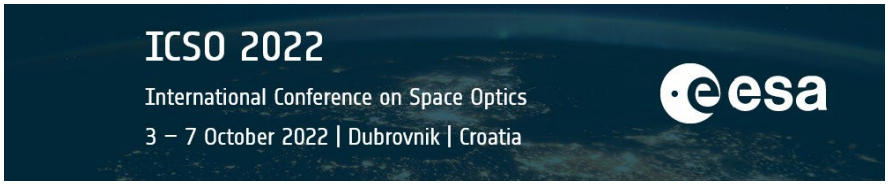
International Conference on Space Optics—ICSO 2022

Dubrovnik, Croatia

3–7 October 2022

Edited by Kyriaki Minoglou, Nikos Karafolas, and Bruno Cugny,



Complex LWIR optical coatings up to 20um (and beyond…)

International Conference on Space Optics — ICSO 2022, edited by Kyriaki Minoglou, Nikos Karafolas, Bruno Cugny, Proc. of SPIE Vol. 12777, 1277752 · © 2023 ESA and CNES · 0277-786X · doi: 10.1117/12.2690909

Complex LWIR optical coatings up to 20um (and beyond…)

David Harrison*[a], Kevin Downing[b] Dan Jasinski[b], Christopher Nunes[b]
Materion Balzers Optics – Materion Precision Optics & Thin Film Coatings Inc., 2 Lyberty Way, Westford Massachusetts, United States, 01886;

ABSTRACT

Materion Balzers Optics (MBO) has been providing optical coatings in the LWIR range for over 40 years. Our technology and capability have advanced significantly over that time. This presentation intends to demonstrate our heritage and capability to manufacture complex optical coatings up to 20um for space and terrestrial applications on a wide range of substrates. These coatings include dichroic beamsplitters, narrow bandpass filters, high performance ARs, as well as edge filters and mirrors. This paper will also include preliminary information on our roadmap 50um capability.

Keywords: coating, LWIR, e-beam evaporation, bandpass filters, beamsplitters. VLWIR.

1. INTRODUCTION

Materion Balzers Optics history dates to 1960 with the founding of Balzers. Our LWIR heritage dates to 1972 with the founding of Barr Associates. Both companies have undergone significant growth and transitions since then to become combined as one of the worlds leaders in optical coatings (see fig 1).

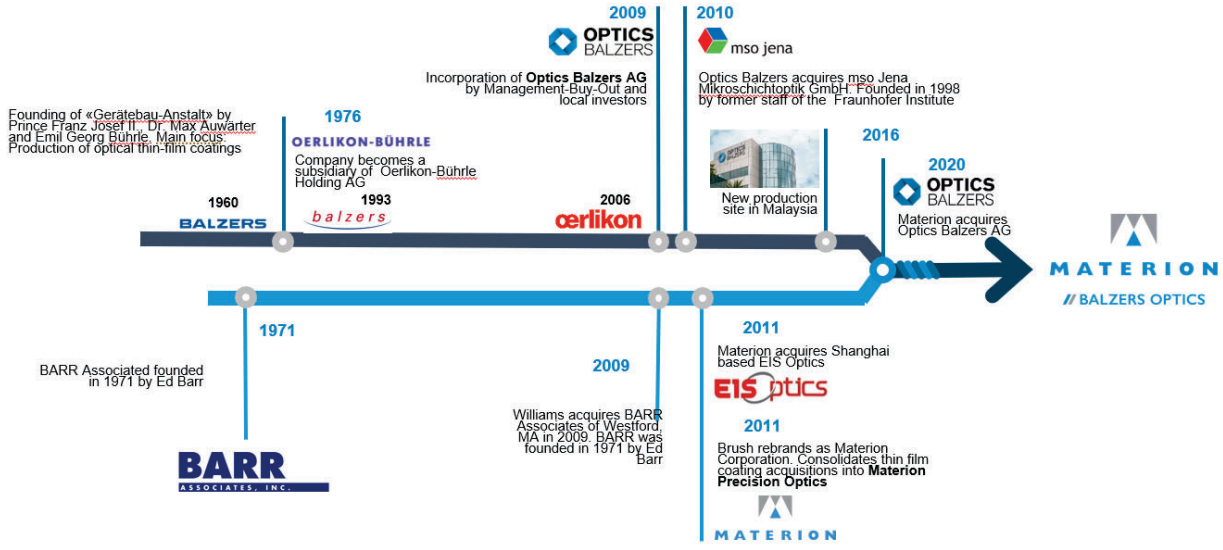


Fig 1

With over 900 employees and 100 deposition systems worldwide MBO offers a uniquely broad rand of optical coatings (see fig 2).

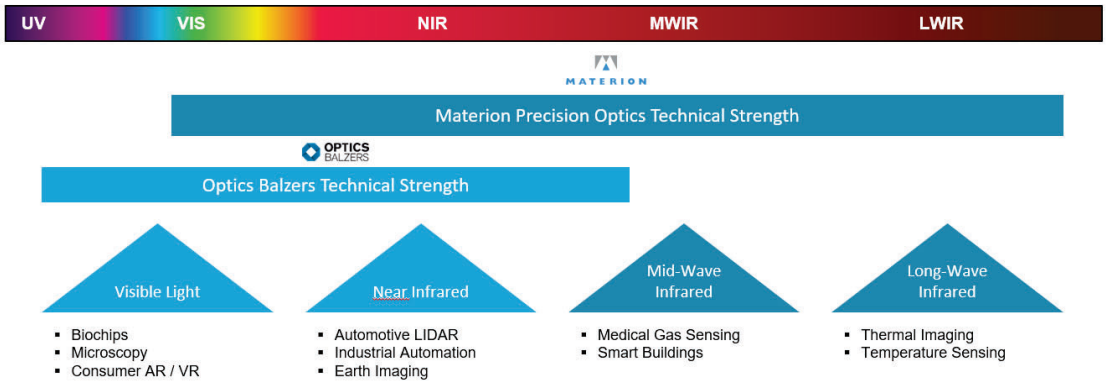


Fig 2

As noted in fig 2, our LWIR strength and capability resides withing our US facility in Westford MA (see fig 3)

Production Facility Westford, USA

- 190 Employees
- Precision optical filtering, UV through LWIR
- Services low to medium volume, high performance applications
- 3,000 Sq. Feet, class 1000 Wafer level coating and photolithography work cell
- Strong capabilities in Mid-wave and Long-wave infrared
- 40+ years experience

Fig 3

*David.harrison@materion.com; phone +01 978-692-7513; www.materionbalzersoptics.com

2. LWIR MANUFACTURING APPROACH

2.1 Deposition systems

LWIR coatings are typically defined as those operating withing the 8.0um – 14.0 um range. Coating in this range offers unique challenges as well as an extremely broad (and growing) range of applications. These include (but are not limited to) flame detection, thermal imaging, medical, non-contact temperature measurement, motion sensors, deep space exploration and climate monitoring. Over the past 40 years MBO has custom designed and built multiple e-beam depositions systems. As specifications tightened with regards to uniformity, wavelength positioning, T% and blocking density MBO responded with custom designed equipment. Including the use of plasma systems for enhanced durability. Our LWIR deposition processes employ some of the most advanced thickness control systems, using state of the art optical, crystal and time/power monitoring. Most having been designed and fabricated in-house based upon decades of LWIR manufacturing experience.

2.2 Substrate selection

Our preferred LWIR substrate materials are Ge, Si, ZnS, ZnSe. Each having their own benefits and tradeoffs. See fig 4 with some information on different substrate materials. This information is key to making the proper substrate selection.

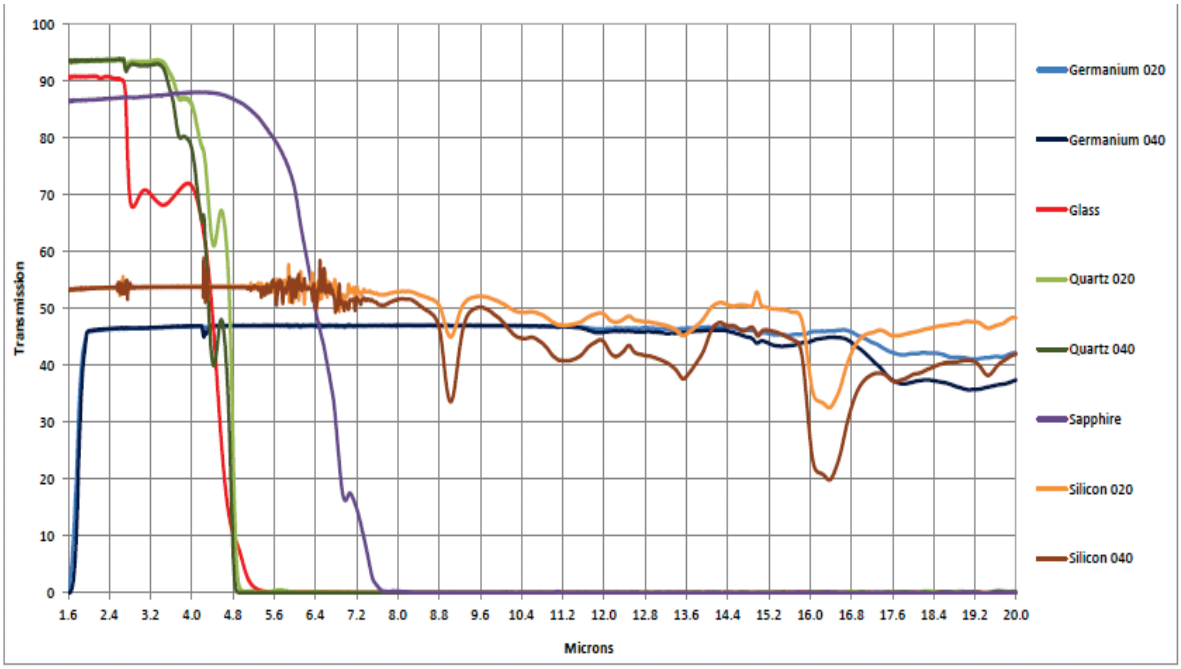


Fig 4

While we do occasionally use other types of substrate material (CdTe for example), those add to the difficulty and complexity of the LWIR coatings therefore are only used in extreme cases when customer specification require this.

2.3 Coating Materials

While there are a limited number of options for making environmentally stable, durable, and high performance coatings we do have a few options we routinely use as well as some unique blends. Our standard materials in this wavelength region are Zns, ZnSe, Ge, CeF_3, Yf_3, Thf_4. Table 1 shows some of the properties associated with these.

Material	Spectral Range (μm)	Index n	Deposition Technique	Stress	Relative Hardness
Fluoride compounds	UV – 12	1.4 – 1.5	Resist. Heated, E-beam	Tensive	soft
ZnS	0.4 -12	2.2	RH	low	Mod. soft
ZnSe	0.6 -14	2.4	RH	low	Mod. soft
Germanium	2-11+	4.0	E-beam	Compressive	High - med.

Table 1

Several factors go into deciding what material set is best suited for that particular coating design and application. Some of this is based upon design performance and durability, while some is based upon heritage and previous experience. With regards to Thf4. We do use this material on limited occasions however due to it being a radioactive alpha emitter it's use has been mostly phased out. MBO currently replaces this material with Yf3 based materials whenever possible.

2.4 Custom Designs

All our LWIR items are custom designs to customer specifications. Using state of the art software combined with years of experience and heritage MBO can design a wide range of LWIR coatings using a variety of materials and design techniques. Fig 5, 6 & 7 displays some custom design examples.

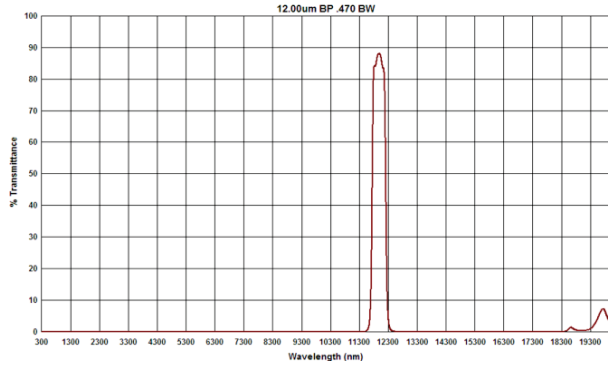


Fig 5 – Customized 12.0um bandpass, 470nm FWHM

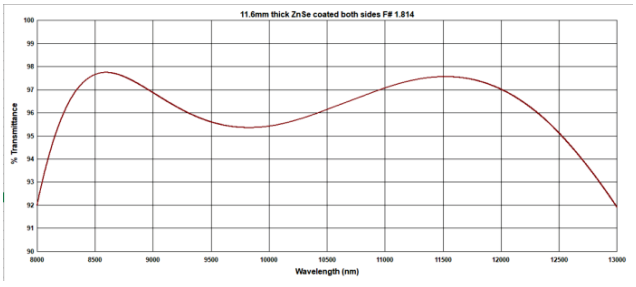


Fig 6 – 8.0 – 13.0um AR coating

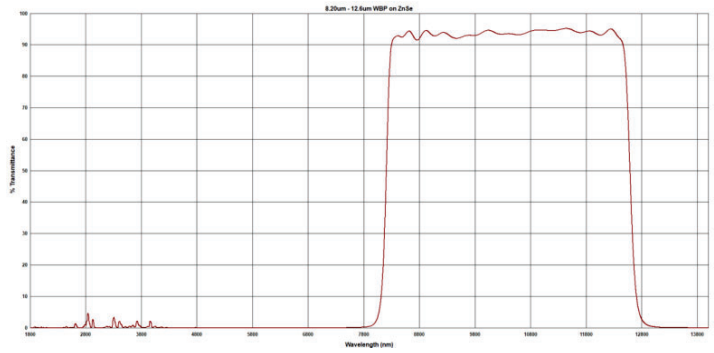


Fig 7 – LWIR wideband filter

3. DEMONSTRATED RESULTS

Measured performance results of a MBO LWIR coating (12.0 um bandpass) are presented in Figs 8, 9 & 10.

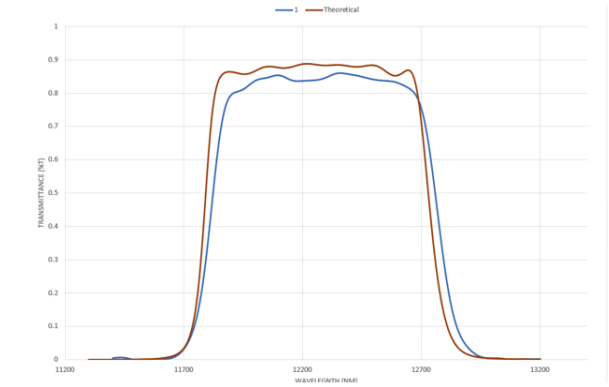


Fig 8 - Theoretical design vs measured results

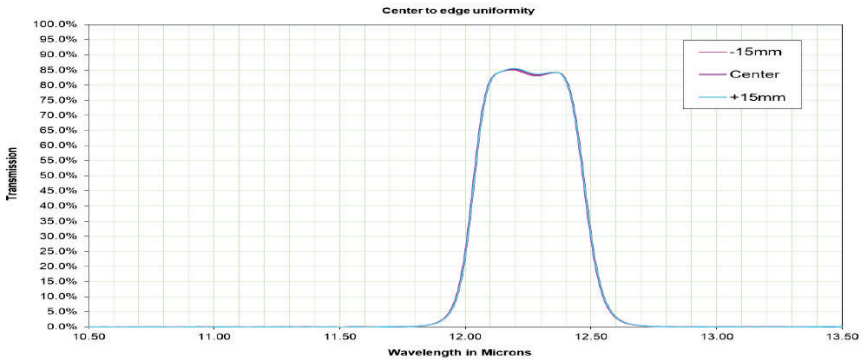


Fig 9 - Uniformity over 30mm dia

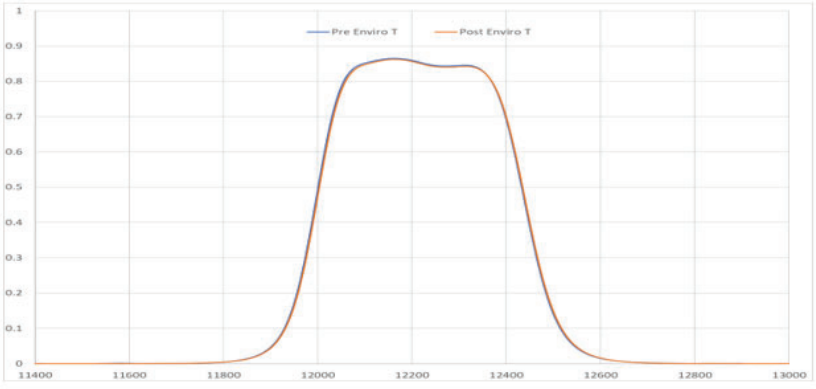


Fig 10 – Environmental stability

Performance demonstrated here is similar to all MBO's LWIR bandpass filter offerings.

4. COMPLEX CUSTOM SOLUTIONS

In addition to the discrete filters referenced previously in this paper MBO has the proven capability in providing assembled LWIR multispectral filter arrays (see fig 10). This is accomplished by combining our butcher block assembly and LWIR coating processes. With demonstrated ability to use multiple substrate materials (Ge, Si, ZnS, ZnSe & sapphire) our LWIR assembled exhibit the following attributes.

- ✓ Filter segments as narrow as 0.050mm and as long as 110mm.
- ✓ Edge chips < 0.075mm
- ✓ Bond lines of 0.015mm (offering OD 5 band to band separation)
- ✓ Detector side co-planarity of < 0.015mm
- ✓ Precision dark mask coating

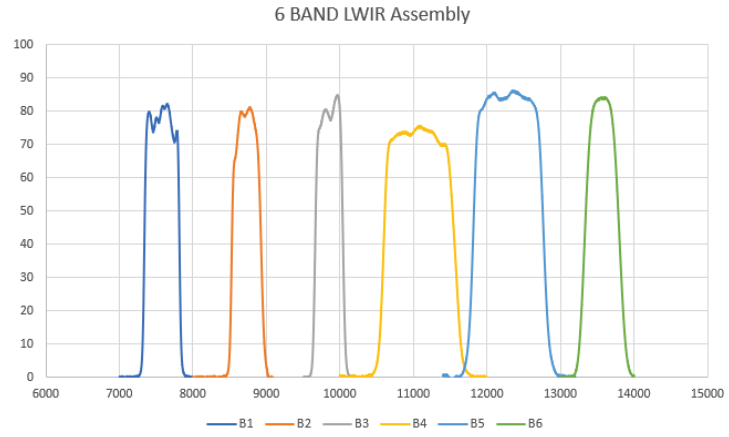


Fig 10 – Measured results from a MBO 6 band LWIR assembly

Materion's LWIR capability extends into wafer level offerings where we have proven capability to coat large form (up to 200mm) wafers with complex LWIR optical coatings. These wafers exhibit ultra-low defect levels (< 0.040mm), precision patterning, deep well coating, getter and metallization. Fig 11 illustrates our comprehensive wafer level capability.

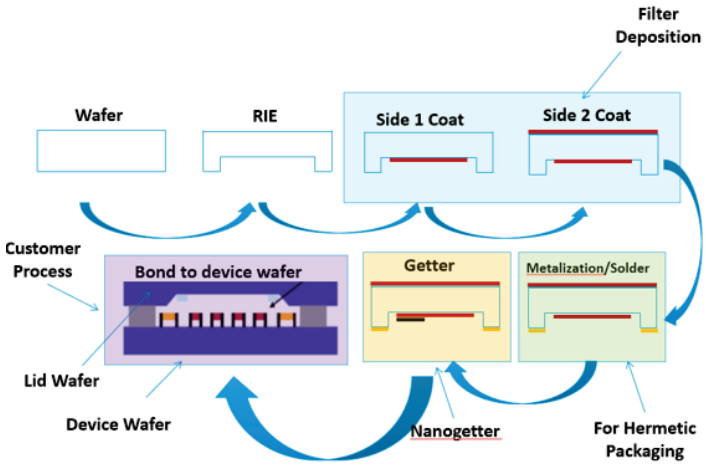


Fig 11 – MBO wafer level process flow.

5. VLWIR – FUTURE OFFERING?

Recent request to Materion for optical coating beyond 20um (50um - 100um) have initiated internal discussion and evaluation on how best to achieve these performance requirements. To date the challenges have been identified and preliminary investigation has begun to determine the optimal approach for solving each. Some of these challenges are.

- Ability to measure & confirm results > 20um
- Coating materials (standard LW materials, tellurides, others)..
- Design program limitations (index tables, error analysis)
- Durability concerns (coating thickness limitations, adhesion)

6. CONCLUSION

In this paper, Materion Balzers Optics shows existing LWIR processes and capabilities. Covering a variety of optical coating types (band passes, beam splitters, etc..) used in multiple configurations including discrete filters, multispectral arrays and wafer level coatings. The paper additionally presents our interest and willingness to push our capabilities beyond 20um.

ACKNOWLEDGEMENTS

Materion Balzers Optics would like to thank all partners for their support during development and manufacturing of optical components discussed.

REFERENCES

[1] Austin A. Richards, Alien Vision: Exploring the Electromagnetic Spectrum with Imaging Technology, Second Edition (SPIE Press Book)

[2] Coating Materials News. https://materion.com/resource-center/newsletters/coating-materials-news. For example: V27 Issues 1, 2, 3; V28 Issue 2.

[3] James D. Rancourt, Optical Thin Films User's Handbook, 1994, McGraw Hill

[4] "Coatings Used in Space", Coating Materials News. https://materion.com/resource-center/newsletters/coating materials-news.