MATERION

Multispectral arrays (UV – LWIR)

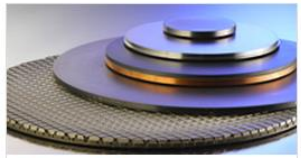
EPIC Meeting on New Space – September 2019

Materion Corporation

A Global Platform

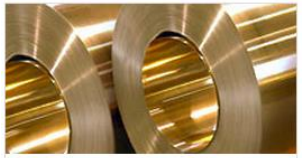
Precision Optics
Largest manufacturers of precision thin film coatings and optical filters.

Aerospace Metal Composites
Manufacturer of High Performance Metal Matrix Composites and Alloys.



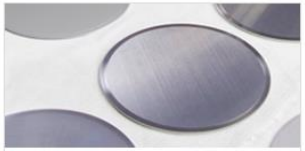
Advanced Materials Group
Specialty materials for thin film deposition, microelectronic packaging products and inorganic chemicals.

Beryllium & Composites
Global producer of beryllium-based metals and metal matrix composites.



Performance Alloys
One of the world's leading suppliers of high-performance alloys.

Ceramics
Global leader in high-performance engineered ceramics.



Electrofusion
Focused on beryllium x-ray windows, ultra high vacuum (UHV) components and Truextent acoustic solutions.

Large Area Coatings
Specializing in the physical vapor deposition (PVD) of inorganic materials onto flexible polymeric films.

Technical Materials
The world's leading resource for customized, high-performance specialty strip metal products.

2502
Employees

50
Countries served by us

30
Facilities

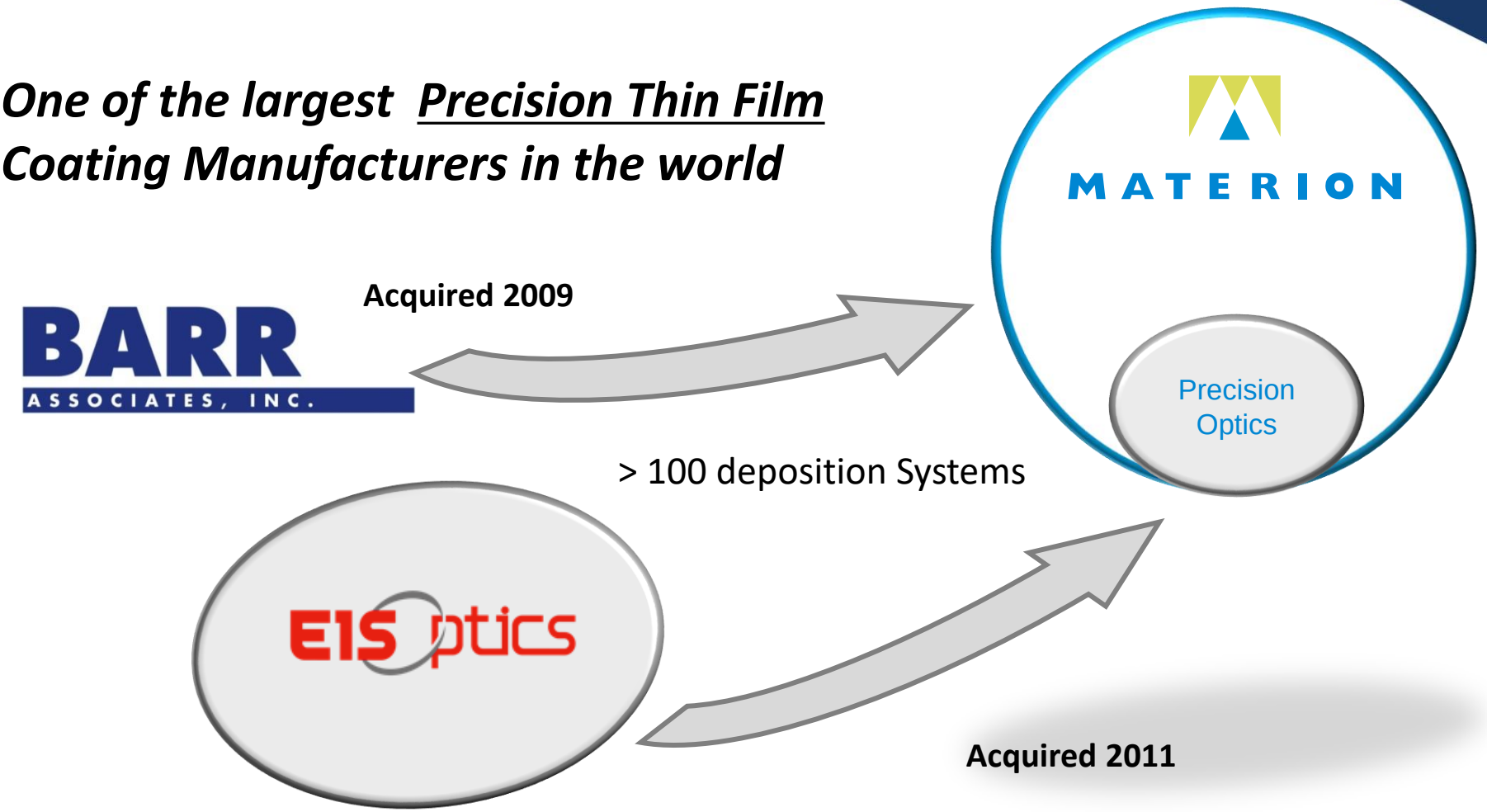
11
Countries with our operations

$1.0B
2018 Sales

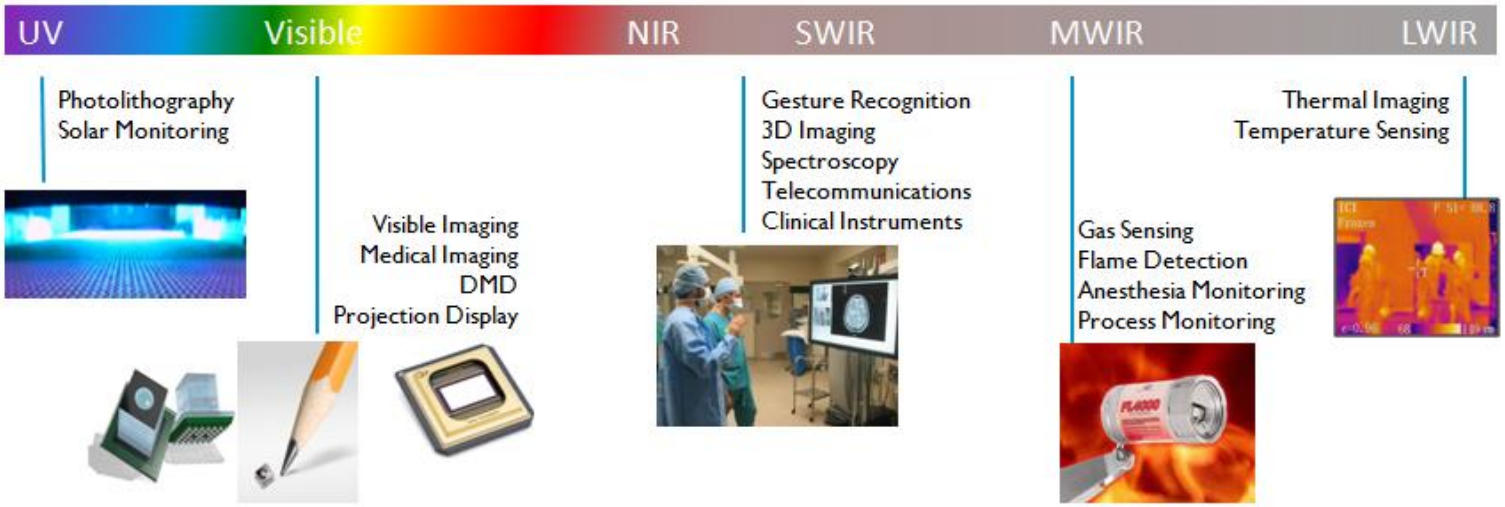
MTRN
NYSE

Materion Precision Optics Heritage

One of the largest Precision Thin Film Coating Manufacturers in the world



Precision Optical Filters & Coatings



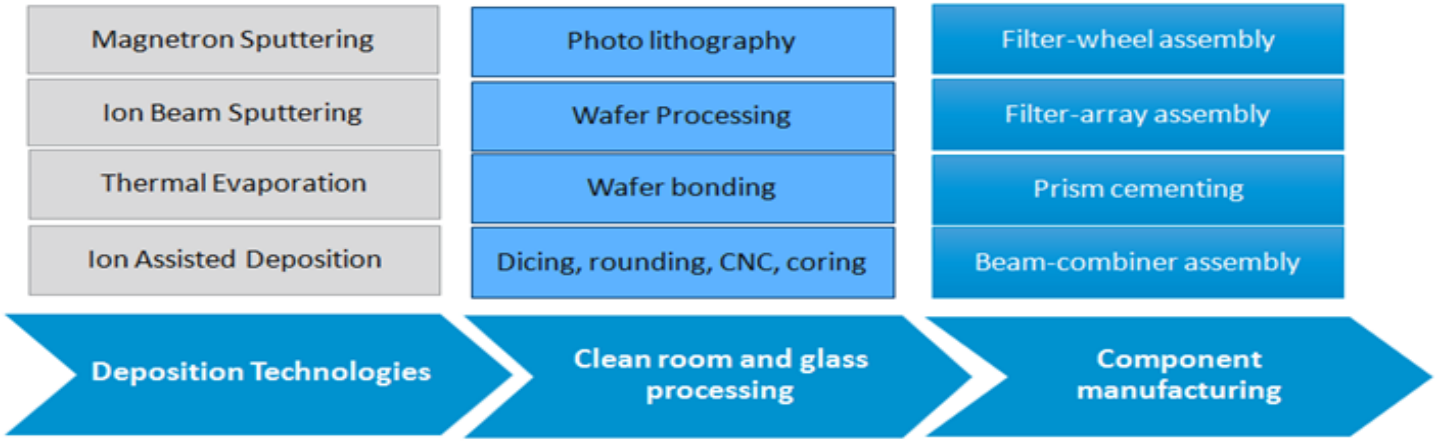
APPLICATIONS

- Analytical instruments
  - Medical
  - Environmental
- Astronomy
- Calorimetry
- Colorimetry
- Countermeasures
- Direct view optics
- Flame detection
- Fluorescence spectroscopy
- Gas detection
- Gesture recognition
- Guidance systems
- Laser communications
- Laser protection
- Night vision
- Non-dispersive infrared (NDIR) spectroscopy
- Photometry
- Raman spectroscopy
- Space Exploration
- Telecommunications
- Threat warning
- Thermal imaging

FILTERS

Function	Type
Reflect	Mirrors (protected or enhanced metal, or dielectric)
Transmit	Antireflection (AR)
Block	Dark mirror (DM), Neutral Density (ND)
Split	Power Beamsplitter (split T and R), Dichroic Beamsplitter (Polarizing or Non-polarizing)
Isolate	Long pass (LP), Short pass (SP & Suppressed SP), Wide bandpass (WBP), Narrow bandpass (NBP), Multiple bandpass, Notch, Induced transmission (MDM)
Miscellaneous	Hyperspectral, Gain flattening, Diamond like coating (DLC), Hermetic sealing, Indium tin oxide (ITO)
Special	Rugate, Linear variable (LVF), other technologies

Core Capabilities



SUBSTRATE MATERIALS

- Aluminum
- Barium Fluoride
- Borosilicate Glass
- Cadmium Telluride
- Calcium Fluoride
- Chalcogenide glass (AMTIRx, BDx, IGx, ITx, IRGx)
- Color Glass
- Copper
- Gallium Arsenide
- Germanium
- Magnesium Fluoride
- Nickel plated metal
- Plastics, polymers
- Pyrex
- Quartz (fused and crystal)
- Sapphire
- Silicon
- Soda Lime Glass
- Stainless Steel
- Zerodur
- Zinc Selenide
- Zinc Sulfide (Cleartran)
- Others materials coated upon request

COATING MATERIALS

- Aluminum
- Aluminum nitride
- Aluminum oxide
- Cerium fluoride
- Cerium oxide
- Chromium
- Cryolite
- Germanium
- Gold
- Hafnium oxide
- Indium tin oxide
- Lead telluride
- Magnesium fluoride
- Nickel
- Niobium oxide
- Silicon
- Silicon dioxide
- Silicon monoxide
- Silicon nitride
- Silver
- Tantalum oxide
- Thorium fluoride
- Titanium
- Titanium oxide
- Yttrium fluoride
- Yttrium oxide
- Zinc selenide
- Zinc sulfide

Materion Space Flight Heritage

- Spans over 40+ years
- Supports major International Space Agencies and Aerospace Primes
- Bandpass and edge filters, dichroic beam splitters, enhanced mirrors, conductive coatings
- Formats
  - Discreet elements
  - Assembled multi-spectral arrays
  - Patterned multispectral arrays
  - Mounted or unmounted
  - Grounding straps, transparent conductive heaters, EMF shielding
- All optics are fully space qualified and are at TRL 9 [flight proven]

- Remote Sensing
- LIDAR
- Free Space Communication
- Deep Space Exploration

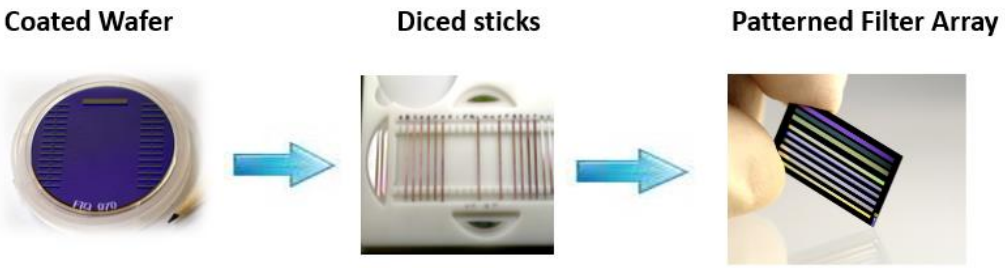
Multi-spectral Filter Arrays (UV – LWIR):

35+ years of MS Arrays

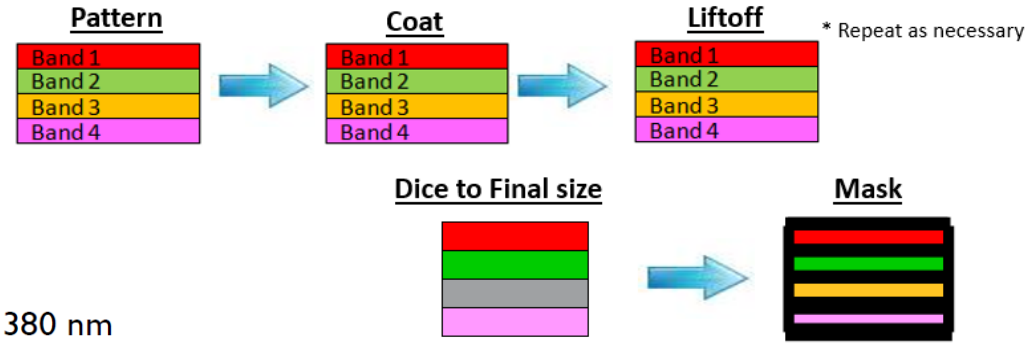
MS Arrays

- ✓ 35+ years
- ✓ VIS/NIR
- ✓ Large Gov't programs
  - ✓ UV, MW, LW
- ✓ Smaller from Factor
- ✓ Improved system performance
- ✓ Lower overall cost
- ✓ Higher resolution
- ✓ Increased wavelength range
  - ✓ Greater functionality

Butcher Block (Asm) Array



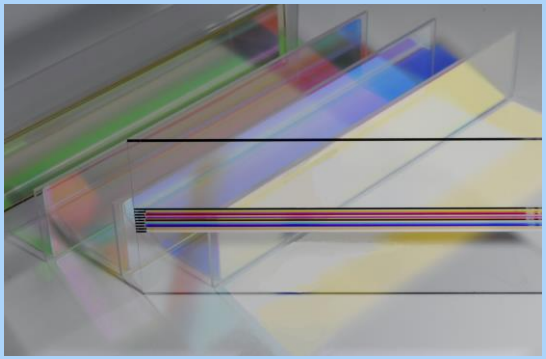
Monolithic (single substrate) Array



UV	Ultra violet	200 – 380 nm
Vis	Visible	380 – 760 nm
NIR	Near infrared	760 – 1400 nm
SWIR	Short wavelength infrared	1.4 – 2.3 μ
MWIR	Mid wavelength infrared	2 – 6 μ
LWIR	Long wavelength infrared	6 – 15 μ

Butcher Block Assemblies

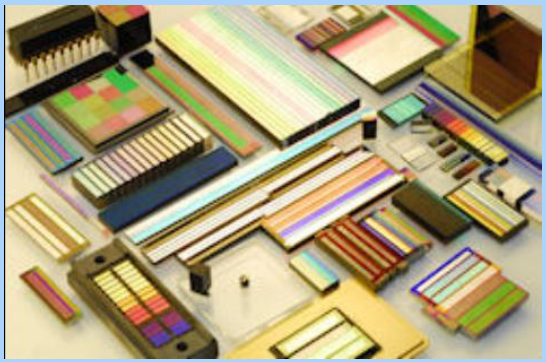
❑ Current Features and Capabilities

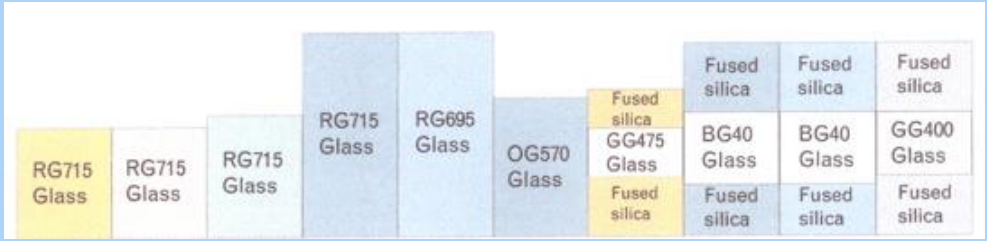


- **Up to 150 bands demonstrated**

- **Multiple substrate material in a single array**
  - **Fused Silica, Ge, Si, ZnSe, CFG, BK7, radiation hardened glass**

- **Focal length matching**

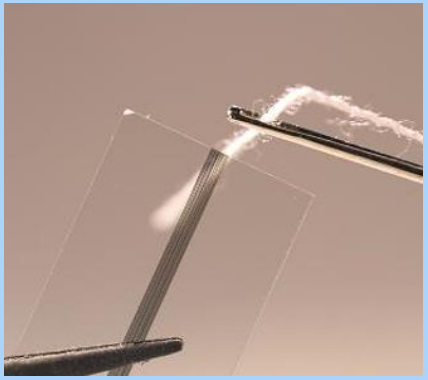


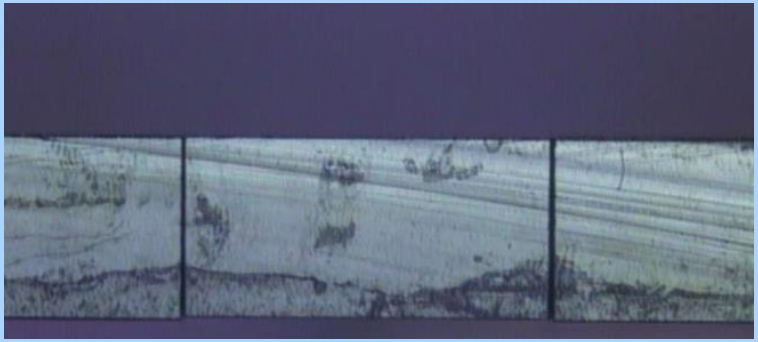


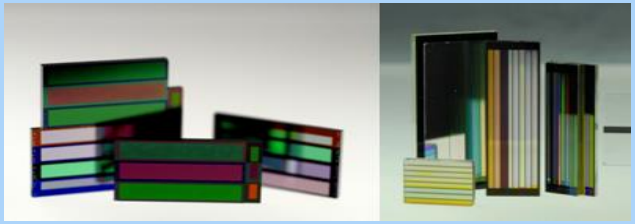
Butcher Block Assemblies

❑ Current Features and Capabilities

- Filter segments as narrow as 0.020mm
- Bond lines ~15um (> OD 5 blocking)
- Edge chips < 10um
- Coplanarity < 10um (detector side)
- Control stray light, ghost and LAS
  - Coating design configuration
  - Materials used
  - Assembly techniques
  - DMC (dark mask)

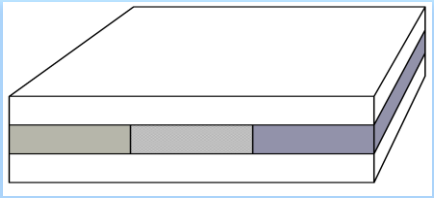






Butcher Block Assemblies

❑ Current Features and Capabilities



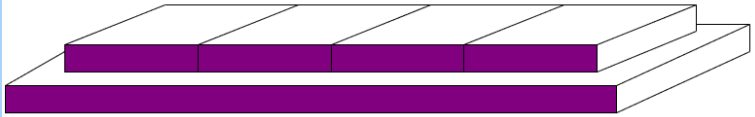
- **Wide range of configurations**
- **Stress balancing for wavefront control**

Laminated, Edge Bonded and Polished

Advantages

- Surface chips removed, subassembly flat and parallel due to polish.
- Easier to apply masking

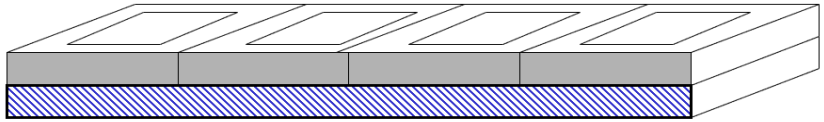
Assembled Array on Mask



Advantages

- Superior masking achieved - bondline gaps and defects covered.
- May be easier to align to next assembly
- Extra surface(s) for filter coatings.

Edge Bonded Array bonded to window



- simple assembly, with very accurate alignment
- Beam alignment is tolerant of tip-tilt effects. Multiple surface masking available
- Individual substrate material and thickness' are independent. Optical path can be adjusted, band-by-band.
- CTE mismatches very minor issue. Multiple materials can be employed

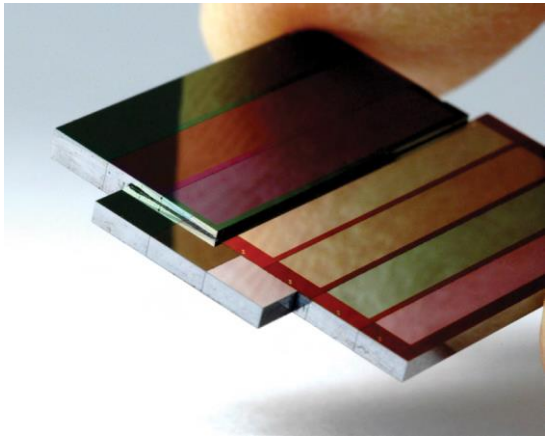
Commercial Space

Changing Landscape

Expansion & growth in the Commercial Space area has driven the size of satellites smaller and smaller while also calling for increased functionality.

- Past – Predominantly Science & Exploration
- Current – Commercial enterprise $$, cost effective Gov't sponsored

Growing need to leverage previous large developmental Gov't programs to meet todays economic challenges



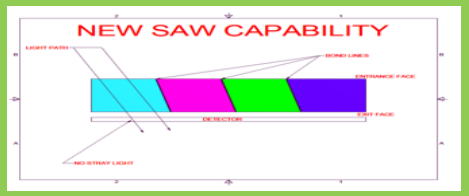
ArrayTec™ Filter Arrays

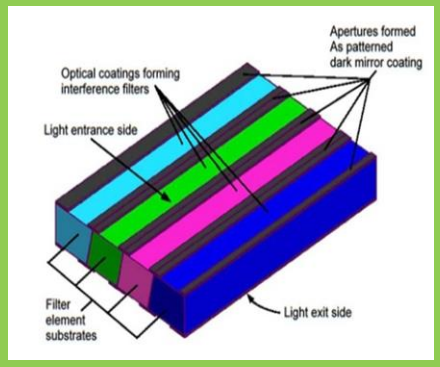
CW (nm)	BW (nm)
443	20nm
490	50nm
531	36nm
565	36nm
665	31nm
675	450nm
783	30nm
865	40nm

What's next??

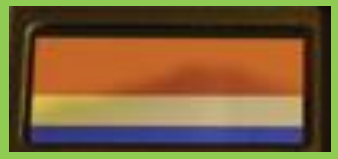
❑ Expanding Capabilities

- **Parallelism Arrays – further reduce stray light**





- **350+ individual bands for BB arrays**
- **Standard Bands to UV & LWIR**
- **Automated assembly and inspection for volume applications**
- **Bands directly onto detectors**



Thank you!

- **Global provider of Precision Optical Filter and Thin Film Coatings**
  - 40+ years **Experience/ Heritage**
  - **Breadth** of coating technologies
  - **Diverse** Product Portfolio
  - Servicing **diverse markets** and **applications**

For additional information or questions, please contact david.harrison@Materion.com

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