



Material Solutions for advanced XR Applications

Dr. Mark Goebel
Technology Fellow
CTO Office Merck Electronics

Merck Electronics KGaA Darmstadt

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Merck: With our focus on electronics, we are well aligned to Merck Group & key market trends

We are curious minds dedicated to human progress.

Healthcare

As one for Patients

- Discovers, develops, and manufactures innovative pharmaceutical and biological prescription drugs to treat cancer, multiple sclerosis, infertility, and growth disorders
- R&D pipeline with a clear focus on becoming a global specialty innovator in oncology, immuno-oncology, neurology, and immunology.

Life Science

Solving the toughest problems in Life Science

- Cutting- edge technologies, products and novel services for diagnostics, research, development and the manufacturing of biological and novel therapies (mRNA)
- Focused on Pharma Biotech, Diagnostics, Academic and Government Research and Industrial

Electronics

Advancing Digital Living

- Advanced solutions for the Semiconductor & Display industries focused on materials, equipment and services
- Pigments and active ingredients for the Automotive, Cosmetic and Industrial industries

Key trends:

Digital Healthcare

Precision Medicine

Commercial Lab

Future Food

Autonomous Driving

5G

IoT

Gene Editing & Novel Modalities

Novel Computing

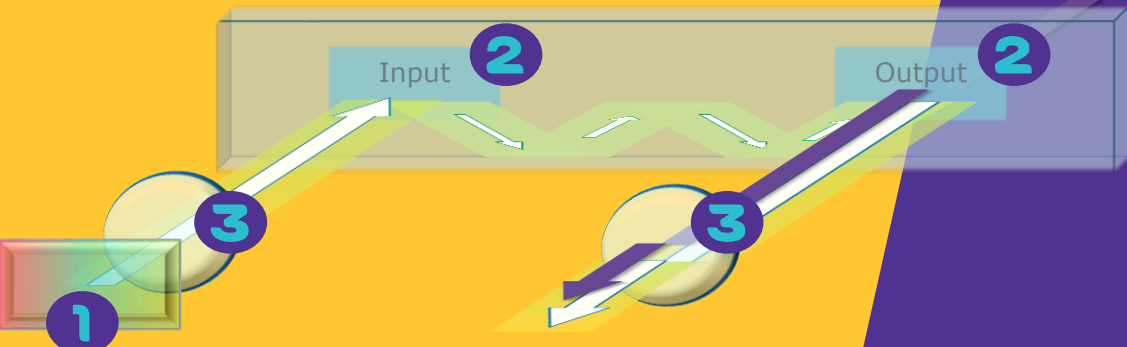
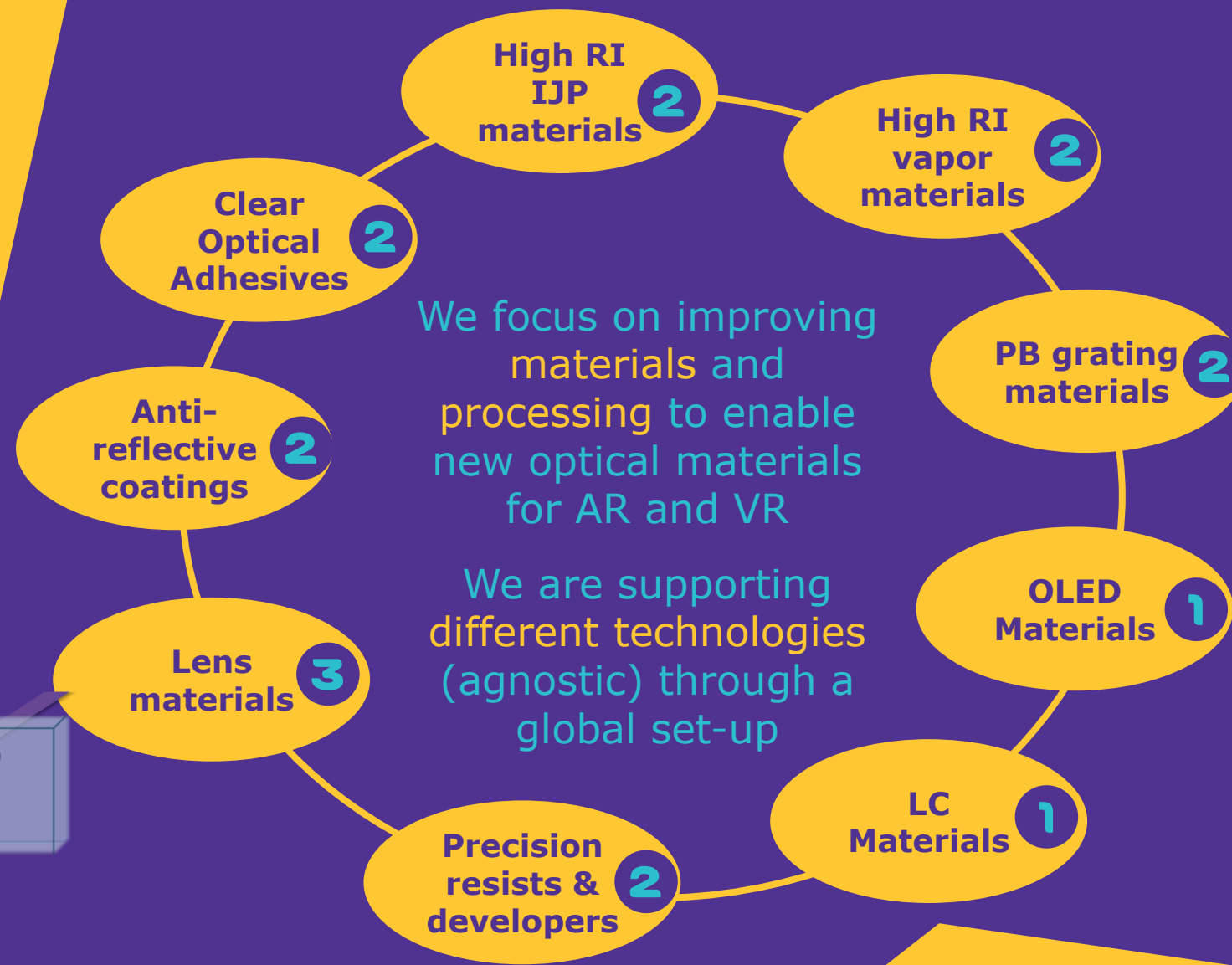
Artificial Intelligence

We are enabling AR/VR devices through improved materials and processes

MERCK provides solutions for many areas in AR/VR

We focus on improving materials and processing to enable new optical materials for AR and VR

We are supporting different technologies (agnostic) through a global set-up





Reactive Mesogens for AR/VR Applications

What are Reactive Mesogens (RMs)?



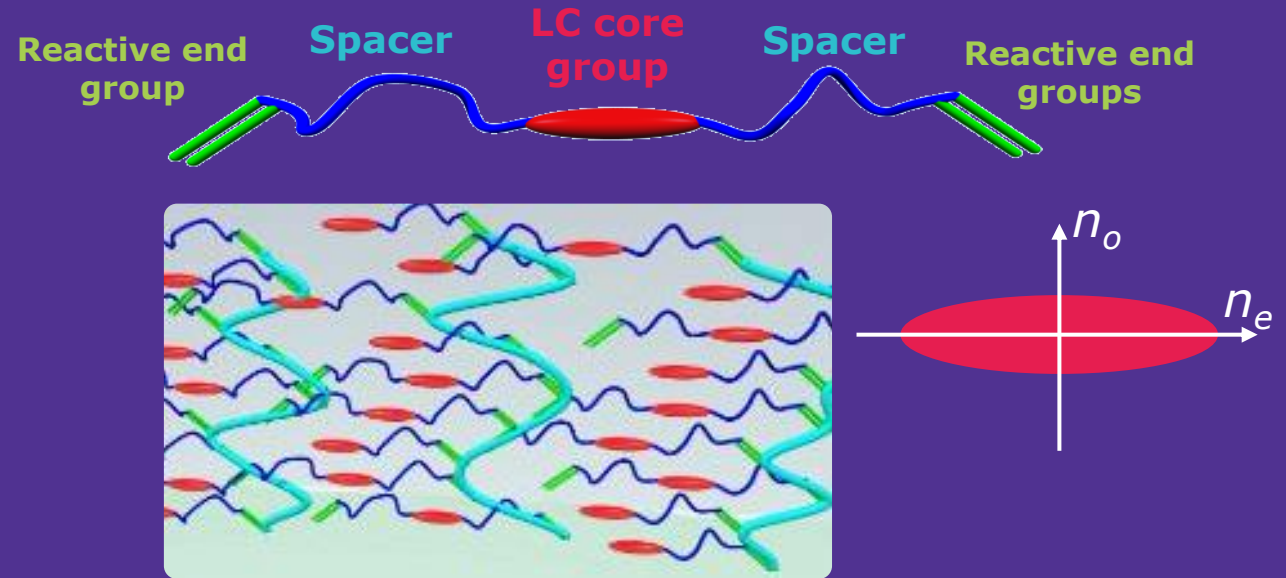
Reactive Mesogens (RMs) are polymerizable liquid crystal (LC) materials



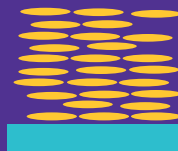
The LC phase can be locked (polymerized) into a durable, plastic film



Anisotropic properties of the RM film can be controlled, often used in compensation films



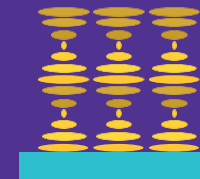
Planar



Homeotropic



Cholesteric



Alignment layer required on substrate to provide preferred direction to RM.

Typical Pancharatnam-Berry (PB) technology

Example of Manufacturing Process

1

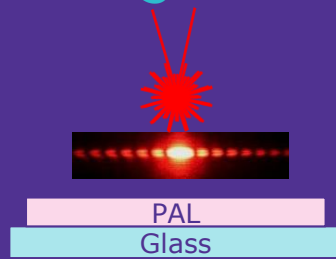
coating PAL



Photoalignment layer $\sim 100\text{nm}$

2

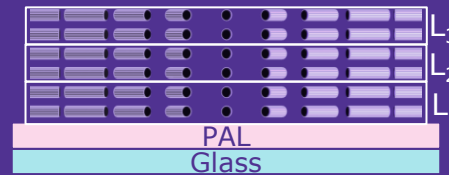
writing pattern



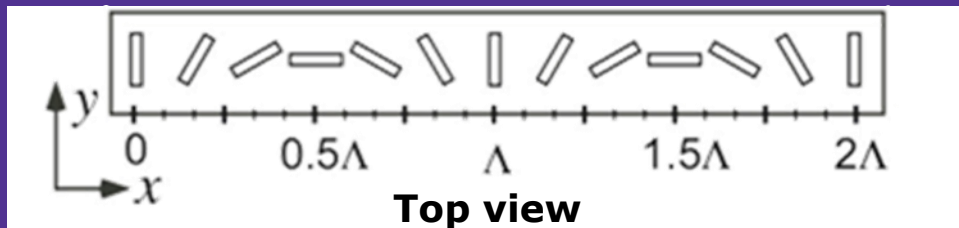
Irradiated with laser diffraction pattern

3

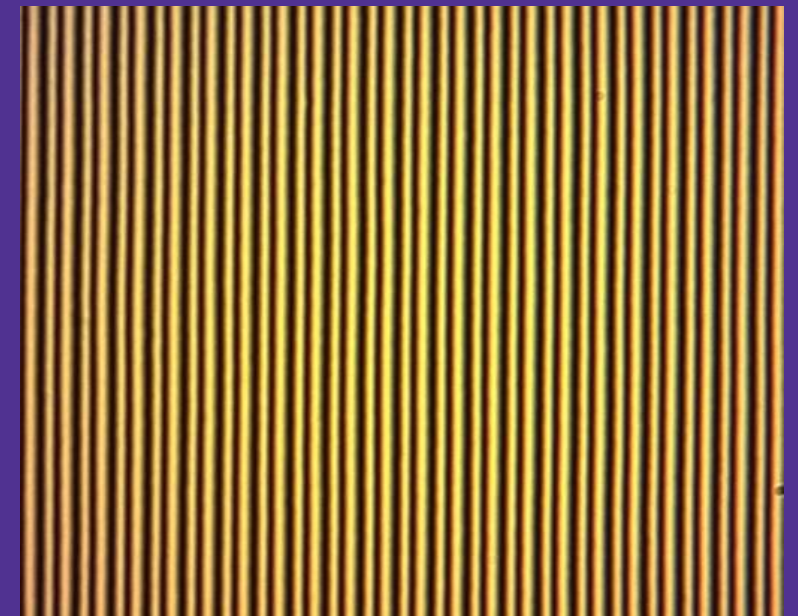
coating reactive Mesogens (polymerizable liquid crystals)



Multiple RM layers coated to produce grating



Top view



Example of PB grating prepared using $\Delta n = 0.24$ RMM.

Up to **99%** diffraction efficiency for circularly polarized light!!

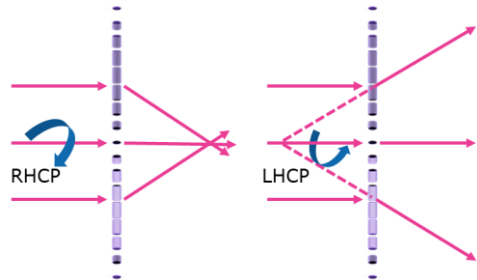
MERCK

Showcased at SID2023!

RM materials enable thin optical elements

Lens

Highly efficient, thin lens with high optical power

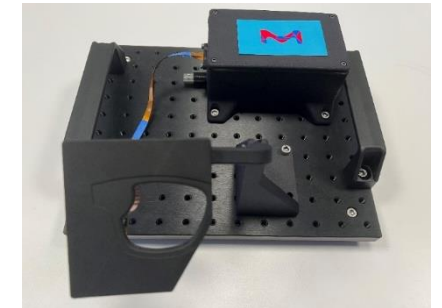
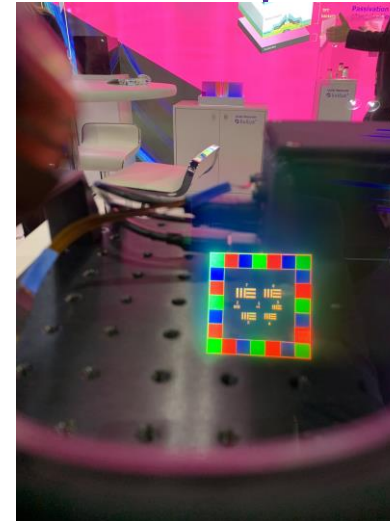
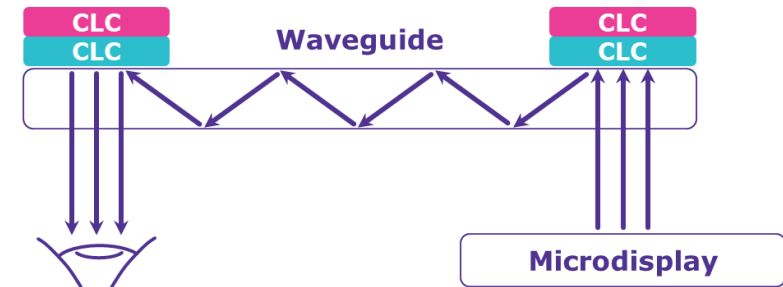


Optical combiner (for AR near eye display)
Colour correction lens
Diffractive deflection film
VR pancake lens

PB Grating

Output Grating

Input Grating



waveguide demo shown at
booth at SID, May '23

R(L)HCP: Right(Left) Handed Circular Polarized

CLC: Cholesteric Liquid Crystal

Reactive Mesogens – Important Information



Coating performance

Each layer aligned by layer below.

Each retardation layer must also be good aligning layer.

Strong adhesion between each layer.

No de-wetting when overcoating.



Optical performance

Birefringence can be tuned to customer request.

Each layer must satisfy half wave condition.

Developed own metrology for multilayer stacks.



Durability

Long experience in optimizing durability of our materials..

Change in film retardation values and twist need to be monitored and controlled.



Tunability

Our broad portfolio of materials can be customized to match customer requirements (material properties and processing conditions)

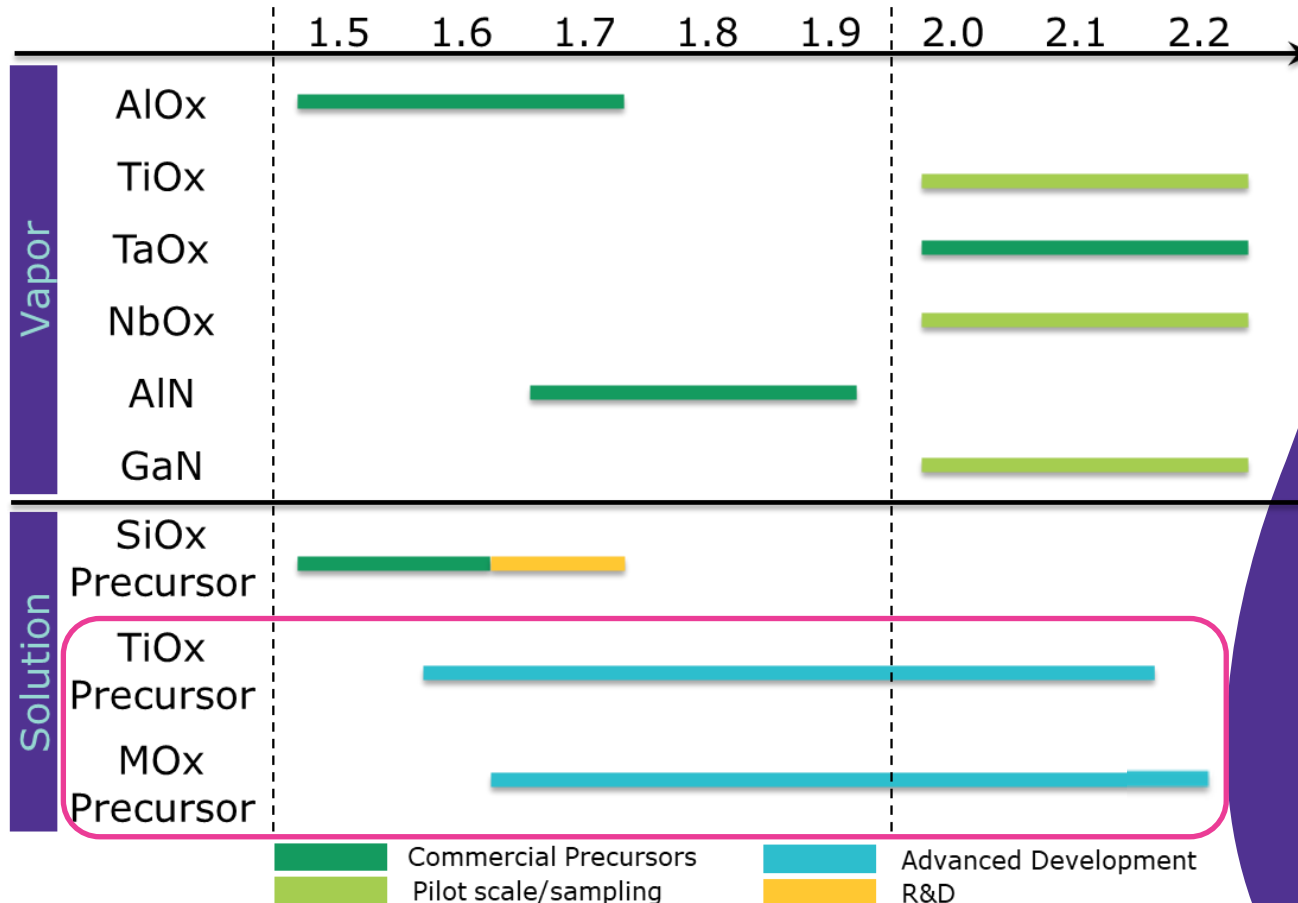


High refractive index gap fill materials

Non-yellowing Gap filling materials without particles

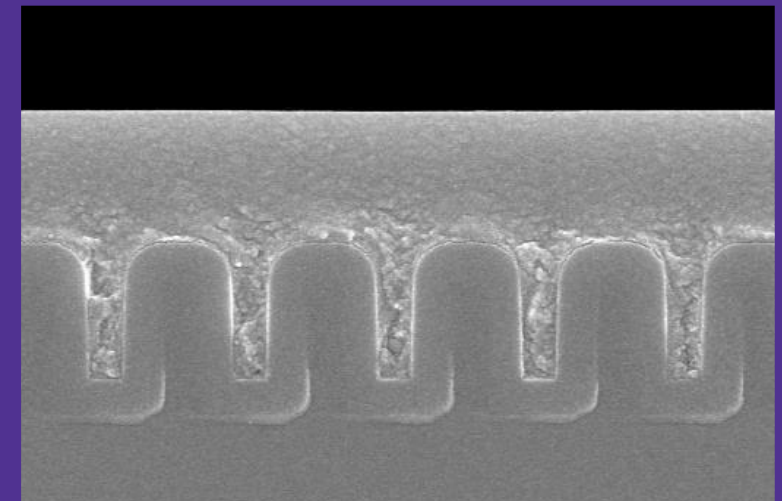
Materials High RI for Vapor or Solution Deposition

status



Higher refractive index increases the Field of View, giving a more immersive user experience

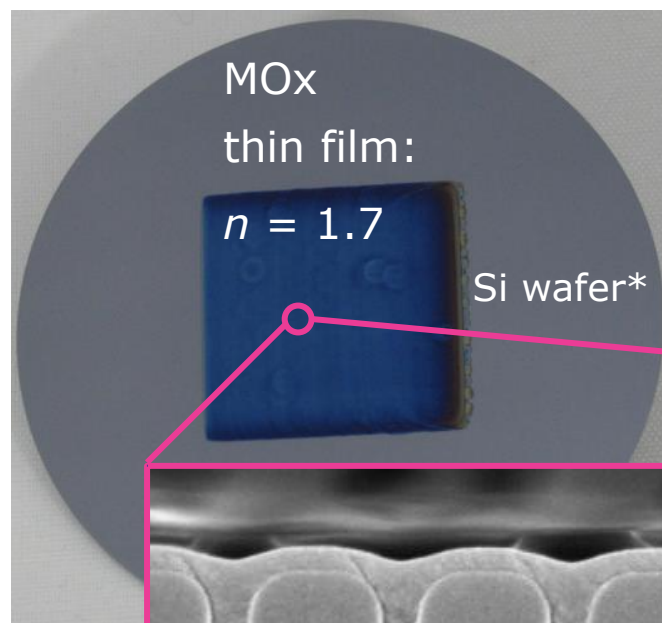
- **Solution processing** has several advantages over **Vapor deposition**
- Our materials are :
 - **Particle free** (concern: scattering)
 - **Inorganic based** (do not yellow)
 - **Low absorption** (<0.1% per 100nm)



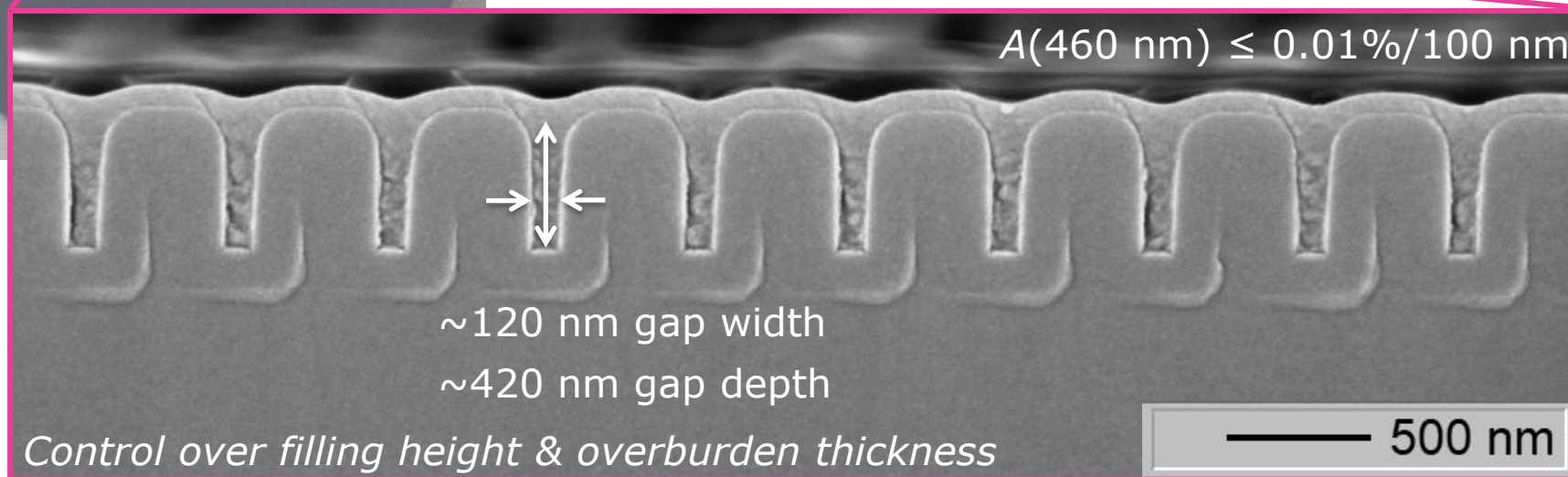
 Will be shown in more detail on next slides

Example to highlight IJP high RI gap fill materials

High RI Materials for Solution Deposition



Tuning the optical performance of SRGs of a high index metal oxide formulation via IJP + bake process



**Coated onto Silicon wafer in order to show film uniformity. When coated onto glass there is no visible film. Color occurs only due to thin film interference.*

Gap Fill Materials – Important Information



Temperature Dependency

All materials show a strong dependency on maximum RI based on processing temperature

More options are available for high RI if the max bake temperature is $>150^{\circ}\text{C}$



Gap Fill Performance

Materials are optimised for high quality gap fill small features ($<50\text{nm}$)

Materials form high quality optical films with low surface roughness and low net absorption, typically $A < 0.1\%$ per 100nm



IJP

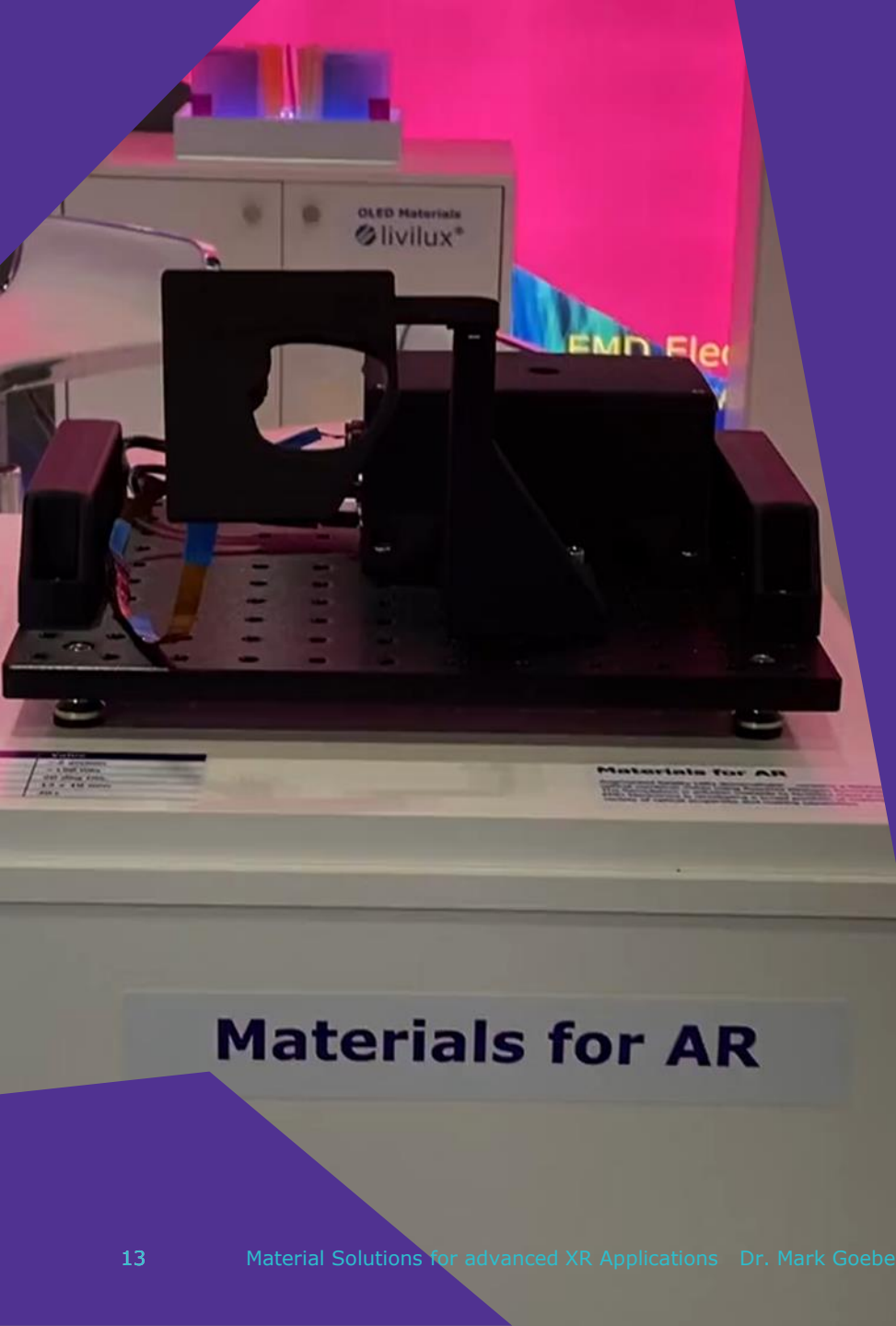
Some of our material systems are already optimised for deposition by ink jet printing (IJP)

We have the knowledge to optimize additional formulations for IJP



Tunability

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SUMMARY

- We believe AR/VR is the next evolution of computing platforms.
- Merck is the company covering key enabling materials for AR/VR in optical engine, optics, and peripheral materials.
- Especially, There is a drive towards high performance glasses-form-factor headsets which requires improved materials and processes. We believe this will be an inflection point for the technology.
- Merck's technology solutions contribute to unlock AR/VR technology.

Thank You !

