Solvent-Free Polymer Films: from Inception to Commercialization

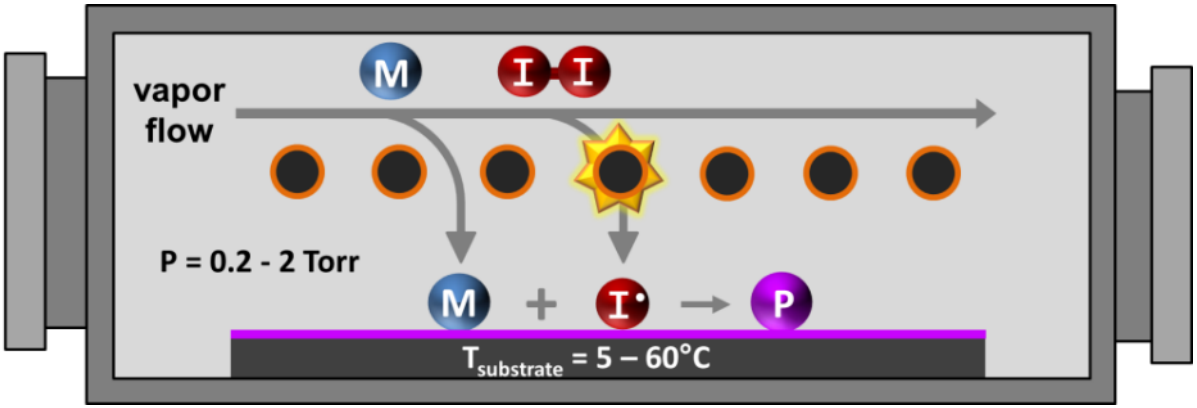
Prof. Karen K. Gleason
Alexander and I. Michael Kasser Professor
Department of Chemical Engineering
MIT

Chief Scientific Advisor
GVD Corporation

Surface Modification by CVD Polymers

- *Functional Organic Surfaces (>70 polymers)*
- *Ultrathin (<30 nm)*
- *Conformal*
- *Grafted (high adhesion)*
- *Scales to large areas and roll-to-roll manufacturing*
- *Versatile surface composition & applications*

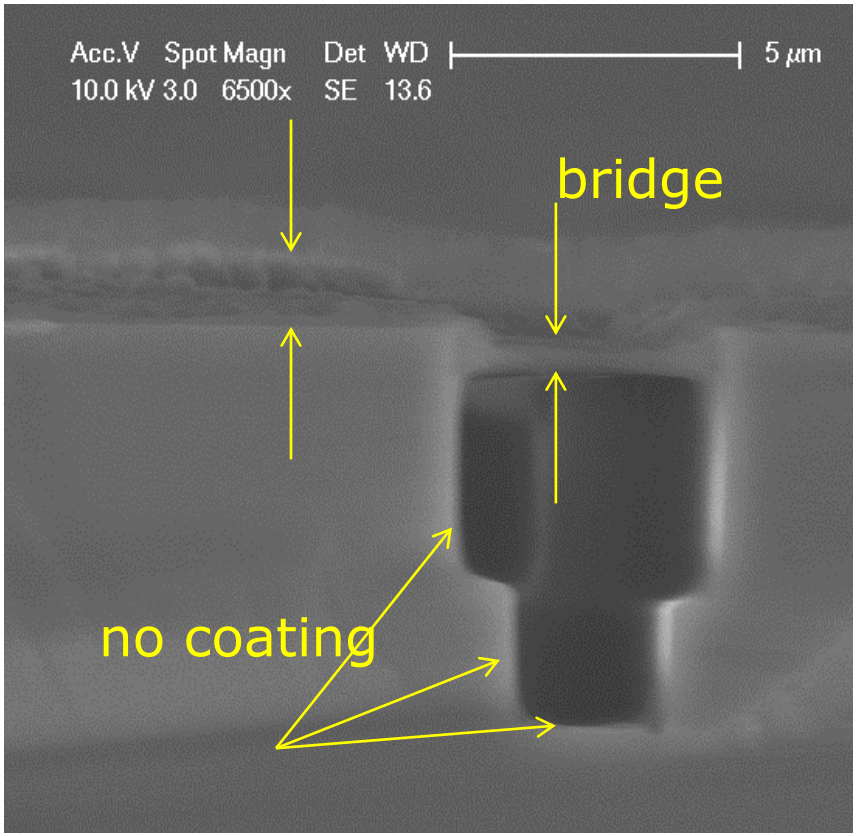
iCVD

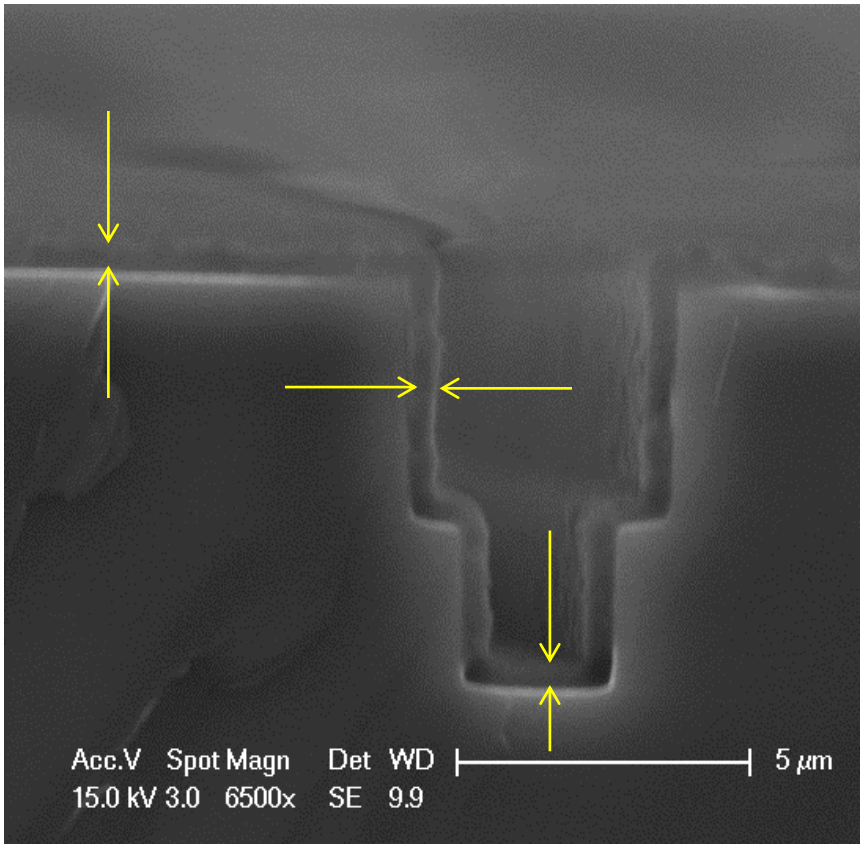


www.gvdcorp.com

Conformal coverage over microstructures

fluoropolymer over a tiered via in Si





Liquid condensation: bridging

iCVD: conformal, showing uniform thickness over the entire feature

Polytetrafluoroethylene (PTFE)

PTFE is top of its class in almost all of its properties:

- Lowest coefficient-of-friction
- Highest chemical resistance
- Lowest dielectric constant
- Low surface energy (hydrophobic)

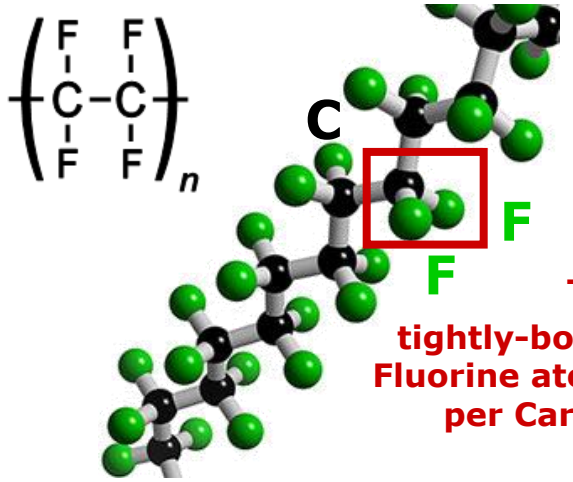
Unique properties derive from unique chemical structure:

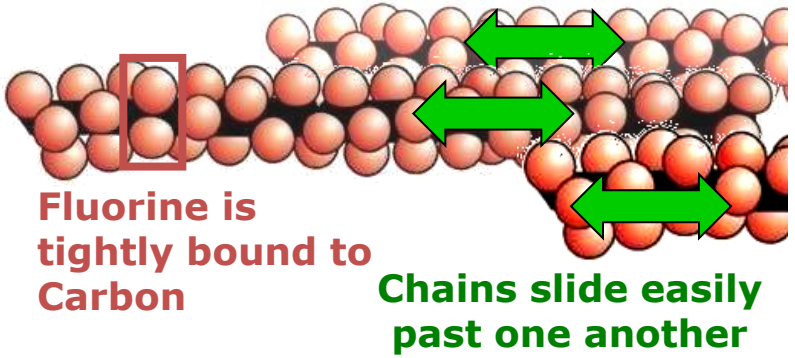
- Fluorine = chemical/thermal resistance
- Compact chains sliding = lubricity

BUT…. Traditional PTFE coating requires:

- **Priming surface**
- **Spraying**
- **Curing at high temp (370°C = 700°F)**

iCVD PTFE provides same material properties without harsh processing





History

- Founded in 2001 – spinout from MIT based on Dr. Karen Gleason's polymer coating technology

Executive Team

- Hilton Pryce Lewis, Ph.D., Founder, President & CEO
- Shannan O'Shaughnessy, Ph.D., CTO

Business Model

- Coating services and technology licensing with lease of equipment

Revenue Sources

- **Commercial customers**
  - Major semiconductor part manufacturer (GVD coatings used for lubricity)
  - Major rubber manufacturer (GVD coatings used for mold release)
- **Government funding**
  - SBIR funding from Navy, Air Force, Army, DARPA, NIH, NSF, DOE, EPA
  - **Current Phase II SBIRs** with Navy, NIH, and EPA

GVD Capabilities

- **Cambridge, MA – R&D Headquarters**
  - 4,500 square feet of office and laboratory space
  - Eight chemical vapor deposition coating reactors
  - Humidity chamber and analytical instrumentation
- **Greenville, SC – Manufacturing Facility**
  - 5,400 square feet of production space
  - Two fully-automated production coating systems
  - Production capacity: >1,000 tire molds per year

GVD
Ultrathin Polymer Coatings

Voir ce site en français

(617) 661-0060

Home | Why GVD? | Industries | Services | Tech Specs | News | Contact

COATING SERVICES | VIEW TECH SPECS | CONTACT US

Coatings for
Electronics Protection

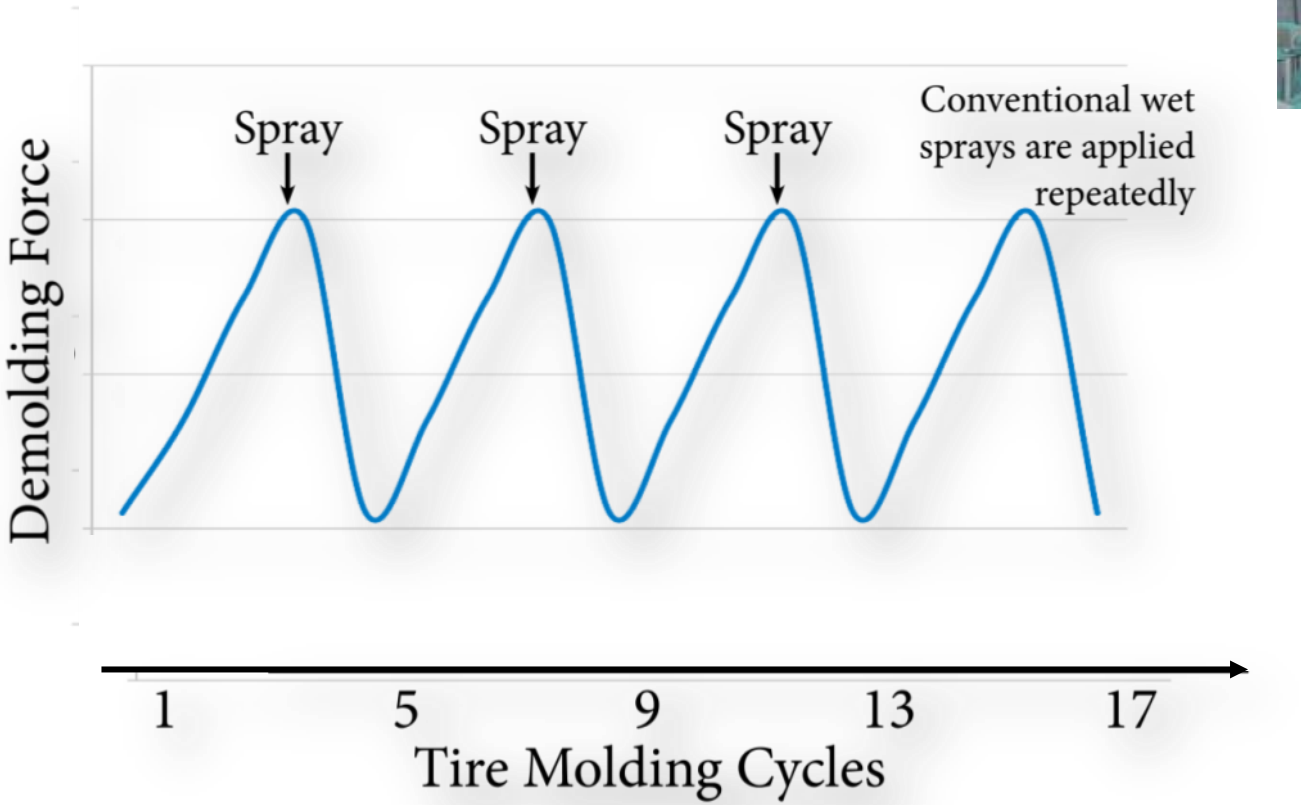
Thin conformal coatings for printed circuit boards

Coatings for
Mold Release

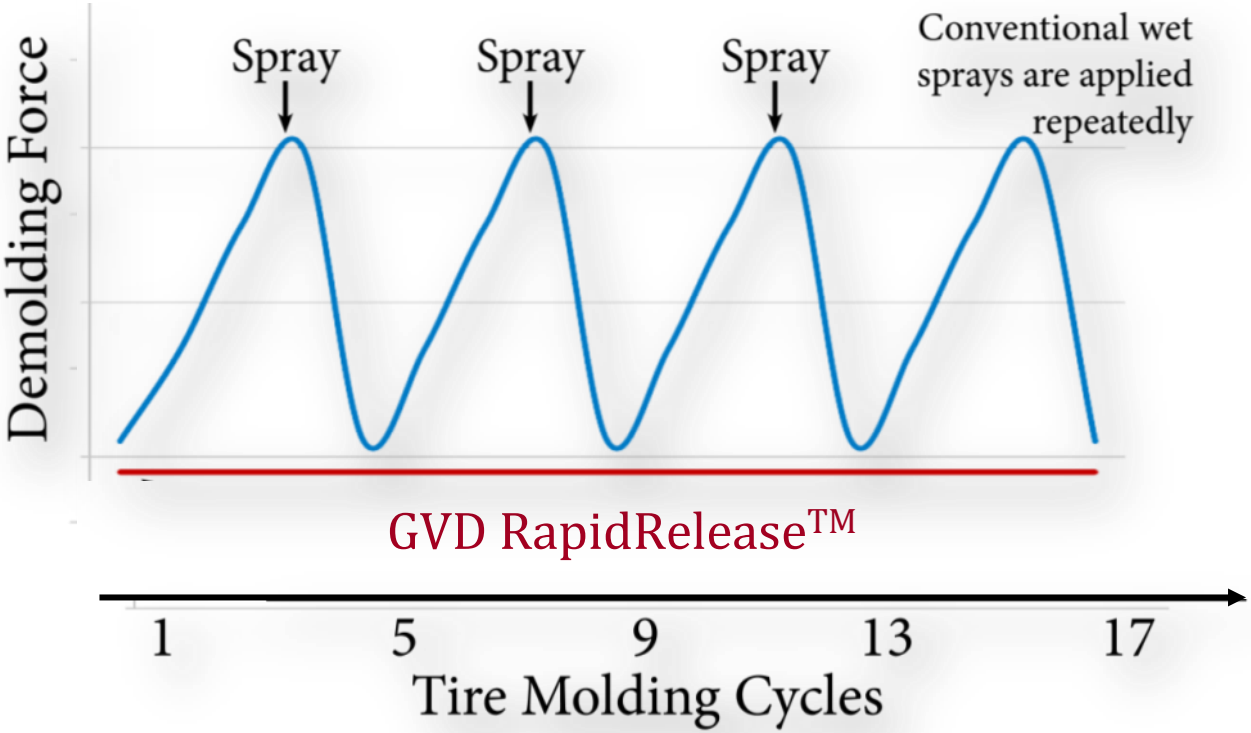
Permanent release agents for molds and molded parts

David E. Sauriol
Director of Sales
dsauriol@gvdcorp.com
(617) 233-7157

Simplifying Tire Demolding

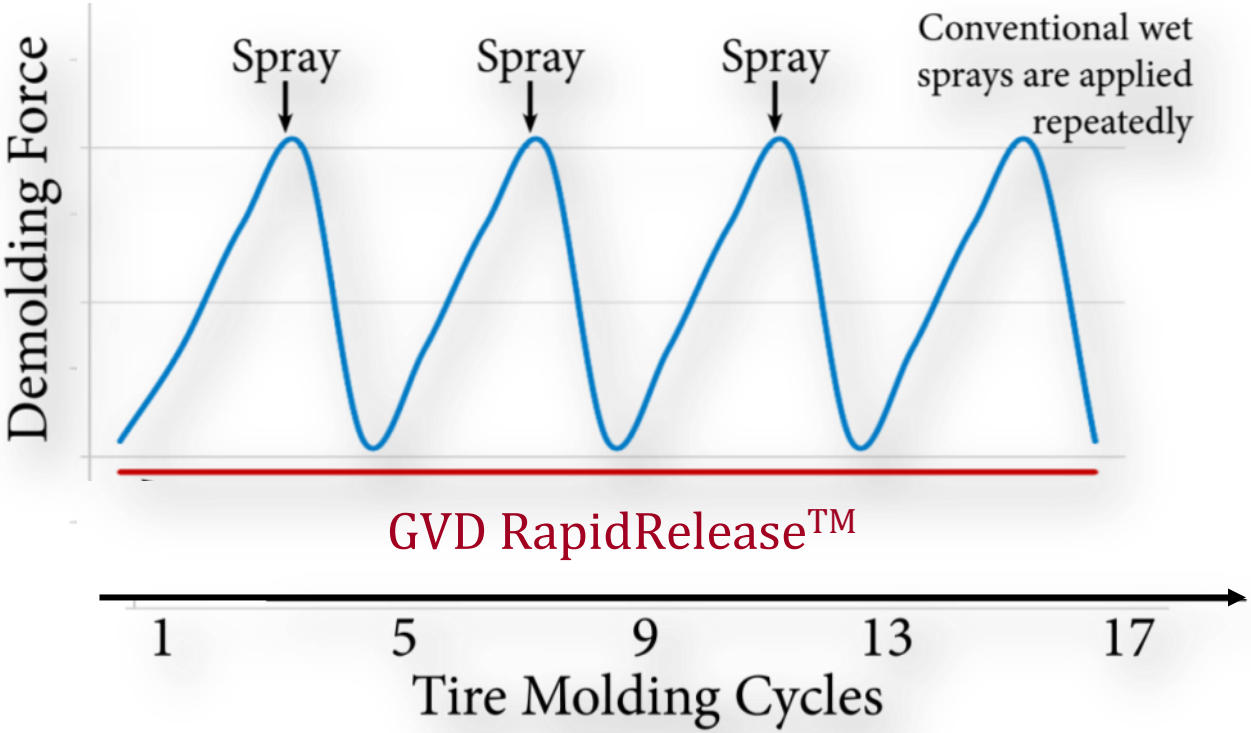


Simplifying Tire Demolding



>4500 cure cycles

Simplifying Tire Demolding



>4500 cure cycles

ERC analogy: spin on vs CVD low k dielectrics!

Overview

RapidRelease™ Coating System

- True permanent mold release coating
- ***Eliminate spray/paint mold release***

EPA Phase II SBIR
for continued development

- Extend mold uptime and service life
- Improve tire quality and consistency
- Enable challenging rubber chemistry
- Enable more aggressive tread design

Mold fouling caused by buildup of rubber and release paint/ lube on mold and inside vents

Coating Equipment Types

i-Trek Radial Coating System

(Tire Tread Molds)

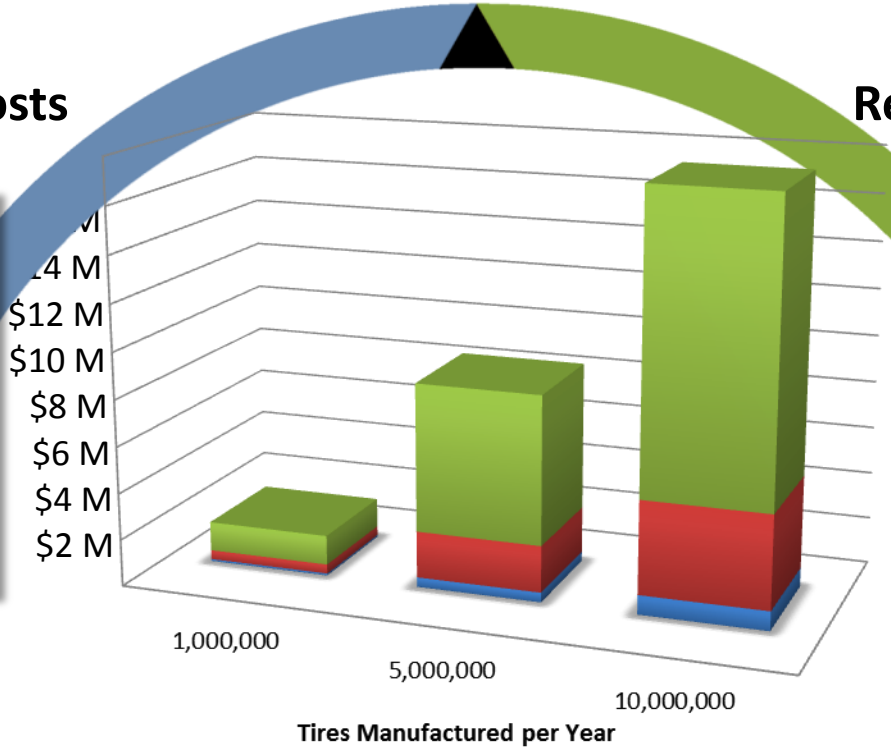
Echelon Horizontal Coating System

(Sidewalls, Bead Rings, Etc.)

Tangible Financial Benefits

Reduced Cleaning Costs

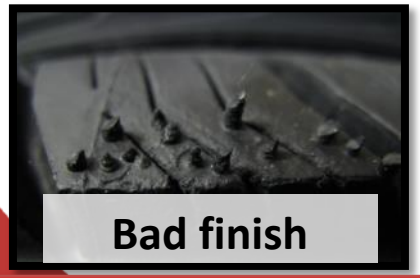
Reduce/Eliminate:
- Tire paint/lube
- CO_2 cleaning
- Labor

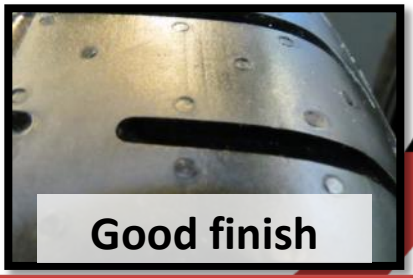


Recapture Lost Production

Save Time:
- No mold release spray
- Less demolding time
- Reduced cleaning frequency

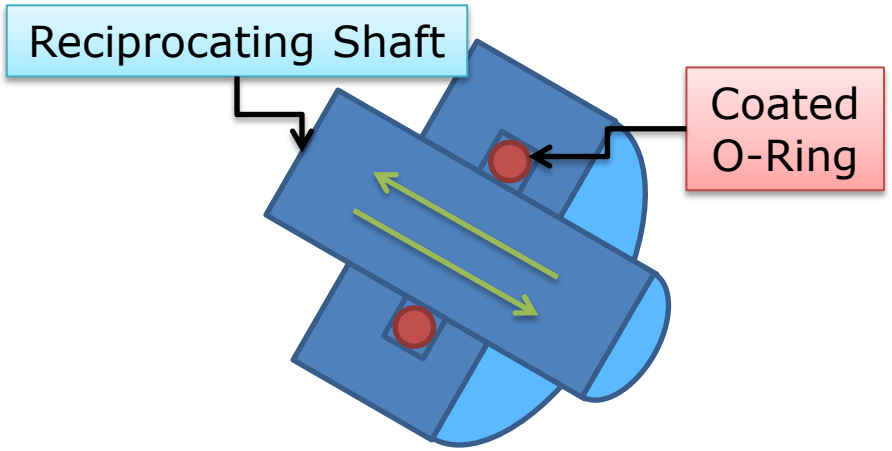
Reduced Scrap Rates

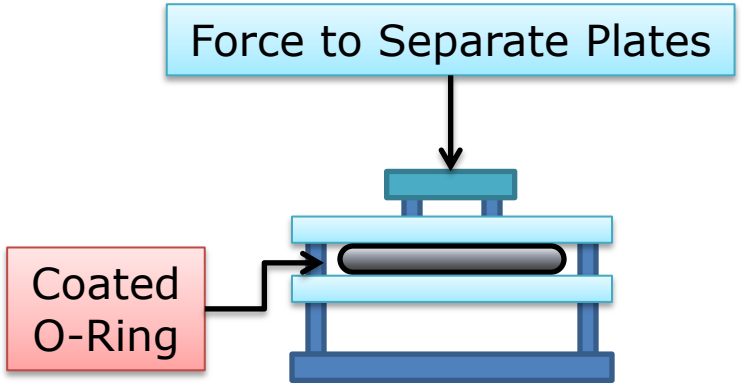


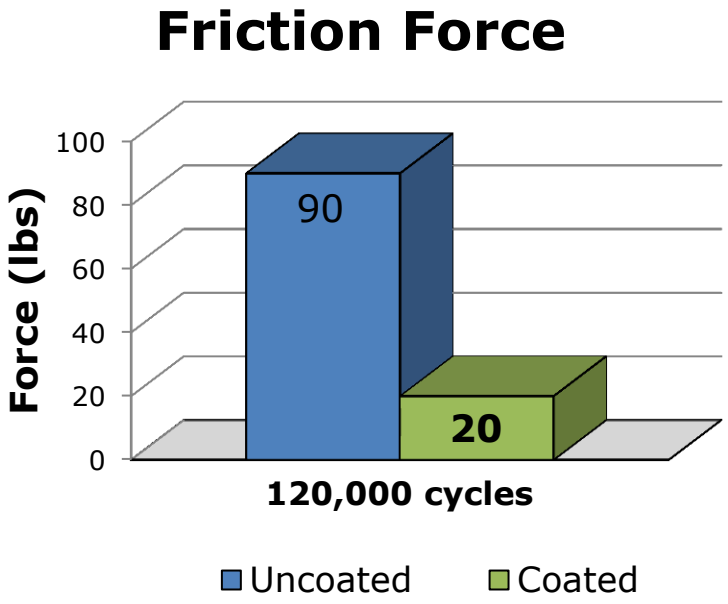


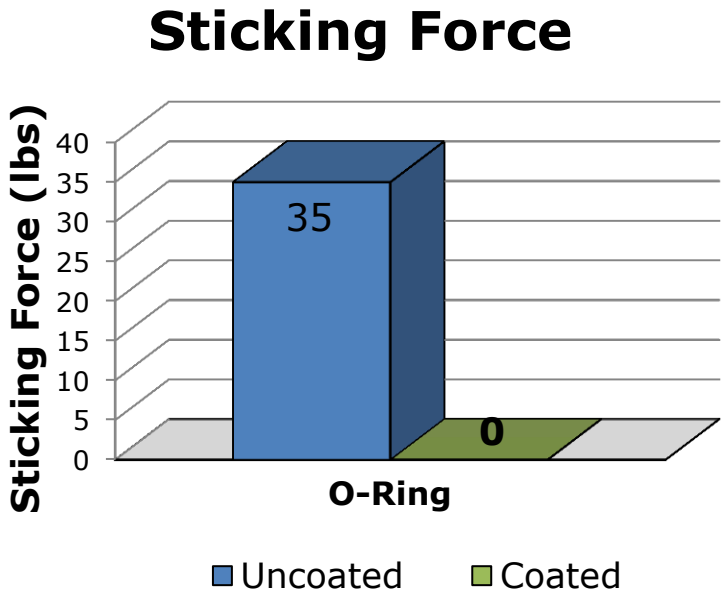
Achieve:
- Less tire sticking
- Lower release forces
- Improved rubber flow

Application - Dry Lubrication





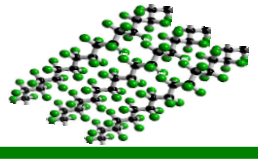




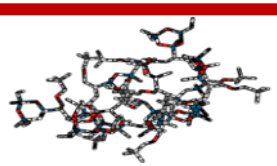
Application - Electronics Protection

GVD introduces iCVD **PTFE*** fluoropolymer and **Exilis polysiloxane ultrathin coatings** for electronics protection. **Breathable coatings** allow water vapor to pass through, but **prevent moisture condensation** on board and component surfaces.

GVD PTFE



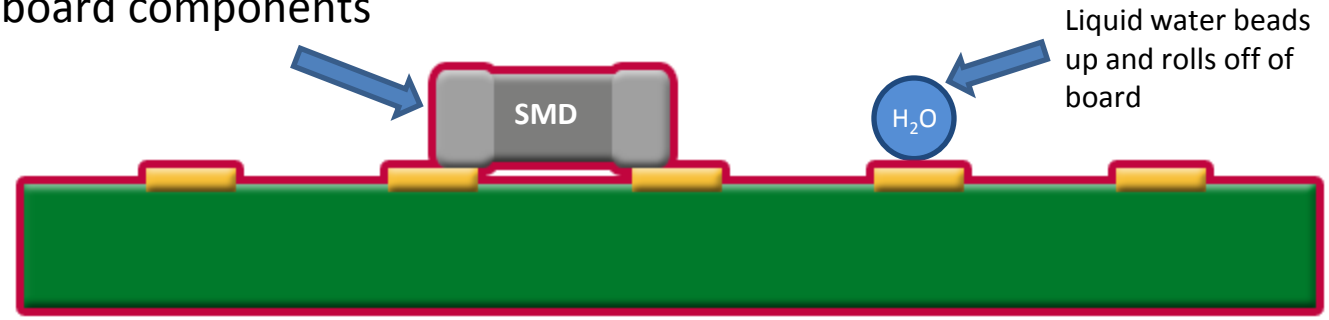
GVD Exilis

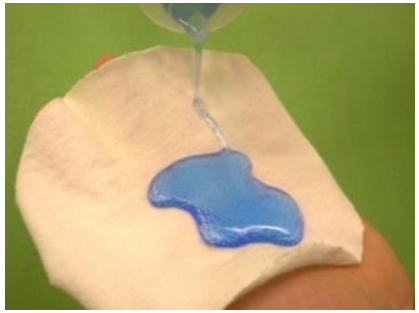


Performance Premiums:

- Negligible RF Impact
- High dielectric strength
- Nano-to-Micron Scale Thickness
- Excellent adhesion + pinhole free provides superior reliability

Conformal coverage of board components





Water rolls off ordinary cloth coated with GVD's PTFE

*PTFE=polytetrafluoroethylene (akin to Teflon® by DuPont)

iLab Coating System

A powerful, easy-to-use tool for depositing a broad range **(70+)** of polymer compositions on virtually any surface

With its small footprint, high performance, customizable configurations and low cost of ownership, the iLab Coating System was designed specifically to bring cutting-edge vapor deposition technology to the laboratory

How does it work?

A polymer vapor deposition method that creates a revolutionary processing platform which produces ultrathin polymer coatings in a single step without solvents, heat or additional processing equipment.

Austin Nowak, Sales Engineer
617-661-0060 x38
anowak@gvdcorp.com

How is it being used?

Undergraduate Course Tool

- University of Connecticut
- Northeastern University

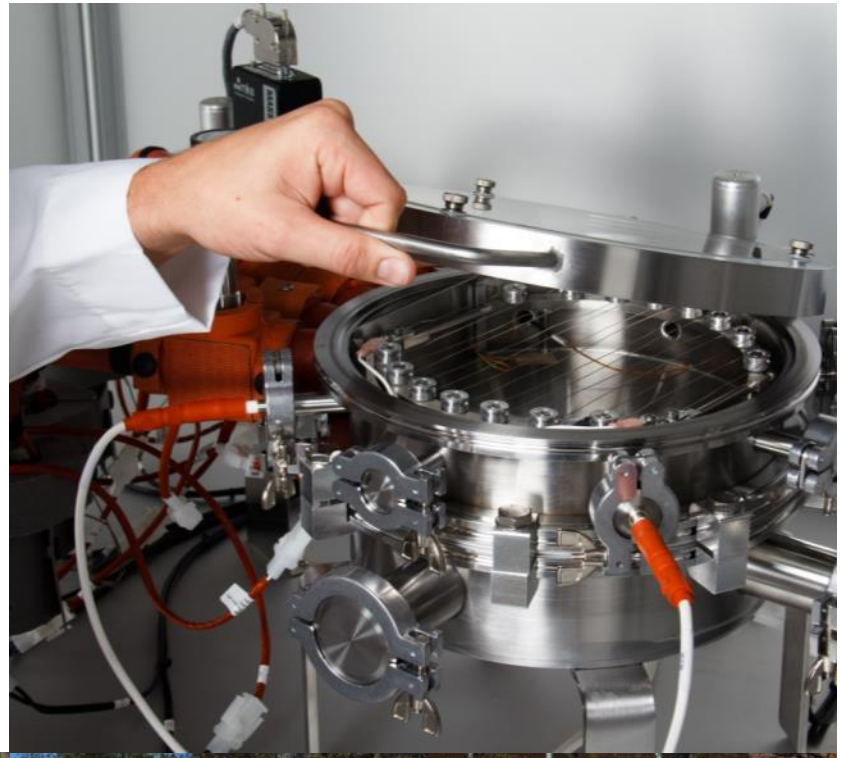
Graduate Research Tool

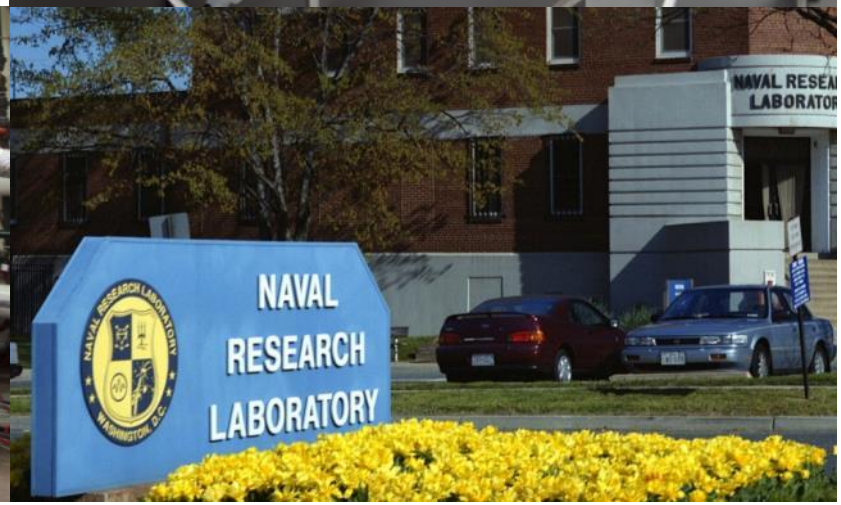
- University of Southern California

Corporate Product Development

Research Laboratory Development

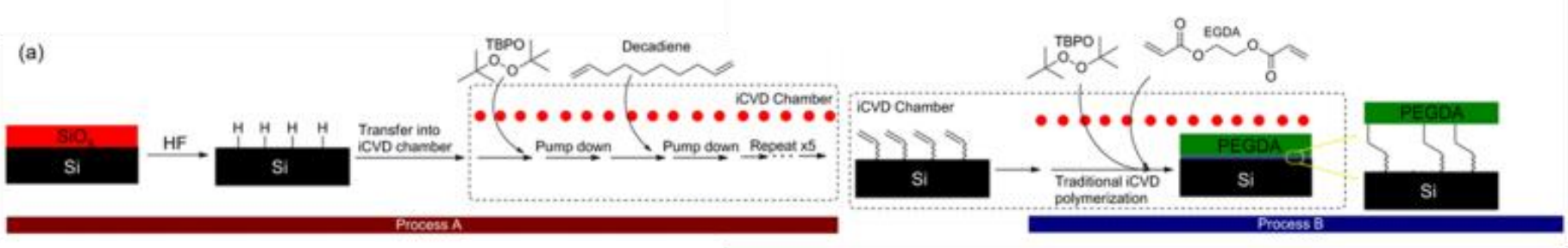
- Naval Research Laboratory



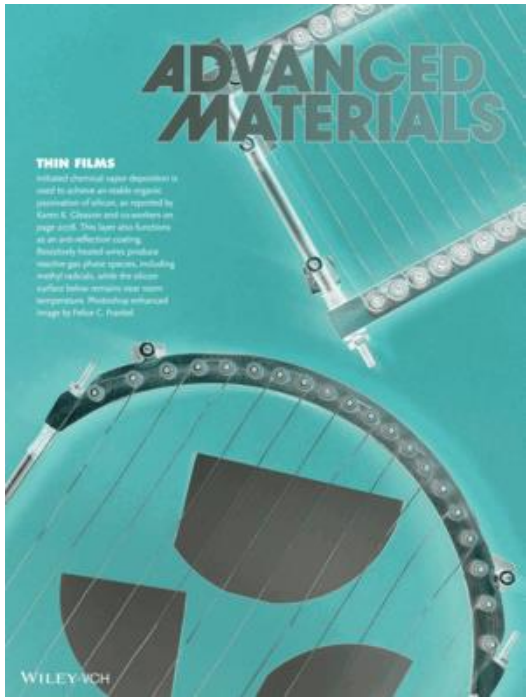


polymer CVD research continues

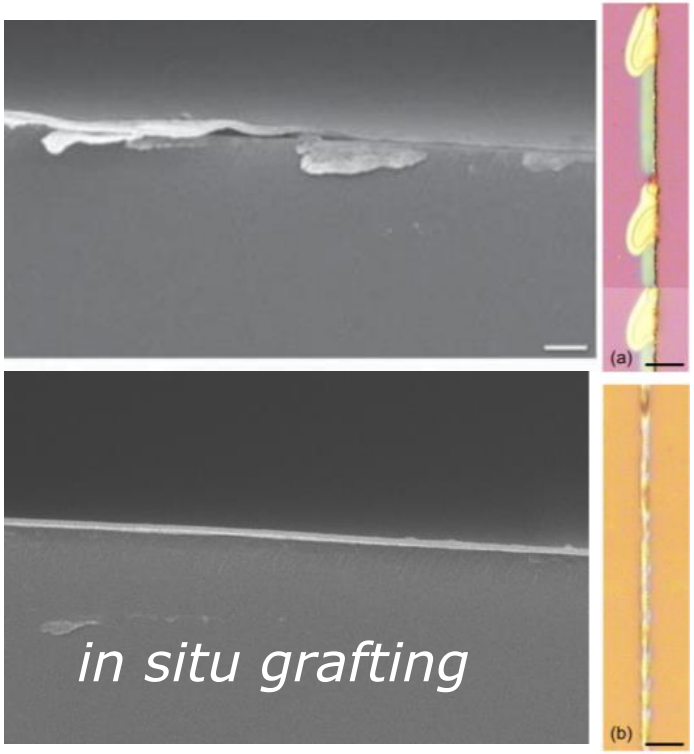
room temperature passivation of Si



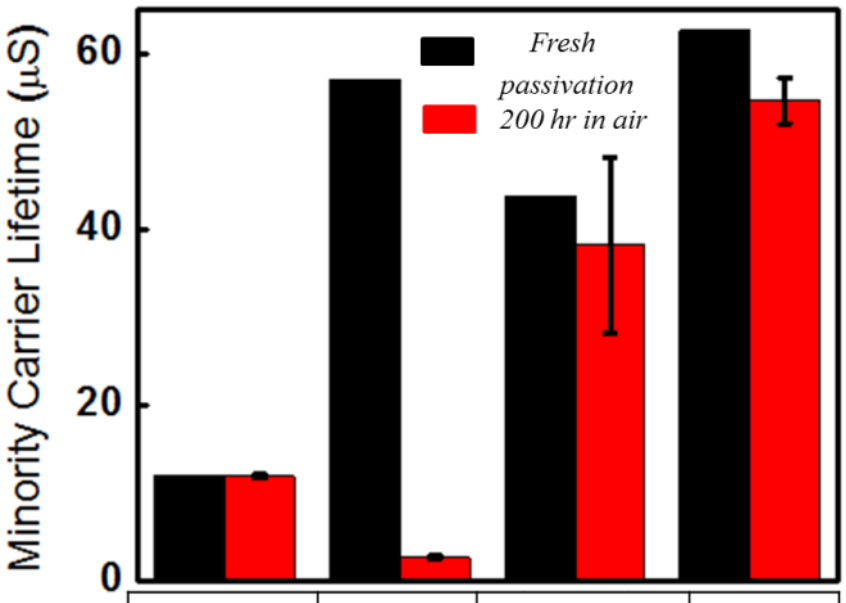
- Room temperature process lowers energy input and cost
- passivation and antireflection coating (ARC) in single step
- Si to polymer bonding (grafting) created in situ by CVD polymerization enhances adhesion



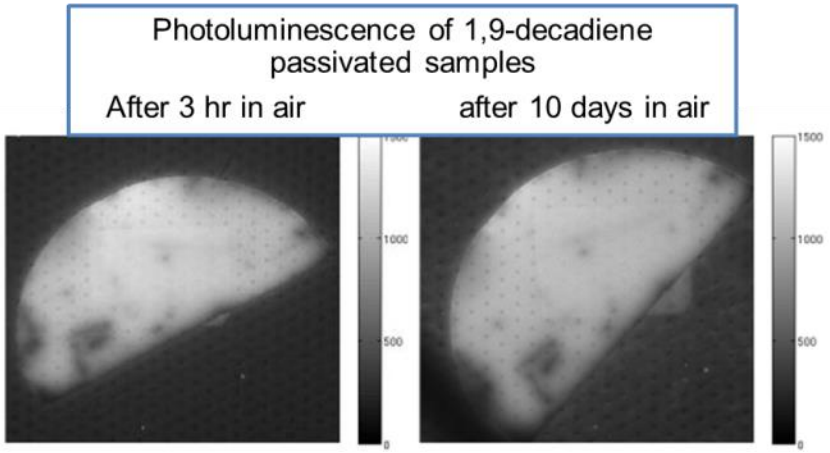
R. Yang, T. Buonassisi, K.K. Gleason, Advanced Materials, 25, 2077 (2013).

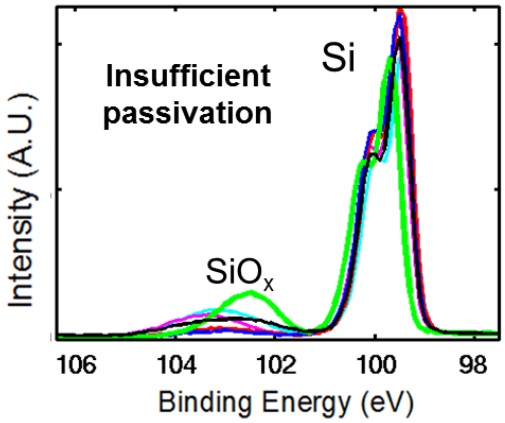


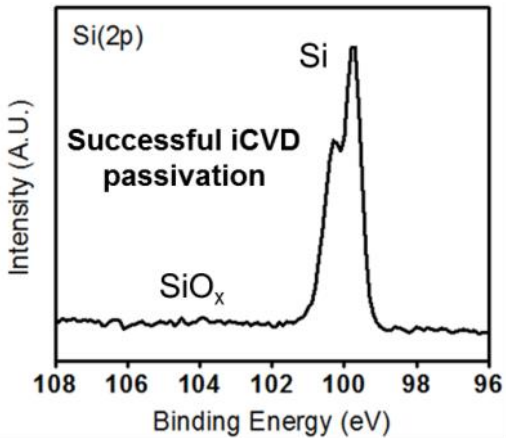
iCVD Room Temperature Passivation



Si_xN_y	E-I	Best organic passivation	iCVD-dd
Substrate temperature/°C			
400-1000	25	25	25





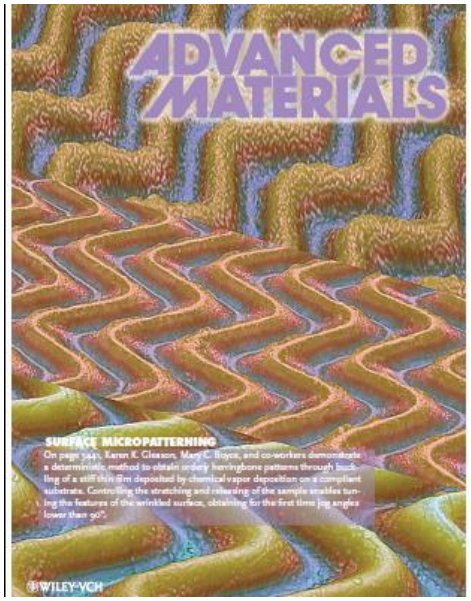


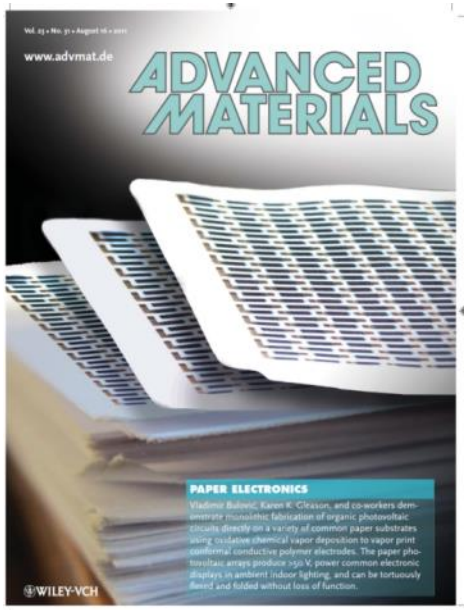
R. Yang, T. Buonassisi, K.K. Gleason, Advanced Materials, 25, 2077 (2013).

Recent Polymer CVD from MIT

2D wrinkling patterns

2012, *24*, 5441.



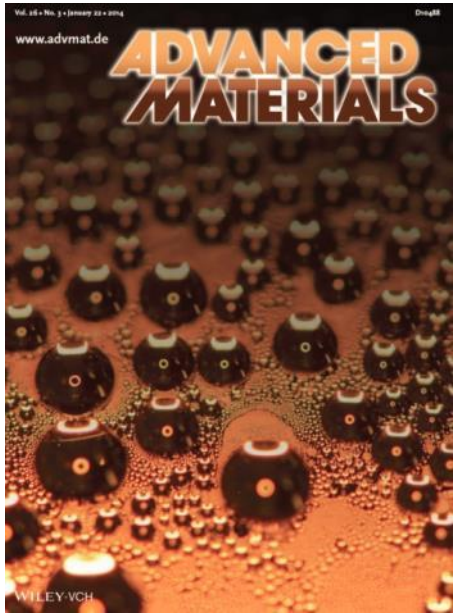


paper photo-voltaics

2011, *23*, 3500.

durable surfaces for efficient condensation heat transfer

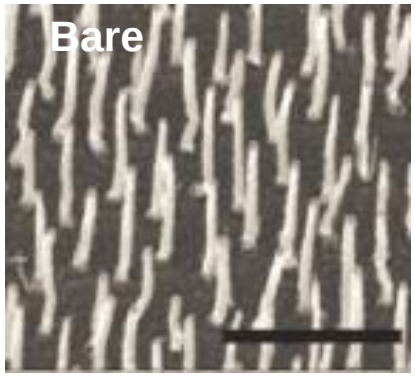
2014, *26*, 418–423

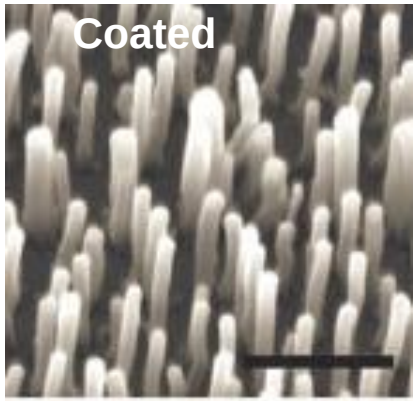


biosensor

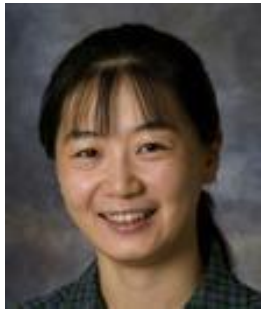
2011, *21*, 4328.

Polymer CVD from around the world



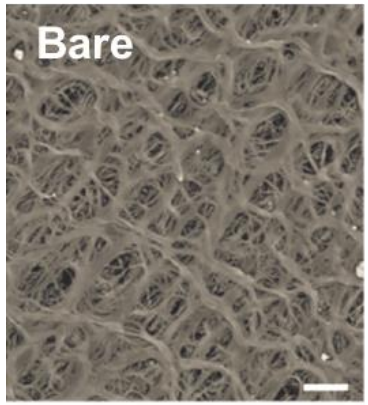


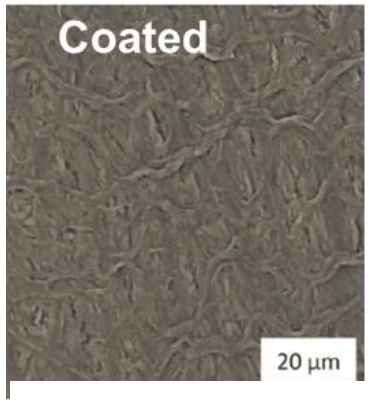
Conformal Coating Of CNTs (bar = 2 μm)



Prof. Jessie Mao
Oklahoma State

J. Mater. Chem., 2012, **22**, 2449–2455





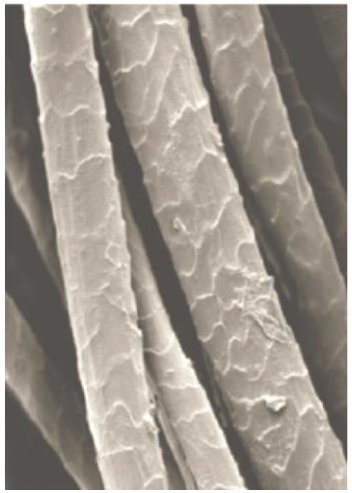
Polymer 54 (2013) 24–30

Fuel Cell Membranes

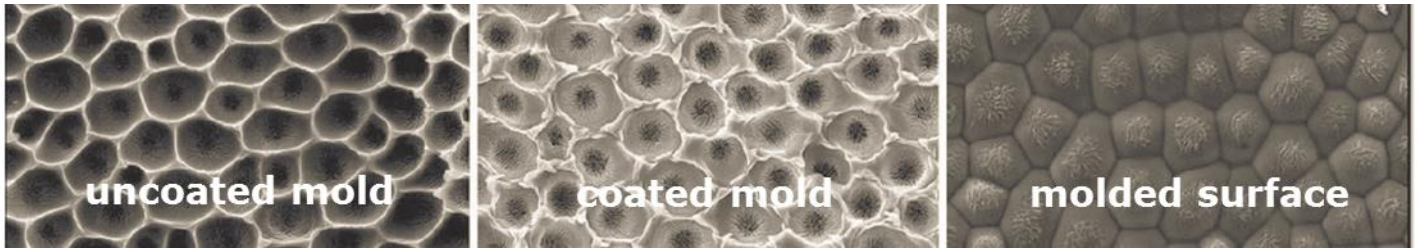
Prof. Anna Coclite

TU Graz (Austria)

iCVD on wool
New Zealand



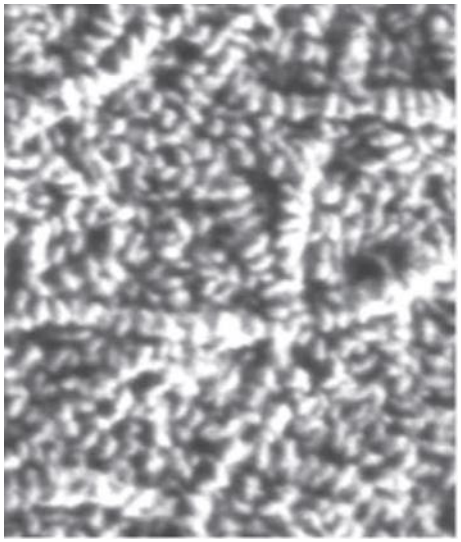
ACS Appl. Mater. Interfaces
2013, 5, 1548–1555



iCVD for Micromolding: Dr. Mustafa Karaman, Selcuk University (Turkey)

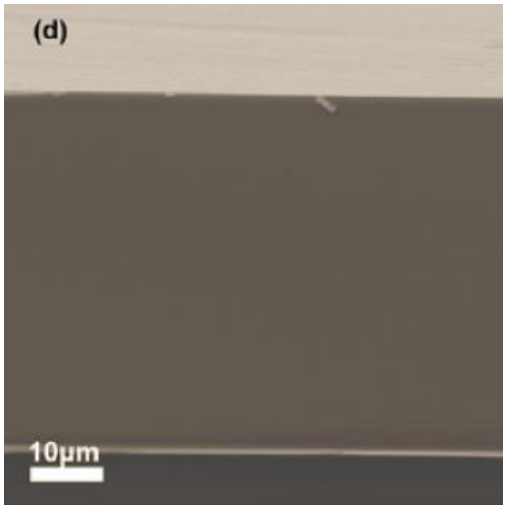
Applied Surface Science 259 (2012) 542–546

Polymer CVD from around the world



13 nm iCVD PTFE
Crystallites on CNTs
Prof. Ken Lau, Drexel

Macromol. Rapid. Comm. 2013, 34, 251



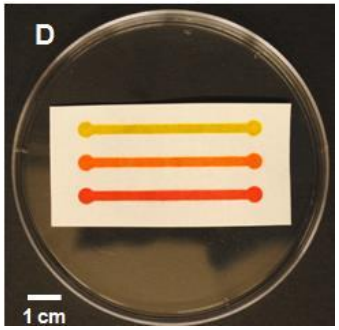
Langmuir 2012, 28, 16580

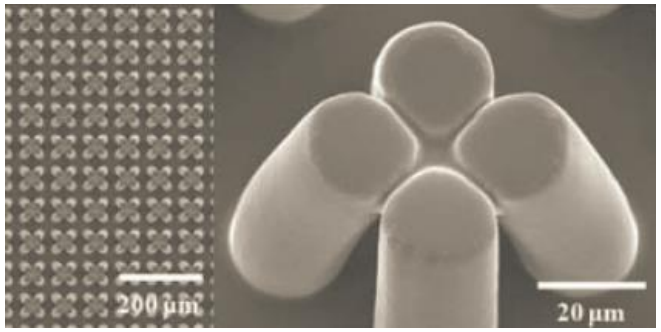
high deposition rate, smooth iCVD surfaces
Prof.Mitch Anthamatten
Univ. Rochester

iCVD Wafer Bonding
Prof. Magnus Bergkvist
Suny Albany

MRS Proc. 2014, 1648

Anal. Chem. 2012, 84, 10129

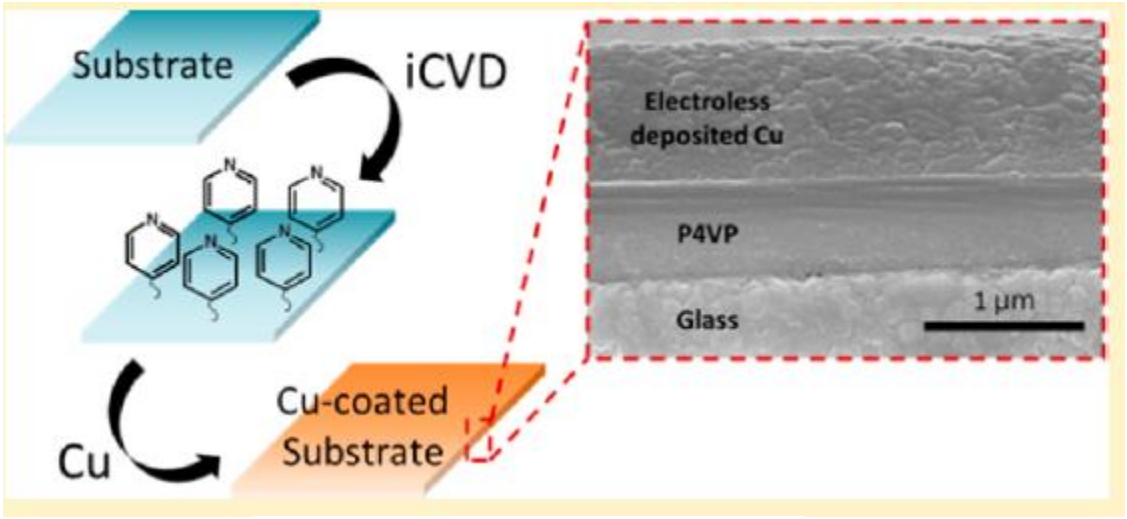




ACS Appl. Mater. Interfaces 2011, 3, 4201

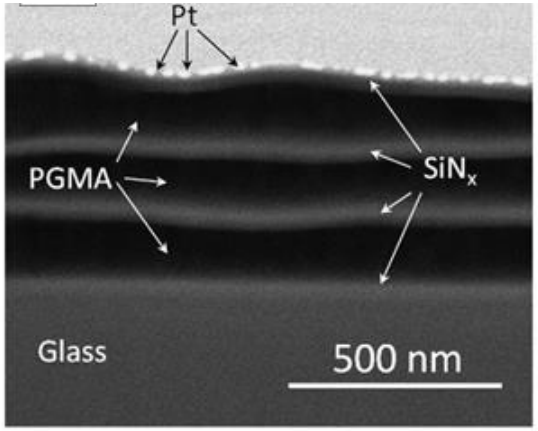
Paper-based Microfluidics for Medical Diagnostics
And iCVD for Self Assembly
Prof. Malancha Gupta, USC

Polymer CVD from around the world

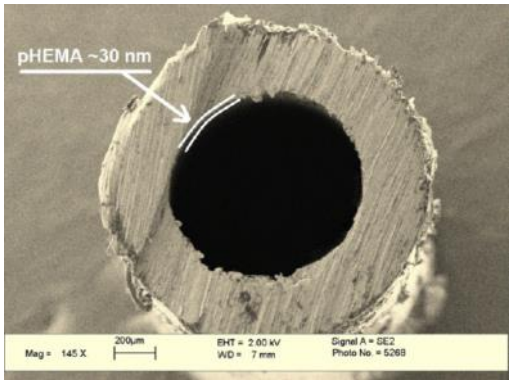


Langmuir 2014, 30, 916−921

Adhesion Enhancement of Electroless Deposited Cu: Prof. Sung Gap Im, KAIST (Korea)



iCVD PGMA Multilayer Barriers: Prof. Ruud Schropp, TU Eindhoven (Netherlands)

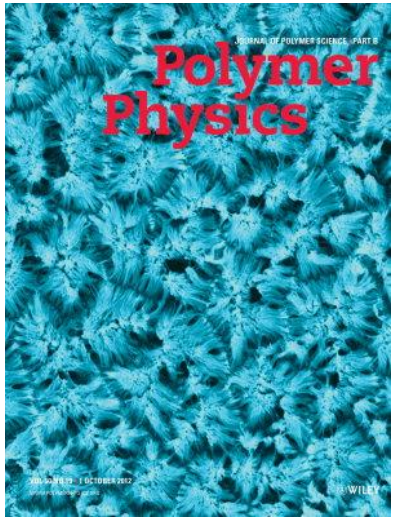


Heat Transfer Enhancement inside tubes Prof. Gozde Ince Sabanchi U. (Turkey)

Polymer Chemical Vapor Deposition Reviews

IOP Publishing
Rep. Prog. Phys. 75 (2012) 016501 (40pp)
Reports on Progress in Physics
doi:10.1088/0034-4885/75/1/016501

CVD of polymeric thin films: applications in sensors, biotechnology, microelectronics/organic electronics, microfluidics, MEMS, composites and membranes



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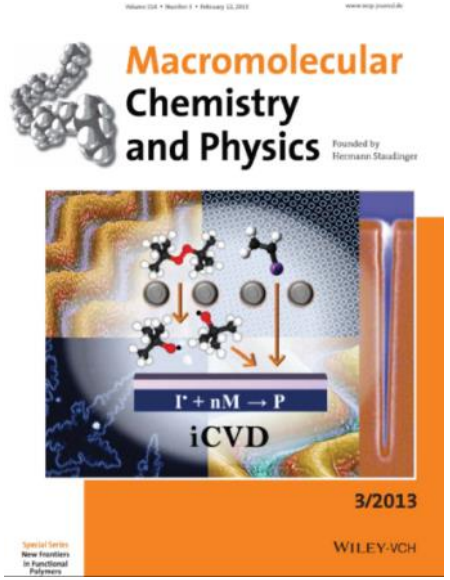

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