Exposure Schedule for the PQ/PMMA Holographic Medium

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Background

Holography is the recording and reading of diffraction interference patterns within a photosensitive material [1]. It's explained by simple key steps described:

- Diffraction occurs when light approaches the edges of objects.
- Diffraction interference is caused by two coherent light sources intersecting each other.
- The interference is recorded within a photosensitive material.
- The wavefront of either light source can be recreated with the other.

Introduction

Volume holography has garnered interest for its notable angular Bragg selectivity. The angular selectivity of the PQ/PMMA photopolymer is of interest within applications that require beam steering, such as LIDAR. PQ/PMMA was manufactured onsite and exposed to varying amounts of energy. The hologram was created using two-beam transmission. The reference beam entered the sample normal to the surface while the object beam entered at 12.5 degrees to the sample. Sample exposure energy varied from 5 to 100 joules. After developing the samples over the course of several days, an analysis was done to measure what percentage of light was ultimately diffracting from them. Obtaining the highest diffraction efficiency with a consistent exposure schedule will provide a starting point for anyone interested in utilizing this photopolymer for holography.

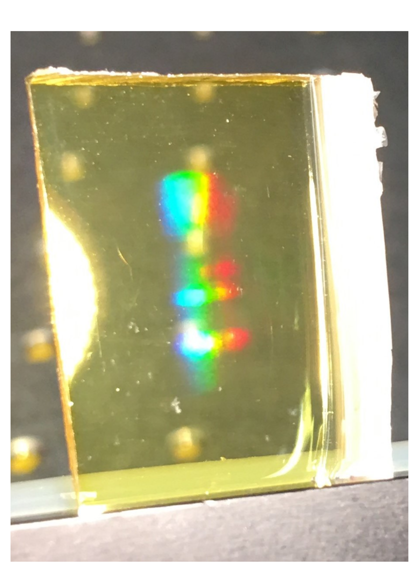

Figure 1: Surface diffraction from sample

Methods

A summarized step process is listed:

1. Manufacture PQ/PMMA [2]
2. Align optical setup and produce clear beam profiles
3. Set object and reference beam power equal
4. Calculate exposure time needed for energy delivery desired
5. Record hologram
6. Develop material under incoherent light sources
7. Measure diffraction efficiency of hologram

A two-beam transmission optical setup was used to record the holographic gratings within the material. Exposure time was calculated in MATLAB and carried out through switching of the shutter for the prescribed time. Multiple laser output powers were used, although it seemed to have a negligible effect on diffraction efficiency, as long as the exposure time was adjusted to the power read.

Data Acquisition

Total Power	Exp. Energy	Exp. Time
2.53 W	10 J	3.96 s
2.53	20	7.92
2.53	30	11.88
2.53	40	15.84
2.53	50	19.80
2.53	60	23.75
2.53	70	27.71
2.53	80	31.67
2.53	90	35.63
2.53	100	39.59

Table 1: Calculations of exposure time

All data acquisition was calculated and saved in MATLAB. Total power was calculated from power readings of the object beam. Energy desired was then divided by total power readings to determine the exposure time needed.

Main Takeaway

Obtaining a high diffraction efficiency within the PQ/PMMA photopolymer relies heavily upon the quality of sample manufactured as well as the energy delivered to the medium.

Experimental Setup

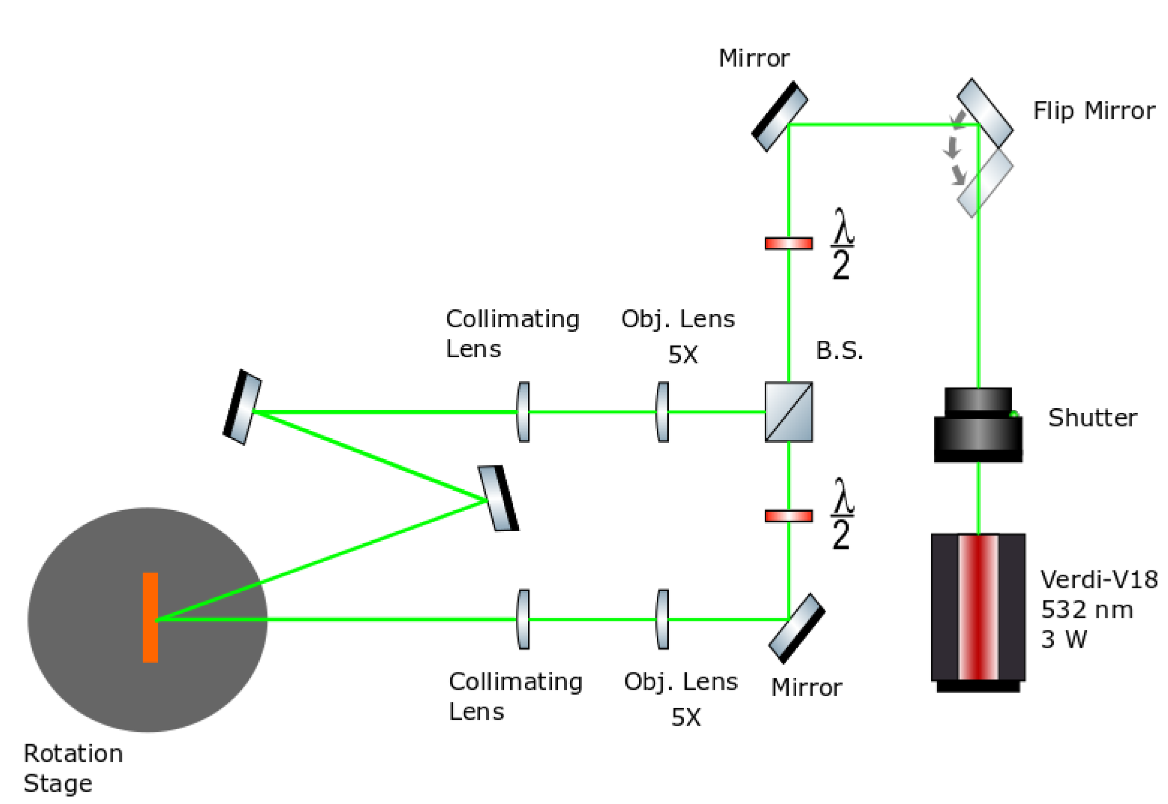

Figure 2: Two-beam transmission schematic

Results

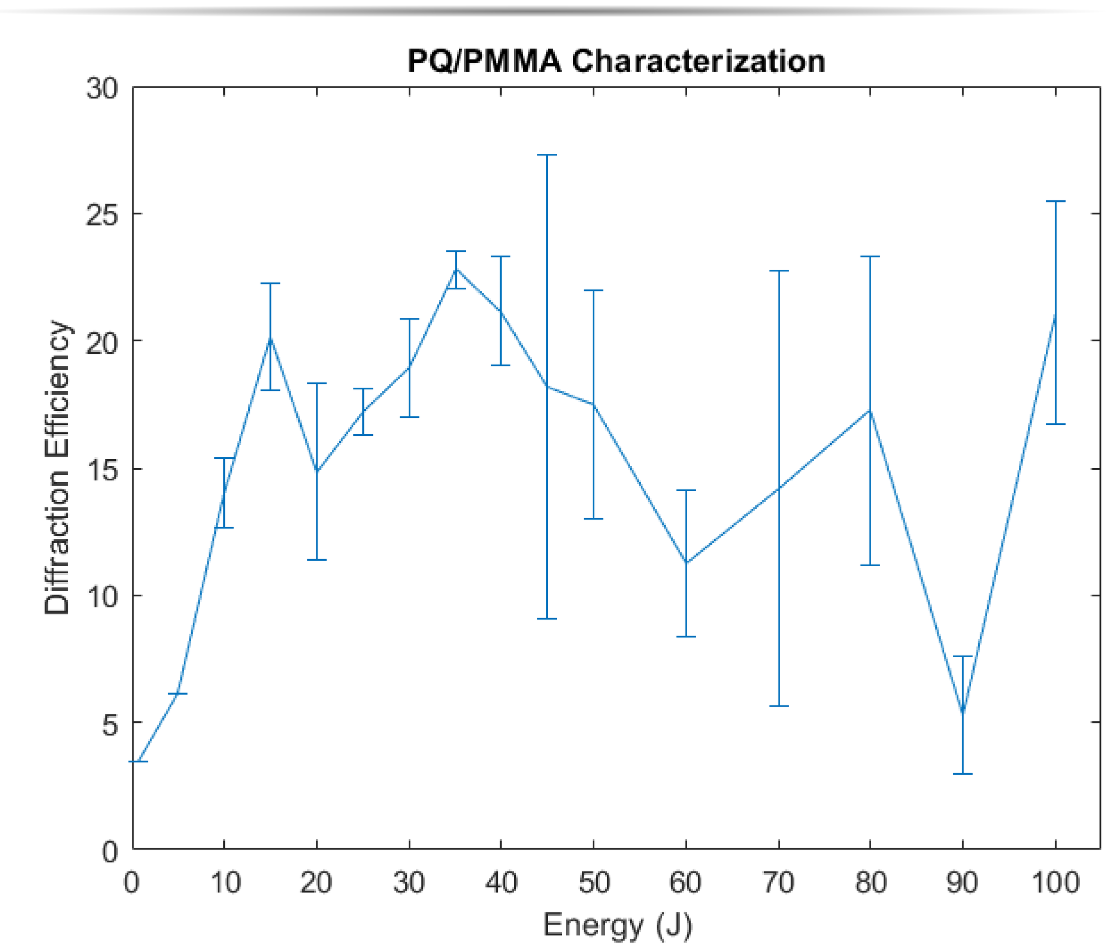

Figure 3: Diffraction efficiency shown with exposure energy

Conclusion

The PQ/PMMA material shows a positive trend toward the higher end of exposure energies delivered. However, taking the mean result of each exposure energy shows the most consistent diffraction efficiency is achieved at 35 joules. Highest diffraction efficiency achieved in an individual sample was 40 percent at a 70 joule energy exposure.

Future Work

Other aspects of the hologram recording process can be exploited to achieve high levels of efficiency, such as:

- High and low power range recordings
- Varying cooking techniques of PQ/PMMA
- Programmable shutter
- Multiplexing efficiency analysis

References

[1] P. A. Blanche.
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[2] Raymond K. Kostuk Atsushi Sato.
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Organic Holographic Materials and Applications, 5216, 2003.

Acknowledgements

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