

Optical Optimization for Pump-Probe Spectroscopy

Jessica Jenick¹

¹Department of Physics, University of Dayton

Research Mentor: Dr. Imad Agha, Graduate Assistant: Zhanibek Bolatbek

Introduction

- Sought to improve pump-probe spectroscopy of phase-change materials
- Phase-change materials have useful applications in electronics and optics
- Example: Antimony triselenide (Sb_2S_3) can be used in wave plates¹
- Sb_2S_3 transitions from amorphous to crystalline
- Sample is pumped by a 7W, 445nm blue laser to instigate thermal processes
- Probed by a 150W white lamp
- Spectrum taken using Ocean Optics spectrometer or university detector array

Methods

Lighting elements

- Sent through an optical attenuator to reduce the power
- Passed through a fiberoptic cable to improve spatial coherence
- Shone through a series of lenses to collimate the beam, and then through a beam splitter.

Spectroscopy elements

- First camera for reflection analysis
- Second camera for imaging sample
- Diffraction grating separates wave for diffraction array

Challenges

- Difficulty in overcoming the spatial incoherence of white light
- Collimated white light to maximize power while minimizing spot size after focusing
- Used a more powerful laser to maximize the spot size of blue light.

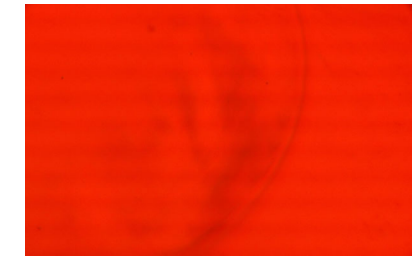
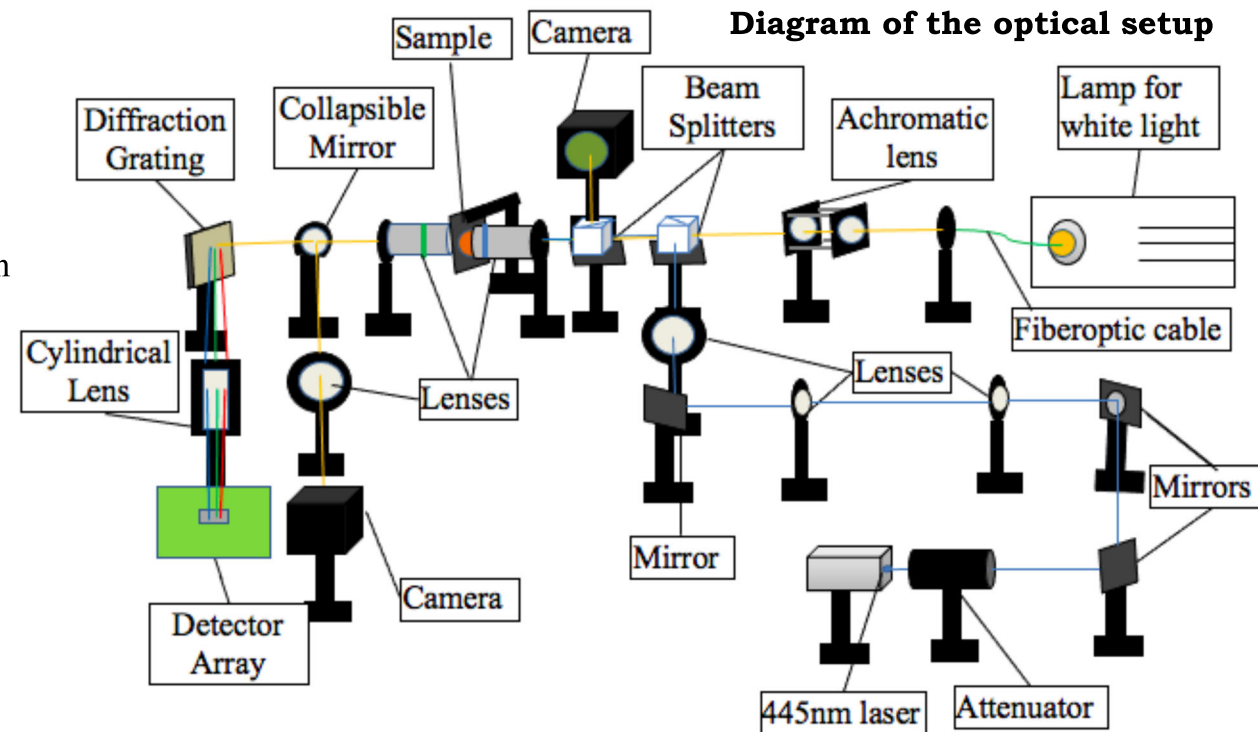


Image of amorphous Sb_2S_3

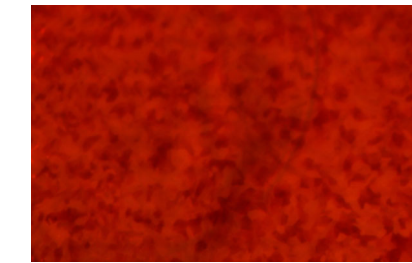
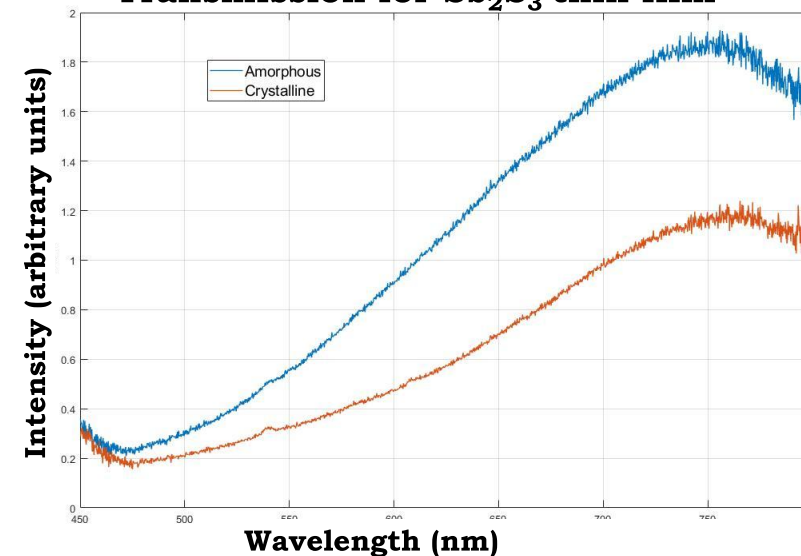


Image of crystalline Sb_2S_3

Transmission for Sb_2S_3 thin film²



Results

- Results from conventional spectroscopy are promising
- Will be connected to the spectrometer designed by the physics department
- Hope to start recording data at one MHz. State of the art is 1 KHz

Conclusions

- Success in designing a useful optical setup for a pump-probe spectrometer
- Can be used with in-house ultrafast spectrometer
- Possible near-instantaneous analysis of phase change materials
- Addressed the difficulties associated with white light
- Will allow future refinement of the setup

Acknowledgments

- Thanks to the University of Dayton for this research opportunity and to Dr. Imad Agha and Zhanibek Bolatbek for their invaluable assistance

References

- ¹A. Negm, M. Bakr, M. Howlader, and S. Ali, ACES 978-1-7335096-2-6 (2021). Retrieved from <https://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=9528787>
- ² Figure by Zhanibek Bolatbek