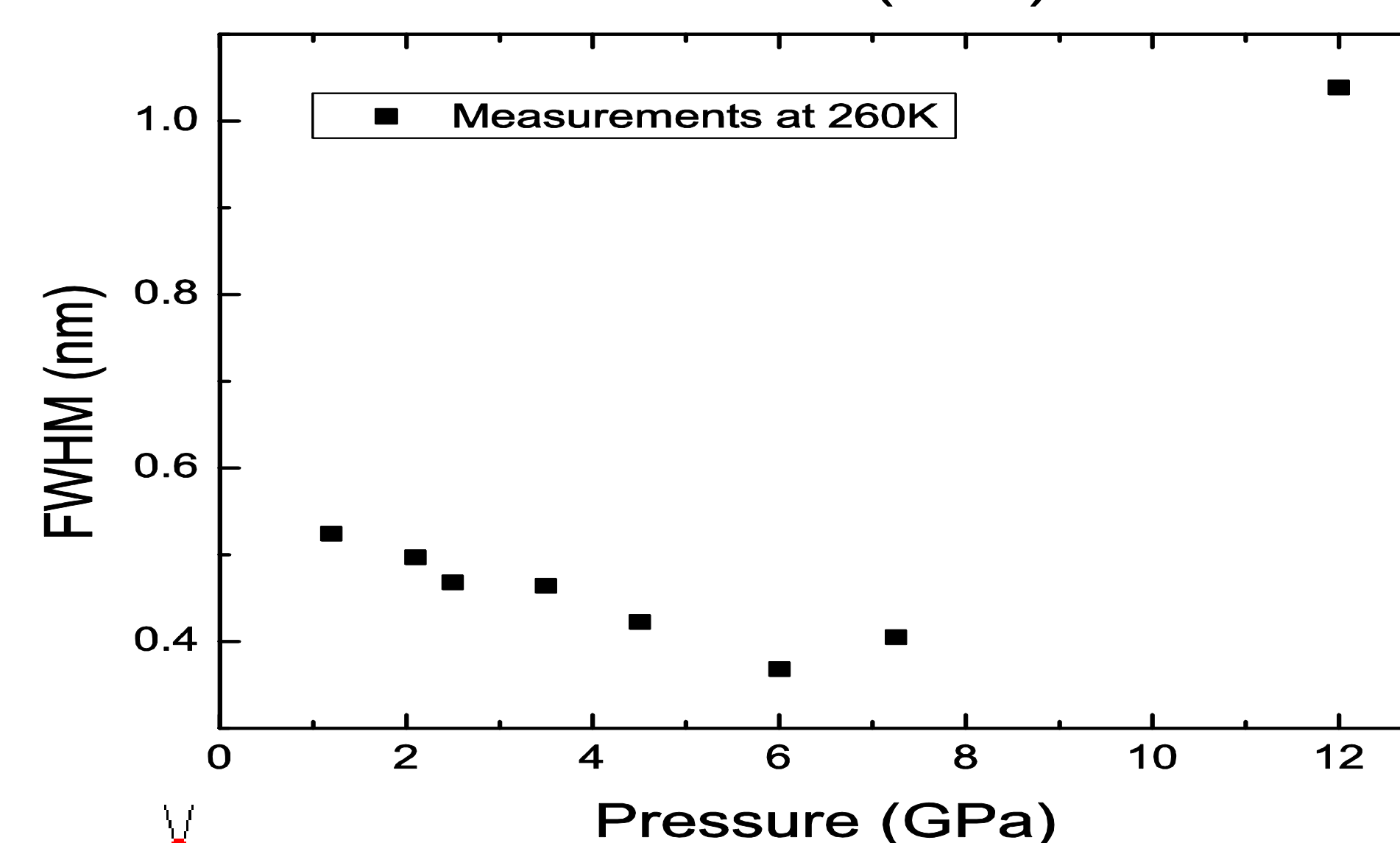
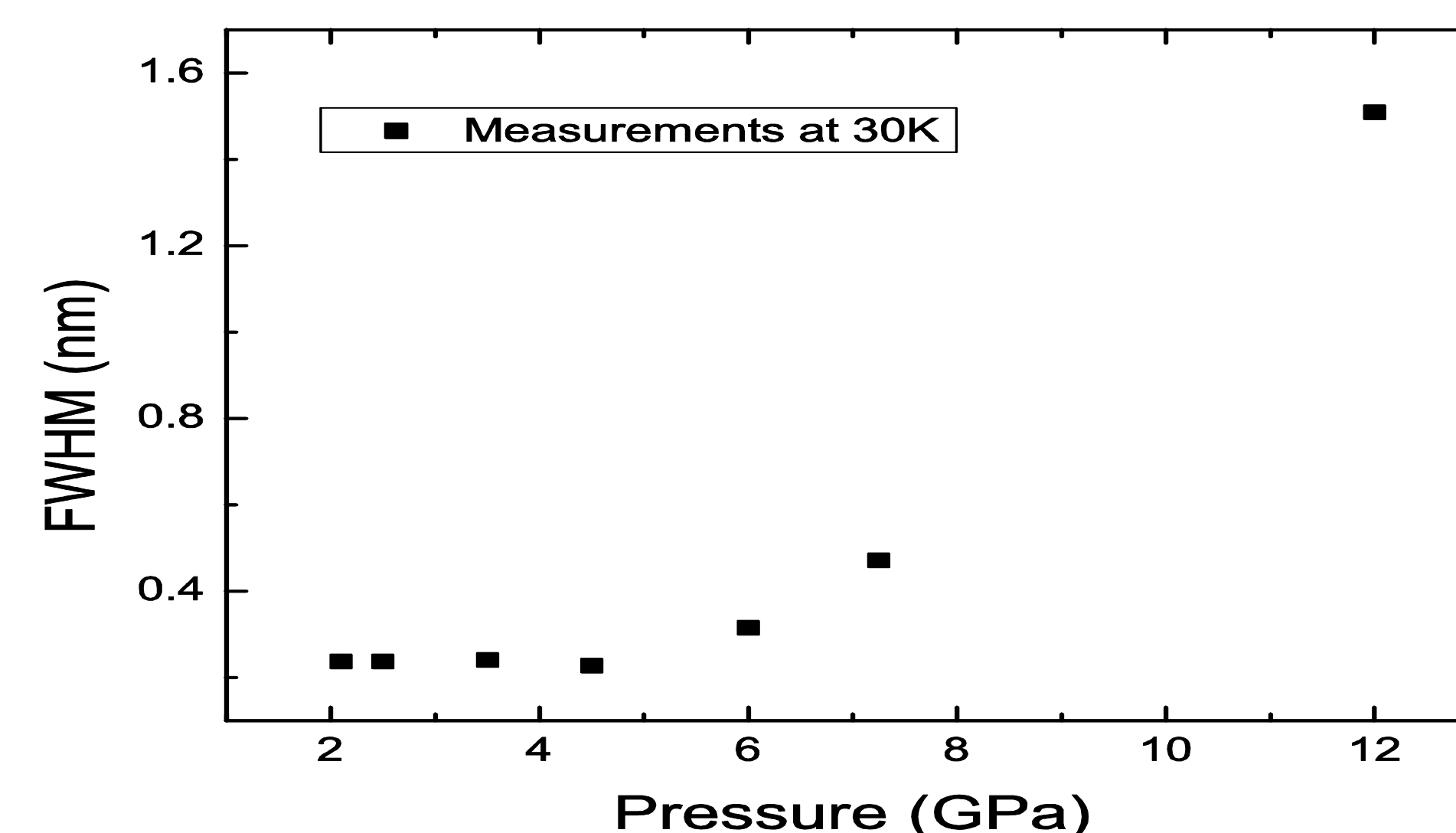
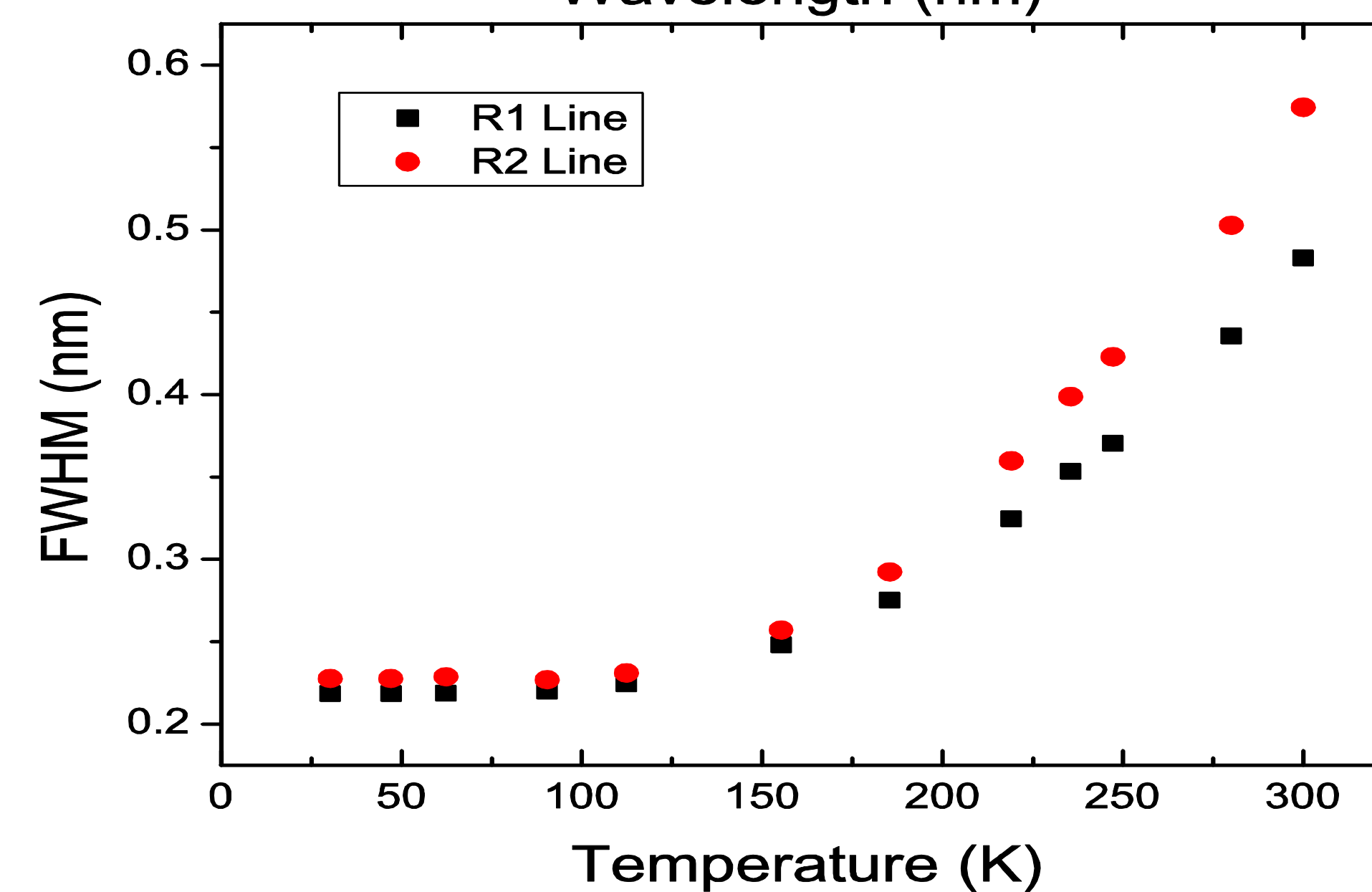
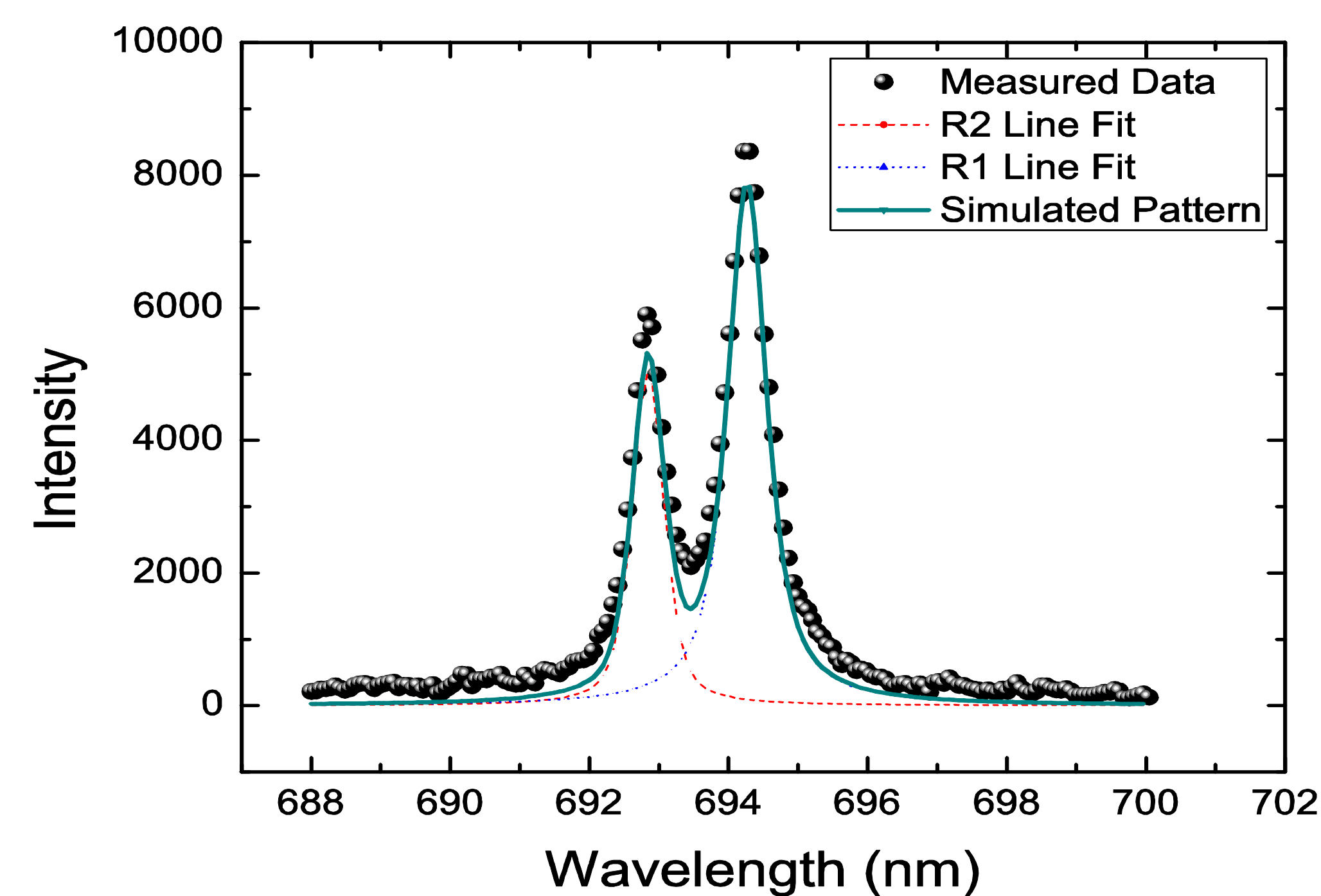
The hydrostaticity of 4:1 Methanol:Ethanol has been well studied at room temperatures using the fluorescence of ruby by fitting the R1 and R2 lines to Pseudo-Voigt functions. The hydrostaticity of the pressure medium was determined by analyzing the full width at half max (FWHM) of the R2 line.

Experiment Details

For this experiment, a Merrill-Bassett type Diamond Anvil Cell (DAC) was used. This DAC was equipped with diamonds with culet size of 400 μ m in diameter. The sample chamber of this system was 130 μ m in diameter with spherical ruby surrounded by a Methanol-Ethanol pressure medium, with a volume ratio of 4:1.

This DAC was placed inside a closed cycle cryo-cooler apparatus (Figure #) to control the temperature of the system during the measurement process. In order to understand what is happening inside the cell, a 405nm laser has been used. The laser beam was focused on the ruby, which then fluoresces, and the light is collected by a home-built fluorimeter system (Figure #) in approximately 40K temperature increments between 300K and the base temperature of the system. The data was collected under pressure at 1, 2, 3, 4, 5, 6, 7.25, and 12GPa. The temperature is controlled through a LabVIEW program designed to tune an internal heater's output power to maintain a temperature set point, similar to a PID controller.

With the data collected, it was fit using a Pseudo-Voigt function to determine peak shape, peak location, and FWHM of each of the ruby peaks. This information was compiled in Origin to produce the plots presented in the next section.



Results

It is reasonable to anticipate a fluid transitioning into a solid at low temperatures and high pressures. Data gathered from graph 3, at 30 Kelvin, shows that the FWHM of the R2 line remains relatively constant until after 4.5 GPa and then increases. The exact point of transition to a solid would be difficult to determine as there needs to be more data taken between 8 GPa and 12 GPa. In the 260K plot, we see a similar trend after 6 GPa, but a pronounced decrease in FWHM of R2 line below 6 GPa, which is to be expected at the higher temperatures. The increase in the 30K plot is much more compared to that of the 260K plot. This maybe happening because of competing factors of broadening peaks. As temperature goes up the peaks broaden with it, which may be the cause of the sudden up shoot at 30 Kelvin.

Conclusions

The effect of temperature and pressure on commonly used 4:1 Methanol:Ethanol mixture pressure transmitting medium has been investigated. The FWHM is found to increase with pressure above 6 GPa at 30 K indicating non-hydrostatic stress due to solidification of the medium. Further investigations on other commonly used media are under progress for comparison.

References

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Acknowledgements

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