Improving DMD Window Transmittance at Longer Wavelengths

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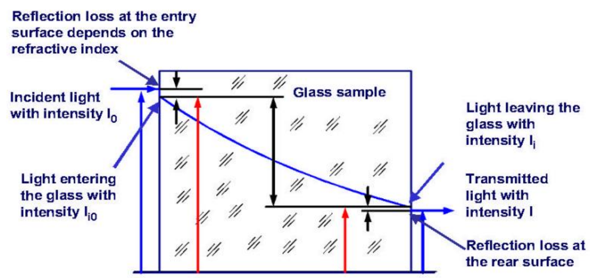
Abstract

The Digital Micro-Mirror Device (DMD), which was originally developed for digital projection using visible light source, has seen numerous applications in automotive, manufacturing, spectroscopy, and underwater imaging that require wavelength beyond visible. The DMD window is an important part of the packaging that protects the digital mirror array. Since the light goes through the top and bottom surfaces of the window glass twice during operation, the transmittance of the window is usually optimized for the range of wavelengths specified by the applications through optical coatings. In this research work, we will explore the effectiveness of optical coatings for different types of glasses for window transmittance improvement in visible and near-infrared wavelengths. We will evaluate the transmittance of the existing DMD window glasses and explore ideas of improving transmittance in the NIR range without compromising the effectiveness in the visible light range. In doing so, we would be improving the light efficiency of the DMD in a wider wavelength range.

Goals

- Test different coatings and find resulting transmittance on sample glass and choose a coating.
- Test different methods for removing coatings on sample glass.
- Remove coatings and add our own coating to the current glass.
- Improve the transmittance of the window within the NIR range (~700-2500 nm) while increasing or maintaining the transmittance in the visible light range (~400-700 nm).

How does transmittance work?



1. Window transmittance - the reported value needs to be accounted twice because light travels through the window twice.
2. Mirror array fill factor - the fraction of mirror coverage as viewed from the illumination direction
3. Mirror reflectivity
4. Mirror array diffraction efficiency

So, the overall efficiency can be estimated as following:

$$\text{efficiency}_{DMD} = \text{transmission}_{window} \times \text{efficiency}_{fillfactor} \times \text{efficiency}_{diffraction} \times \text{reflectivity}_{mirror} \times \text{transmission}_{window}$$

Using typical values (reference 2): diffraction: 89%, fill factor: 92%, reflection: 89%, transmission double pass: 96% Overall optical efficiency for DLP 9500 DMD in visible wavelengths ~ 70%.

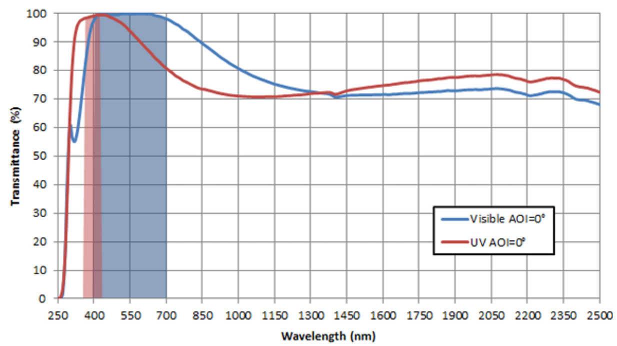
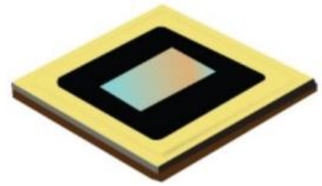


Figure 1. Corning 7056 Visible and UV Window Options

Challenges

- Glass cannot be removed from DMD because it would damage internal equilibrium of the system.
- Removing the coating would require special etching techniques and we lack easy access to helpful equipment.
- We are unsure of the coating's chemical composition.
- It is difficult to improve transmittance in the NIR region without compromising the visible light transmittance.

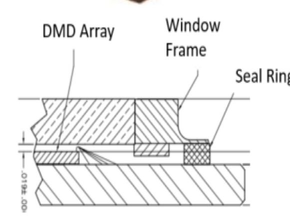


Hermetic packaging (Type A)

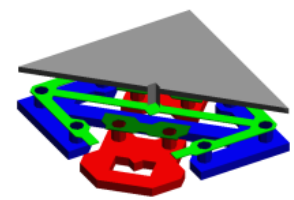
Resolution :1920x1080

Active array area:

- 20.736mm x 11.664mm



DLP 9500 Cross-Section



DMD Micromirror Design
Mirror size: 10.8 µm

Conclusion

Our research to date has been inconclusive. We are in the process of figuring out the chemical composition of the window coatings and trying to hypothesize several ways to remove the coatings without damaging the window, packaging, and overall transmittance. With this, we are also looking to source the needed tools/equipment to safely remove/add coatings as well as collect accurate data with better measuring equipment than what is currently available to us. We hope to successfully complete this research in hopes it will aid in the imaging for automotive, manufacturing, spectroscopy, and underwater applications.

References: 1) Wavelength Transmittance Considerations for DLP® DMD Window (revised December 2019) https://www.ti.com/lit/an/dlpa031e/dlpa031e.pdf?ts=1685719649190 2)TIE-35 Transmittance of optical glass (revised October 2005) TIE-35 Transmittance.doc (schott.com)3)DLP 9500 Product Page DLP9500 data sheet, product information and support | TI.com