

# PDMS Films for Printed Electronics – Methods and Advancements

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**DELPHON** Industries

# DELPHON



## Device Protection Solutions



- Manufactures proprietary polymers and films
- Used to protect, process and transport fragile, high value devices

**Gel-Pak**  
Protecting the World's Valuable Devices

## Specialty Printing



- Service provider that offers highly specialized printing capabilities

**TOUCHMARK**  
MEDICAL DEVICE PAD PRINTING

## Cleanroom Tapes & Labels



- Manufactures specialty adhesives and elastomers for demanding cleanroom applications

**UltraTape**  
Adhesive Tapes • Labels • Graphic Overlays

Goal for FHE: Develop specialty substrates for flexible and stretchable electronics

# Outline

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- ▶ Properties & uses of silicones
- ▶ Characterizing challenges with silicones
- ▶ Overcoming challenges with silicones
- ▶ Continuing efforts in silicone films for printed, flexible and stretchable electronics

# Silicone – Unique and Versatile



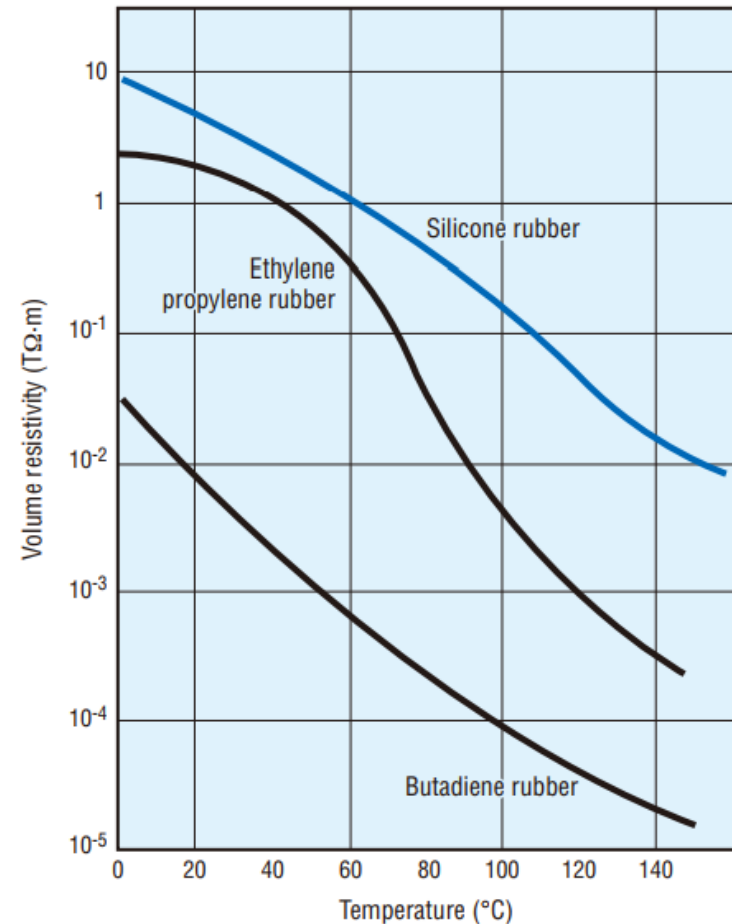
- ▶ Flexible
- ▶ Stretchable
- ▶ Easy to Process
- ▶ Good chemical resistance



# Silicone in electronics



- ▶ Wide operating temperature range from  $-40$  to  $+300^{\circ}\text{C}$
- ▶ Excellent electrical properties
  - Naturally insulative
  - Dope for conductivity
- ▶ UV resistance
- ▶ Vibration Absorbing
- ▶ Resistance to humidity and water

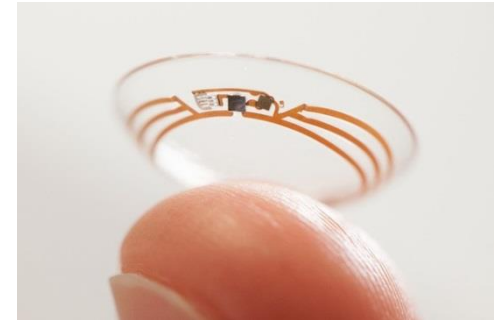
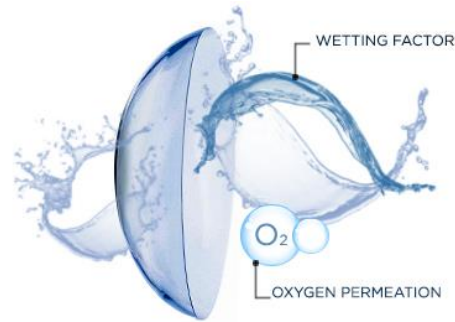




# Silicone for Medical Devices



- Biocompatible
- Physiologically Inert

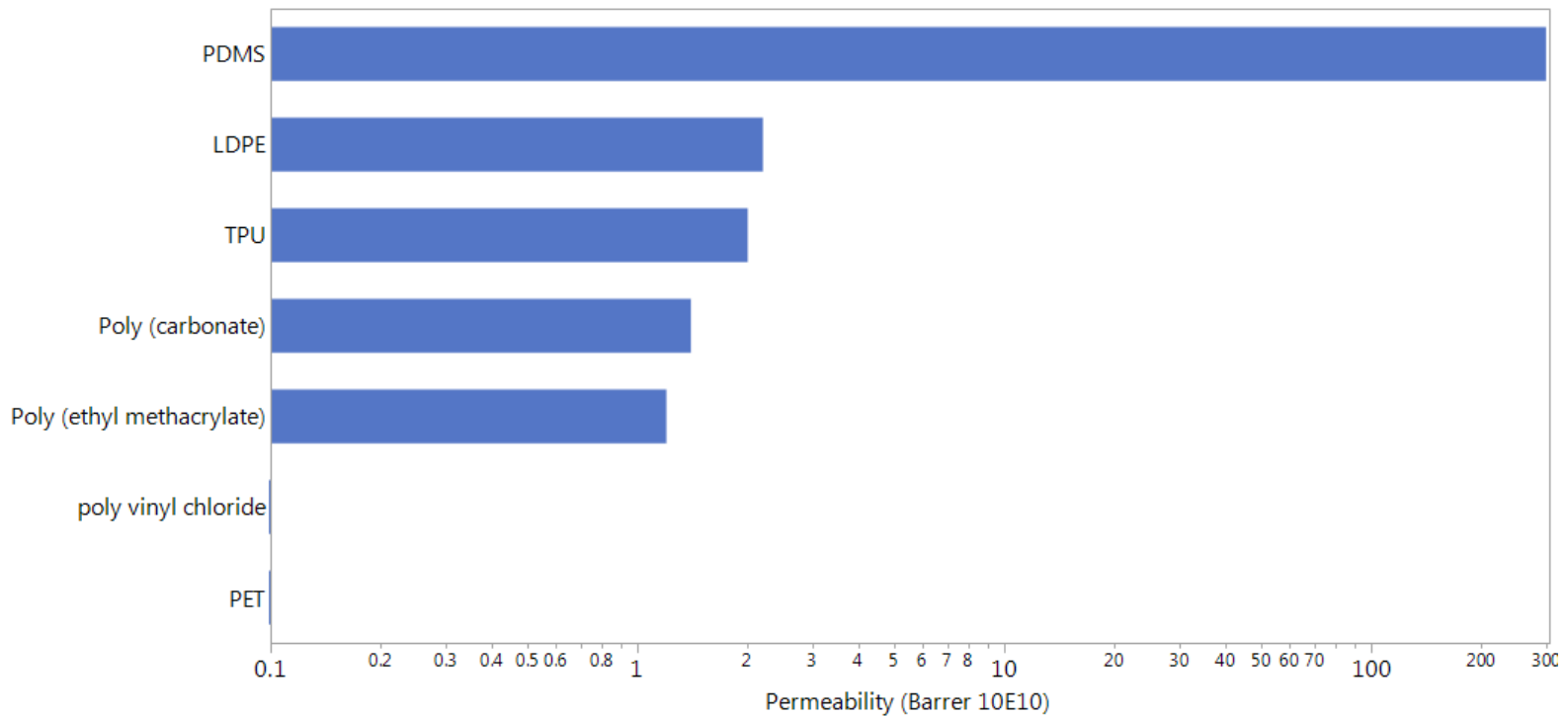


- Medline industries
- Google lens
- PIP breast implant
- Somnotec brachial tracheal stent
- <http://dermaclue.com>

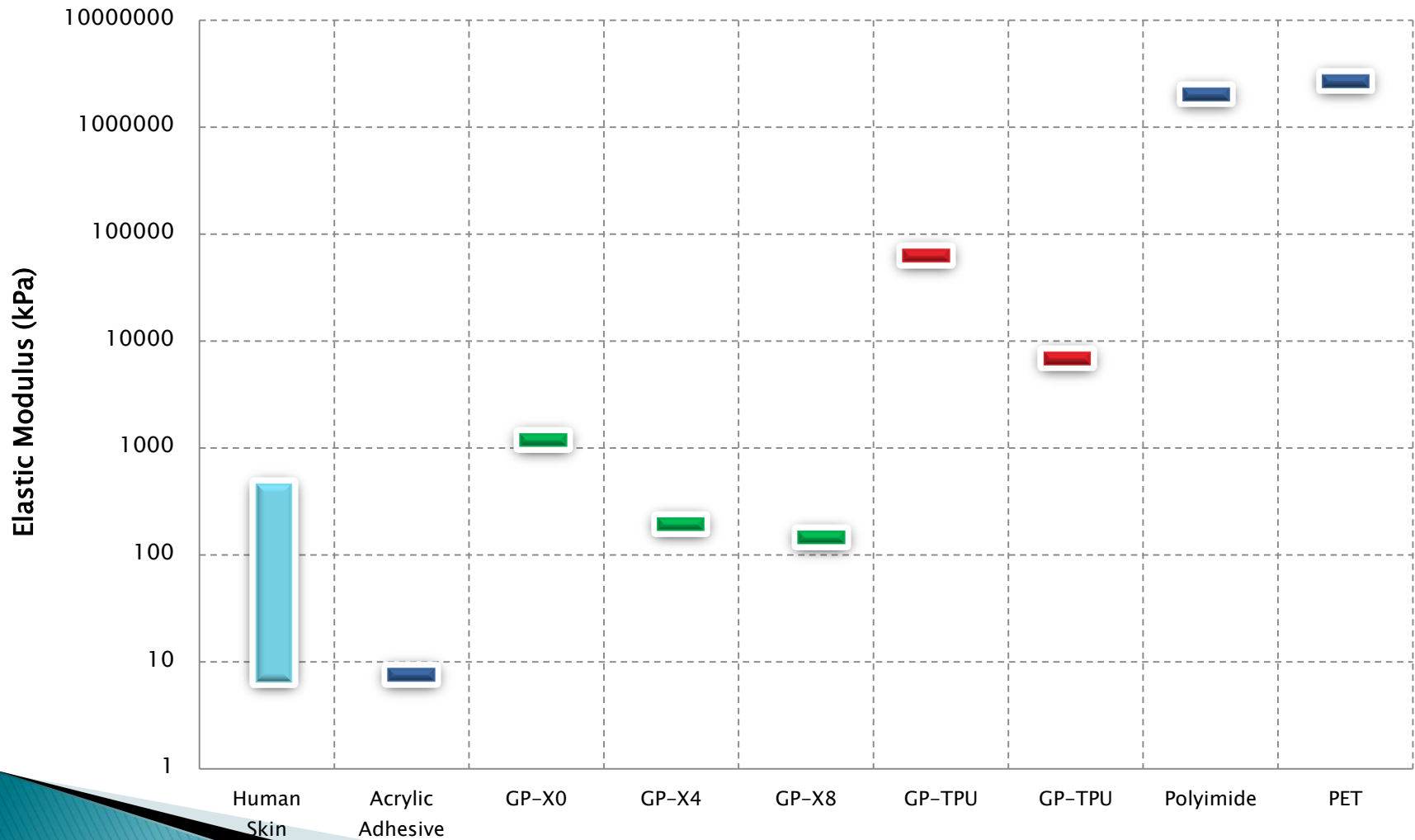
# Oxygen Permeability



**Silicone provides the necessary oxygen permeability for metabolic and biological processes**

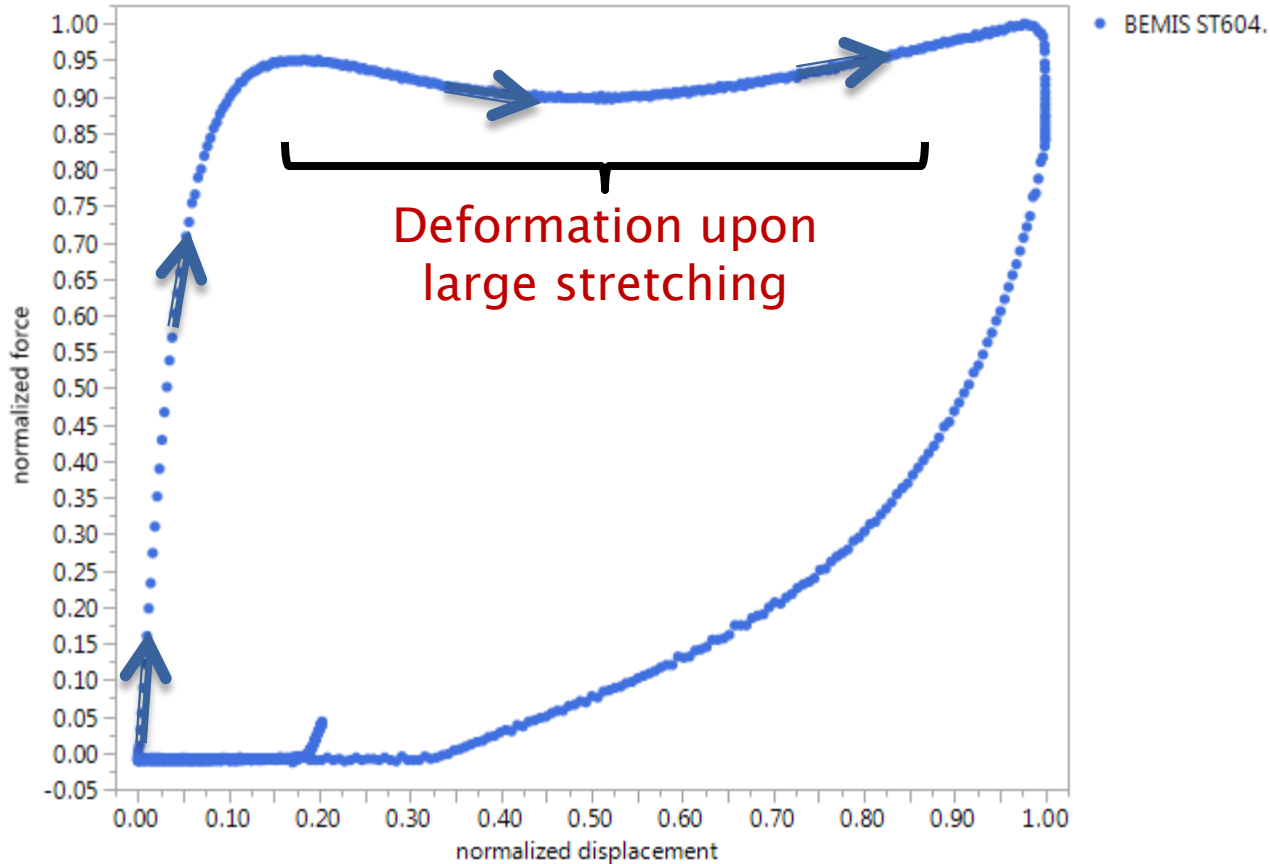


# Silicone is Soft

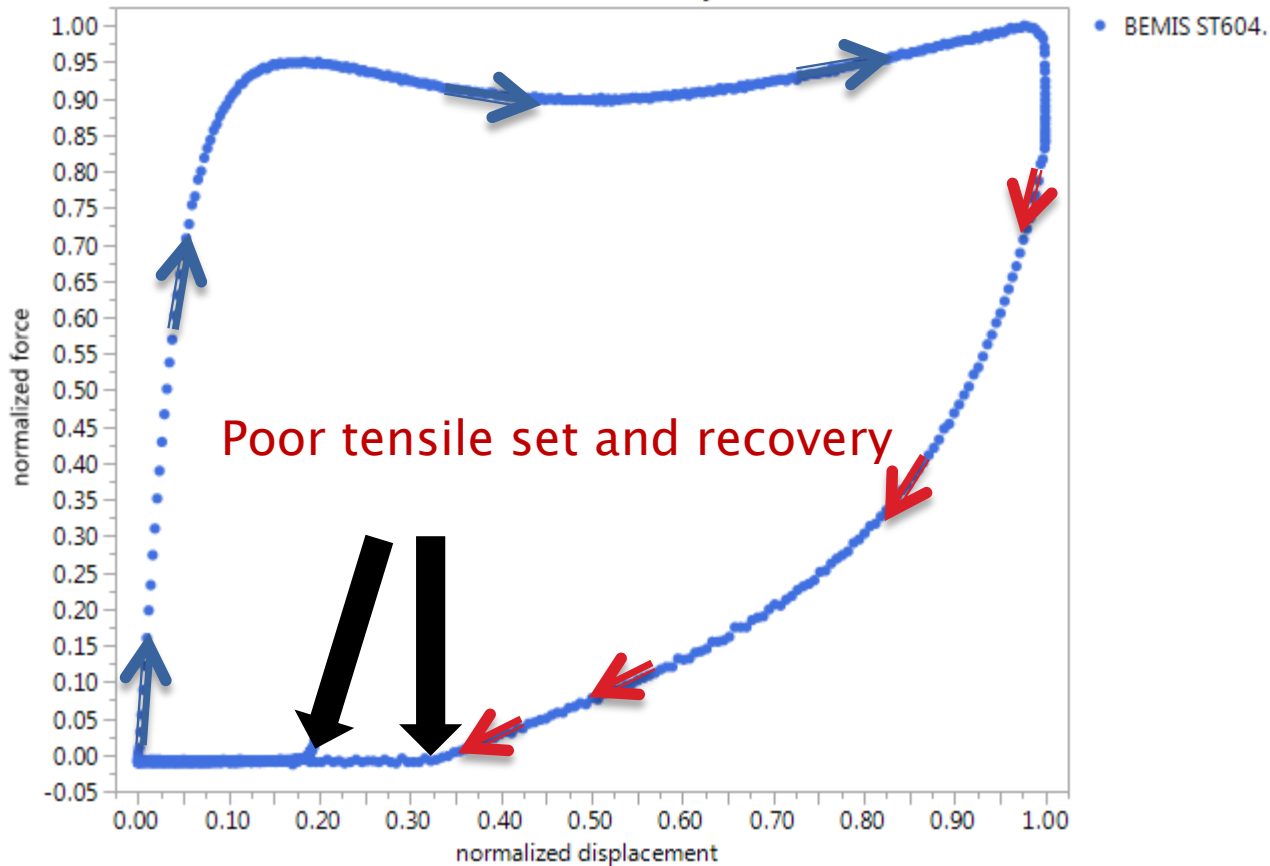




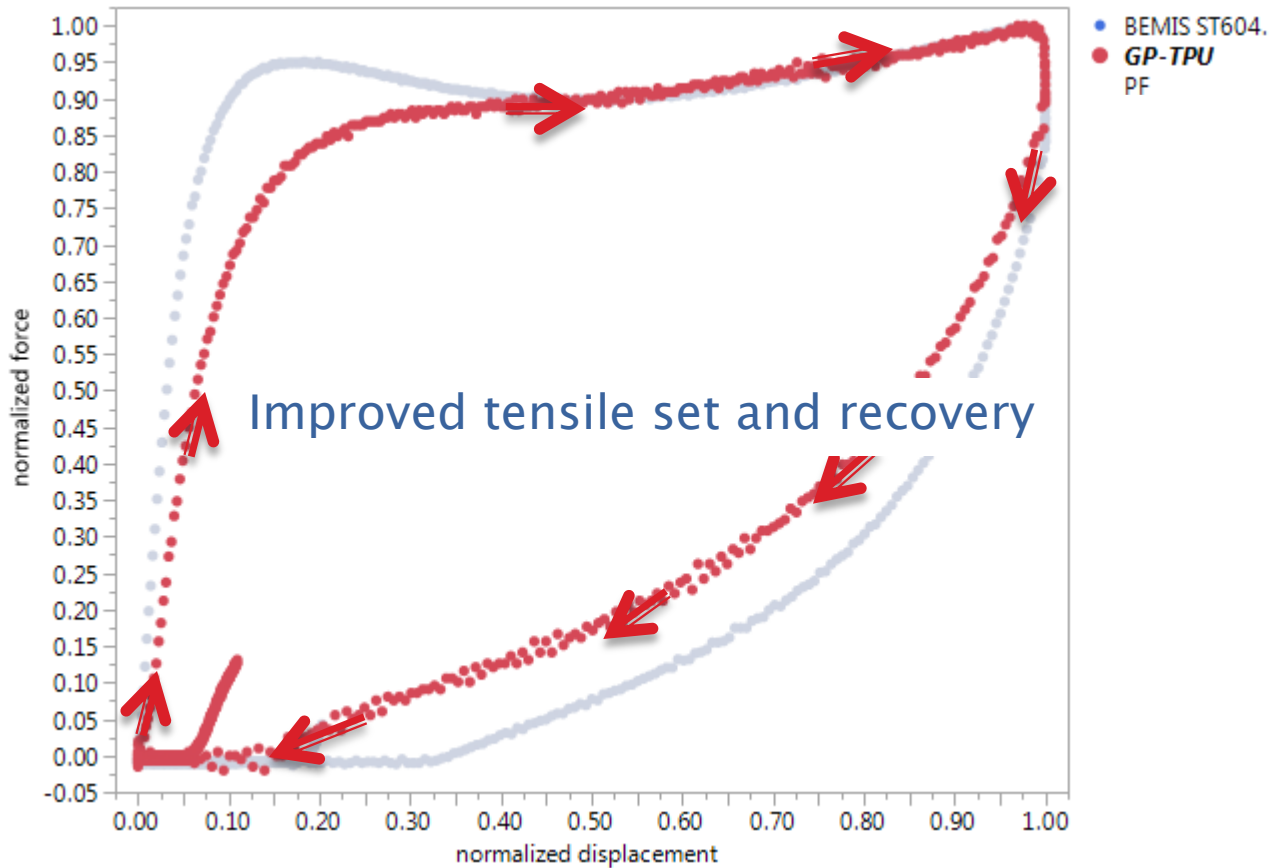
# TPUs & Elasticity



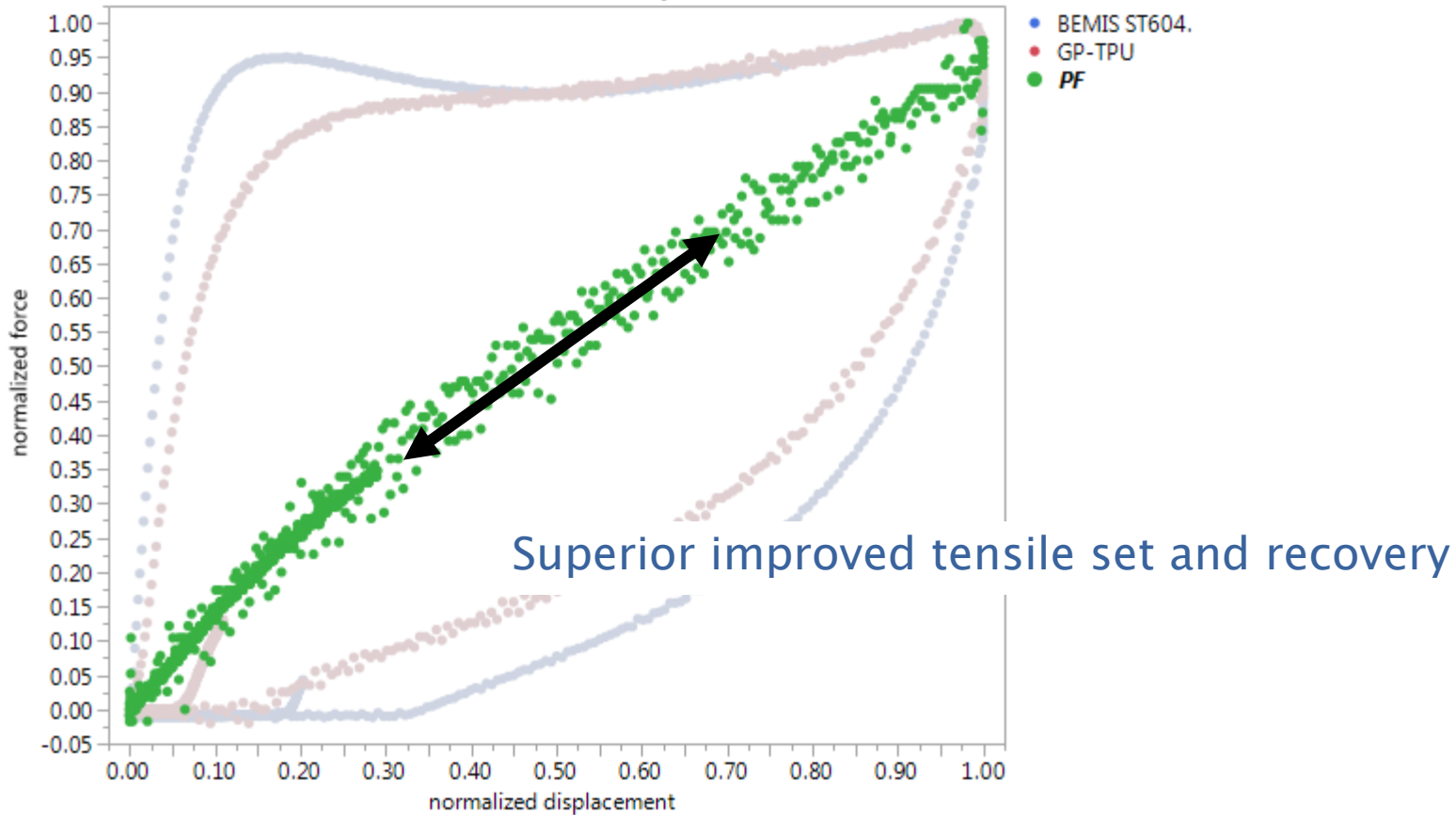
# TPUs & Elasticity



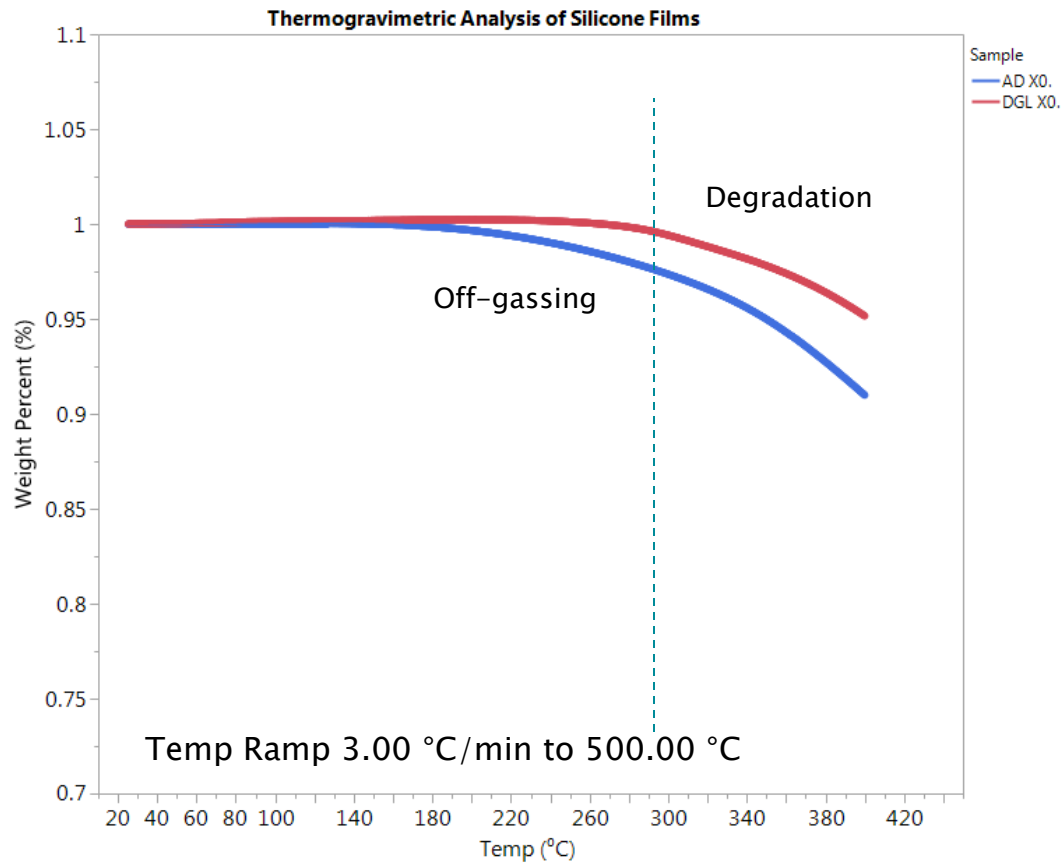
# FHE & Elasticity



# Silicones are Elastic


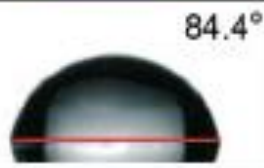





# Silicones are Heat Resistant



# Challenges with Silicone



PDMS	 104.7°
PC	 84.4°
PET	 74.7°
PVC	 76.3°
PI	 73.0°

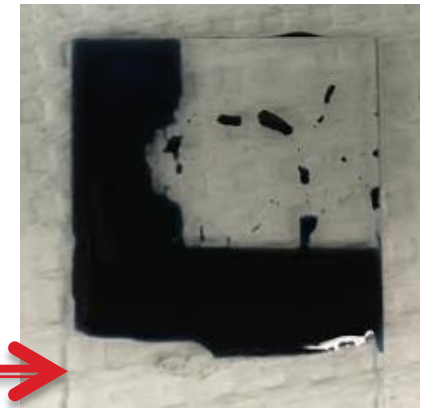
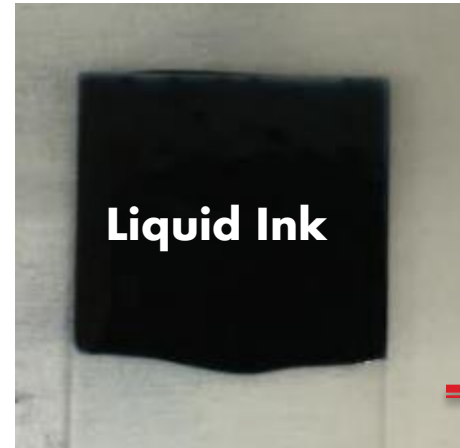
- ▶ Low Energy
- ▶ Low Energy Residue



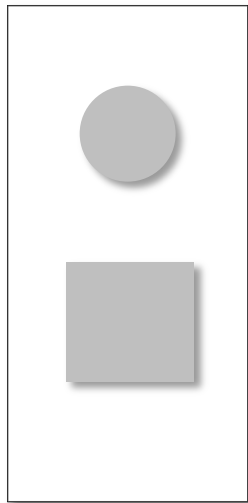
- ▶ Poor surface wetting
- ▶ Poor ink adhesion
- ▶ Poor device bonding



# Silicone Residue Induces Dewetting

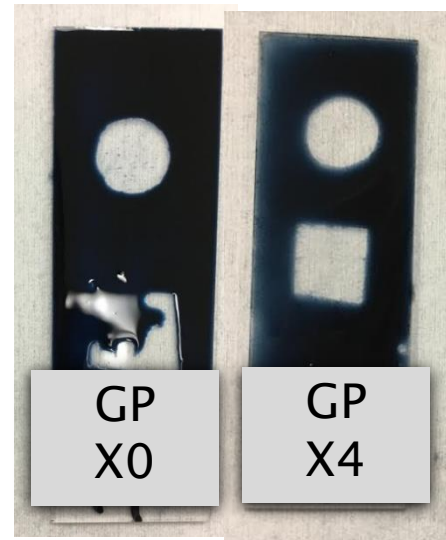


# Ultra-Clean Silicone

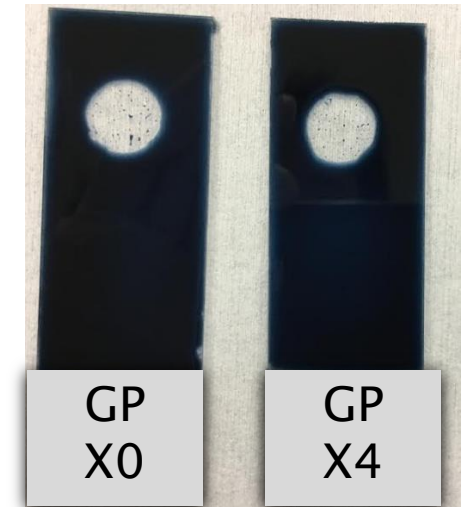


**Positive control**

**Test sample**



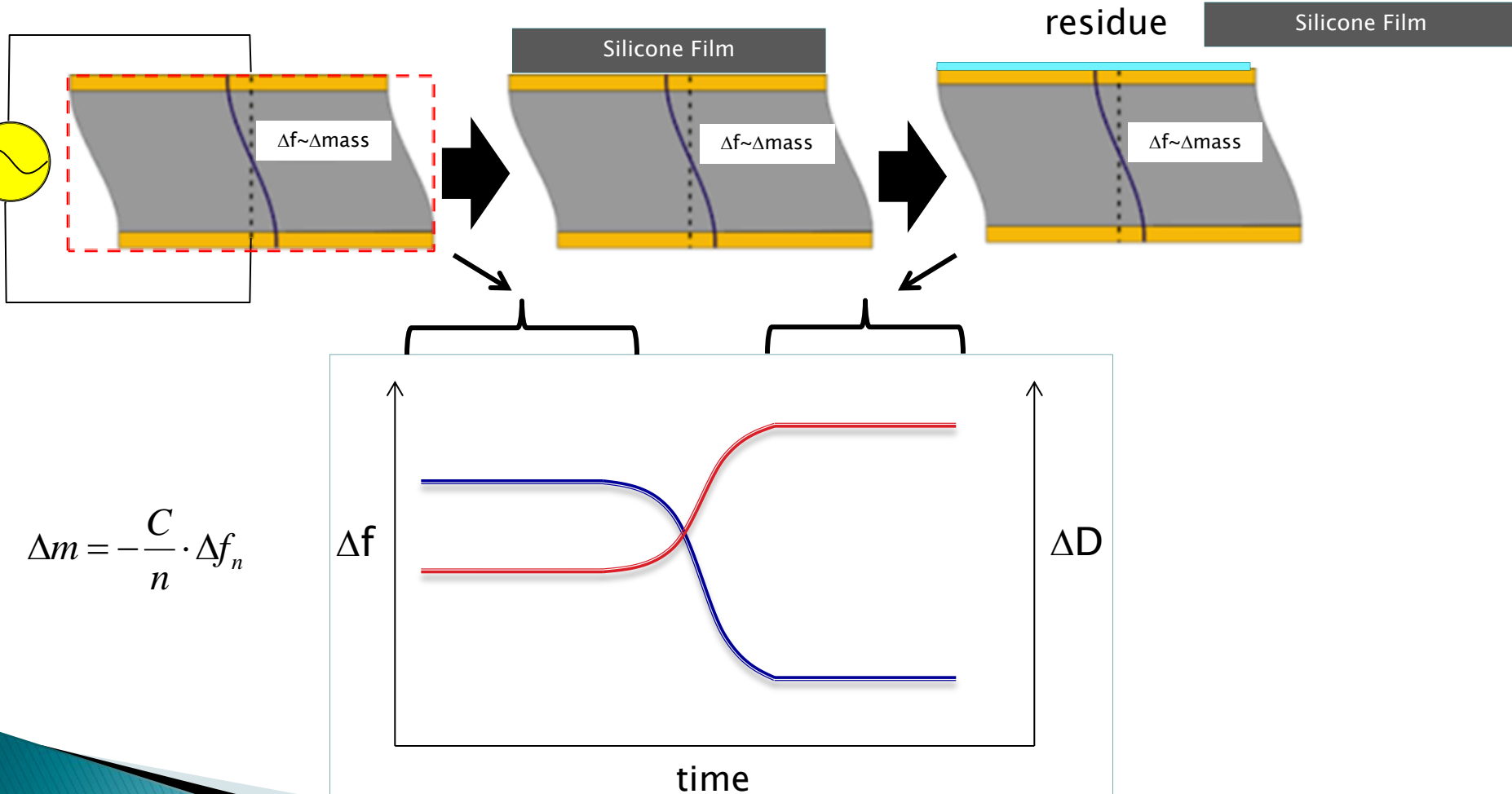
**Standard Silicone**



**DGL film**

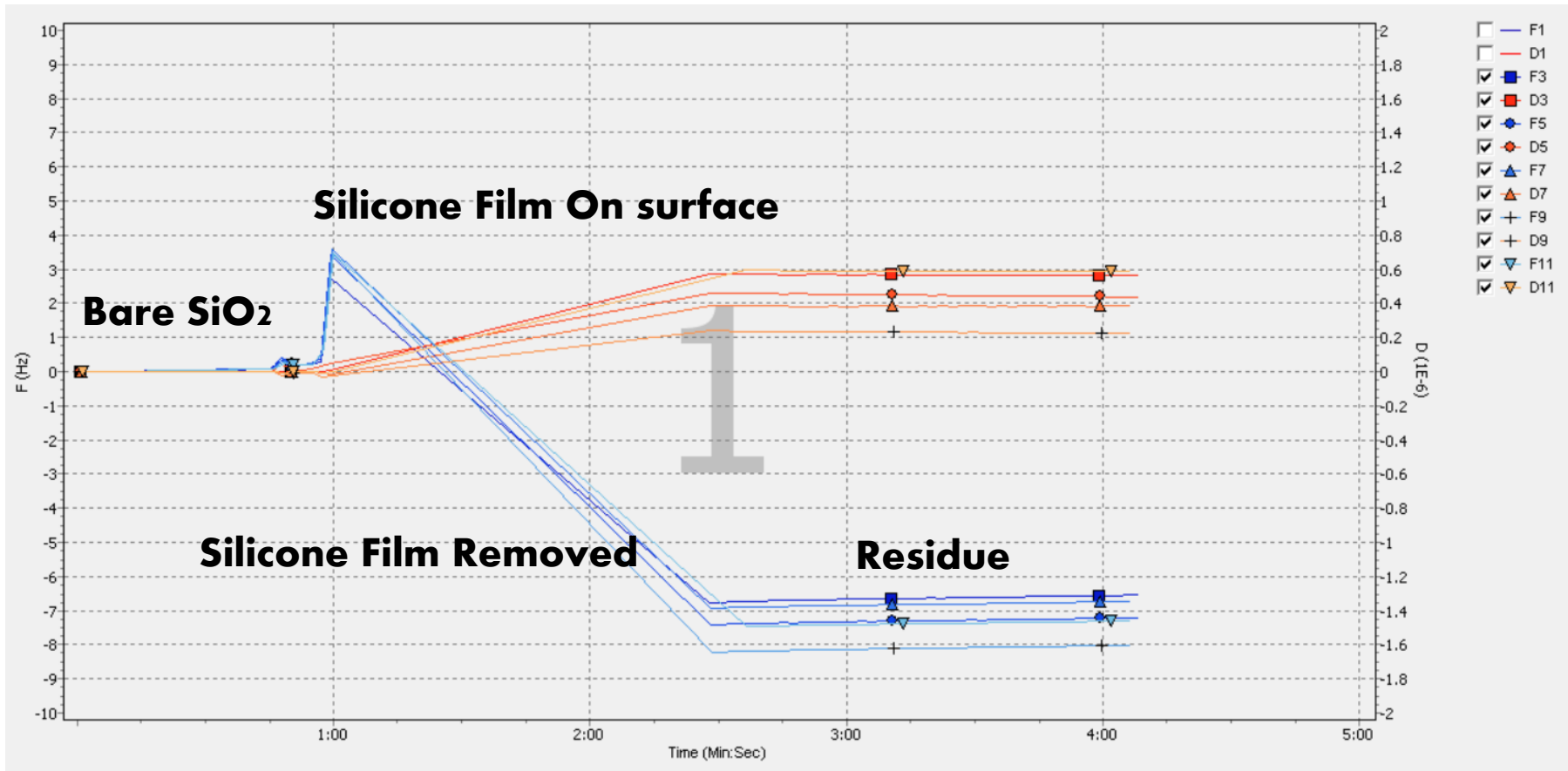
- DGL film minimizes ink dewetting due to residue
- Can we quantify how much residue induces dewetting?

# QCM for Residue Analysis

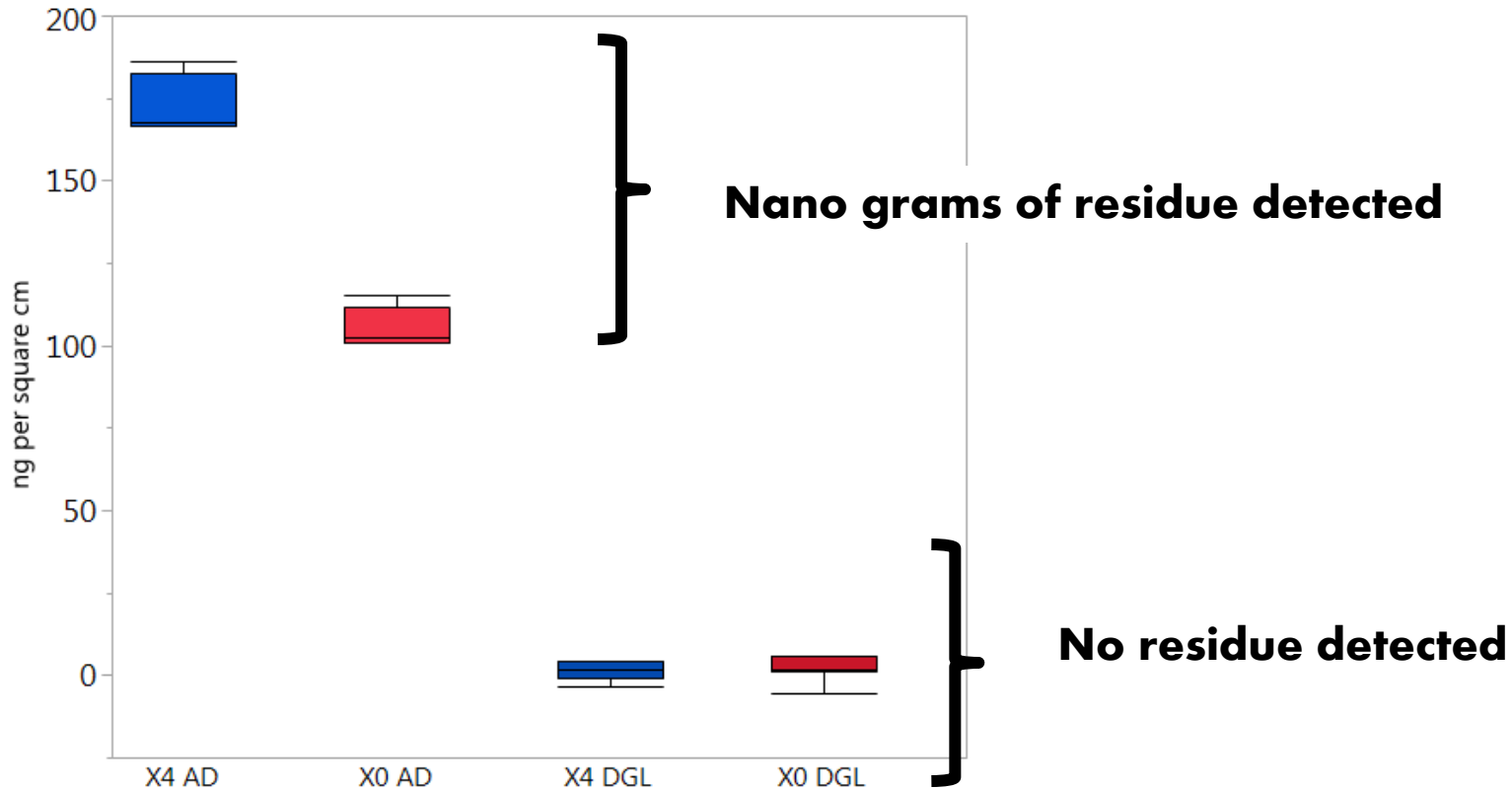


$$\Delta m = -\frac{C}{n} \cdot \Delta f_n$$

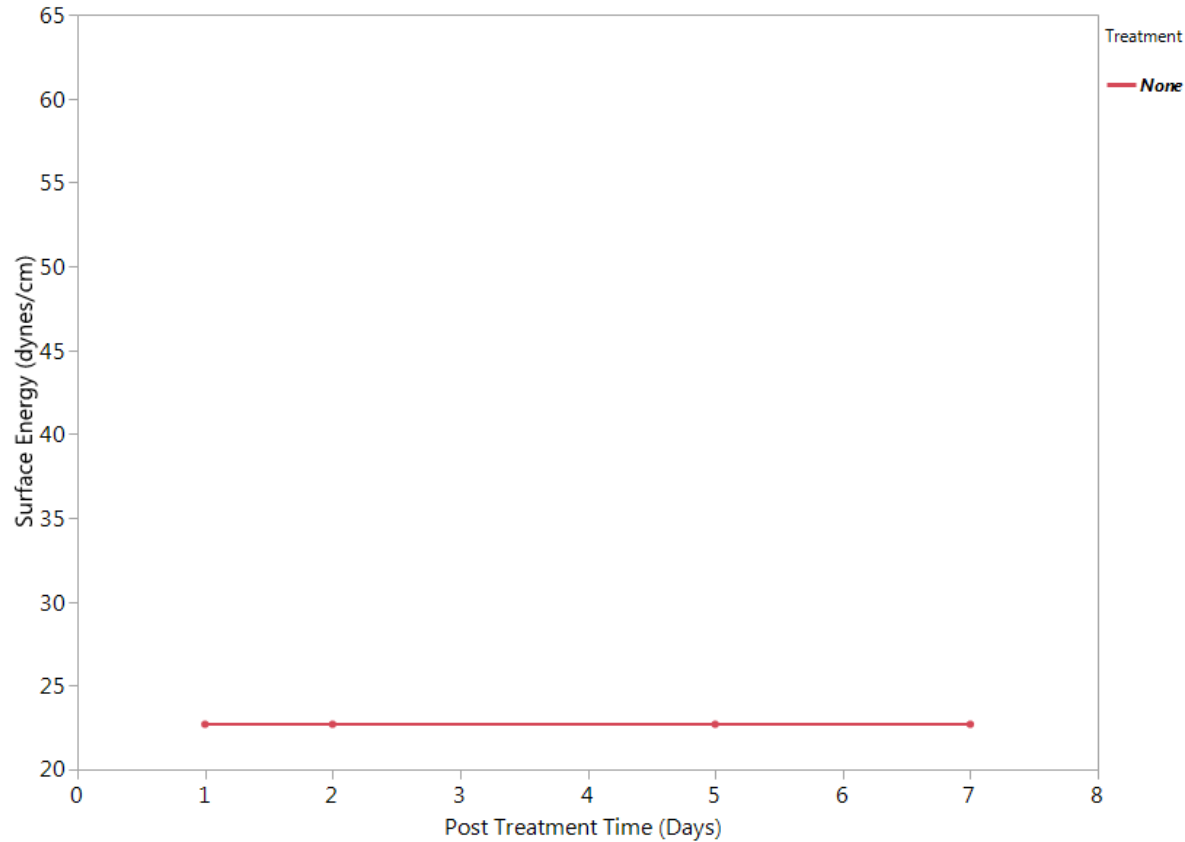
# QCM for Residue Analysis



# No Residue with DGL Films

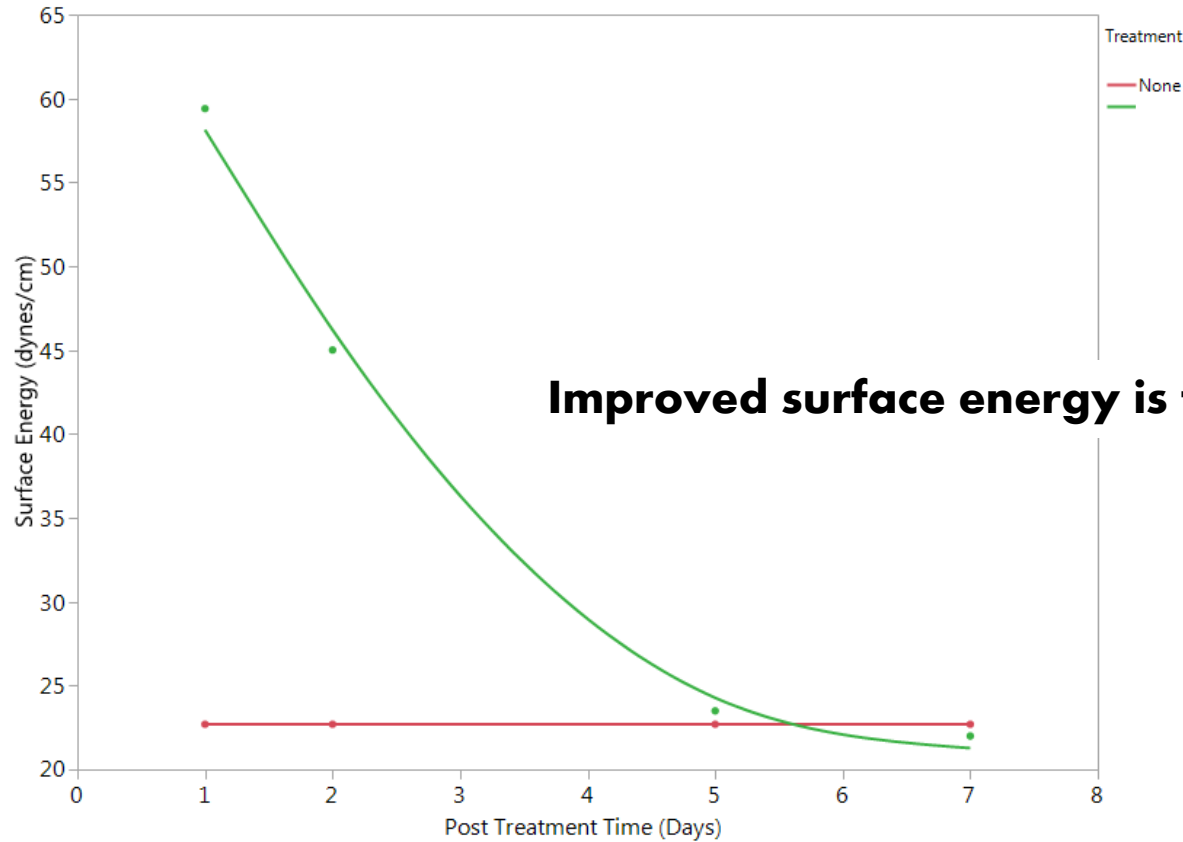


# Surface Energy – Silicone



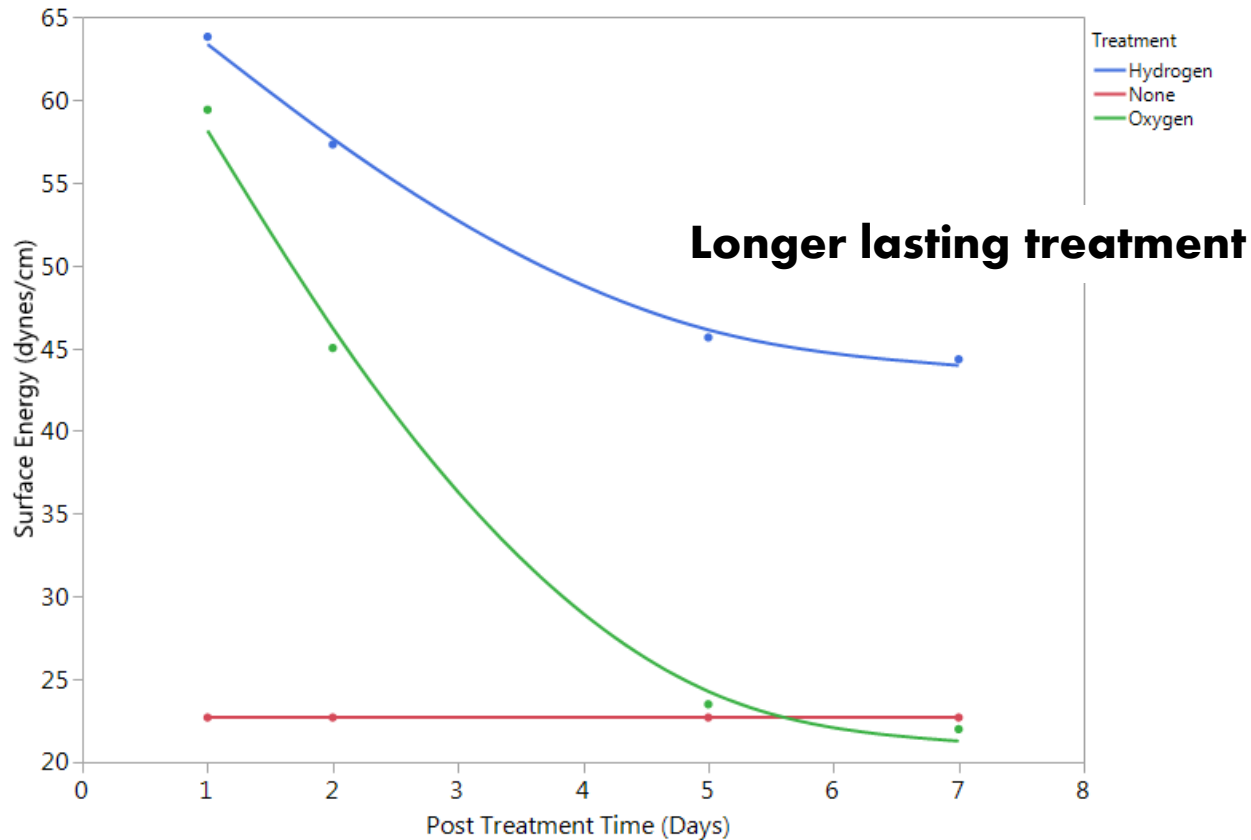


# Oxygen Plasma Treatment



**Improved surface energy is fleeting**

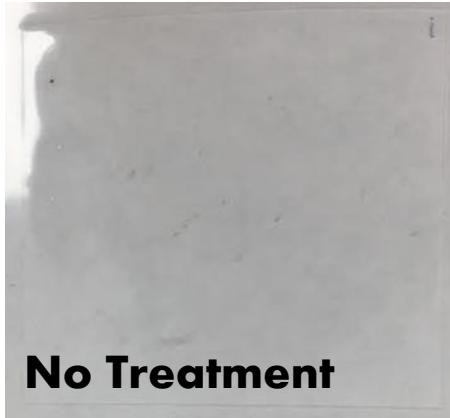
# H<sub>2</sub> Plasma Treatment



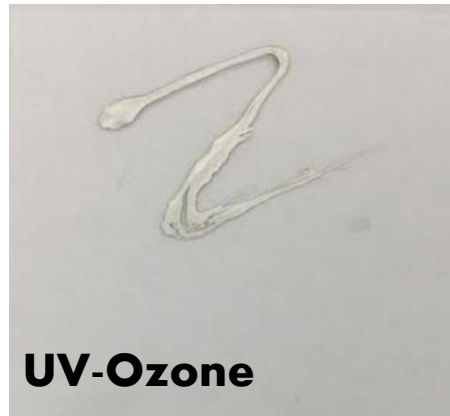
# Ink Adhesion



## Post Stress Testing With Tape



**No Treatment**



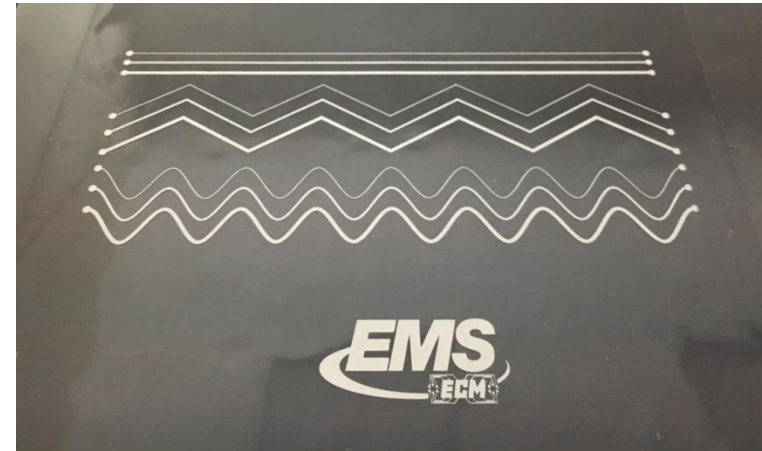
**UV-Ozone**



**No Ink Adhesion**



**Good Ink adhesion**



**Screen Printed**

# Ink Adhesion Summary



Treatment	Days of treatment Effectiveness	Ink Adhesion (EMS-CI-1036)	Comments
UV Ozone	1	Good	Treatment <u>not</u> effective after ink cure
O <sub>2</sub> Plasma	3	Good	Treatment <u>not</u> effective after ink cure
H <sub>2</sub> Plasma	>7	Good	Treatment <u>remains effective</u> after ink cure

# Continued Challenges

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- ▶ Treatment Equipment and Time Availability
- ▶ Film handling
  - Soft
  - Film Support
  - Release Properties of film, coversheet and substrate
- ▶ Post printing processes
- ▶ **Goal: Work with partners interested in unique silicone and other substrates**



# Delphon Silicone Offerings



POLYCARBONATE COVERSHEET	POLYETHYLENE COVERSHEET	POLYETHYLENE COVERSHEET
Silicone Film	Silicone Film	Silicone Film
POLYETHYLENE SUBSTRATE	POLYESTER SUBSTRATE	Bonding Agent
		POLYESTER SUBSTRATE
		Optional PSA

	<b>DGL</b>	<b>PF</b>	<b>WF</b>
<b>Composition</b>	<b>Silicone</b>	<b>Silicone</b>	<b>Silicone</b>
<b>Appearance</b>	<b>Transparent</b>	<b>Transparent</b>	<b>Grey, Translucent</b>
<b>Silicone Thickness</b>	<b>1.5 mil, 6.5 mil, 17.0 mil</b>	<b>1.5 mil, 6.5 mil, 17.0 mil</b>	<b>1.5 mil, 6.5 mil, 17.0 mil</b>
<b>Coversheet</b>	<b>Polycarbonate, 5 mil</b>	<b>Polyethylene, 1 mil</b>	<b>Polyethylene, 1 mil</b>
<b>Substrate</b>	<b>Polyethylene, 4 mil</b>	<b>Polyester, 5 mil</b>	<b>Polyester, 5mil</b>
<b>Hardness (Shore A)*</b>	<b>32-50</b>	<b>32-50</b>	<b>32-50</b>
<b>Tensile Strength (MPa)*</b>	<b>6.7</b>	<b>6.7</b>	<b>6.7</b>
<b>Ultimate Elongation %*</b>	<b>&gt;140</b>	<b>&gt;140</b>	<b>140</b>
<b>Hysteresis**</b>	<b>&lt;1%</b>	<b>&lt;1%</b>	<b>&lt;1%</b>
<b>Use Temperature</b>	<b>-40°C to 220°C</b>	<b>-40°C to 220°C</b>	<b>-40°C to +150°C</b>
<b>Features</b>	<b>Ultraclean</b>	<b>Peelable</b>	<b>Bonded to substrate. Available with optional pressure sensitive adhesive backing</b>



# Summary

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- ▶ Silicone is a versatile substrate
  - Excellent biocompatibility, softness, and elasticity
- ▶ Learnings
  - Silicone residue and low energy potential problem for ink adhesion
  - Ultra-clean DGL can be a solution
  - Surface treatments have varying degrees of efficacy
- ▶ Continued challenges
  - Treatment availability and time
  - Film handling
- ▶ **Goal: Work with partners to develop unique substrates for their products**

# Acknowledgements

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- ▶ Contacts:
  - Victoria Tran – Research and Development Director – [vtran@delphon.com](mailto:vtran@delphon.com)
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# Thank you

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