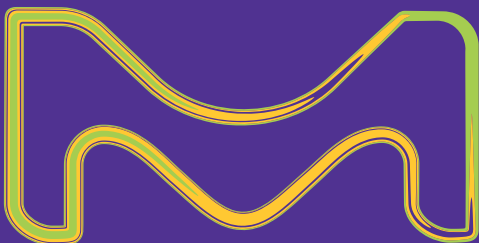


products and services

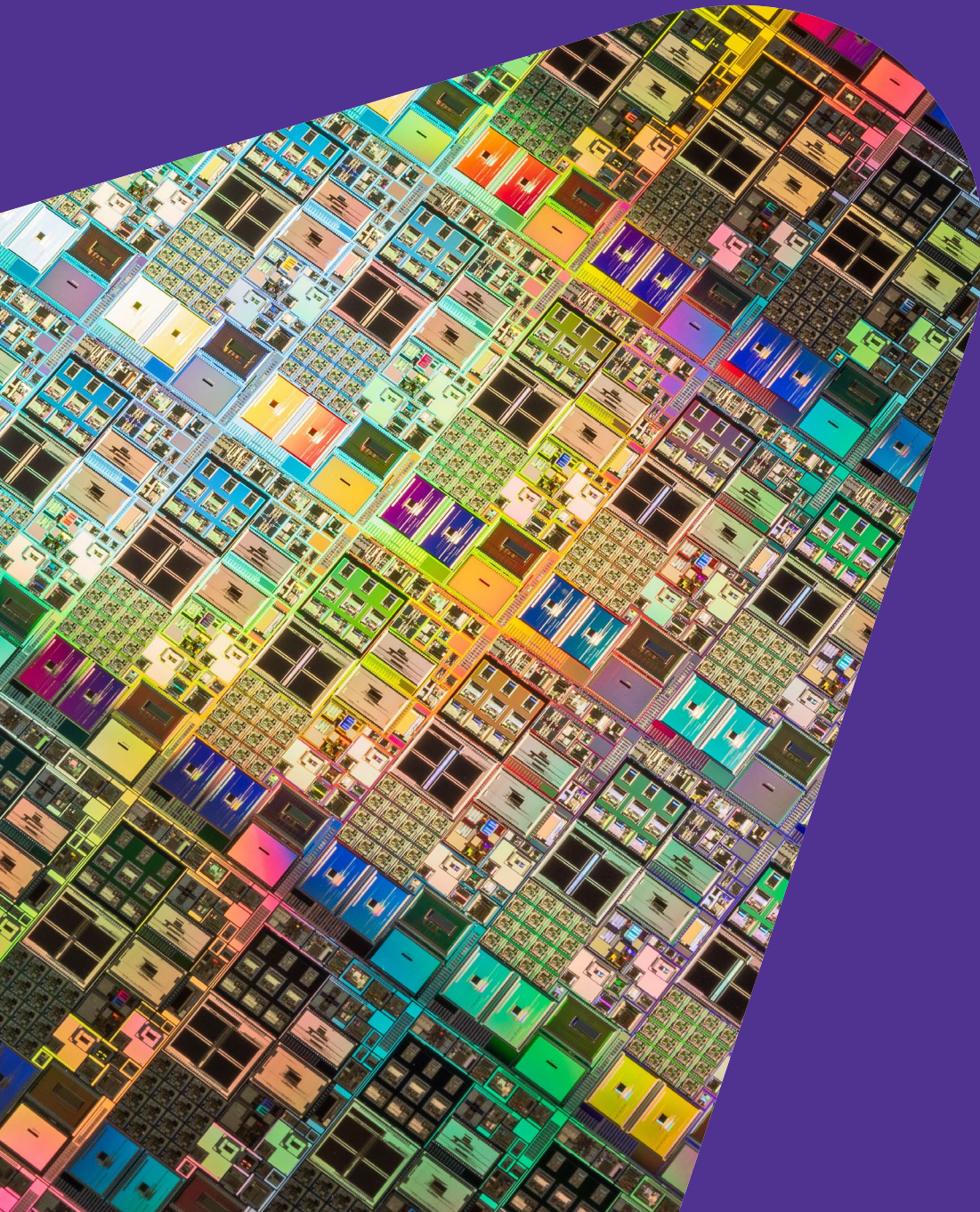
**Performance Materials
Electronics Specialty Gases Conference**

October 2020



The performance materials business of Merck KGaA,
Darmstadt, Germany operates as EMD Performance
Materials in the U.S. and Canada.

**EMD
PERFORMANCE
MATERIALS**

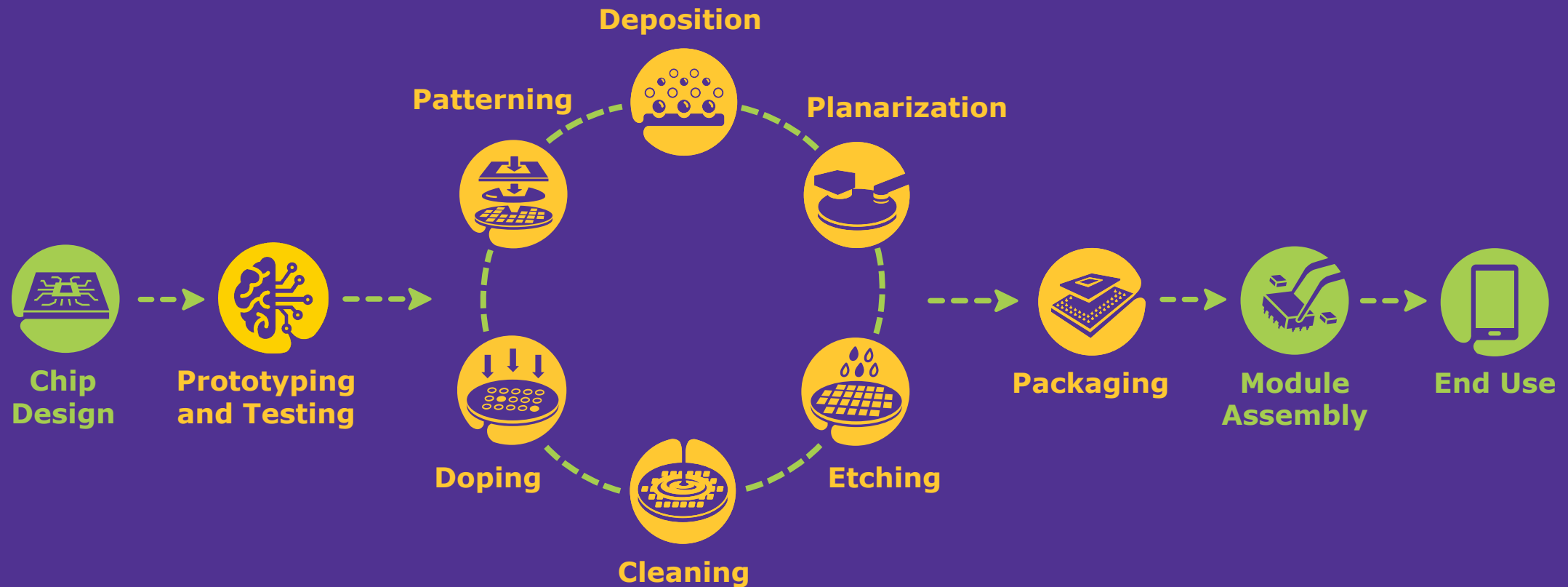


semiconductors at EMD performance materials



Trusted partner for the semiconductor industry

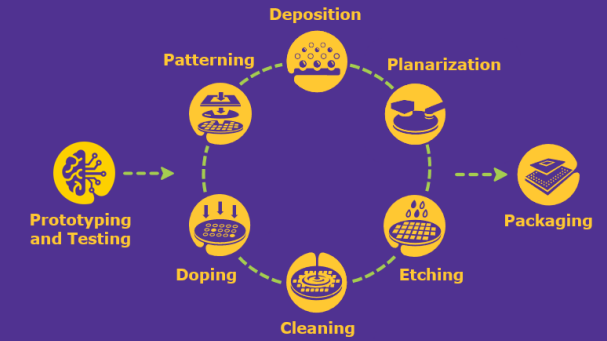
Together as one company, we have increased our capabilities in the semiconductor space. We can now **deliver innovation across the value chain**.



Semiconductor Materials

We deliver innovation across the value chain

The combination of our business creates a **complementary portfolio of materials, equipment and services** for the electronic industry.



Thin Film

Organosilanes & Organometallics for CVD, ALD, PECVD PEALD and FCVD
Spin on dielectrics



Patterning

DSA, Patterning enhancement, Thick film resist
SP&C: Resist strip, Al PERR, Advanced IC cleans



Planarization

Slurries: Oxide, Cu Bulk, Cu Barrier, Tungsten
Post CMP Cleans



Specialty Gases

Etching Gases: C_4F_6 , ClF_3 , HCl
Deposition Gases: WF_6 , N_2O
Dopant Gases: B_2H_6 , AsH_3
Cleans Gases: NF_3 , ClF_3



Packaging

Conductive pastes, Thick film resist, Advanced polymer removal



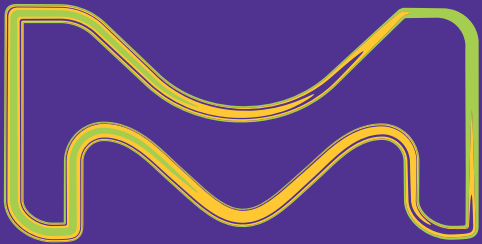
Intermolecular

Advanced materials innovation
High through-put experimentation
High quality material development services



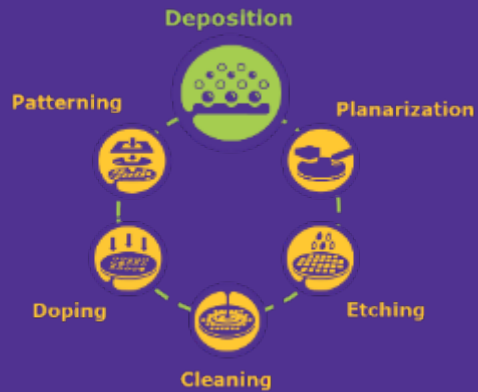
our combined products & capabilities

Thin Film Solutions



EMD
PERFORMANCE
MATERIALS

Thin Film solutions



Key locations



Close collaboration

to enable material innovation and solve unique problems



R&D

Broad chemistry/materials science base
Computational Modeling
Chemical synthesis/purification
Applications testing and film metrology
Containers and delivery
Advanced materials analytical capability
In-fab process characterization
Access to Intermolecular capabilities

Application Area

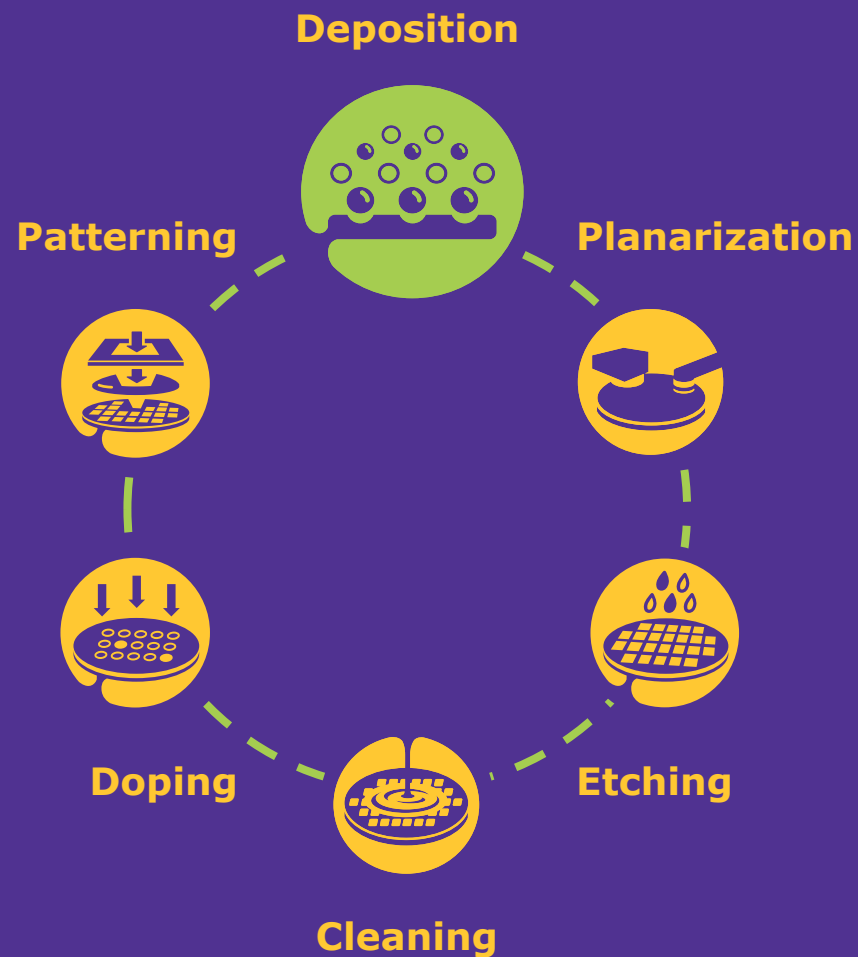
Gap fills
Low-k
3D Structures
Conformal films
Advanced Patterning
Gate stacks/Work Function
Barriers
Contacts
Wordline
Hardmasks
Selective deposition
Displays

Products

Spin-on Dielectrics
Organosilanes
Organometallics



Our portfolio



Leading positions in Thin Film solutions:

- **Spin-on Dielectrics**
- **Organosilanes**
- **Organometallics**

Click below to

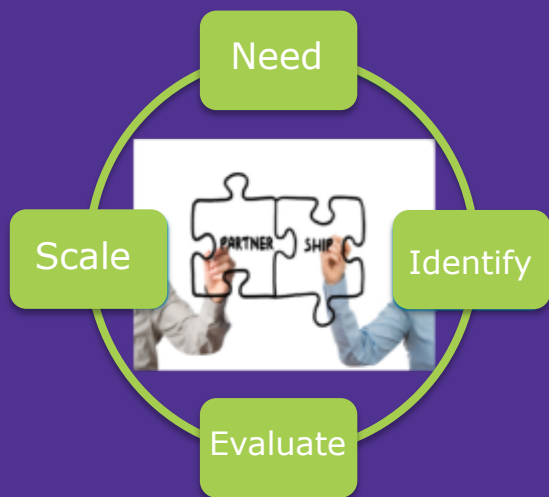
- check out our [EMD solutions](#)
- see our legacy [Versum offering](#)



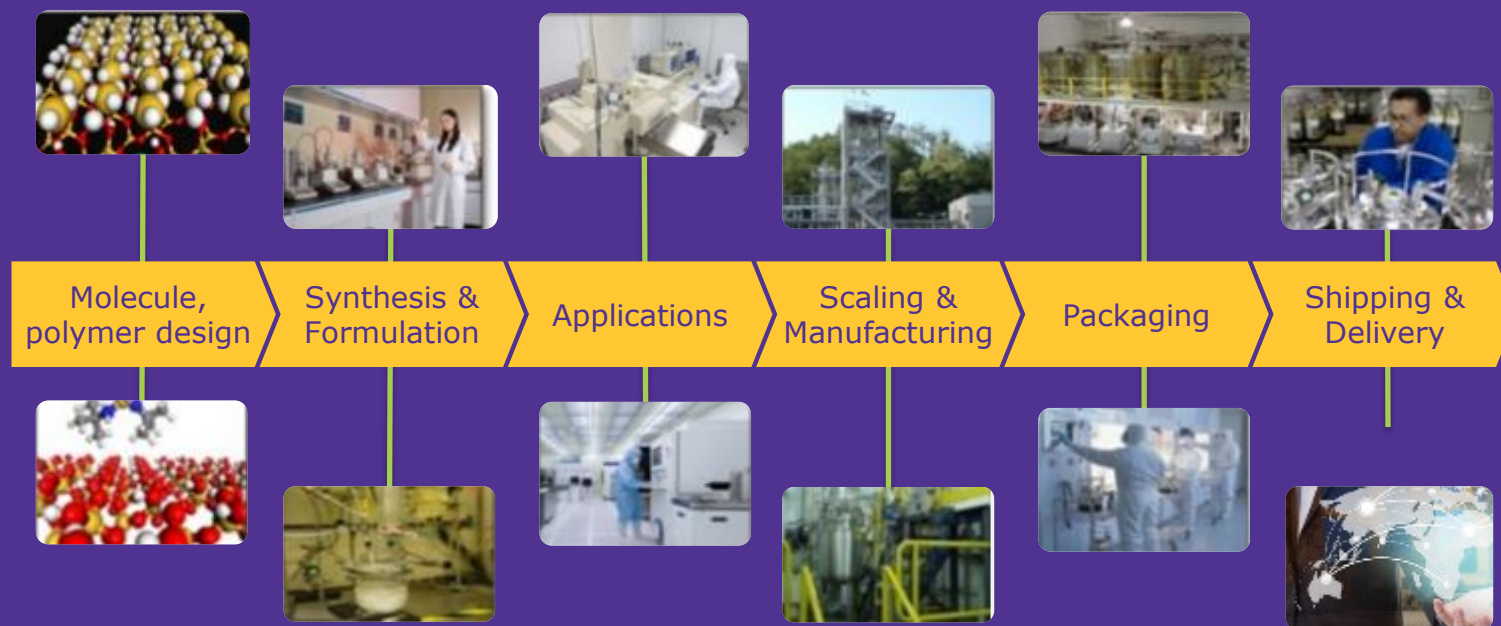
close collaboration

to enable material innovation and solve unique problems

Close collaboration...



...that drives mutually
beneficial growth



Application Areas

- **Gap fills:** SOD, FCVD, ALD, and CVD
- **Low-k:** BEOL and FEOL
- **3D Structures:** FinFET, 3D NAND, and Packaging
- **Conformal films** for high aspect ratio features at both low and high temperatures
- **Advanced Patterning**
- **Gate stacks/Work Function**
- **Barriers**
- **Contacts**
- **Wordline**
- **Hardmasks**
- **Selective deposition**
- **Displays**

Our Offerings

Spin-on Dielectrics

- Existing: Spinfil® and Ancillary, RS series,
- New: Spinfil® and RS series next gen, Multi-Color Materials, PSOD

Organosilanes (PECVD, ALD, and FCVD)

- Existing: AP-LTO® and AP-LTN® product lines, PDEMS® franchise for Structure former and Porogen, BTBAS/3DMAS/TEOS/3MS/4MS/TSA
- New products: new ALD precursors; PECVD based advanced Low-k; new FCVD

Organometallics (CVD and ALD)

- Existing: Co/Ta/Al/Ti/Hf/La/Cu
- New: Mo/W/Zr/Ru/Y/Nb
- Differentiation through containers
- Dopants and other specialty chemicals



OUR R&D Capabilities

Technology solutions for:

- Spin-on Dielectric
- Organosilanes
- Organometallics
- Other specialty chemicals

Broad chemistry/thin-film science base

- Silicon based polymers
- Silicon, metal, and dopant precursors
- Organic chemistry

Computational Modeling

- Process modeling
- Molecular modeling

Chemical synthesis/purification

- Bench top, Kilo-scale, and Pilot capabilities
- Full engineering and scale up

Applications testing and film metrology

- Spin-on, PECVD, and ALD deposition: 300mm and screening tools
- State-of-the-art analytical tools

Precursor containers and delivery

- Collaboration with the EMD's Delivery System to solve unique problems

Advanced materials analytical capability

In-fab process characterization

Access to Intermolecular capabilities



Global capabilities & capacities

11 Manufacturing and 8 R&D Facilities

US:

Haverhill (MA),
Sheboygan (WI),
Carlsbad (CA),
Hometown (PA)
Catoosa (OK)

Manufacturing

Haverhill (MA),
Sheboygan (WI),
Carlsbad (CA),
Hometown (PA)
Tempe (AZ)

Research &
Development

Korea:

Anseong,
Sihwa,
Banwol

Manufacturing

Banwol

Research
&Development

Japan:

Shizuoka

Manufacturing
Research
&Development

Taiwan:

Kaohsiung,
Nanke

Manufacturing

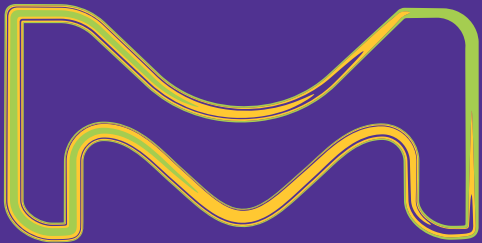
Kaohsiung

Research &
Development



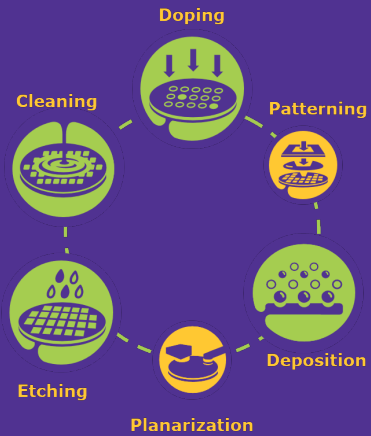
our combined products & capabilities

Specialty Gases

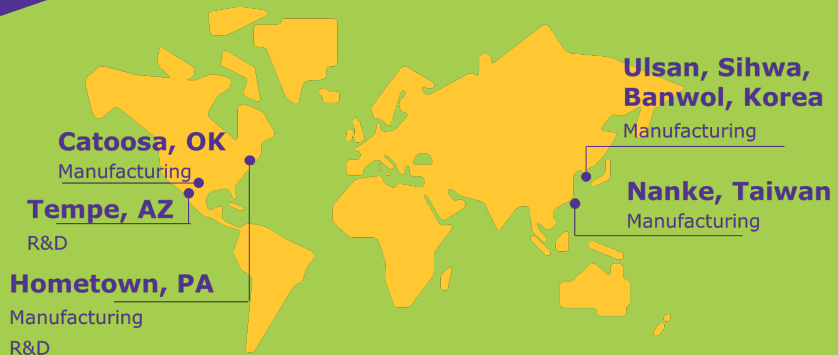


EMD
PERFORMANCE
MATERIALS

specialty Gases



Key locations



A **recognized leader** in electronics specialty gases and the end-markets we serve



R&D

New Etching Gases
Product Synthesis
New Hard-Mask Gas

Products

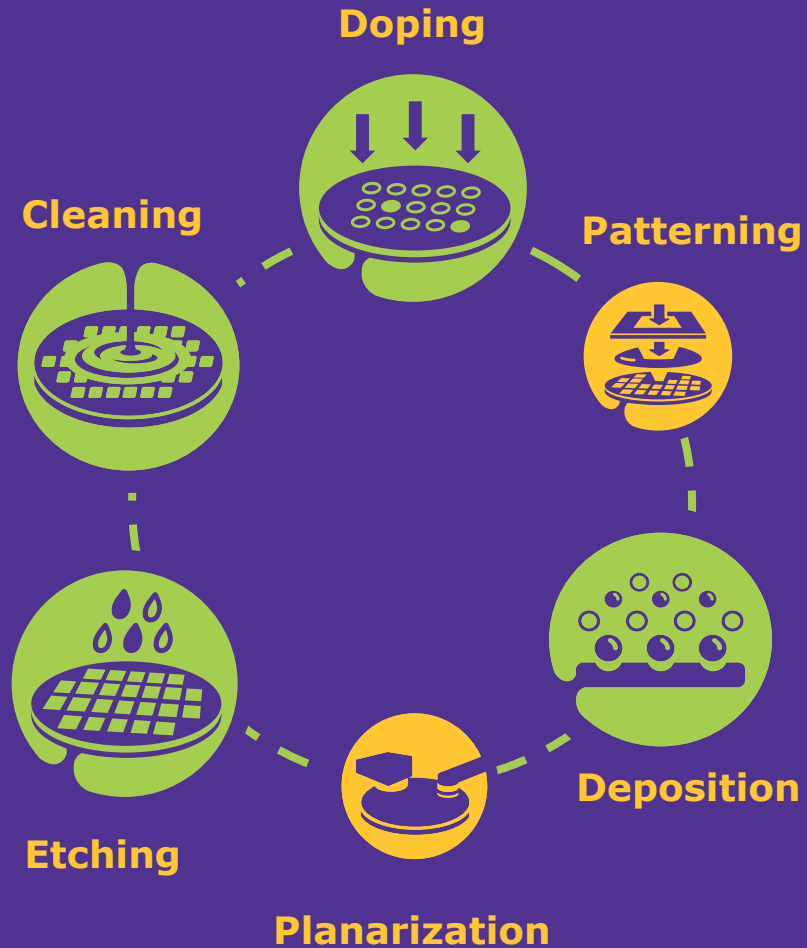
We offer all major Specialty Gases in the market, covering following platforms



Etching Gases
Cleaning Gases
Deposition Gases
Dopant Gases



Our portfolio



- Leading provider of **Specialty Gases**
- Large **Electronics Fluorine** franchise
- >40 Broad Specialty Gas product portfolio

Click below to

- check out our [EMD solutions](#)
- see our legacy [Versum offering](#)



A **recognized Leader** in electronic specialty gases and the end-markets we serve

Broadest portfolio, geographic reach, technical support, applications know-how and customer intimacy

Etching Gases:



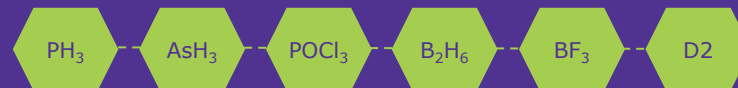
Cleaning:



Deposition:



Doping:



new product development



Focus on **new materials solution development**, partnering with customers



Develop new product matching with customers' technology roadmap



Develop high purity product **synthesis and purification** technology

New Etching Gases

Product Synthesis

New Hard-Mask Gas

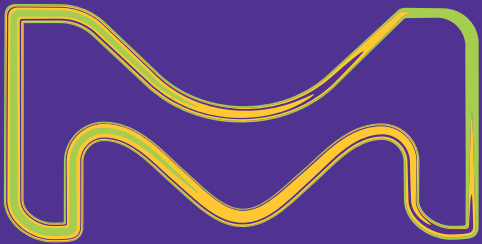


Global capabilities & capacities



our combined products & capabilities

Planarization

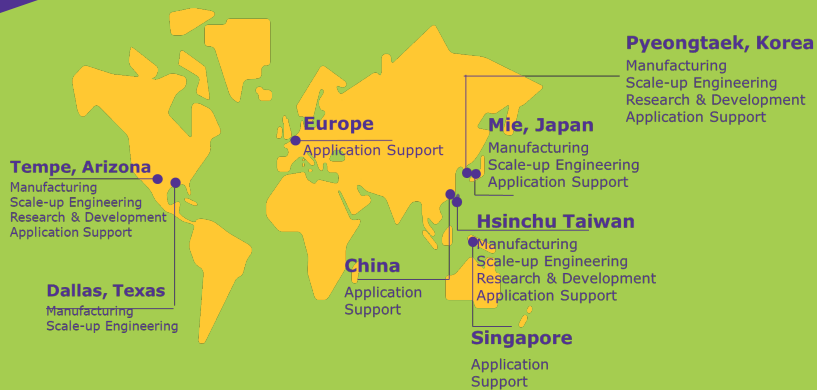


EMD
PERFORMANCE
MATERIALS

planarization



Key locations



Global Leader in Chemical Mechanical Planarization (CMP) Technology



Broad product portfolio with strong positions at leading customers

FEOL Dielectrics

- STI, ILD and bulk oxide slurries

MOL MG & Contacts

- W Bulk and Buff slurries
- Co & Mo slurries

BEOL Interconnects

- Cu Bulk slurries
- Cu Barrier slurries



R&D

Innovation in chemical additive and abrasive chemistry

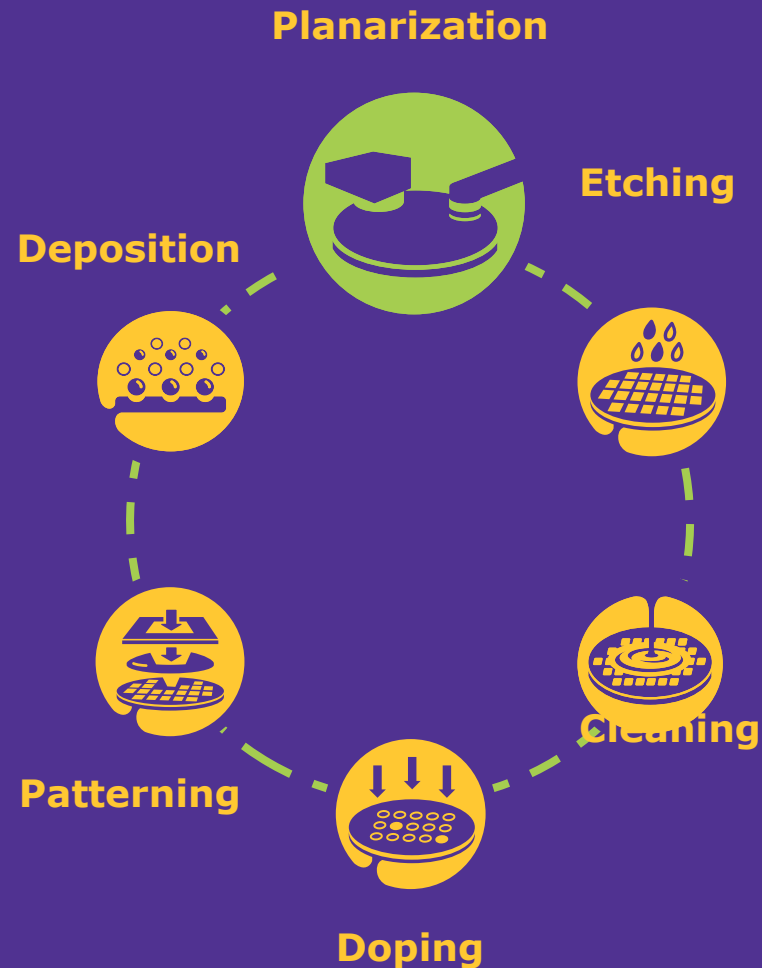
Slurry formation design

Film property characterization and correlation with polishing performance

Integrated slurry and pCMP clean design



Leading supplier position with
our **portfolio**



We have a **broad Chemical Mechanical Planarization (CMP) portfolio**, specifically targeting **innovative new products**

- STI & Advanced Oxide Slurries
- Copper Bulk Slurries
- Copper Barrier Slurries
- W and new metals (Co, Mo) Slurries
- Post CMP (pCMP) Cleans
- Wafer Polishing Slurries

Click below to

- check out our [EMD solutions](#)
- see our legacy [Versum offering](#)

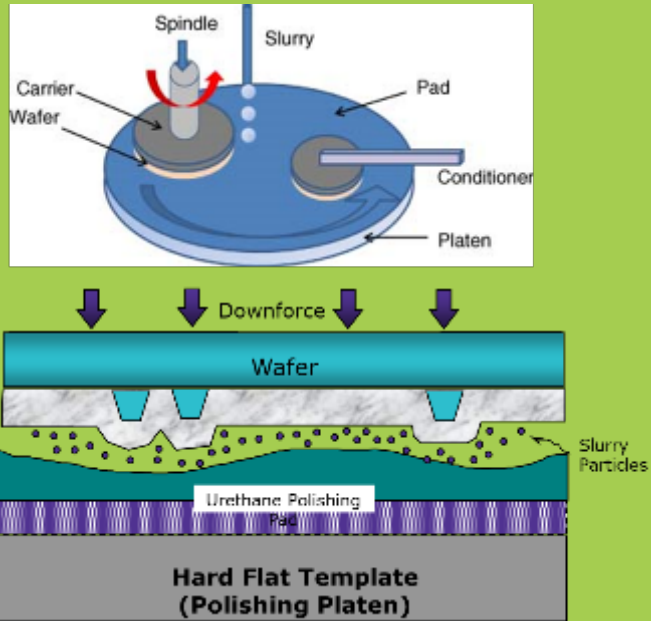


GLOBAL LEADER IN CMP TECHNOLOGY

- Performance tested products with long POR track-record with leading global foundry and memory fabs.
- Products are designed to provide high tunability and wide process windows to meet broad customer performance requirements.
- Highly experienced applications engineers/technology/commercial team to work with customers on the tool for product adoption.



What is CMP?



Chemistry and abrasion is used to polish the wafer surface

Why is CMP needed?

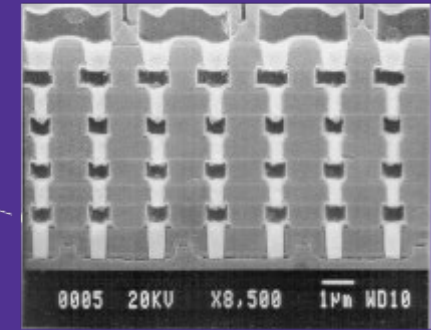
2 - 3 Metal Levels

0.8 μm

0.5 μm

>3 Metal Levels

0.35 μm



Without CMP

- Large Depth-of-Focus required
- Large Thickness Etch required
- Poor Step Coverage

With CMP

- Uniform and Planar Surface
- Higher Performance
- Improved Die Yields and Device Reliability
- Simplified Lithography



Our Offerings & Application Areas

Integrated CMP and pCMP Offerings

CMP
Slurries

FEOL Dielectrics
STI, ILD & Oxides

STI2100/STI 2305/STI 2503
STI2401/STI2910
STI2601/2TI2910
HPD 8XXX (Development)

- Reduced defectivity
- High Selectivity (Nitride and Poly)
- Low oxide dishing

CeClean 2020
CeClean 2022

- Ceria nano particle removal
- Reduced Defect
- Increased PVA brush life

MOL MG & Contacts
W and Co

W5X00
Co7000 (Co Bulk)
Co7200 (Co Barrier)

- Dishing improvements
- Low defectivity
- Removal rate tuning

WPC1090 (acidic)
CP98D (alkali)

- Corrosion control
- Metal contamination
- Reduce particle defect

BEOL interconnect
Cu Bulk /Barrier

Cu3980/Cu3086 (Cu Bulk)
Cu4545/BAR6610R (Cu Barrier)
BAR6520 (Cu Barrier)

- Low defectivity
- Optimized COO
- Tunable selectivity
- Compatible w. new metals Co/Ru

CP72B: Cu, CP98D: Cu/Co
CP1002: Cu/Co/Ru

- Corrosion control
- Organic residue removal
- Reduce metals & particle defect

Development Product

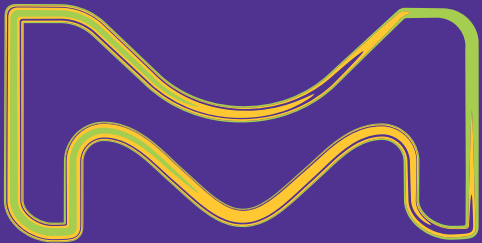


Global capabilities & capacities



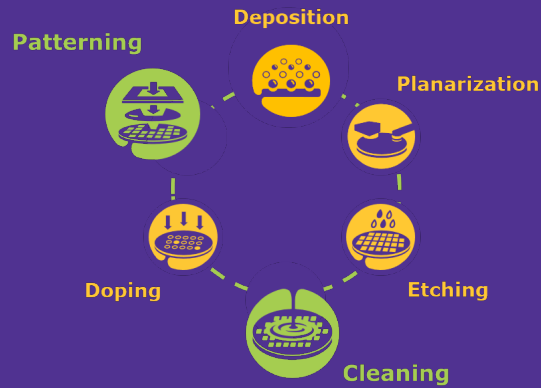
our combined products & capabilities

Patterning



EMD
PERFORMANCE
MATERIALS

patterning solutions



Key locations



Enable advanced **patterning solutions** for next generation devices



Products

Photoresists

Anti-reflective & Underlayer Coatings

Process Enhancement Solutions

Cleaning Solutions (SP&C)



R&D

Revolutionary patterning materials (e.g. DSA)

Pattern enhancement materials for Patterning

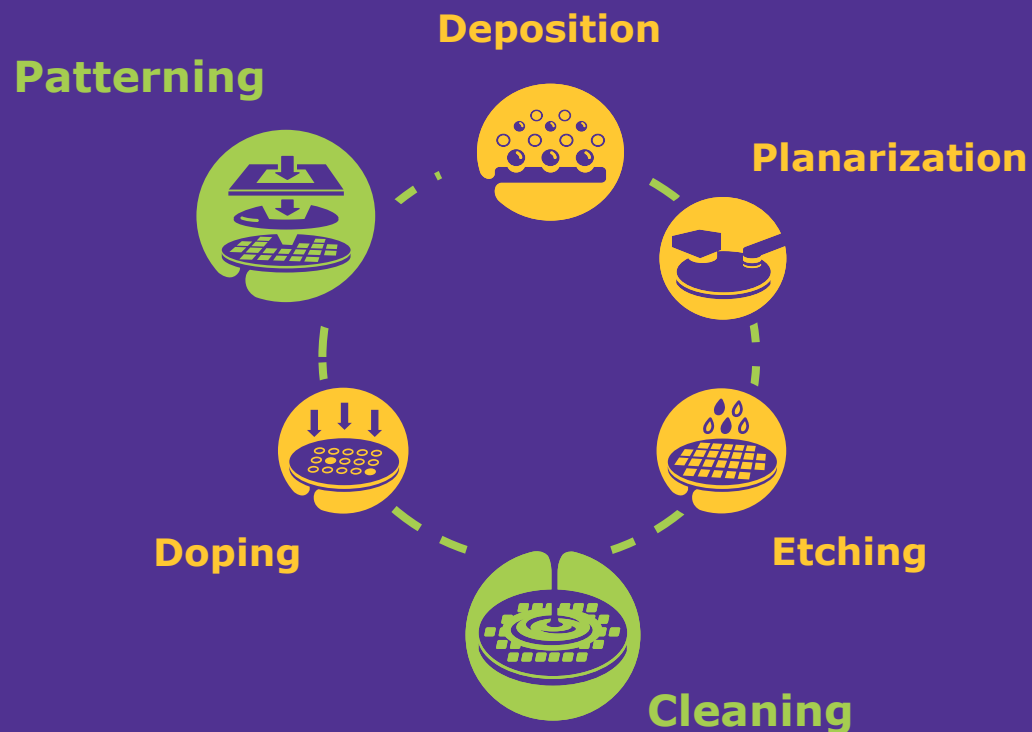
High performance Photoresist for specialty applications

High purity cleaning Solutions



Our portfolio

Our vision: Enable advanced patterning solutions for next generation devices



Strong portfolio supporting image transfer steps in semiconductor

- **Photoresists**
- **Anti-reflective & Underlayer Coatings**
- **Process Enhancement Solutions**
- **Cleaning Solutions (SP&C)**

Click below to

- check out our [EMD solutions](#)
- see our legacy [Versum offering](#)



OUR FOCUS

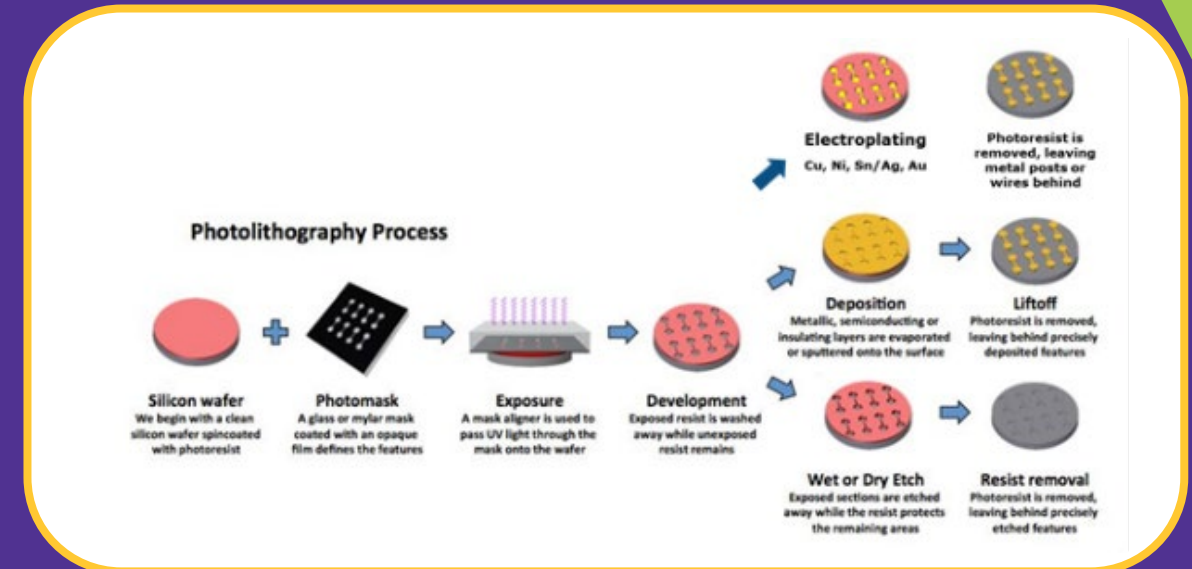
enable the growth through innovation and market position

The Markets:

- Support Moore's Law oriented Leading Edge innovation
- Enable novel material solutions for 'More than More' technologies
- Drive development for Patterning in advanced Wafer Level Packaging

Innovative Solutions:

- Highly innovative Lithography materials
- Advanced Surface Prep and Cleans Solutions



- Growth driven by semiconductor device miniaturization, adoption of 3D structures and introduction of new material stacks
- Leverage TEL and SCREEN OEM relationships to amplify innovation cycles



Application Areas

- **Lithography:** i-line & KrF wavelength for
 - **3D NAND staircase** patterning
 - **Electroplating** (bumping, RDL, Cu pillars)
 - Metallization by **Lift-Off** (SAW devices)
 - High AR **implants** (CIS)
 - Litho on special substrates – SiC, GaAs, GaN
- **Advanced patterning: Directed self-assembly (DSA)**
- **Litho process enhancement:**
defect control, shrink, anti-reflex coating, pattern collapse
- **Multi layer etch stacks:** CUL, MHM
- **Cleaning:** resist & etch residue removal
- **Advanced selective etch**

our offerings

Patterning Solutions

- Existing: i-line & KrF Photoresists
- New: DSA, Metal HM, lift-off KrF resist

Process Enhancement Solutions

- Existing: TARC (AZ AQUATAR VIII®), Shrink, BARC (AZ BARLI®), Rinse
- New products: Solid Rinse, EUV Rinse

Process Materials

- Existing: Edge Bead Removers, Polyimide Developers, MIF & Inorganic Developers

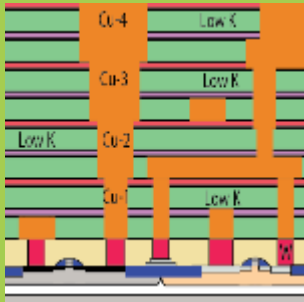
Cleaning Solutions (Front-End, Back-End & Packaging)

- Existing: Post Etch Residue Removers, Resist Removers,
- New Products: Selective Etchants, Solid Clean



Surface preparation and cleans Business at Glance

Advanced IC Cleans



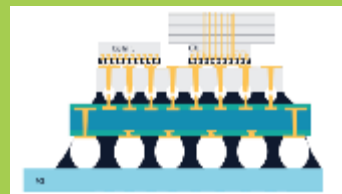
- **MHM PERRs:** HX-210 series, BHP-800s
- **Selective Si/SiGe Etchants:** SG series*, AFE series
- **Selective SiN:** ANR series*

TFRR and Wafer Level Packaging Cleans



SINGLE DIE PACKAGING CLEANS

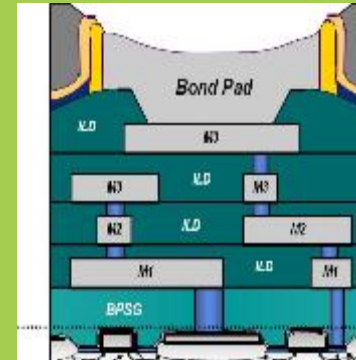
- **Pre-wired bond cleans:** BPS 100, BPS 106, BPS 170, BPS 600, NE111
- **Dicing Cleans:** BPS 729A, BPS 729B



ADVANCED PACKAGING CLEANS

- **Thick Film Resist Removers:** Dynastrip® AP7990T, AP7880T, AP8070 Dynastrip® AP7900C, Dynastrip® AP1050
- **PERRs & Si recess etchants:** NE89, XT1100, EZSTRIP® 528H, VSEs, Dynastrip® DL9150

Legacy PERR IC Cleans



- **HA based:** ACT® 915A, ACT® 927C, ACT® 935, ACT® 940, ACT® 945, ACT® 114A, ACT® ELT101
- **F-based:** ACT® NE14, NE89, NE111, EZSTRIP® 528H
- **Solvent-based:** ACT® CMIK-S, ACT® 690S/SX
- **Semi-aqueous:** ACT® 970

Polymer Removal



- **Anhydride-cured Epoxy/Urethane Remover:** Dynasolve® 711
- **Amine-cured Epoxy Remover:** Dynasolve® AP185
- **Silicone Remover:** Dynasolve® 200s
- **Acrylic Remover:** Dynasolve® 699



Global capabilities & capacities

Branchburg, New Jersey

Manufacturing
(pilot)
Research &
Development

Tempe, Arizona

Manufacturing
(pilot)
Research &
Development

Dallas, Texas

Manufacturing

Martin, South Carolina

Manufacturing
Research &
Development

Wiesbaden/ Darmstadt, Germany

Manufacturing

La Motte, France

Manufacturing
Research &
Development

Shanghai/ Suzhou, China

Dedicated sales
Dedicated
customer
service

Pyeongtaek/ Anseong, Korea

Manufacturing

Zhubei / Hsinchu, Taiwan

Manufacturing
(pilot)
Research &
Development

Shizuoka, Japan

Research and
Development
Manufacturing



Directed Self Assembly (DSA)

Fine patterning from Self-Assembling materials, rather than lithography

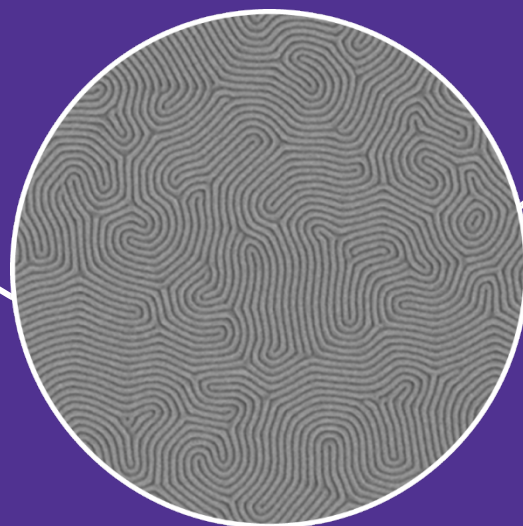
Block CoPolymers

can naturally form ...



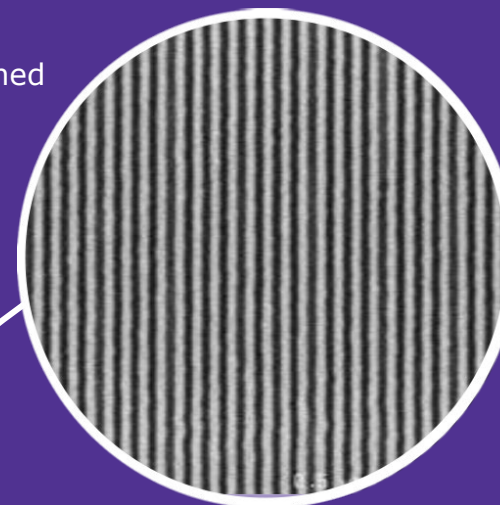
Self Assembled Lines

which are aligned
to create ...

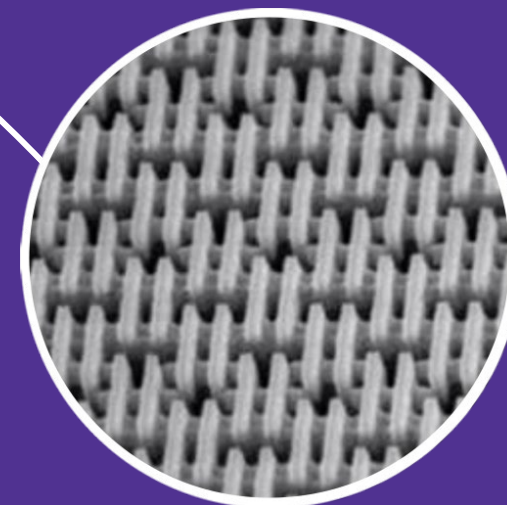


**Extremely Fine Pitch
Parallel Lines**

for manufacturing...

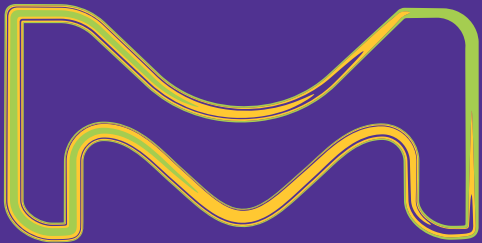


High Density Transistor Arrays



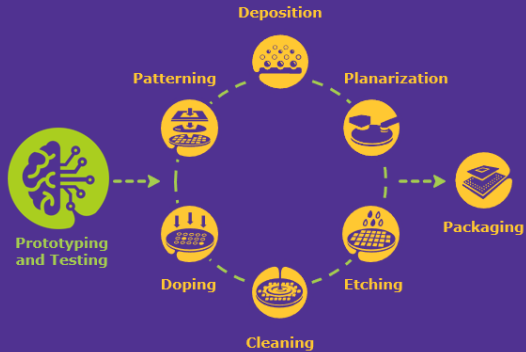
our combined products & capabilities

Intermolecular



EMD
PERFORMANCE
MATERIALS

intermolecular



Key location



INTERMOLECULAR®

We are **THE TRUSTED PARTNER** for Materials Innovation.

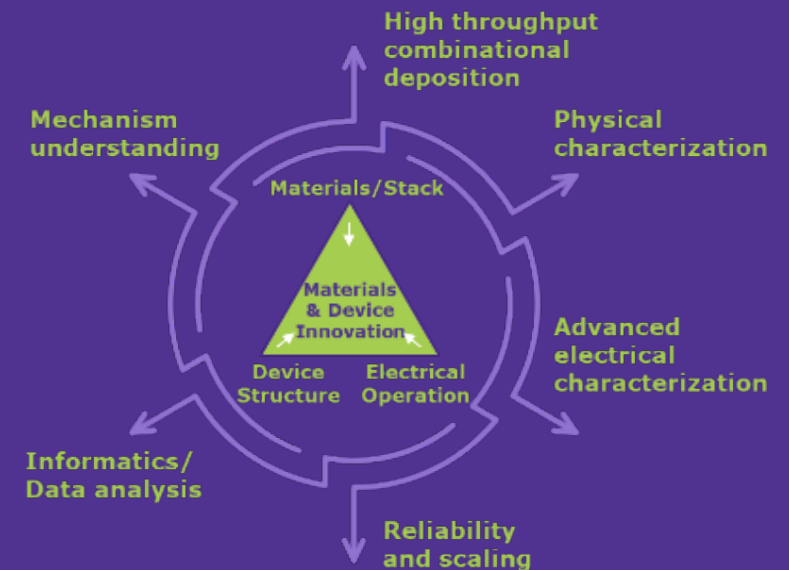
We **explore, characterize and develop advanced materials** that are revolutionizing the next generation of electronics that make lives easier, entertaining and more productive.



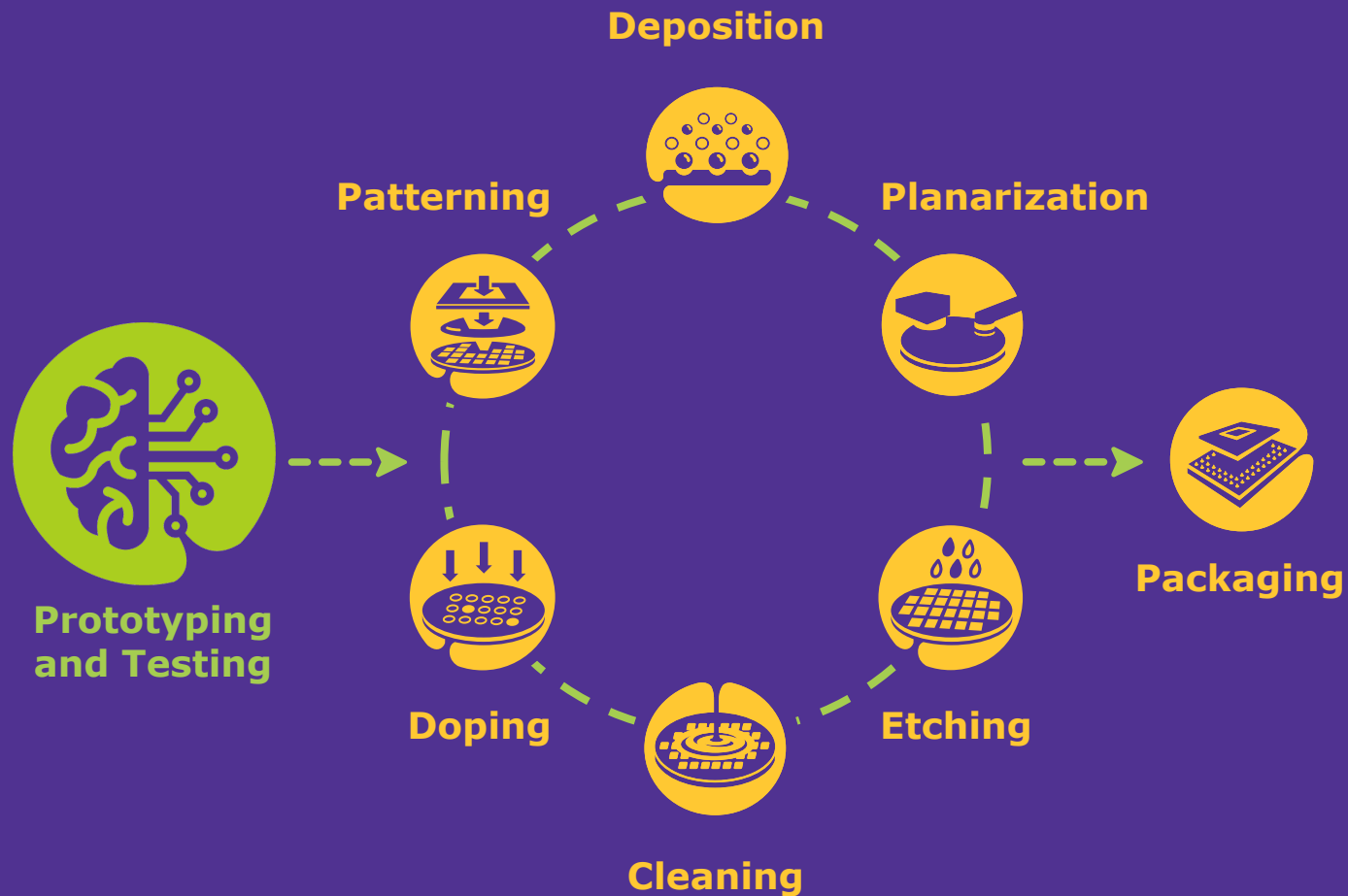
Applications

- **Semiconductor:** NVM, DRAM, 3D-NAND, Logic
- **Display**
- **Quantum Computing**

Enabling Higher Value Development



Our portfolio



- **Accelerate development** and screening of innovative materials
- **Generate data** which correlate materials, process, physical properties, and electrical performance
- **Collaborate with customers** who utilize the generated data to make confident material decisions

Click [here](#) to visit our Intermolecular website!

Independent Materials Innovation as a Service



High Through-put Experimentation



- Advanced capability on combinatorial tools
- Correlations established between materials, physical properties and electrical performance

High Quality Material Development Services



- SOW collaboratively defined to meet client's needs
- High quality, repeatable data generated by a highly skilled cross functional team

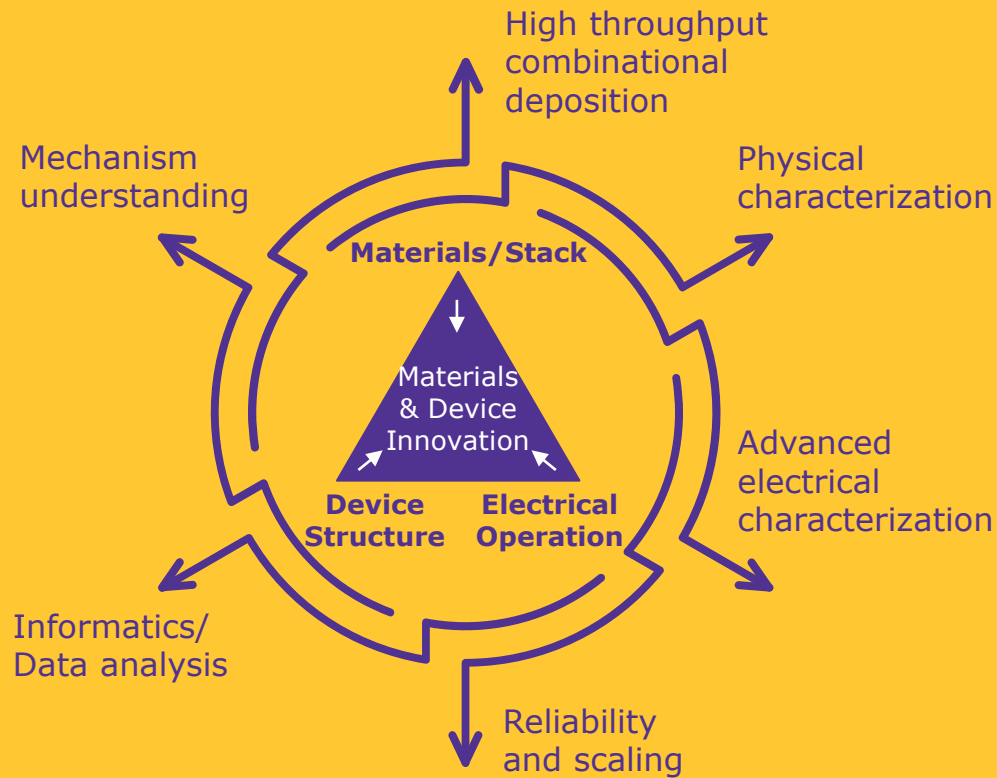
Trusted Partner for Materials Innovation



- Protocols established to maintain confidentiality
- The client owns and can file IP on any deliverables executed by Intermolecular



The Trusted Partner for Materials Innovation



Enabling Higher Value Development

INTERMOLECULAR®



Leading-Edge Team, Capabilities, & Methodologies

- Broad spectrum of expertise in materials, process, equipment, characterization and device integration
- Extension of the customer's team, working together with Intermolecular custom-built tools, workflows and data analysis systems



Accelerate Learning with High Quality, Impactful Data for Decision-Making

- Statistically significant data
- Correlating materials, processes, physical properties, optical properties and electrical performance



Proven Record for Maintaining Confidentiality

- Protocols established to manage confidential information
- Client owns and can file IP on any deliverable produced by Intermolecular



our offerings

- Thin film depositions
- Wet Chemistry
- Physical characterization
- Optical characterization
- Electrical characterization
- Simple test vehicles (or can utilize customer test vehicles)
- Workflows, combining depositions and characterizations, to screen materials and process spaces
- Integration learning
- Mechanism understanding

our Materials Experience

- Metal Oxides
- Metal Nitrides
- Metals
- Alloys
- Chalcogenides

1 H	PVD ALD/CVD or Vapor																2 He	
3 Li	4 Be	PVD Physical Vapor Deposition ALD Atomic Layer Deposition										5 B	6 C	7 N	8 O	9 F	10 Ne	
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	
55 Cs	56 Ba	57 La	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn	
87 Fr	88 Ra	89 Ac	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg								
			58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu		
			90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr		



who we are

We are **THE TRUSTED PARTNER** for materials innovation.

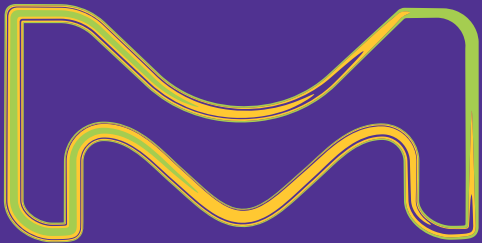
We **explore, test and develop advanced materials** that are revolutionizing the next generation of electronics that make lives easier, entertaining and more productive. For more than 15 years, our team, methodologies and quality data have driven impactful outcomes, market opportunities and innovative product designs for our customers.

As the **Silicon Valley science hub of the Performance Materials business of Merck KGaA, Darmstadt, Germany**, we are perfectly positioned to break the boundaries of science and technology.
We advance digital living!



our combined products & capabilities

Delivery Systems and Services



EMD
PERFORMANCE
MATERIALS

Delivery systems & services



Key locations



Trusted Global leader in the Safe and reliable delivery of hazardous materials to the semiconductor industry



Slurry Delivery

Fab Services

Precursor Delivery

Spec Gas Delivery

FLOWMASTER® CMP

MEGASYS®

CHEMGUARD®
CHEMKEEPER®

GASGUARD®
GasSTAR®
GASKEEPER®



OEM/IDM-aligned
New Product Development

NPD DRIVERS

Higher capacity supply modes
Materials compatibility
Materials properties
Cost of ownership
Controls systems
Safety



DS&S portfolio

Leading positions in...



- ... specialty chemical delivery
CHEMGUARD® | CHEMKEEPER®
- ... specialty gas delivery
GASGUARD® | GASKEEPER®
- ... CMP slurry delivery
FLOWMASTER® CMP & POLYFLOW™ Parts/Carrier Cleaners
- ... onsite in-fab services
MEGASYS®

Click [here](#) to see our DSS offering online!



Trusted Global leader in the safe and reliable delivery of hazardous materials to the semiconductor industry

Solutions Provider for

- Materials
- Equipment
- Service

3

Regional
Manufacturing
Sites with
Tailored
Offerings

3

Regional Teams
Focused on Top
Tier Customers

Flexible
Production
Capacity &
Outsourcing Model

OEM/IDM-aligned
New Product
Development



FAB NEEDS and DS&S offerings

FAB PROJECTS for BULK SPECIALTY GASES



SLURRY DELIVERY - FLOWMASTER® CMP

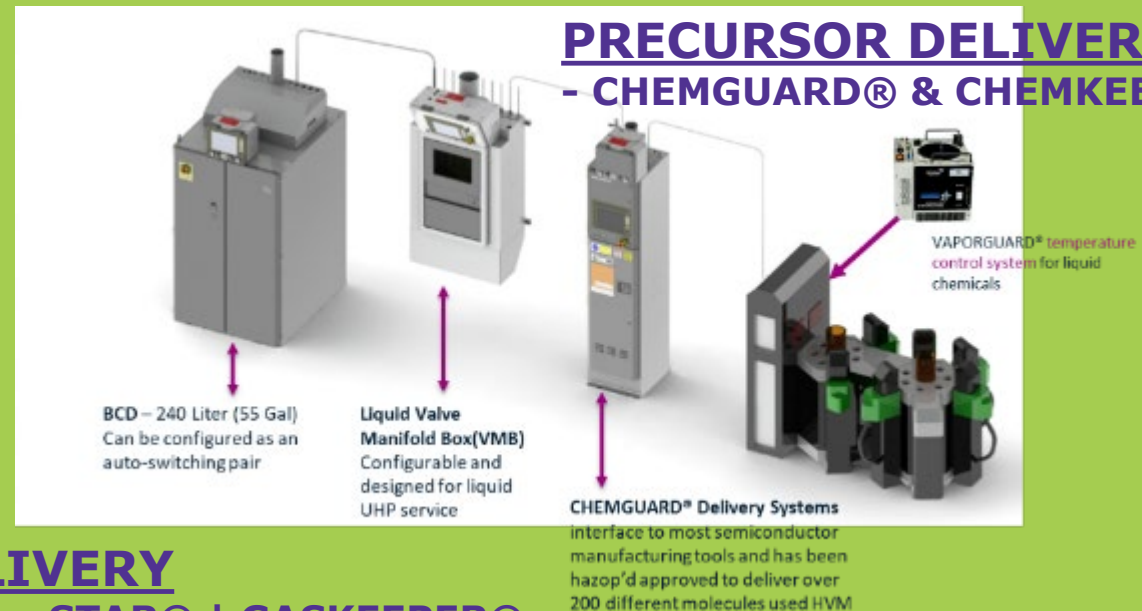


FAB SERVICES - MEGASYS®



SPEC GAS DELIVERY - GASGUARD® | GasSTAR® | GASKEEPER®

PRECURSOR DELIVERY - CHEMGUARD® & CHEMKEEPER®



new product development DRIVERS

R&D capabilities and New Product Development

The Semiconductor industry is experiencing the “Age of Materials” and EMD is positioned to capitalize – but the Age of Materials can not happen without the Equipment to enable it

- Higher capacity supply modes
- Materials compatibility
- Materials properties (solids, lvp liquids)
- Cost of ownership (footprint, uptime)
- Controls systems
- Safety



DS&S production locations & capabilities



Pennsylvania

Vultee Street, Allentown

North America Manufacturing – Gas & Chem Equipment

Sales, Administration, Product Management, Procurement

TEKPark, Breinigsville

North America Engineering & Product Development

Tempe, Arizona

Business Headquarter North America



Shanghai, China

Wai Gao Qiao (WGQ)

China/Taiwan Business Headquarter

China Manufacturing – Gas & Chem Equipment

Sales, Administration, Product Management, Procurement

Ansan, Korea

Korea Business Headquarter

Hsinchu, Taiwan

Toll Manufacturing

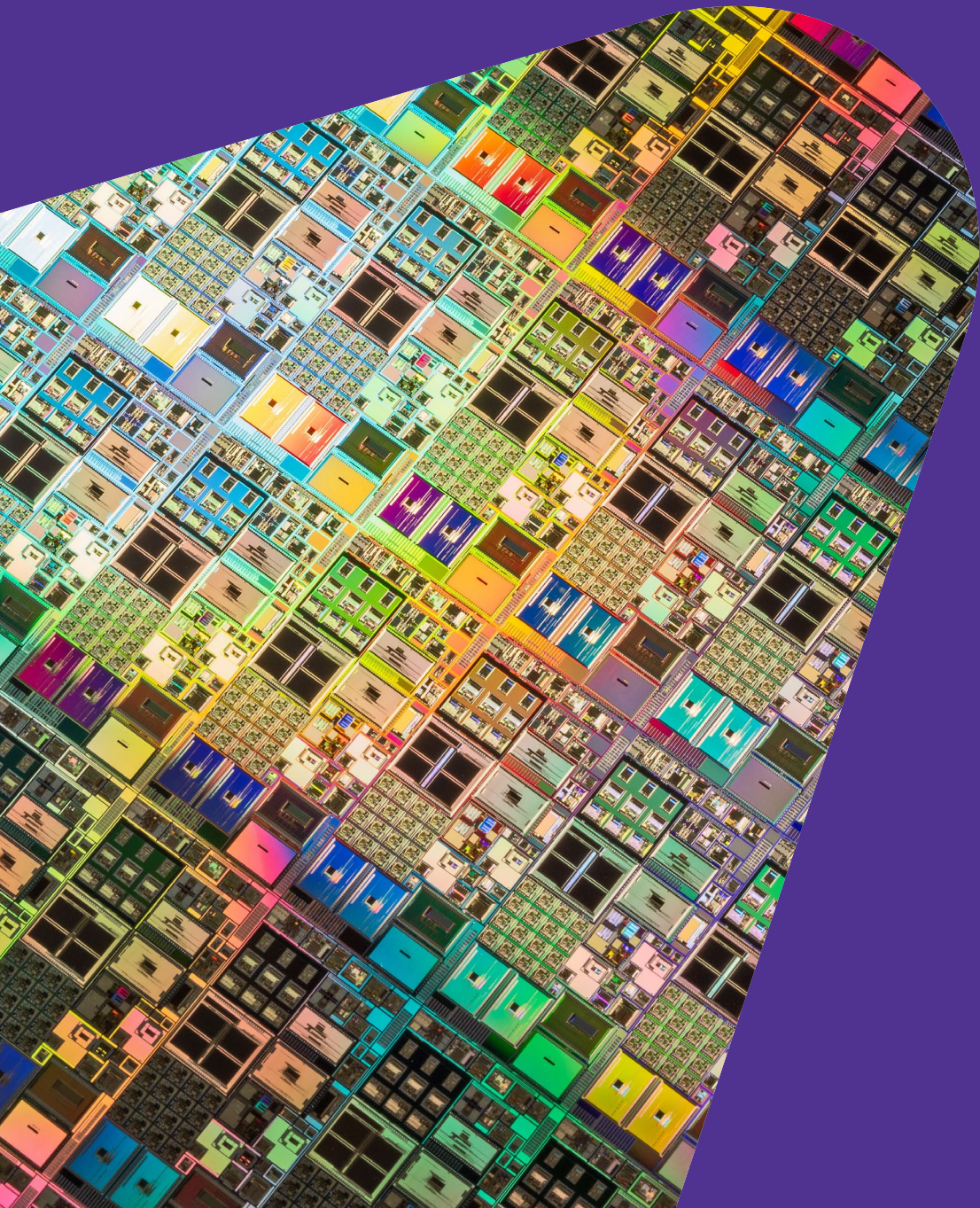


VMHYT

Korea Manufacturing – Gas & Chem Equipment

Sales, Administration, Product Management, Procurement, Engineering





Locations Overview



our truly Global Footprint

will enable unparalleled
customer partnership



United States

- 9 production sites
- 8 technical centers

Europe

- 3 production sites
- 3 technical centers

China

- 2 production sites
- 1 technical centers

South Korea

- 7 production sites
- 4 technical centers

Taiwan

- 4 production sites
- 3 technical centers

Japan

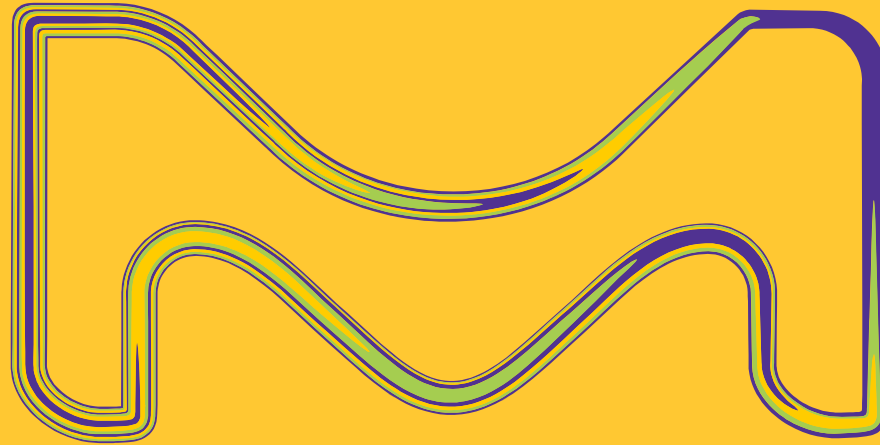
- 1 production sites
- 1 technical centers

● Technical centers or production sites

● Major sales offices

● Regional offices





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