Where Are They Now?
A Former ERC Student Describes His Entrepreneurial Experience

ERC Teleseminar

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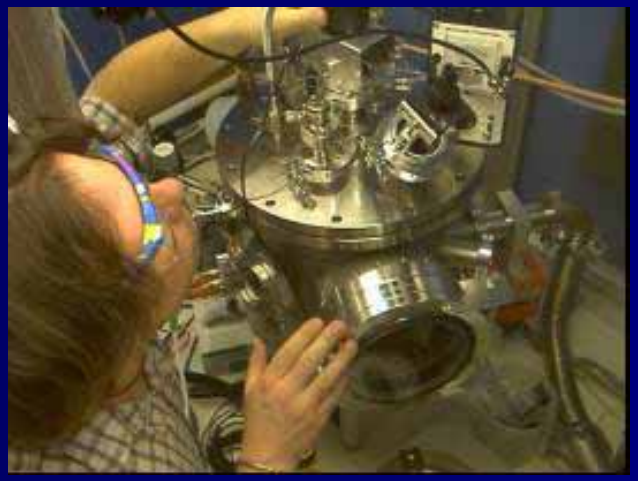
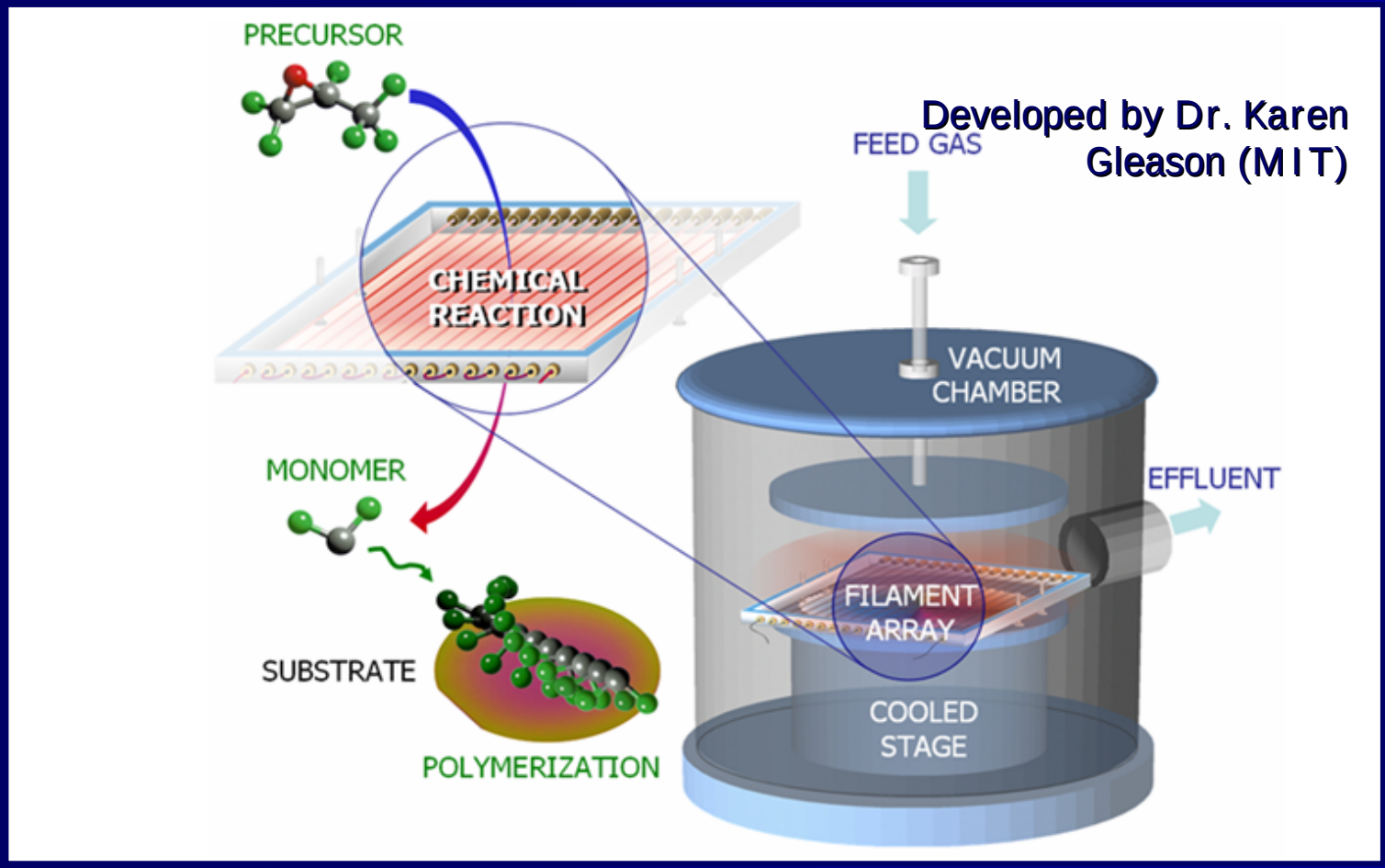
Background



- Ph.D. Student 1997-2001
- Graduate research:
  - Silicone thin films for biopassivation.
  - Directly patternable low-k dielectric.
- Thin films by CVD:
  - PECVD
  - Hot Filament CVD (“iCVD”)
- **Founded GVD in 2001; own facility in 2003.**

iCVD* Technology

*initiated chemical vapor deposition

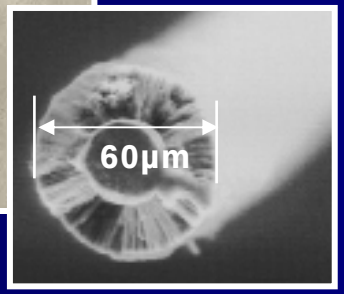


Core Technology

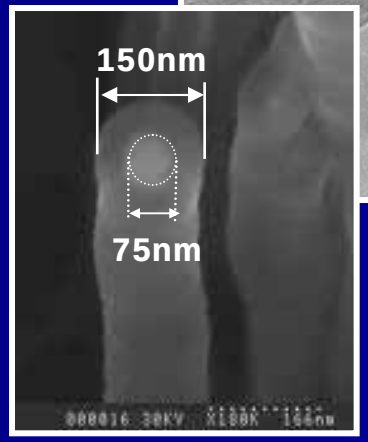
- Low-temperature nanocoating process enables thin polymer coatings on almost any material.

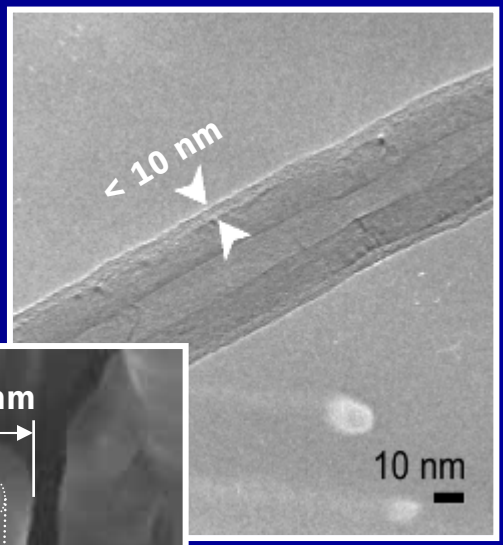
Uncoated Kleenex

Coated Kleenex



µmeter to nanometer





Coated nanotubes

Evolution from Plasma CVD

PECVD/
Pulsed PECVD

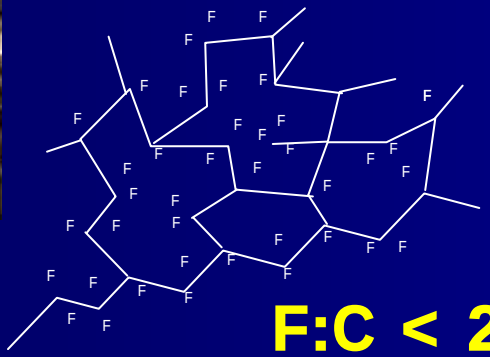
Hot filament CVD/
iCVD

Replace plasma with heating elements

- Reduces plasma damage
- Lower energy input
- Favors discrete polymerization
- Retention of functional groups

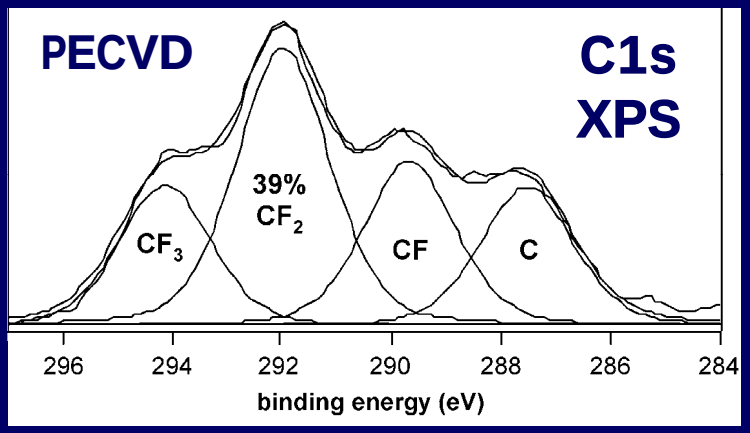
Enables Linear Polymerization

PECVD

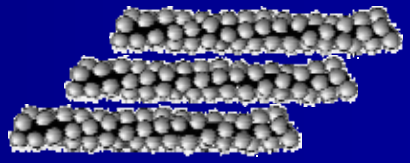


F:C < 2

Complex crosslinked structure

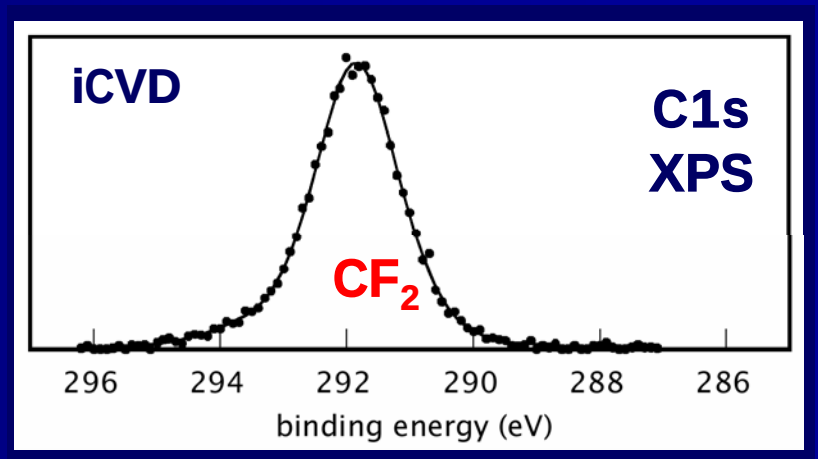


iCVD

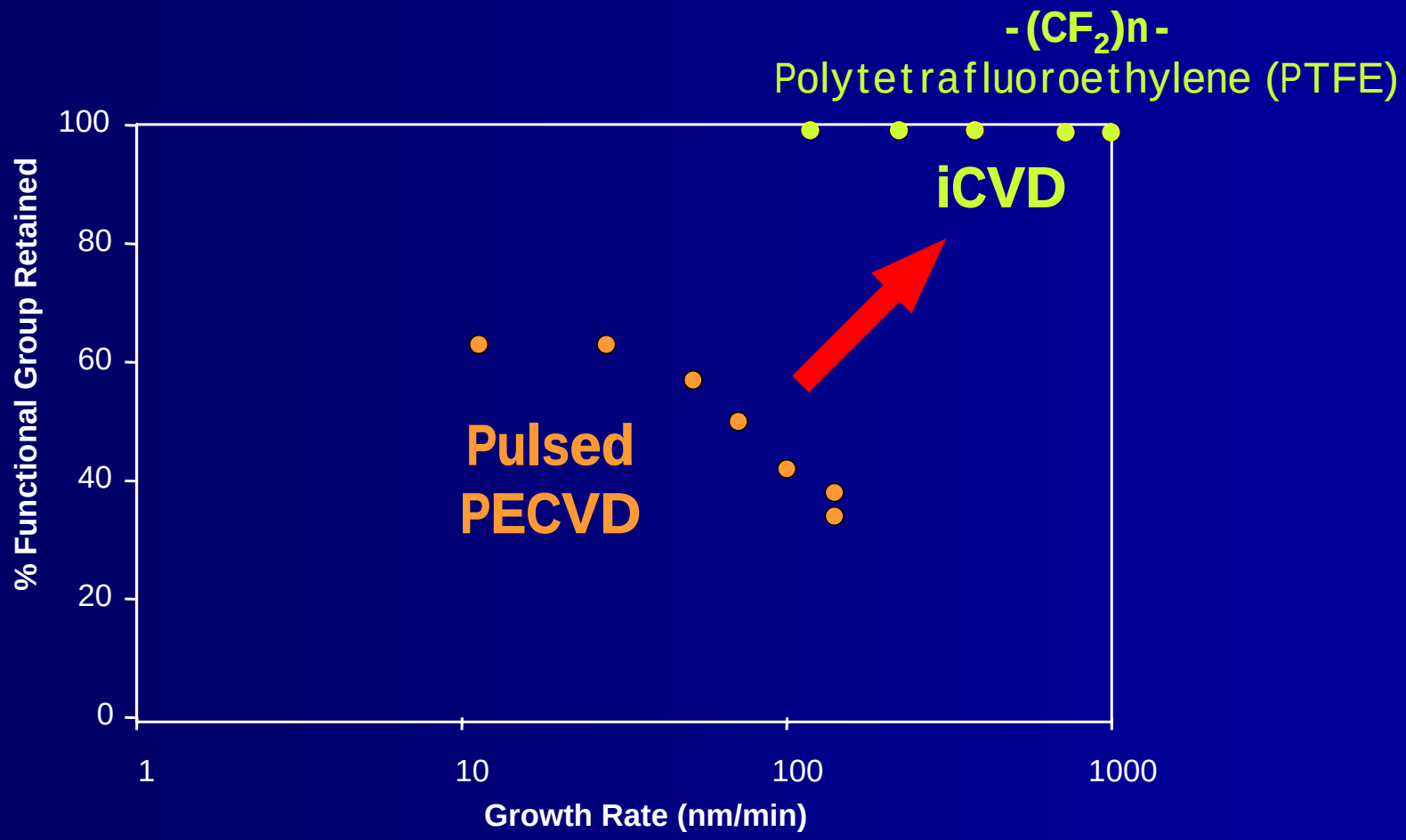


F:C = 2

Linear polymer



Commercially Viable Deposition Rates



Why Is This Important?

iCVD:

- **Enables deposition of polymers that are:**
  - **infusible (don't melt) and**
  - **insoluble (don't dissolve)**
- **Process appears to be scaleable.**

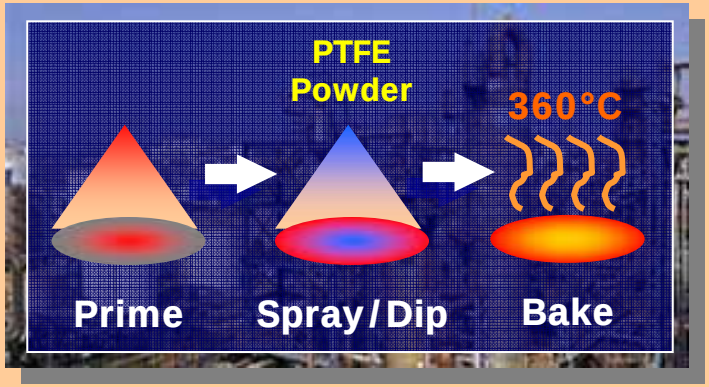
PTFE (Teflon®) Is a Good Example

PTFE has Unique Properties

- **Biocompatibility** (Catheters)
- **Chemical resistance** (Filters)
- **Thermal resistance** (Pumps)
- **Electrical Insulation** (Wire)
- **Low-friction** (Cookware)
- **Water-repellency** (Apparel)

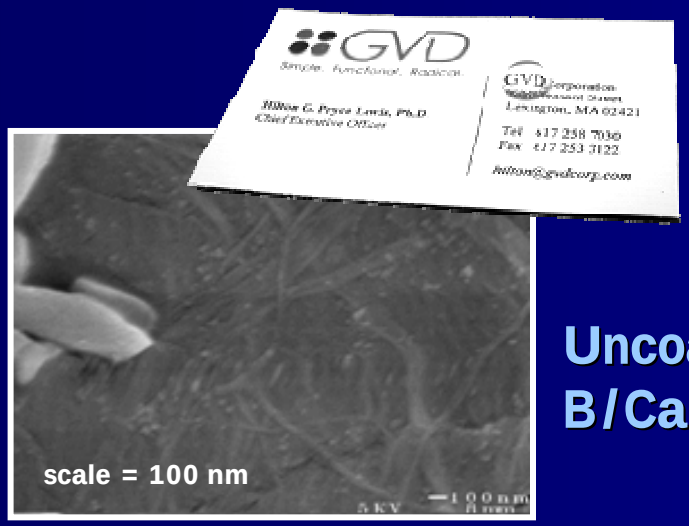
BUT

Traditional Coating Is:

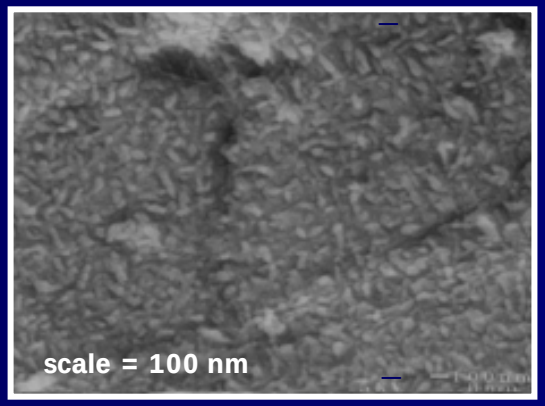


- ☒ **Limited in substrate choice**
- ☒ **Small complex parts tough**
- ☒ **Multi-step process**
- ☒ **Adhesion challenges**

Gentle & Effective Protection w/ PTFE



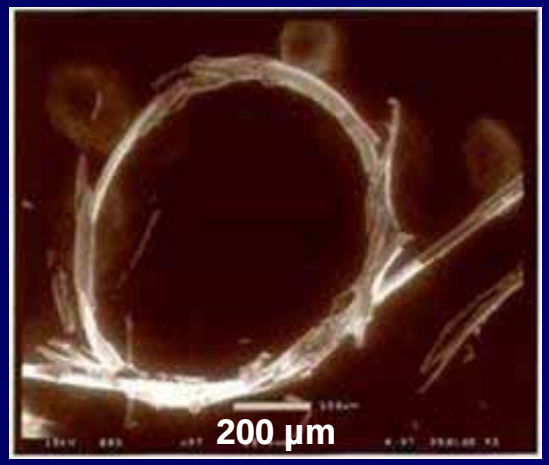
Uncoated B/Card



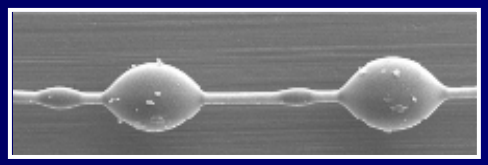
PTFE Coated Biz Card

Protects against aggressive chemicals

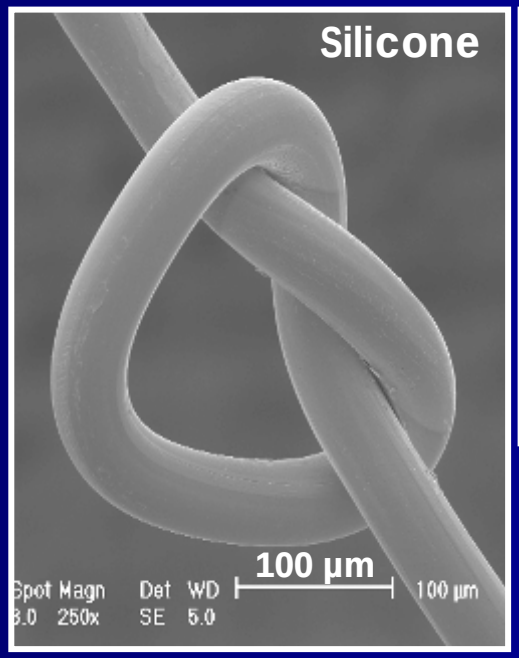
Flexible and Adherent

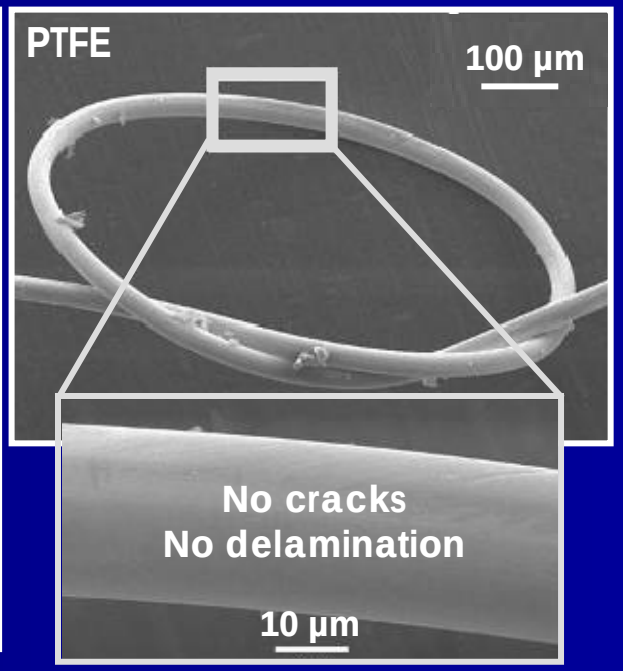


Plasma CVD



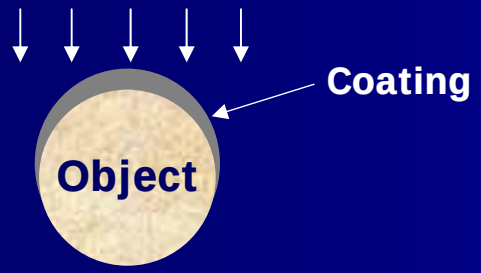
Solution-coated Silicone

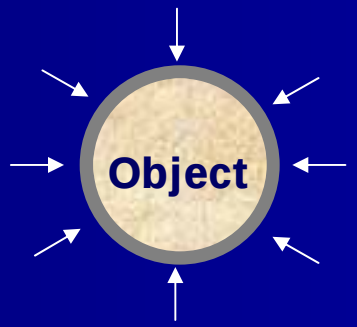




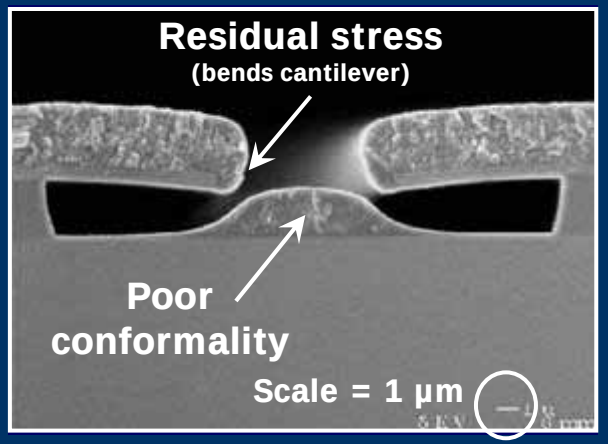
iCVD Silicone & PTFE

Conformal, Uniform Coverage



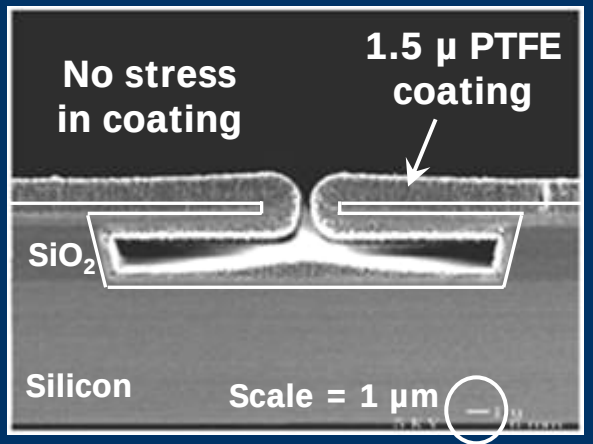


Plasma CVD



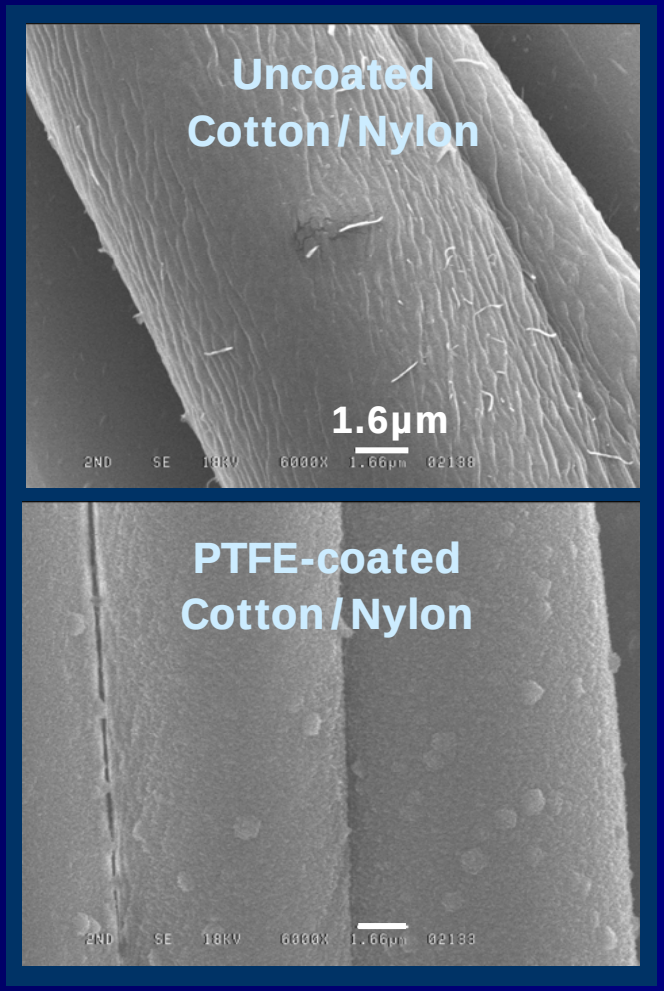
Directional
(e.g. line-of sight)

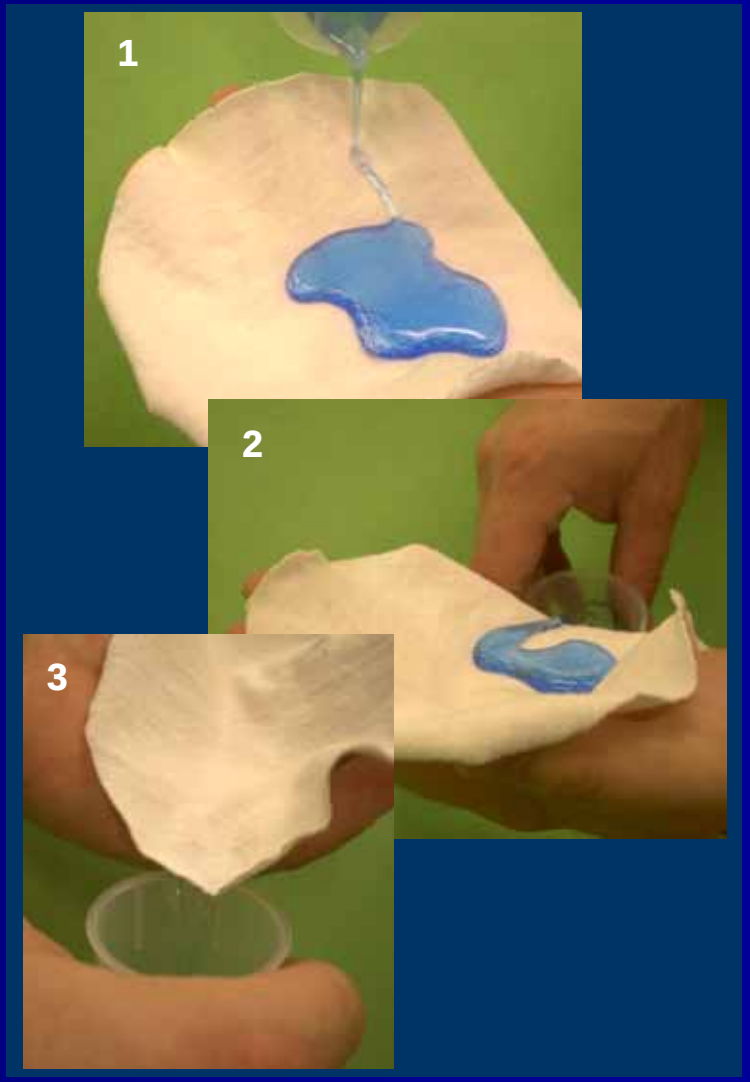
iCVD PTFE



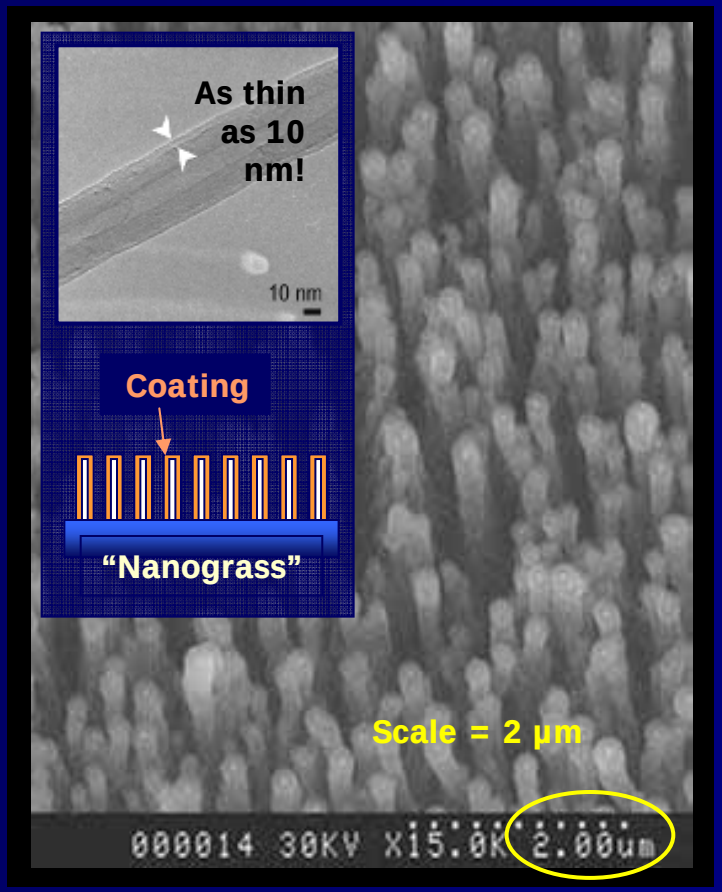
Conformal

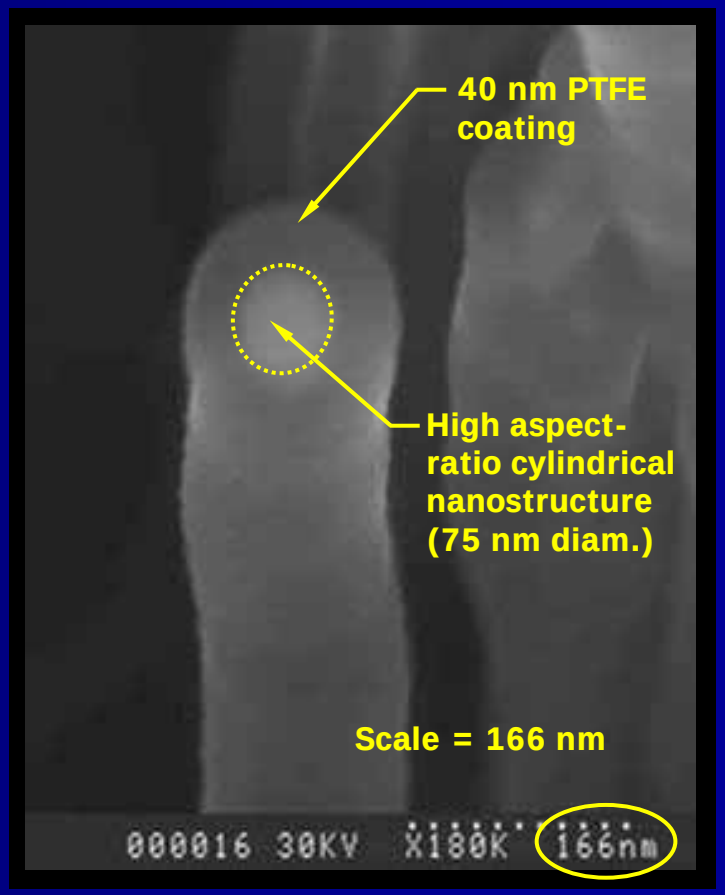
Microscale Coverage



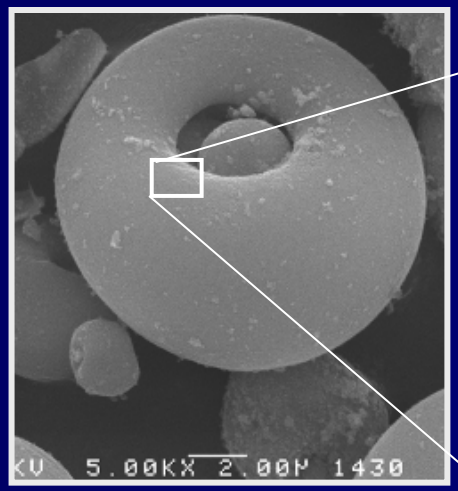


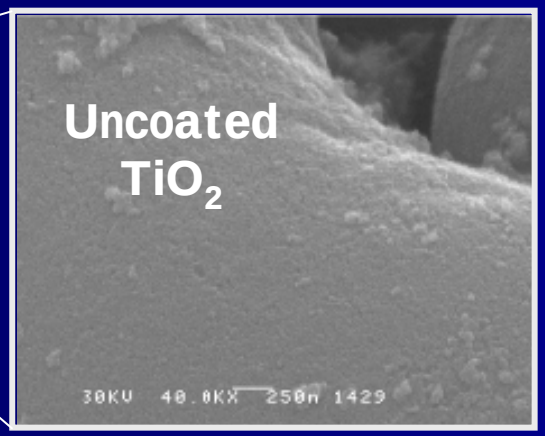
Nanoscale Coverage

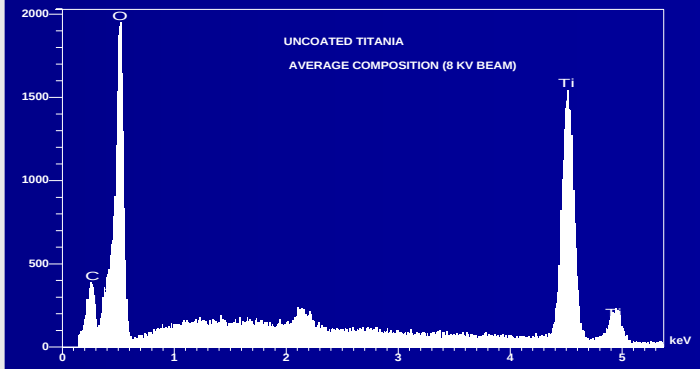


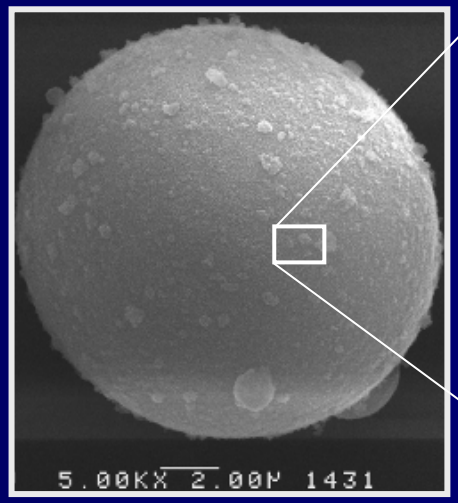


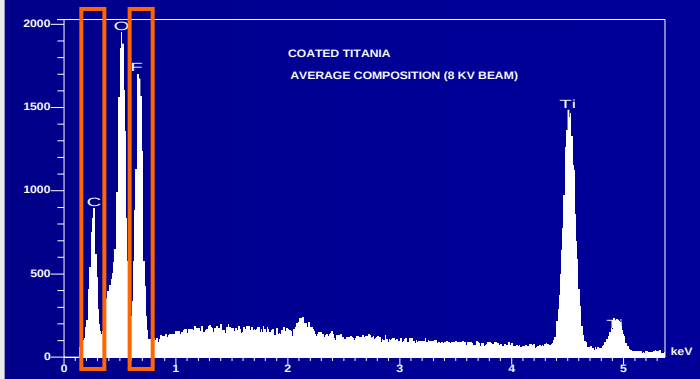
Conformal Coating of Particles





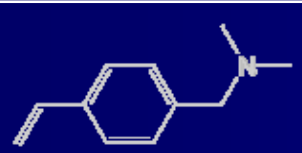
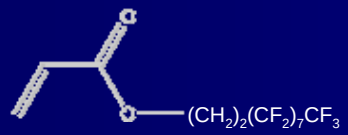
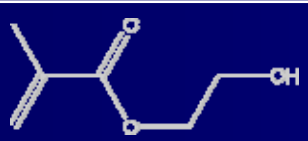
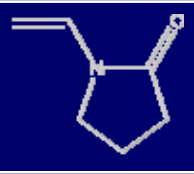
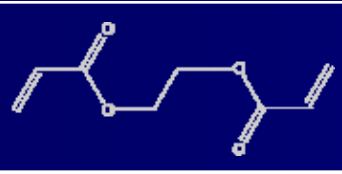






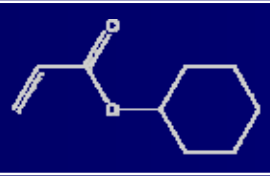
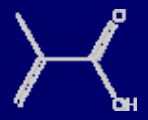
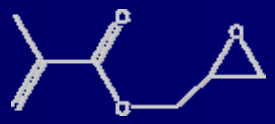
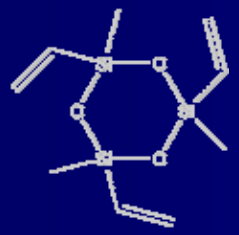
C:F ratio = 1:2

Applicable to Other Polymers (40+)

Monomer Structure	Monomer Name	Function as Polymer
	DMAMS	Antimicrobial
	FDA	Super-hydrophobic Oleophobic
	HEMA	Super-hydrophilic
	VP	Super-hydrophilic
	EGDA	Crosslinker

Courtesy Dr. Karen Gleason & her group at MIT

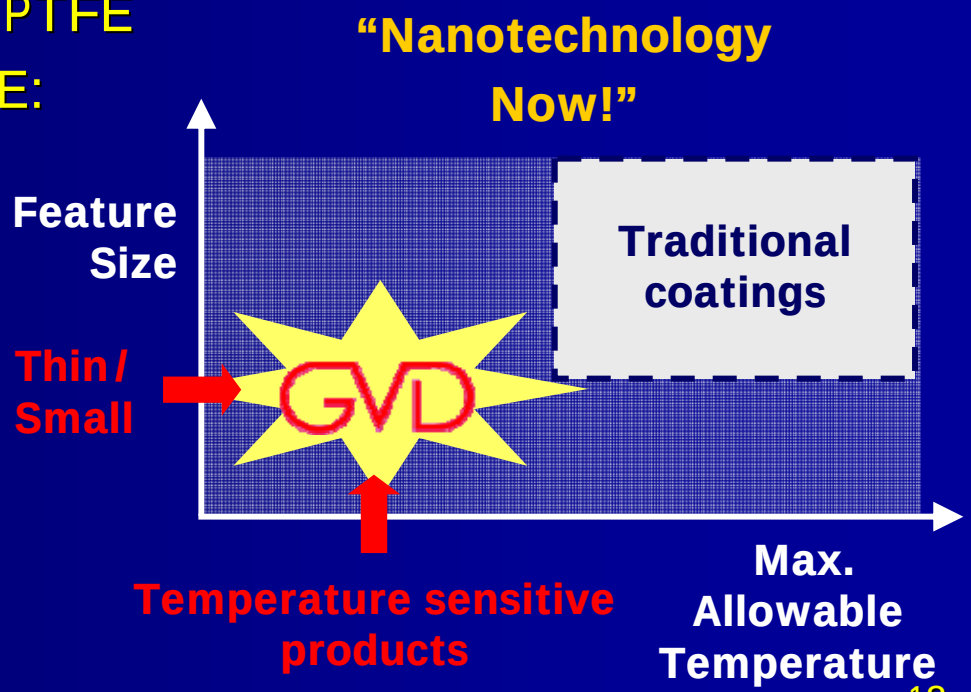
Applicable to Other Polymers (40+)

Monomer Structure	Monomer Name	Function as Polymer
	CHMA	Sacrificial material
	MAA	Enteric material
	GMA	Patternable resist Functionalizable
	V3D3	Biopassivation Low-k

Courtesy Dr. Karen Gleason & her group at MIT

Business Plan (How Do We Make $$?)

- **Starting out:**
  - Commercial interest in PTFE
  - Prototyping capability for PTFE
  - Large list of potential applications for PTFE
  - "Brand awareness" of PTFE
  - Market niche for PTFE:



Material Advantages (PTFE)

Low Friction

- Slippery cutting edges.
- Sliding parts.

Nonstick

- Release coatings.
- Non-fouling surfaces.

Hydrophobic

- Water-repellent fabrics.
- Non-fouling surfaces.

Resistant

- Chemical/biological resistance.
- Environmental protection.

Biocompatible

- Medical devices.

Process Advantages

Low Temperature

- Plastics, organics possible

No Cure Step

- Plastics, organics possible
- No deformation

Solventless

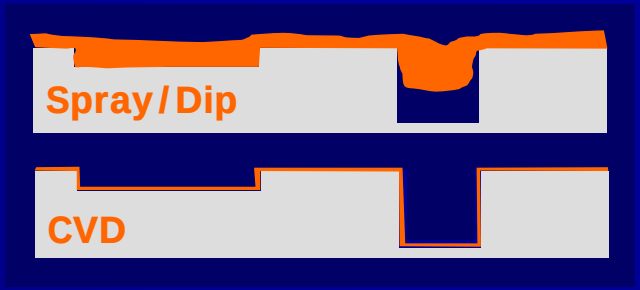
- No compatibility issues
- No solvent waste

Thin (10 nm – 10 µm)

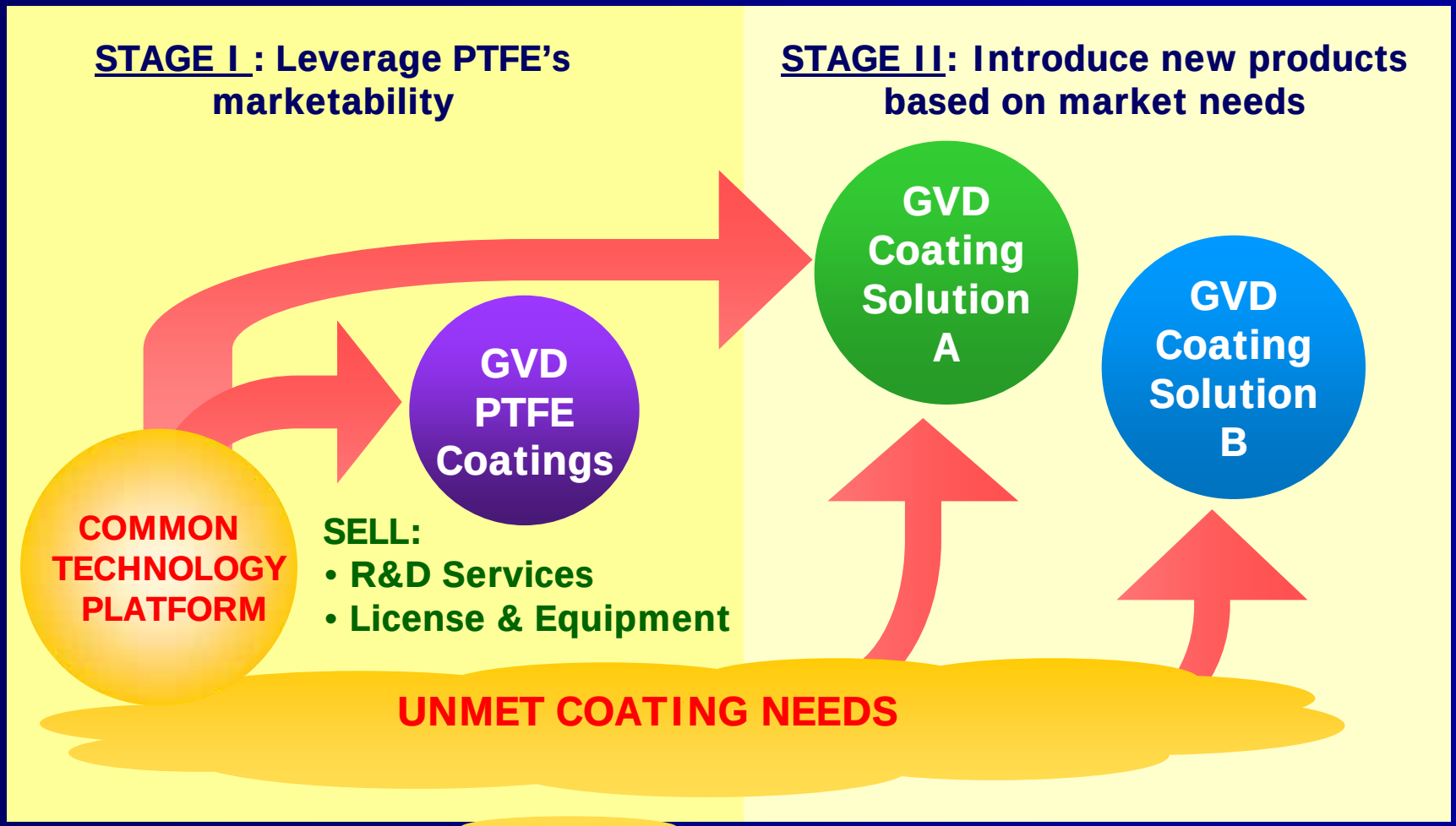
- Low-weight
- Fine, complex geometries

Conformal

- Fine, complex geometries



GVD Growth Strategy



Strategy: Stage I

1. **Focus on PTFE**

2. **Grow organically using industry/gov funds**
   (development $ from industry, government)

3. **Screen applications for REAL problems**
   (avoid dabblers, impossible problems)

4. **Scale process and build capability**
   (capability = people, process, equipment, data)

Process Scaling

2-inch
1990

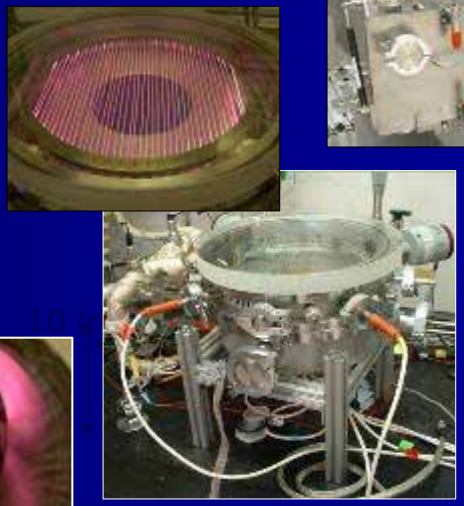
- R&D
- Reproducibility

4-inch
1993

- R&D
- Thickness measurement
- Manual operation

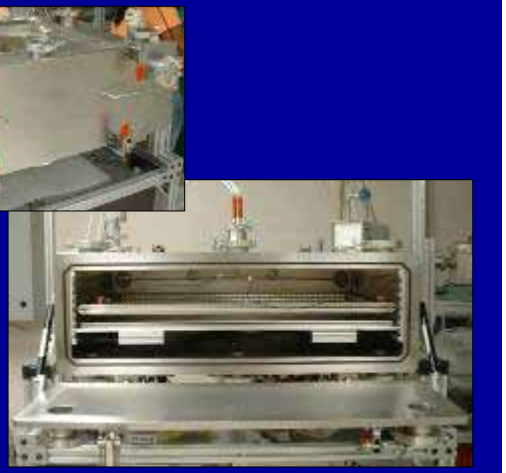
6-inch
1997

- R&D/light production
- Good uniformity
- High efficiency
- Manual operation



10-inch
2000

- Medium production
- Rectangular
- Excellent uniformity
- Adjustable stage
- Semi-automated operation



Echelon™
30-inch
2004

GVD Standard Coating Tools

iLab™

10x

Echelon™

iRoll™

Small Batch

Large Batch

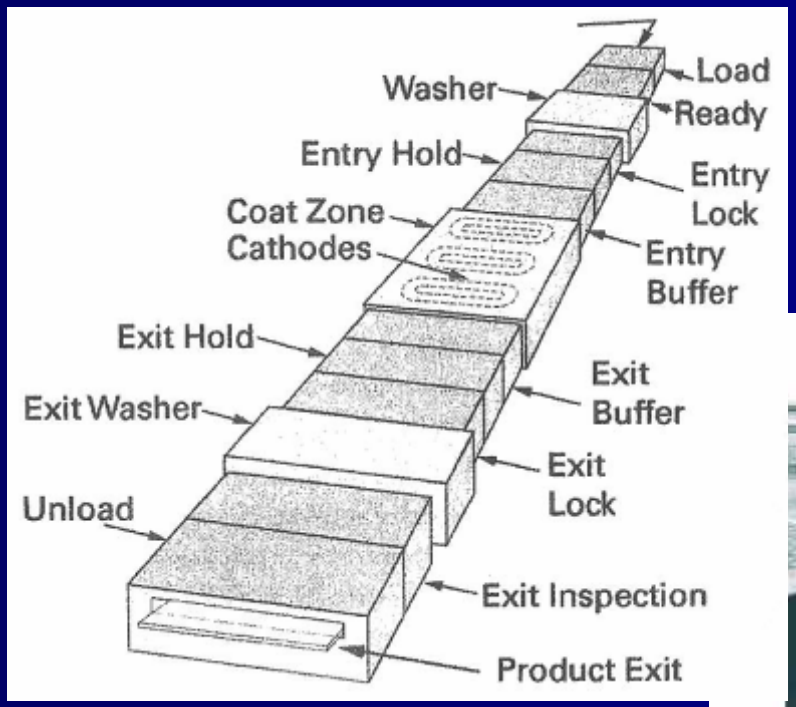
Continuous

* **Current capability:** PTFE (Teflon®)
* **Under development:** Silicones, conducting polymers
* **Future capability:**
  - •Antimicrobial
  - •Superhydrophilic
  - •Enteric coating
  - •Functionalizable

GVD Production System

Remote operation

Scalable Even Further (e.g. metallization)



PTFE Applications

Blades

MEMS

Medical Devices

Molding

lubricious

thin

biologically compatible

repellent

PTFE

conformal

optically transparent

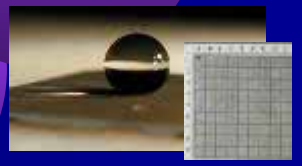
chemically resistant

porous

Flexible Electronics

Medical Devices

Specialty Textiles



Sensors

PTFE Business Model

- **Revenues:**
  - License fees and equipment sale
  - R&D services (through 3 phases below)
- **Three-phase development:**
  - **Phase I Feasibility** (proof-of-concept)
  - **Phase II Development** (statistics, scale-up)
  - **Phase III Commercialization** (license, prod'n)
- **Partnership with customers is key:**
  - Partner brings market knowledge, specifications, funding
  - GVD brings IP, prototyping capability, process expertise

Strategy: Stage II

1. Generate sustainable revenue from:

Low-volume production
Equipment and license

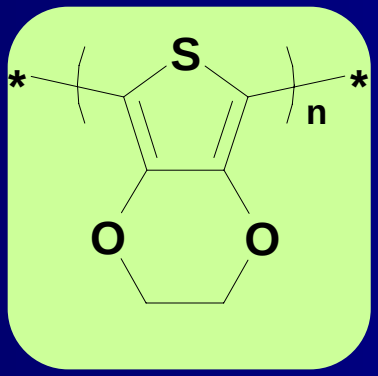
2. Expand product line outside PTFE:

Conducting Polymer
Hydrophilic coating
Antimicrobial

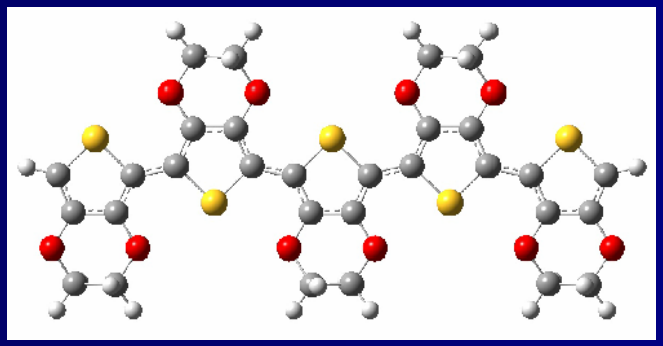
3. Sell a solution that makes sense.

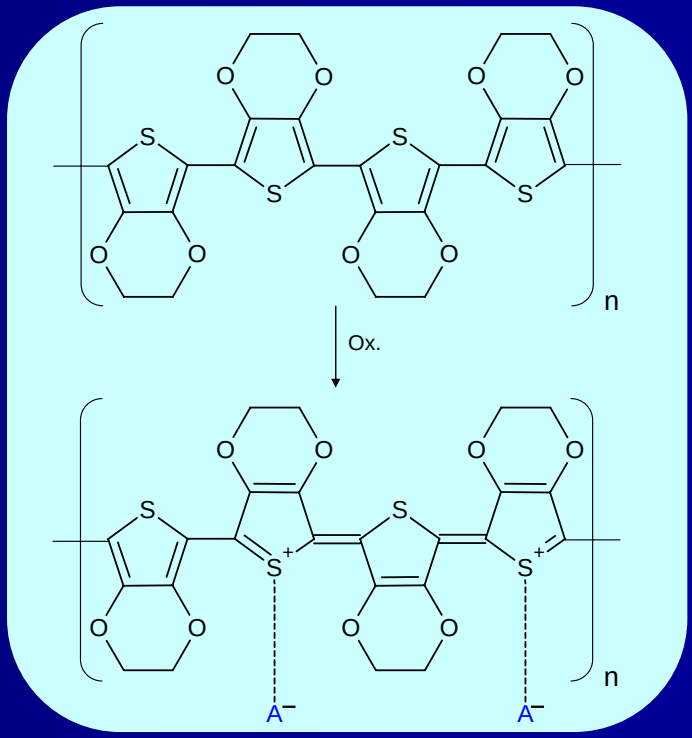
New Opportunity: Conducting Polymers

e.g. PEDOT (Poly 3,4 dioxyethylene thiophene)

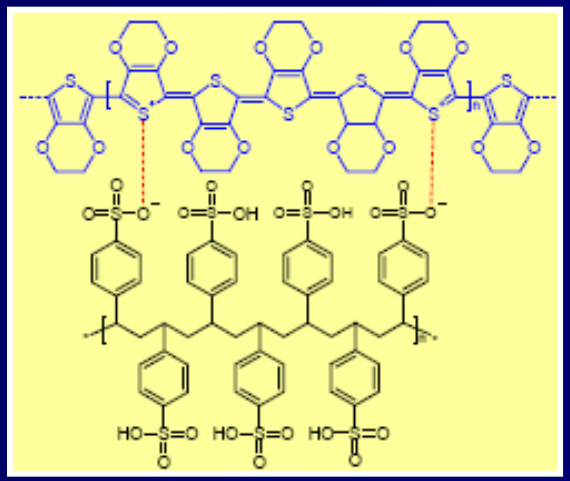


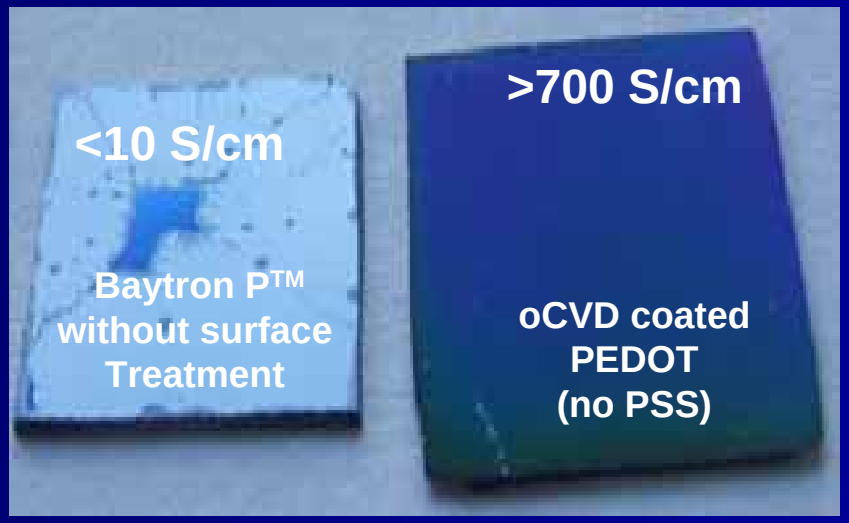
Infusible & Insoluble

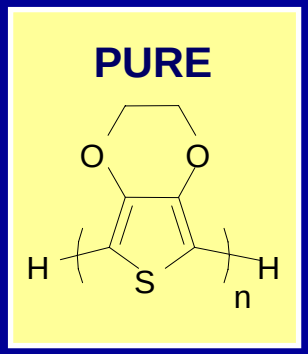




GVD PEDOT vs. Baytron P®

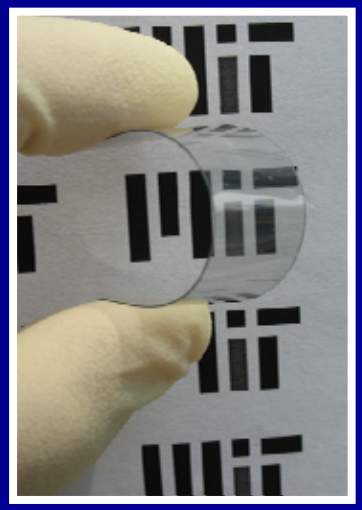






- Shares benefits of PTFE process
- Tunable conductivity
- Tunable work function

Flexible



Markets Complement PTFE

Blades

Conductive Polymers

MEMS

Medical Devices

Conductive Polymers

Molding

lubricious

thin

biologically compatible

repellent

PTFE

conformal

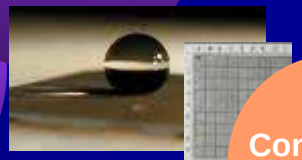
Conductive Polymers

optically transparent

chemically resistant

Flexible Electronics

porous



Conductive Polymers

Specialty Textiles

Conductive Polymers

Sensors

Conductive Polymers

Key Challenges

- **“Bootstrapping” / organic growth**
- **Materials development:** long and expensive!
- **Platform technology:** multiple fragmented markets
- **Making strategic decisions**, not tactical ones
- **Distinguishing real needs** from “dabbling”
- **Corporate turnover** at our customers
- **Negotiating partnership deals**
- **Personnel** …

Summary

- Profitable small business (Stage I)
- Experienced, dedicated team
- Commercial products on market
- Other comm'l products in pipeline
- Financed by non-equity capital
- Scaled process successfully by 100x
- Evaluating next opportunity (stage II)

"Never a dull moment"