3M Science. Applied to Life.™

3M Technology introduction

3M Display Materials and Solutions Division (DMSD)

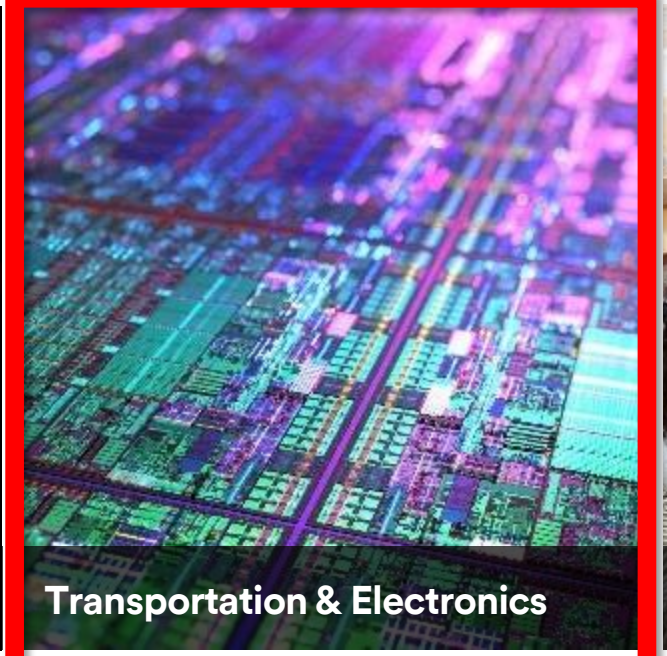
July, 2023

Serving our customers through four Business Groups

Safety & Industrial

Transforming how work gets done

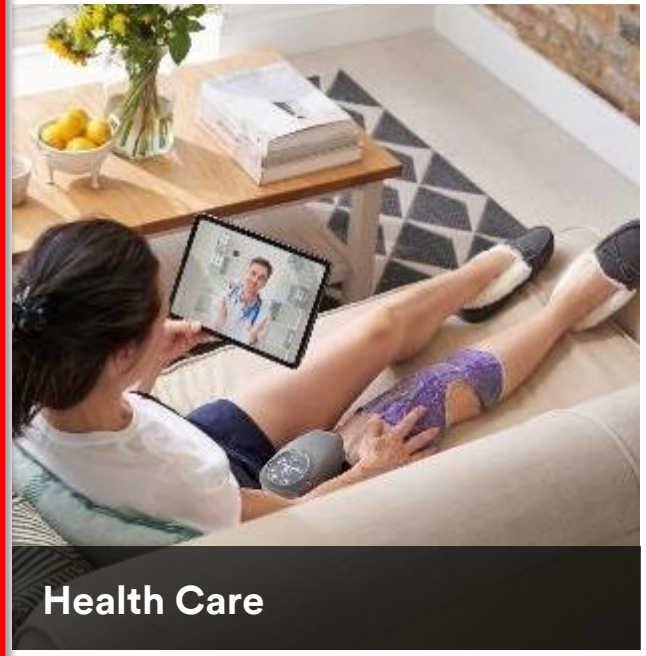
$11.6B
2022 sales



Transportation & Electronics

Solving tough customer challenges to advance a connected world

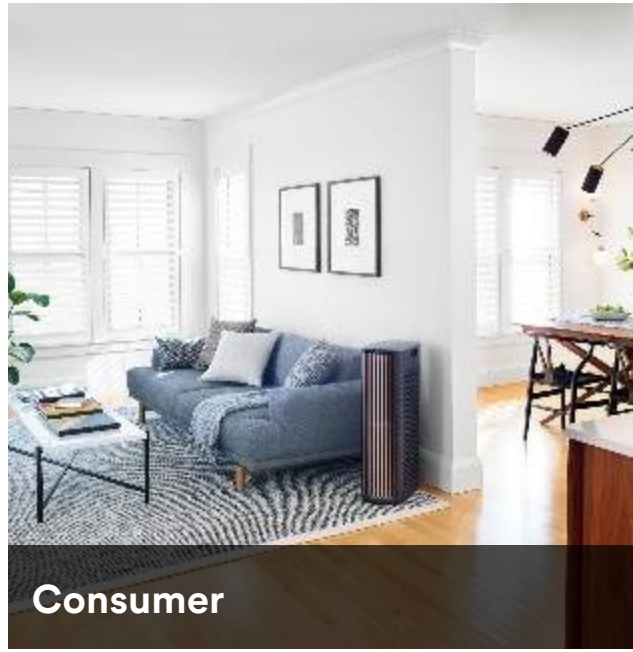
$8.9B
2022 sales



Health Care

Enabling better, smarter, safer healthcare

$8.4B
2022 sales



Consumer

Bringing 3M to the hearts and minds of consumers

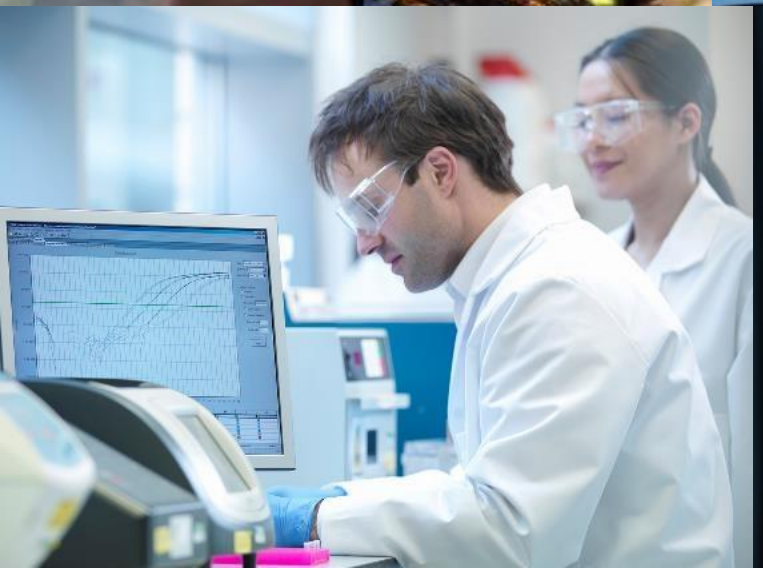
$5.3B
2022 sales

Information reflects Q1 2022 segment reporting changes. See 8-K dated February 11, 2022

Transportation & Electronics Business Group

Winning by solving tough customer challenges

- **Display Materials**
- Electronics Materials
- Automotive & Aerospace
- Transportation Safety
- Commercial Solutions
- Advanced Materials

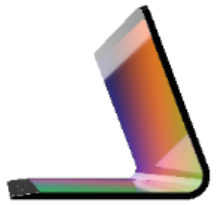


Display Materials and Systems Division

What we do

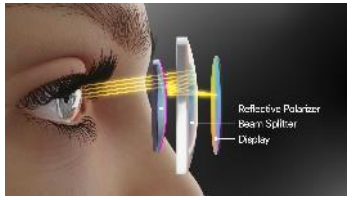
Enable brighter, more energy efficient consumer electronic and automotive displays that also are thinner, more durable; advanced solutions for sensors, privacy and protection

Optical films & optically clear adhesives



Solutions for OLED displays

Systems to make automotive displays safer



Augmented Reality/ Virtual Reality

Privacy and protection filters and films

Core Technologies

Display Optics

Light Management

Adhesives

Material Science

Optical Films

Nanotechnology

Modeling & Simulation

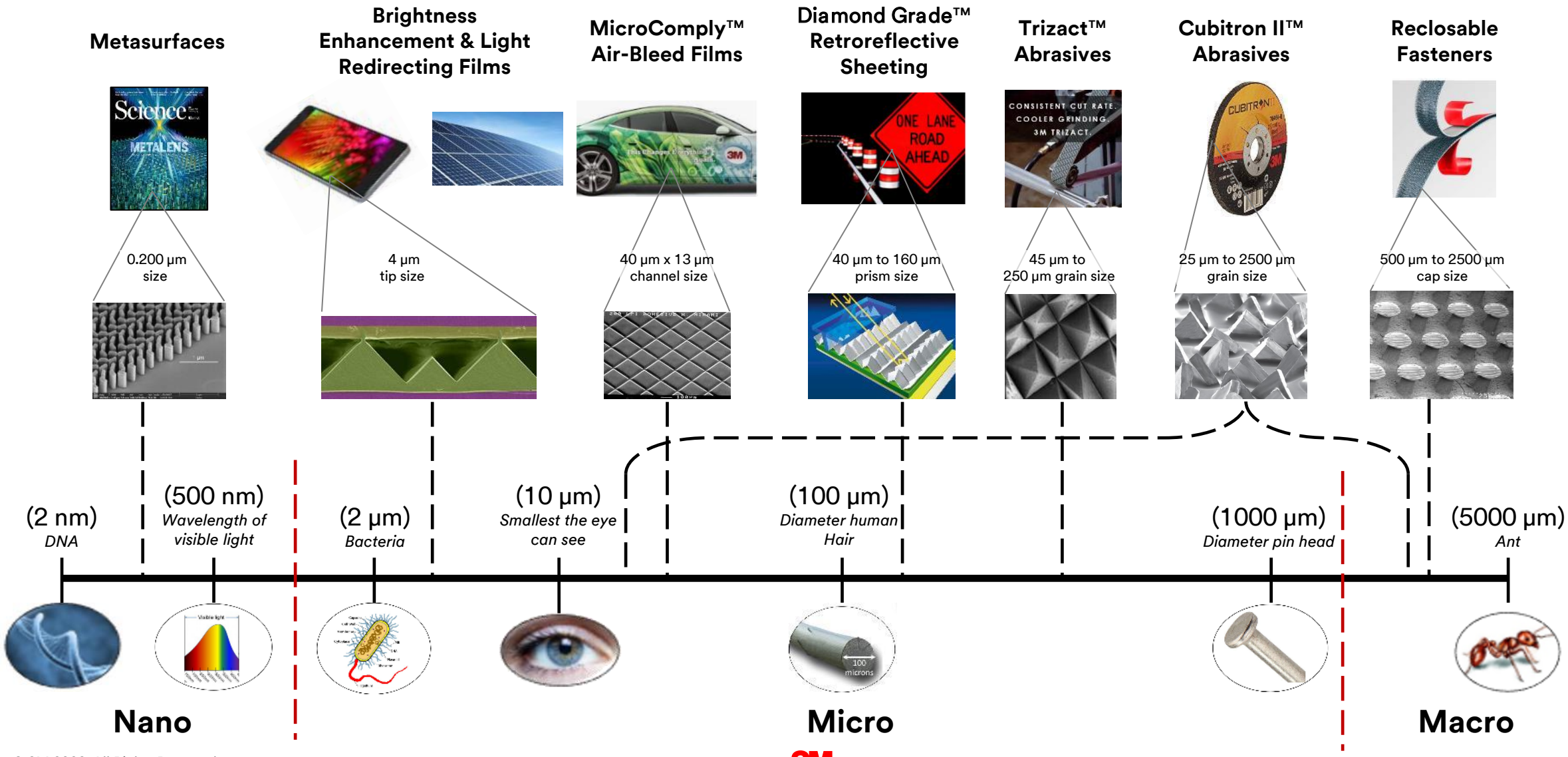
OLED Test Coupons

Technology Platforms

- Micro/Nano-imprint
- Multilayered Optical Films (3M™ MOF)
- Printable Optical Materials
- Adhesives (3M™ OCA)

Micro/Nano-Imprint

Replication at the Industrial Scale



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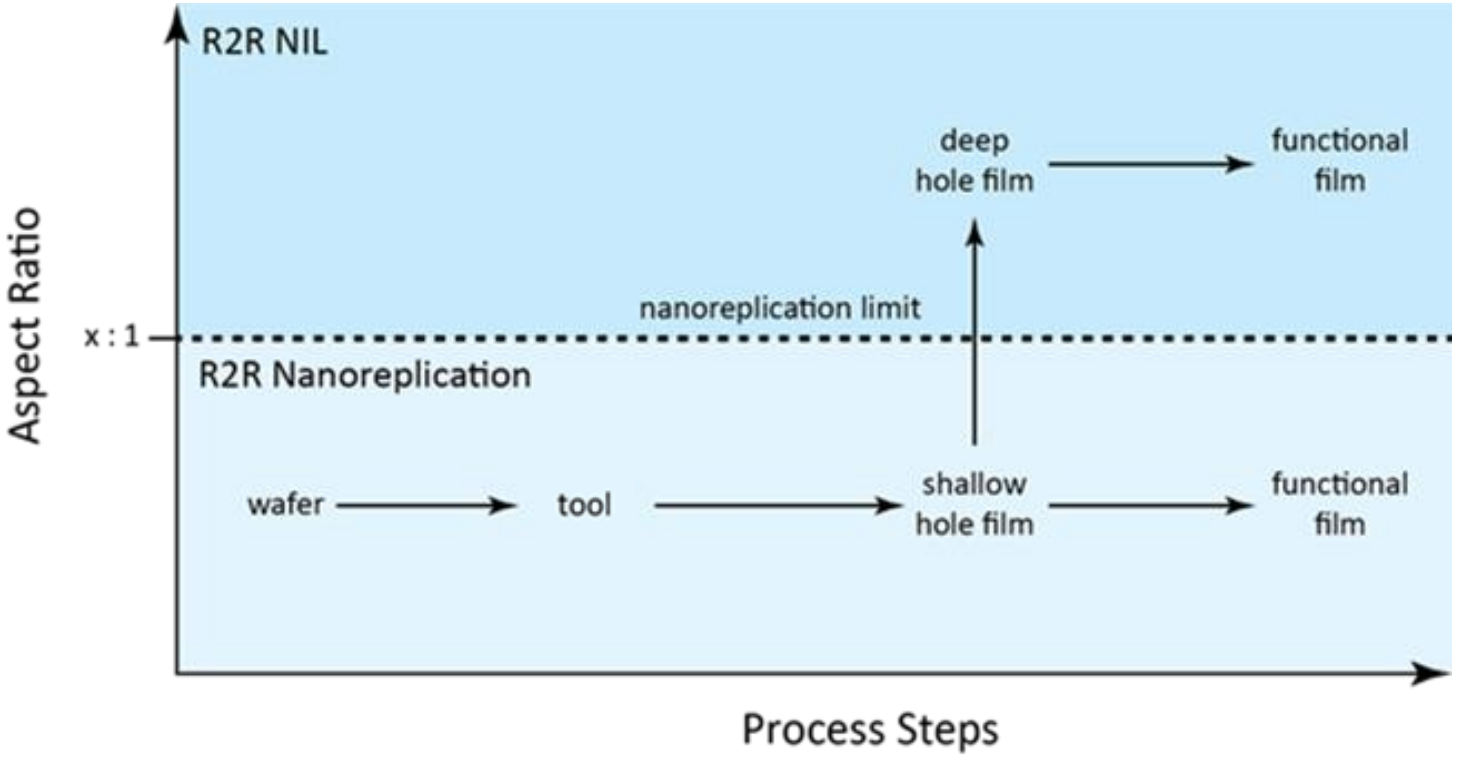
Approaches to High Aspect Ratio Optical Films

Roll-to-Roll Nano-Imprint
Processes to mold functional organic materials on a continuous film substrate

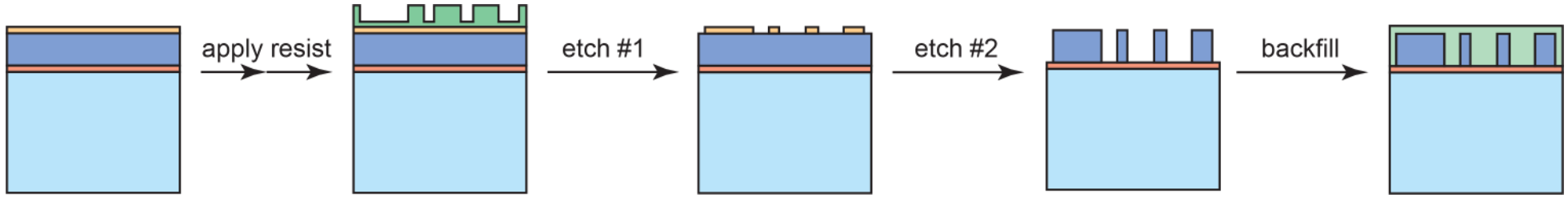
Roll-to-Roll Nano-Imprint Lithography (NIL)
Processes to mold a resist layer on a continuous film substrate followed by R2R etching of one or more sublayers

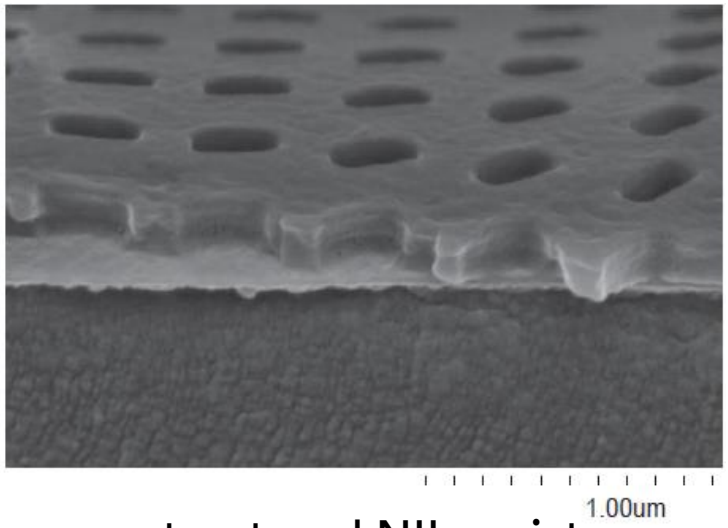
- Two scalable paths to nanostructure functional films
- R2R nano-imprint is limited by Aspect Ratio
- R2R NIL can achieve high AR, but is complex
- 3M is scaling both processes



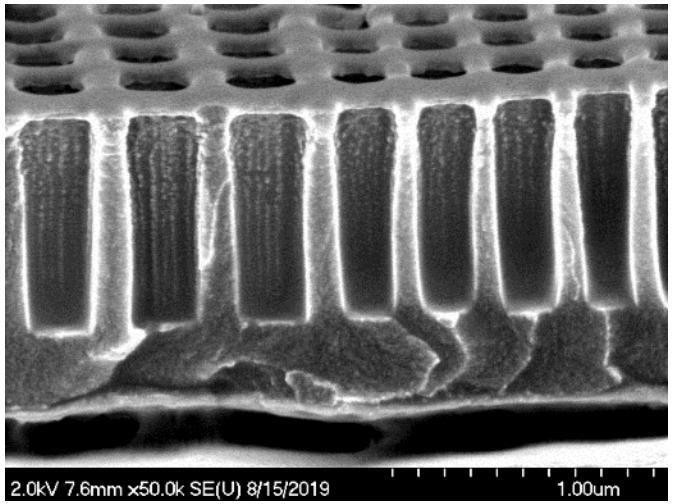
R2R NIL Process Flow

- Transparent flexible film substrate
- Structured resist (imprint) approach with pattern transfer step
- High refractive index material applied to high AR hole film as final step

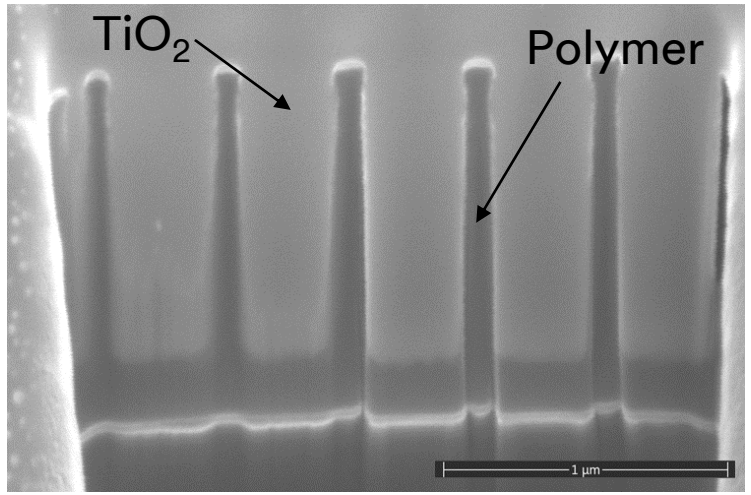




structured NIL resist



RIE etched nanoholes



partially filled nanoholes

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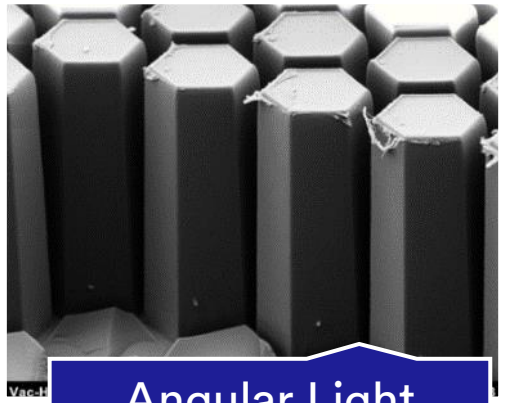
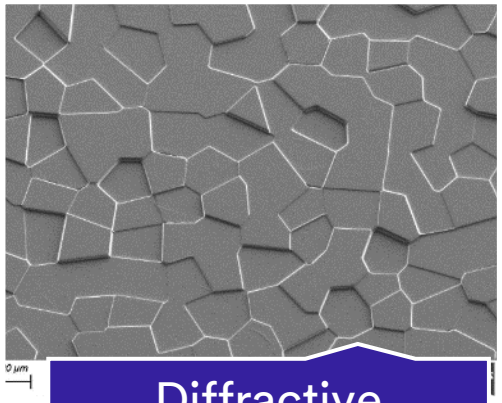
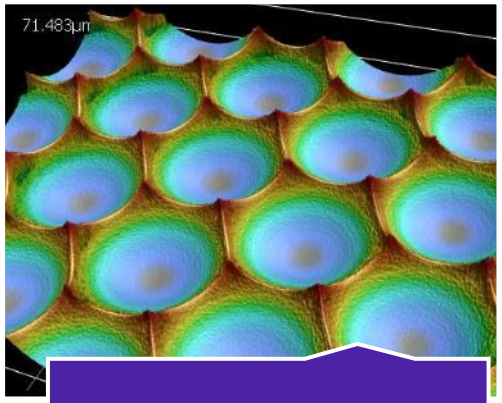
Expanding the Surface Design Space with Nanoreplication



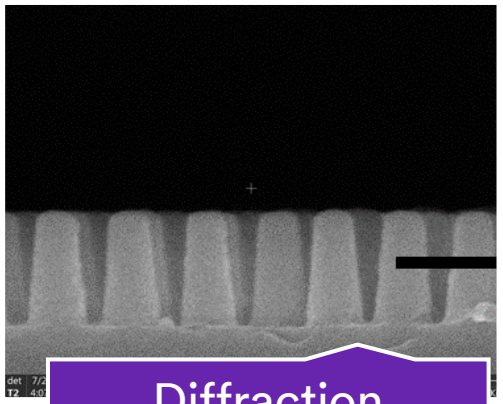
Angular Light Control



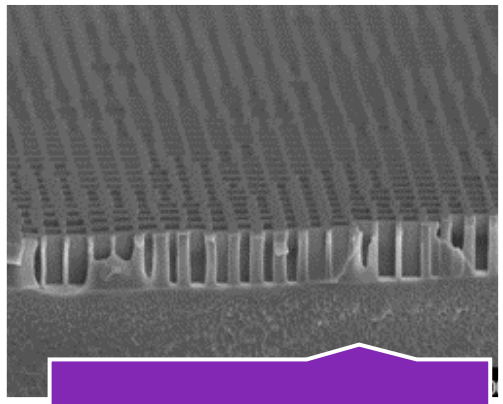
Diffractive Diffusers



Microlens Arrays



Diffraction Gratings



Metasurfaces

3M

Multilayered Optical Films (3M™ MOF)

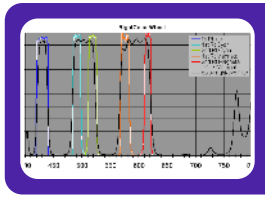
MOF Attributes

Birefringent

- Polarization selective
- No Brewster's angle

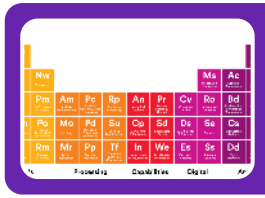
All-Polymer

- Flexible
- Formable
- Metal-free



Customizable

- Viewing angle
- Wavelength
- Absorption



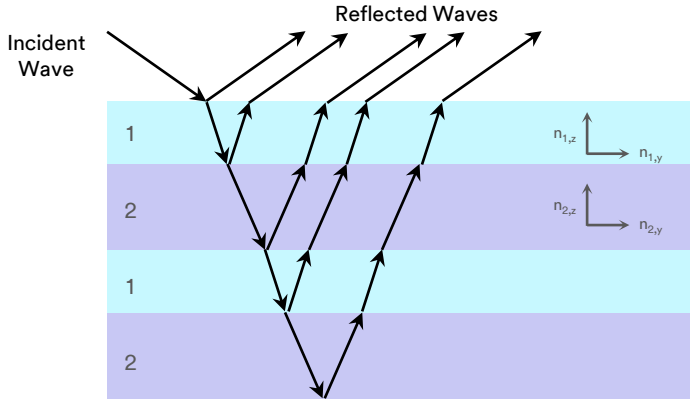
Multi-function

- Access to complimentary 3M technologies

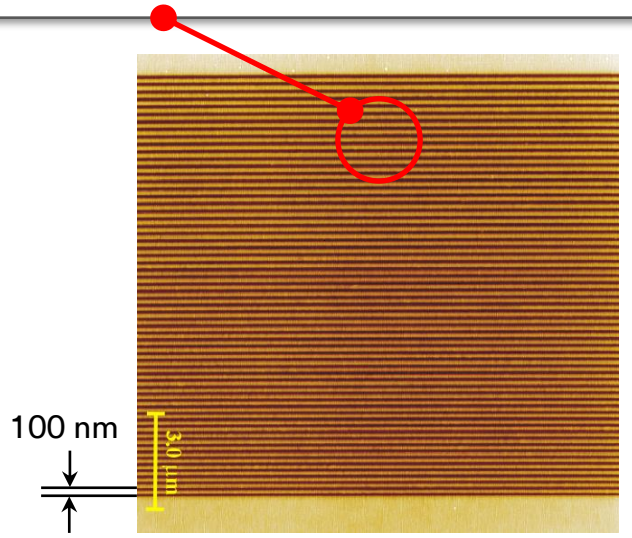
Industrial Scale

- **20+ year history**
- **High quality**
- **Billions of parts** per year

Constructive Interference on a Grand Scale



We carefully choose the thickness of layers to ensure constructive interference — creating a powerful reflection



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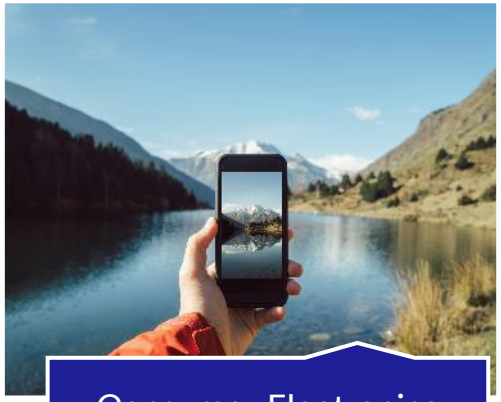
MOF Products



Consumer Electronics Display Enhancement

Automotive Grade Reflective Polarizers

Infrared Mirrors for Automotive and Buildings

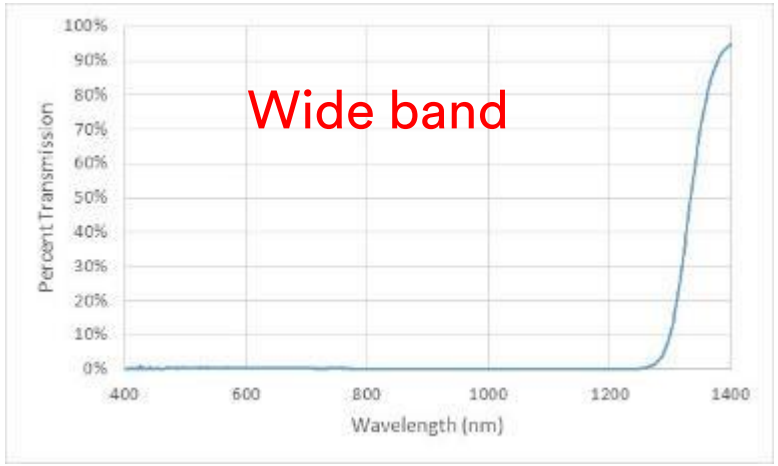
Wearables and Thermoformed Films

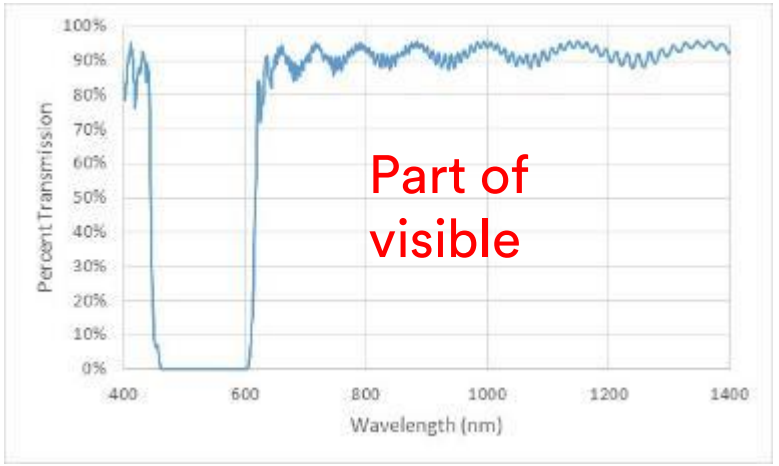
Infrared Filters for Lenses & Sensors

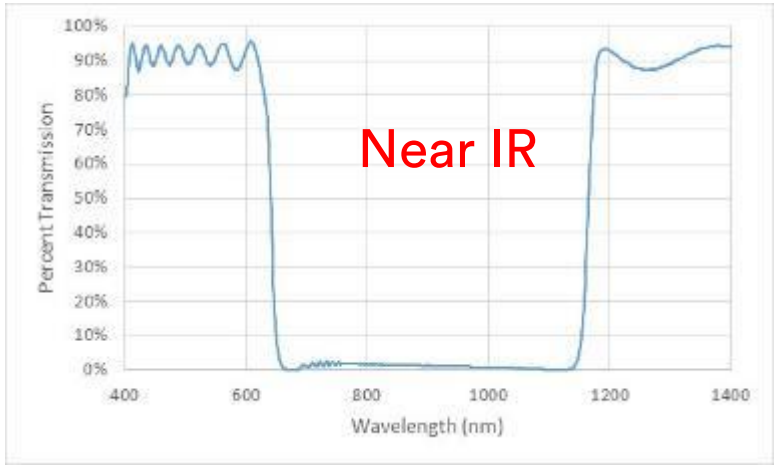
Designed Color Mirror Films

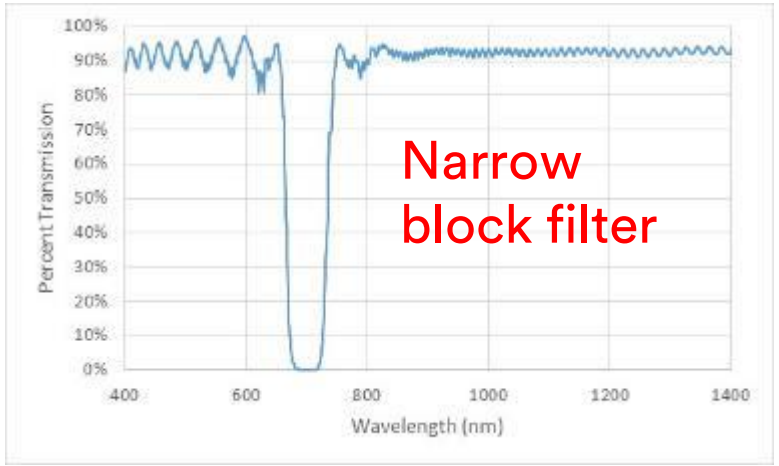
3M

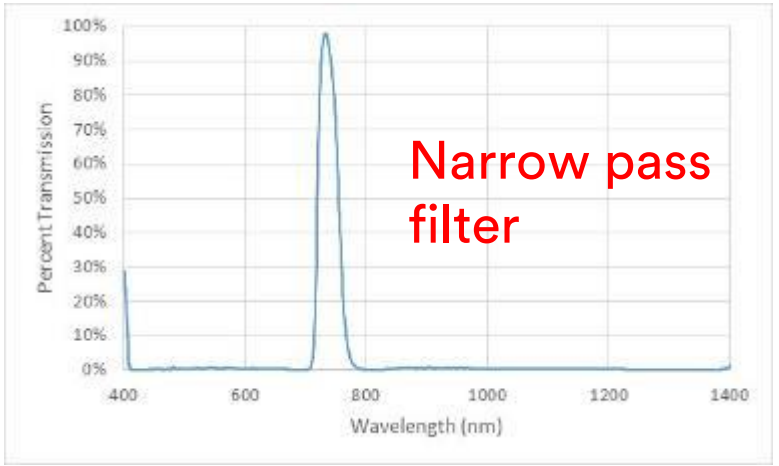
Broad Range of Spectral Features Possible

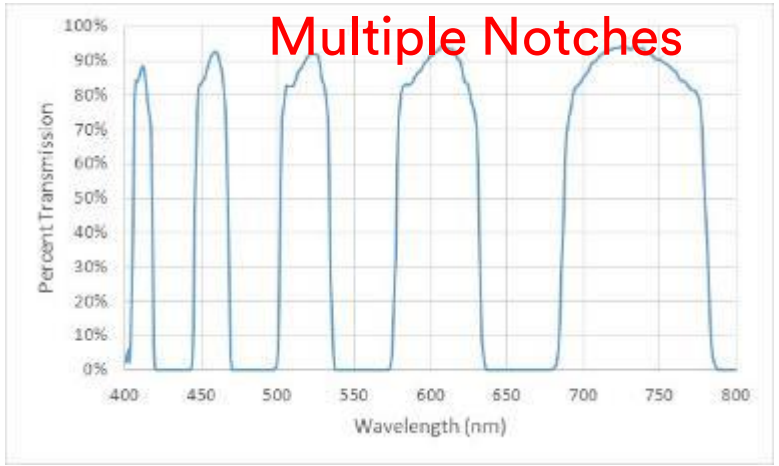












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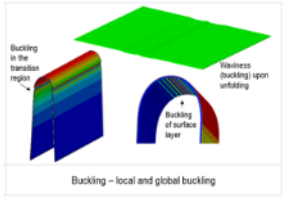
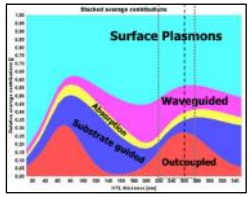
Printable Optical Materials

3M technologies for Inkjet Printing Materials

- Mechanical Modeling



- Optical Modeling



RM Purifications

Formulation

- 10+ years of acrylic based OCA development
- IJP film solutions beyond DMSD
- Strong formulation capability both in US and COM

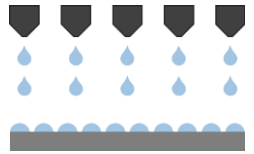
Modeling & System Solutions (Materials/Films/OCA)

3M Display Materials Lab

Ink Characterization

Performance Validation

Process Validation



- Collaboration with Inkjet printing tool companies

Technical capabilities from material designs based on modeling to full performance validations

R&D capability for customization near to customer

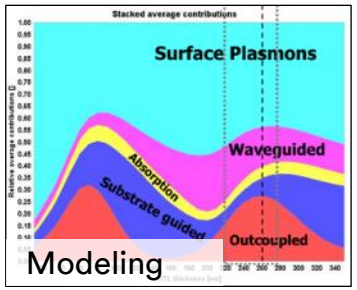
Optimization with customer design

3M-Customer joint test, VOC

Formulation

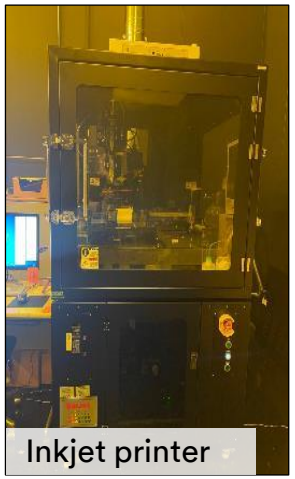
Raw material

Purification

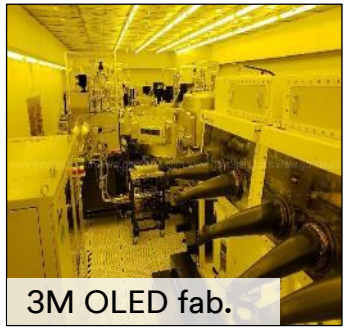


Modeling

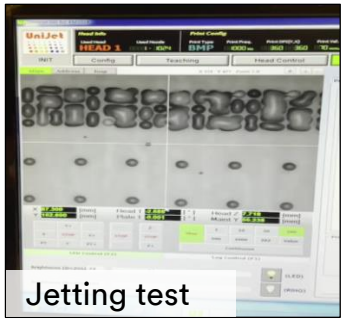
Printing test



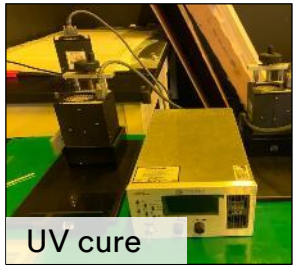
Inkjet printer



3M OLED fab.



Jetting test



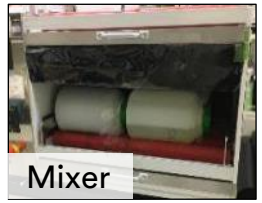
UV cure

Analysis

- Moisture: Karl-Fischer
- Particle level: LPC (KS-42BF)
- Viscosity : Viscosity + Temp. Controller
- Surface Tension : Tension meter
- Modulus/Tg : DMA
- Liquid RI : Abbe Refractometer
- Printed Layer RI : Prism Coupler
- Conversion test (Curing ratio) : FT-IR

Large scale sampling

Clean Booth



Mixer

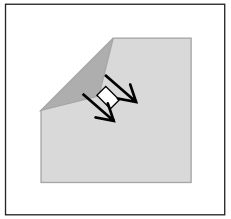
Particle counter

NOWPak system

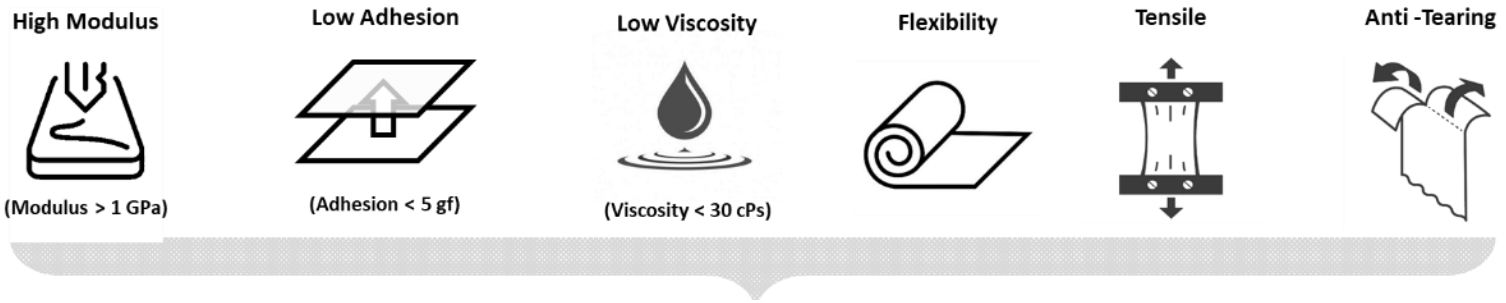
3M

Jettable Protection Film

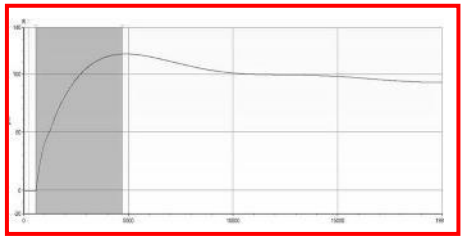
Suggest next generation protection film by inkjet printing process



- **Problem:** Conventional protection film would have potential particle issues during film laser-cut and there is applicable size limit with protection film which can't support large fab. such as over 8.5G.
- **Technical Approach:** Formulate inkjet printing material which can meet target performance of protection film
- **Result:** Achieved required features and properties (customization is required by design and application)
  - Enable island patterning
  - Film-like properties when cured
  - Stable low adhesion over time



Release Force	1.8 gf/inch	Good
Modulus	1.3 GPa	Good
Flexibility and tensile	★★★	Good
Viscosity	25.7 cP	Good



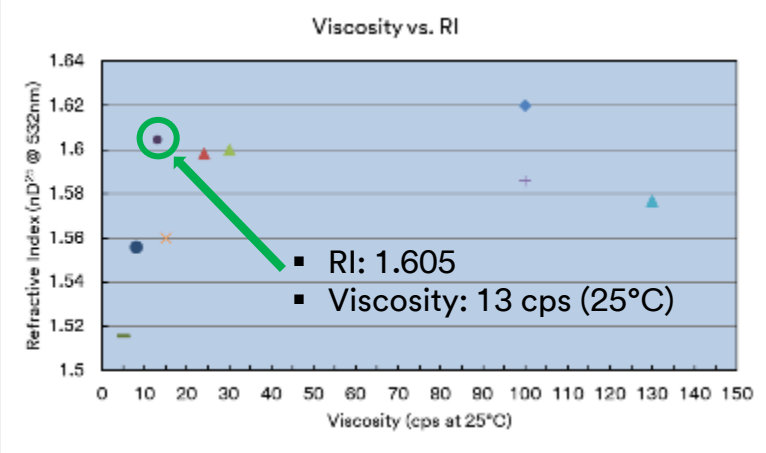
3M

TFE ink – High RI without Nanoparticle

Solve quality issues (non-uniformity, nozzle clogging) from nanoparticle in high RI ink

- **Problem:** Need high RI (Refractive Index) ink to provide more light extraction through high / low RI layers
- **Technical Approach:** Formulated high RI inks with unique high-RI chemistry and without nanoparticles
- **Result:** Excellent inkjet performance with low viscosity and verified improvements in device efficiency

3M Material vs. Commercially Available Chemistries

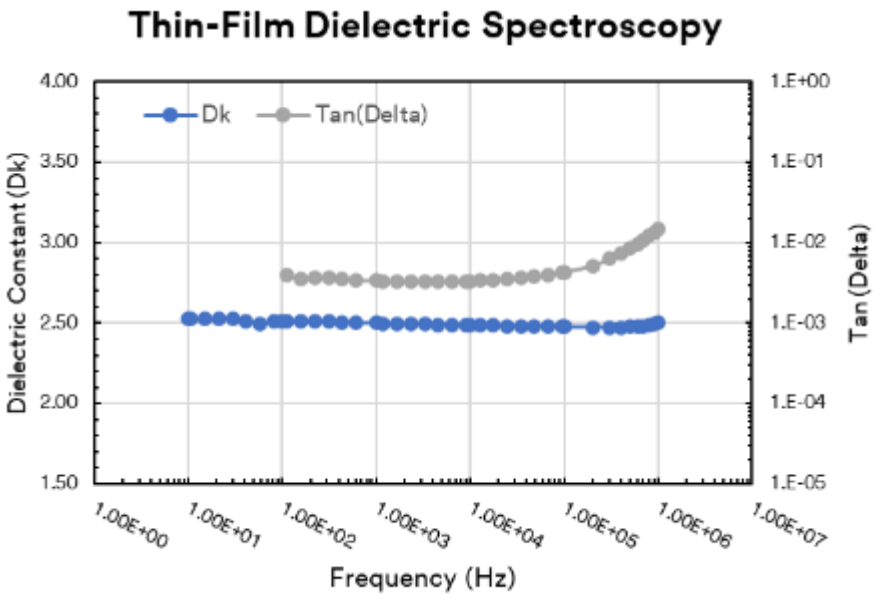


Unique combination of High RI & low viscosity

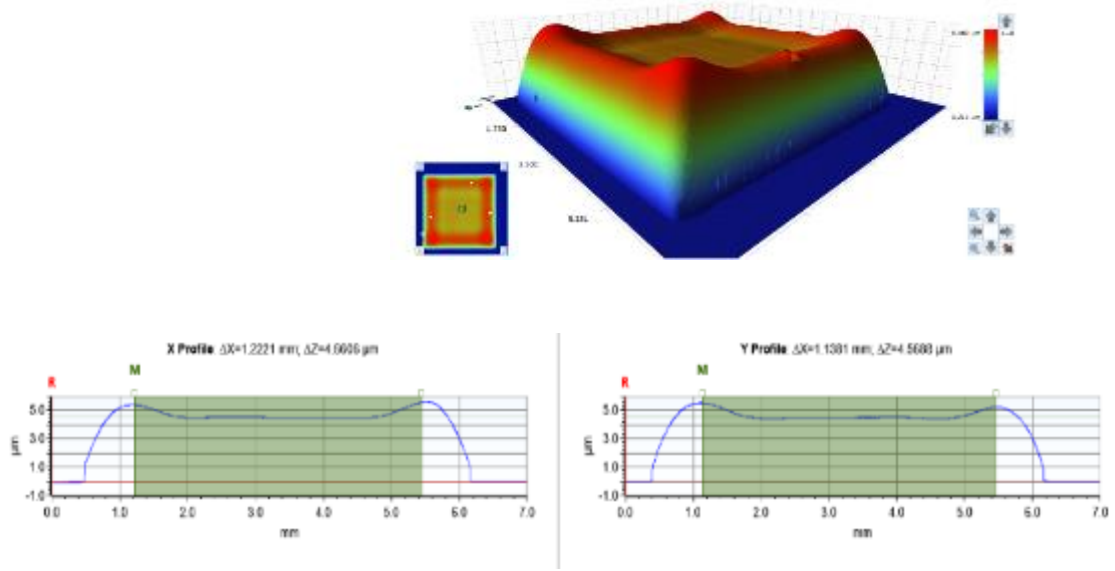
TFE ink – Low Dk

Provide electrical isolation between neighboring layers in OLED stack

- **Problem:** As devices get thinner, good touch sensor function requires electrical isolation from OLED/TFT electronic signals (capacitance should be low)
- **Technical Approach:** Reduce dielectric constant of organic ink using branched hydrocarbon acrylate monomer chemistry combined with high-Tg diluents and crosslinkers



Flat middle part
(low non-uniformity with low thickness)



- **Result:** Dielectric constant reduced from current (Dk~3.0) to 3M ink formulation with Dk < 2.5 in touch sensor frequency range (~100 kHz)

Adhesives (3M™ OCA)

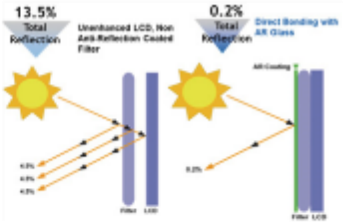
WHY Optical Bonding?

→ Enhance display brightness and contrast / Improve display robustness and ruggedness

Contrast Enhancement Technology

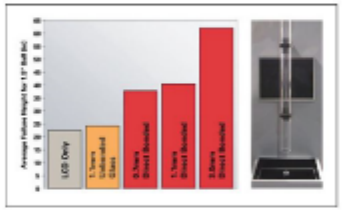
Enhancement of Optical properties

- -Reflectance reduction
- -High Transmittance
- -Good Outdoor readability



Robust performance

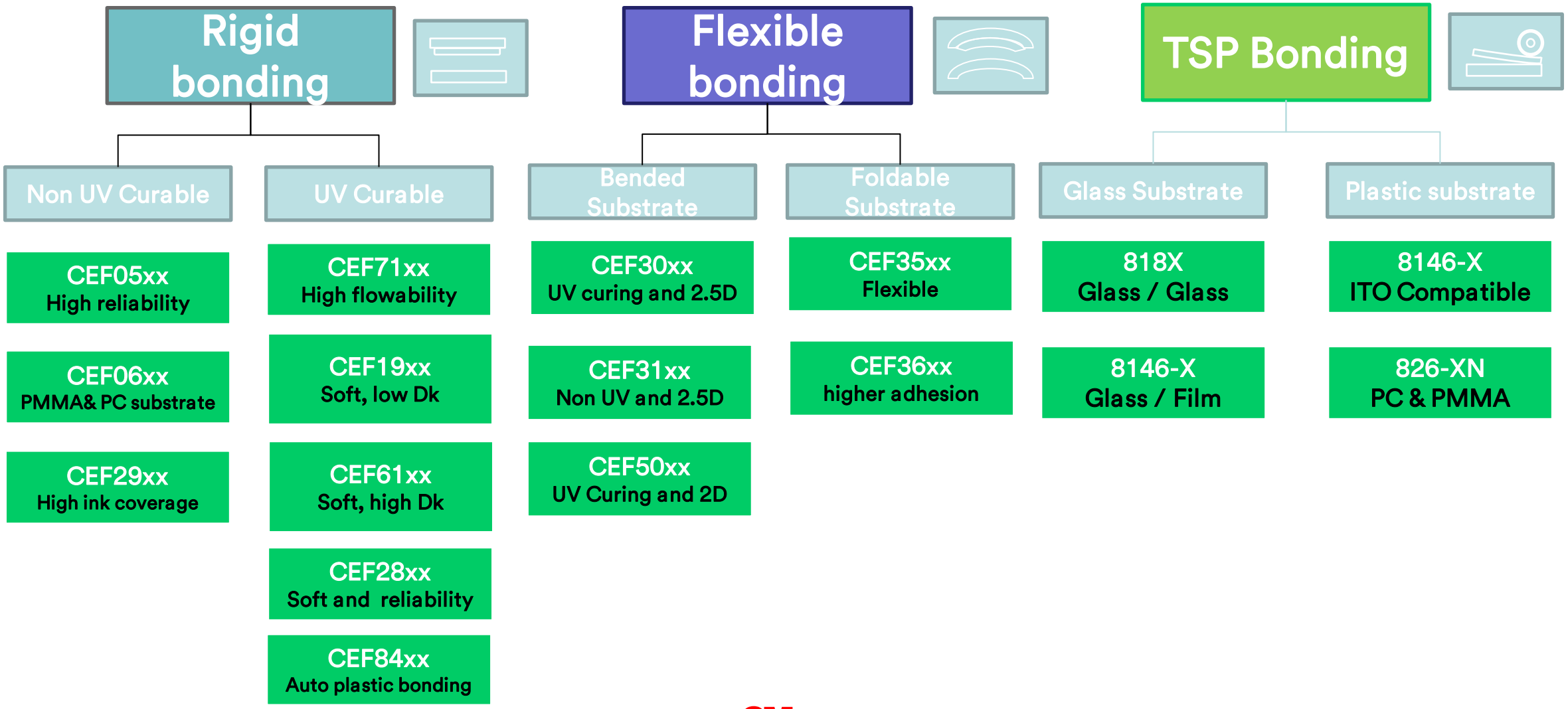
- Enhancement of hardness
- Resistance of shock
- Resistance of moisture, dirt
- Outstanding durability



Stylish Design

- Thin and Light
- Outstanding Appearance features

3M OCA (CEF / Roll OCA) Line up



Thank You

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