PDMS Films for Printed Electronics – Methods and Advancements

February 15, 2018

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DELPHON Industries

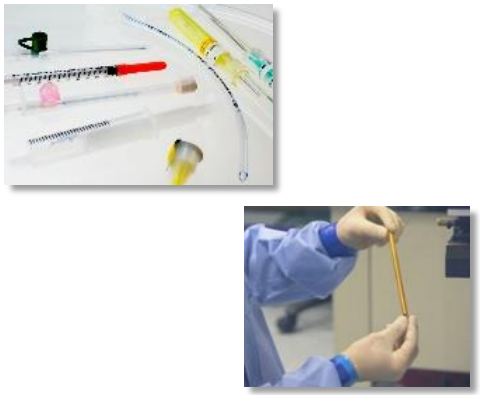
DELPHON

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

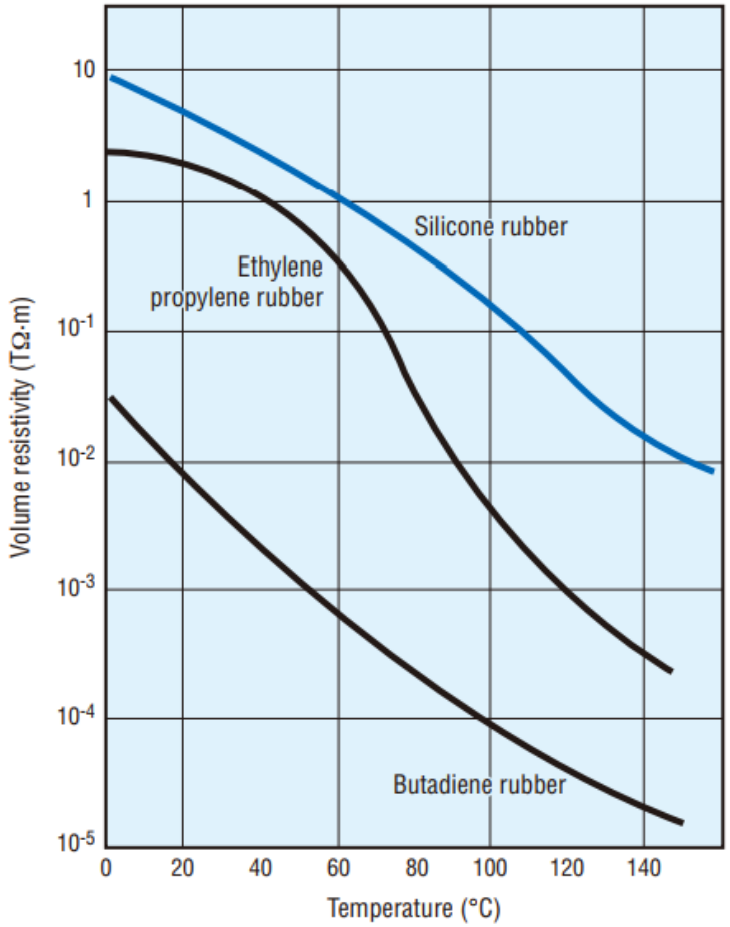
- Properties & uses of silicones
- Characterizing challenges with silicones
- Overcoming challenges with silicones
- Continuing efforts in silicone films for printed, flexible and stretchable electronics

Silicone – Unique and Versatile

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

Silicone in electronics

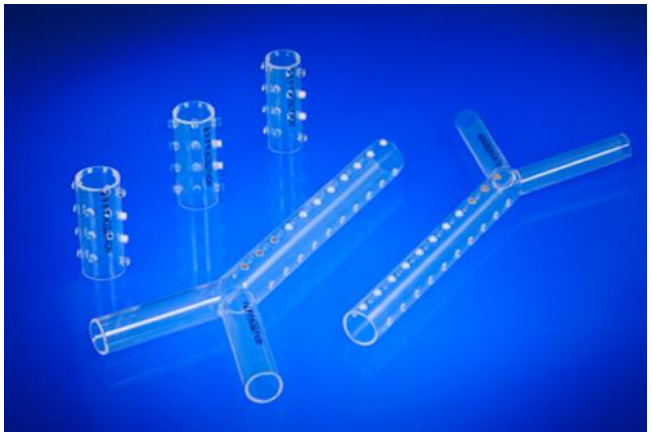
- Wide operating temperature range from -40 to +300°C
- Excellent electrical properties
  - Naturally insulative
  - Dope for conductivity
- UV resistance
- Vibration Absorbing
- Resistance to humidity and water

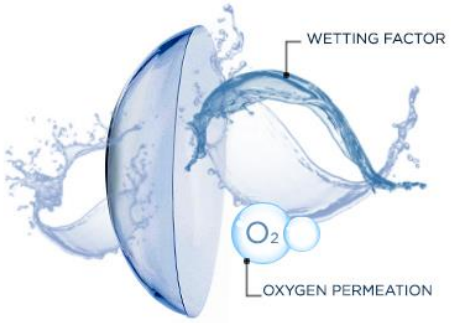


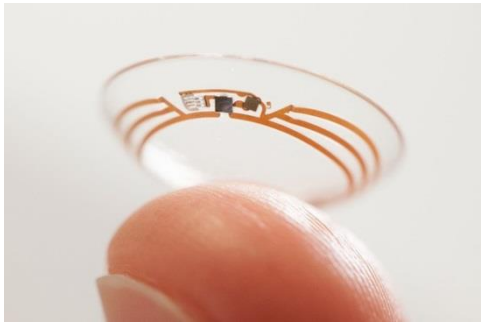
https://acc-silicones.com
https://Shinetsu.com

Silicone for Medical Devices

- Biocompatible
- Physiologically Inert







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

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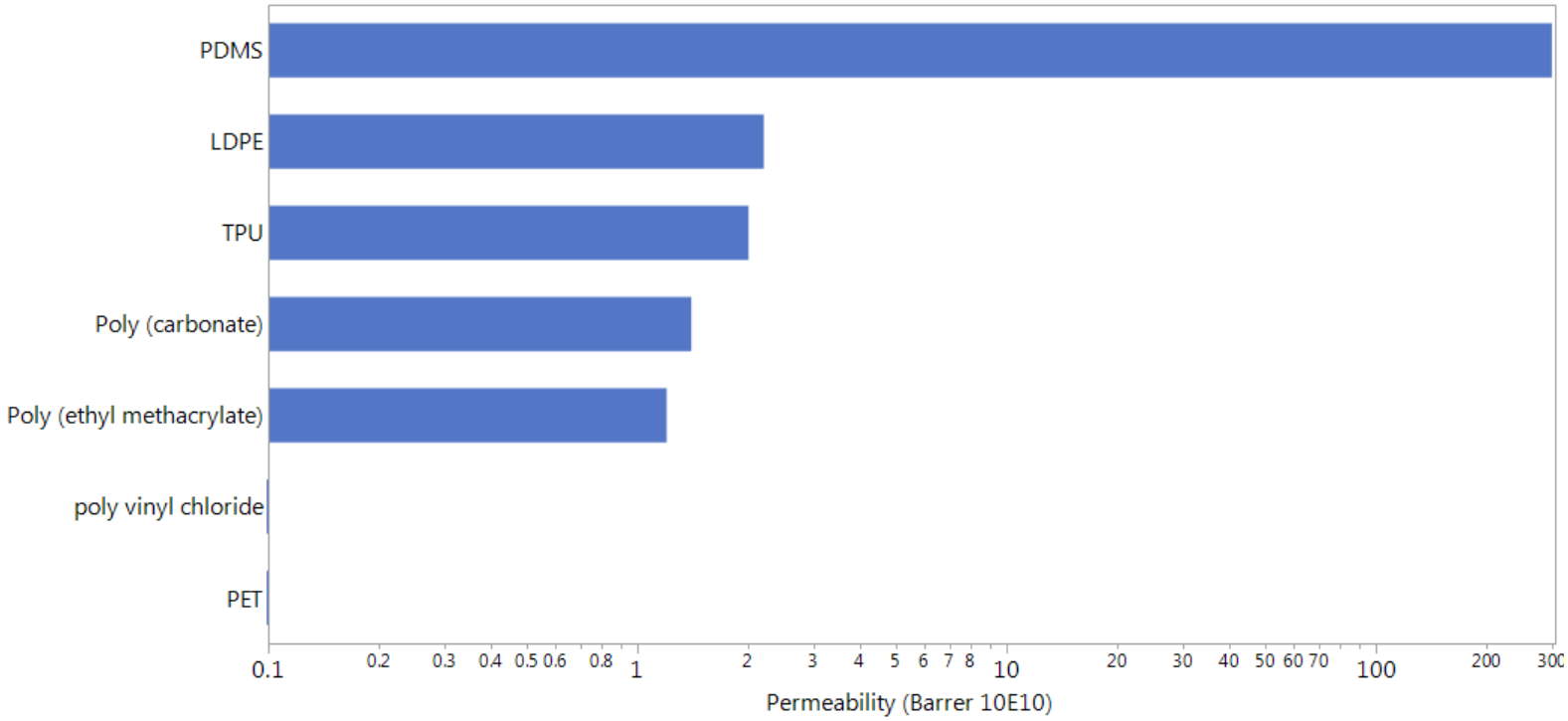
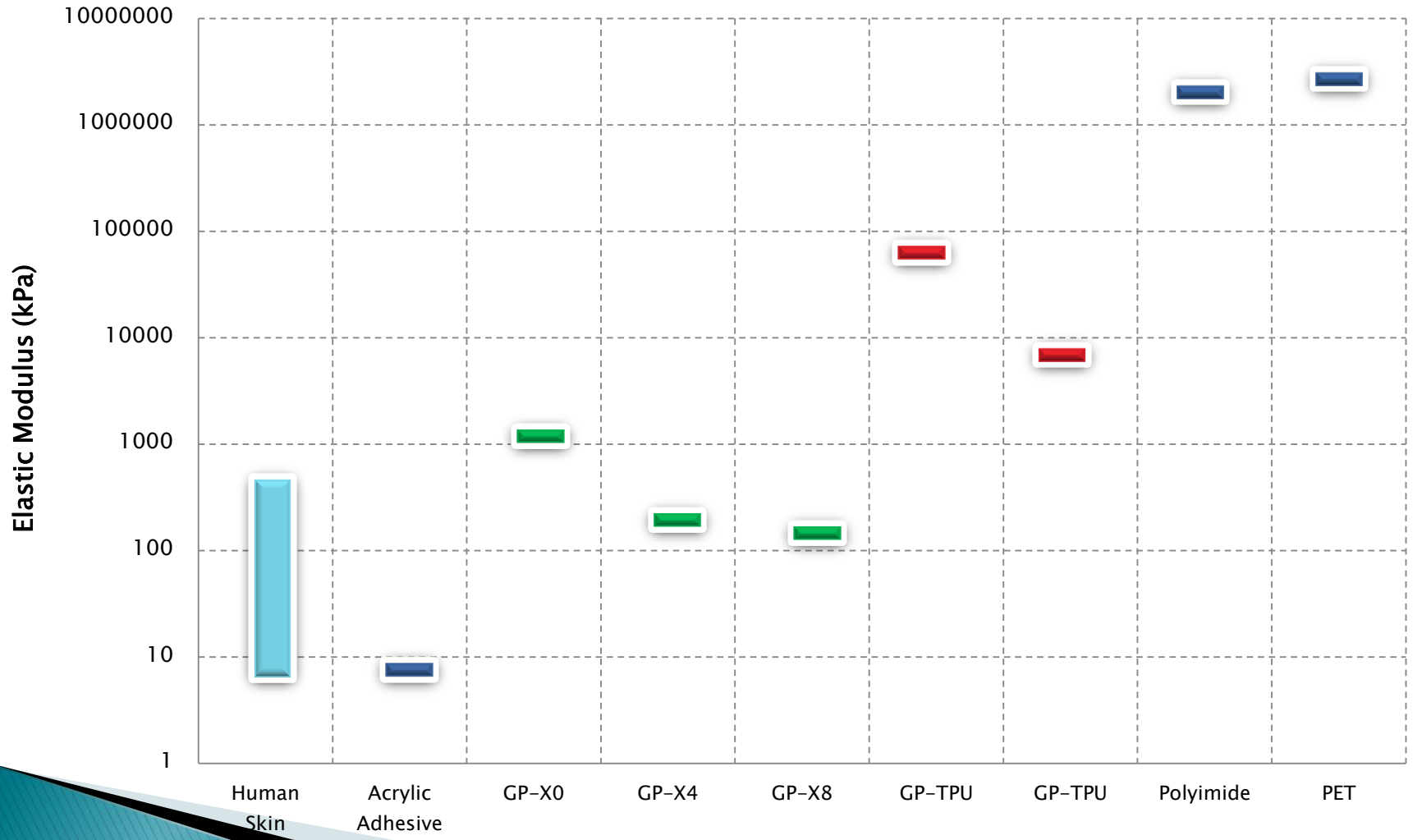
Oxygen Permeability

Silicone provides the necessary oxygen permeability for metabolic and biological processes



Adapted From: Polym. J., Vol. 37, No. 6, 2005

Silicone is Soft



Adapted from: ACS Nano. 2017 Oct 24;11(10):9614-9635

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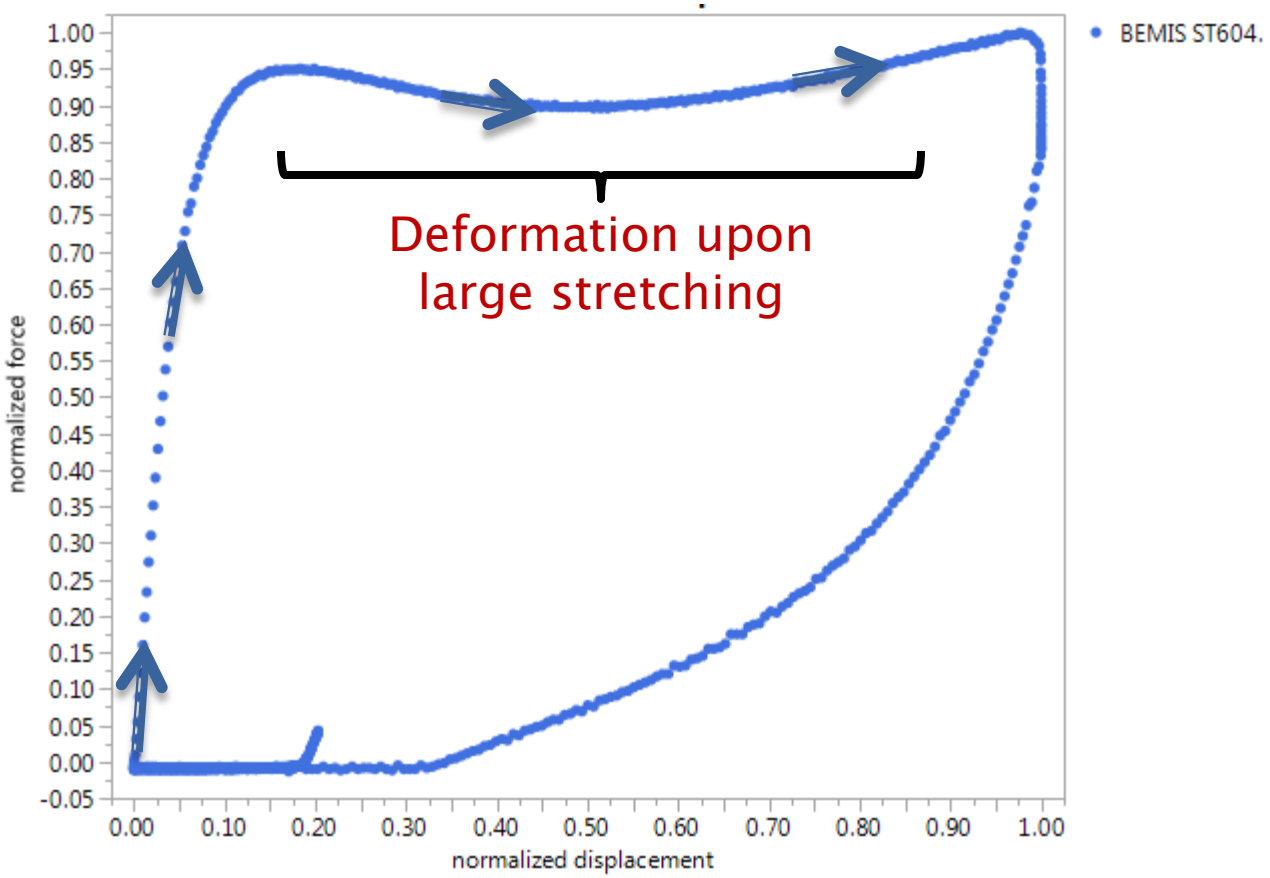
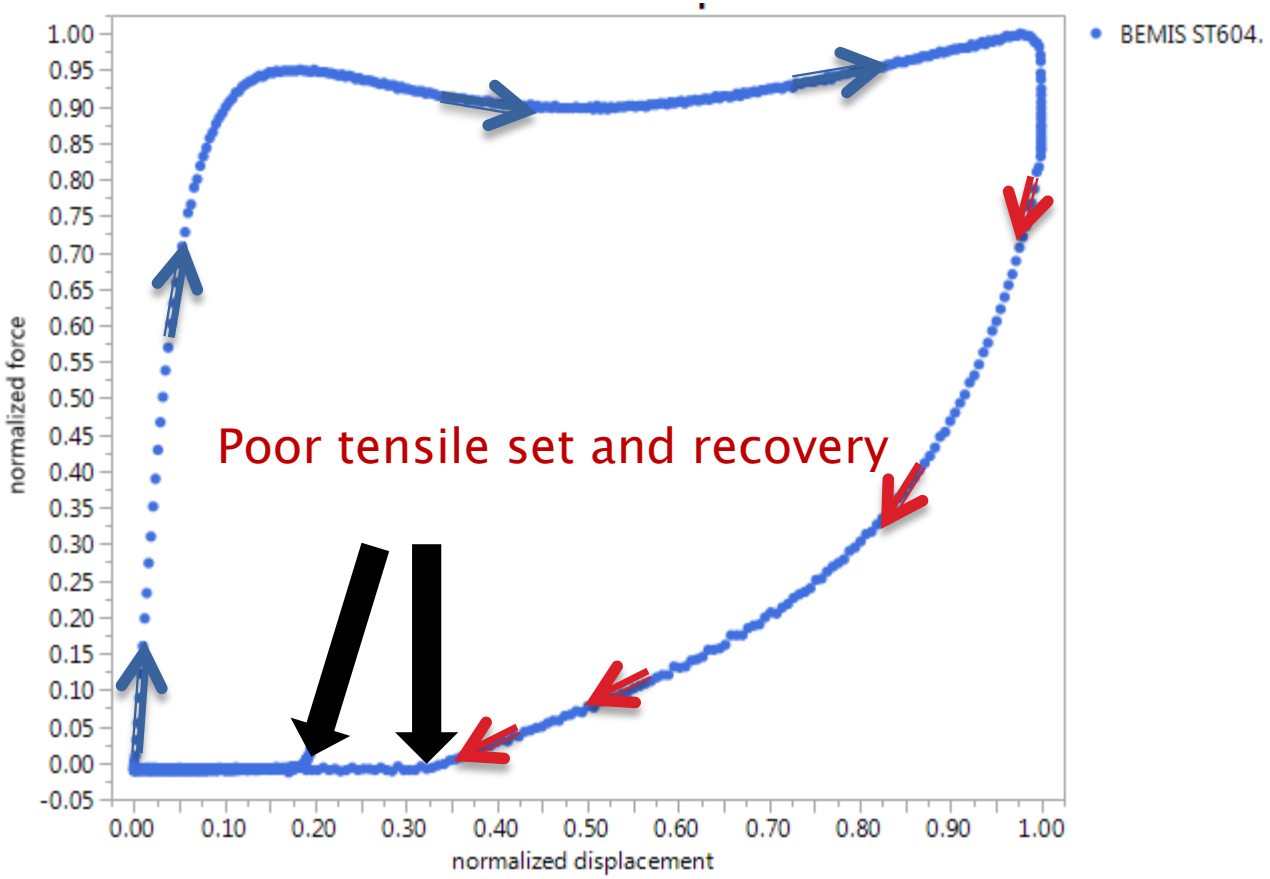
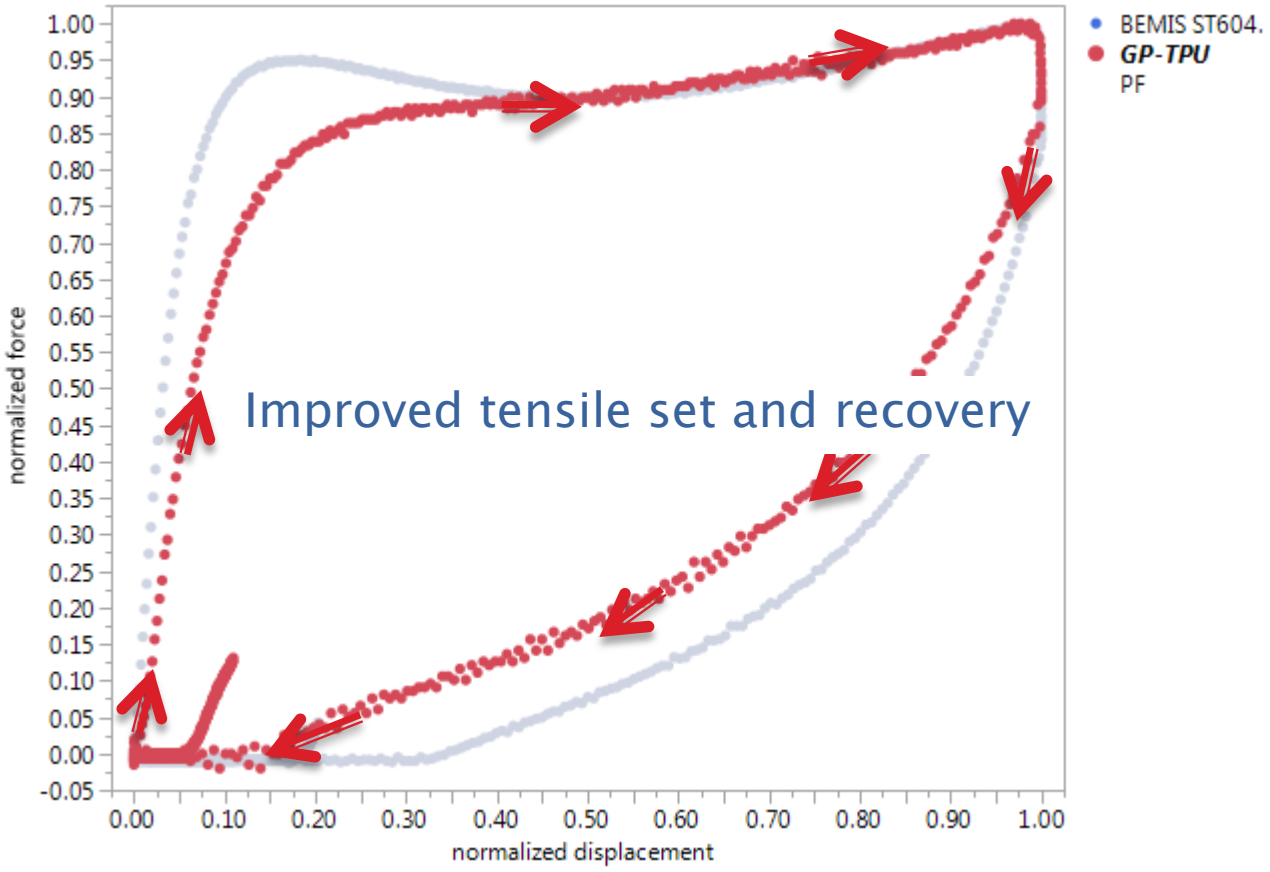
TPUs & Elasticity



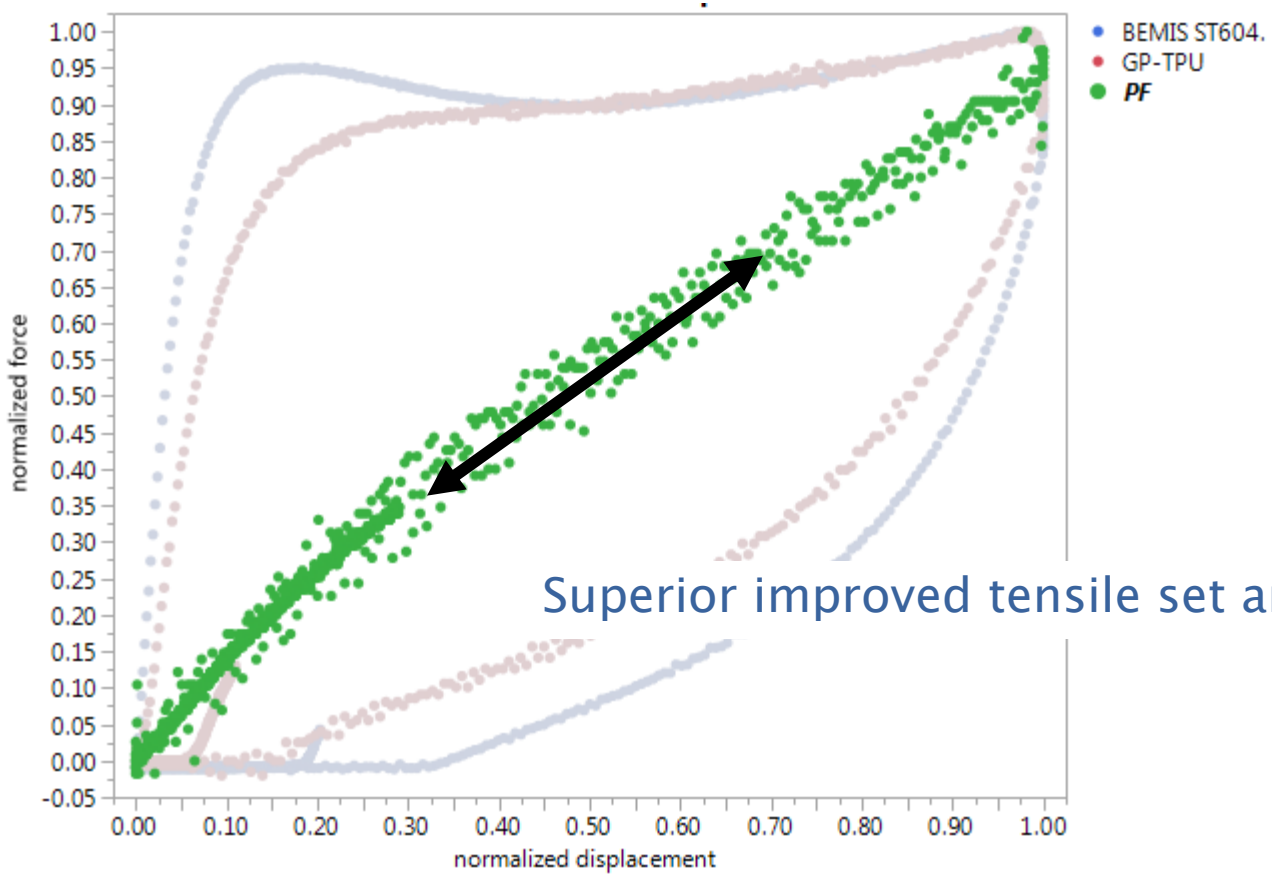
TPUs & Elasticity



FHE & Elasticity

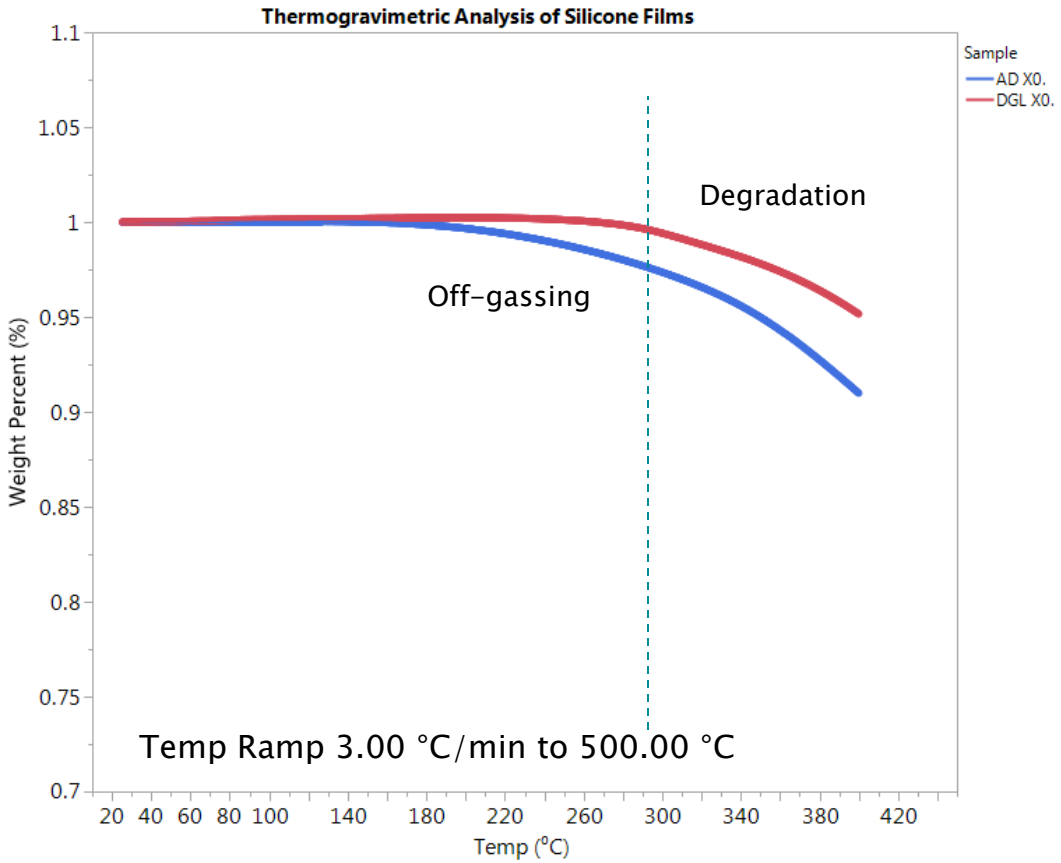


Silicones are Elastic

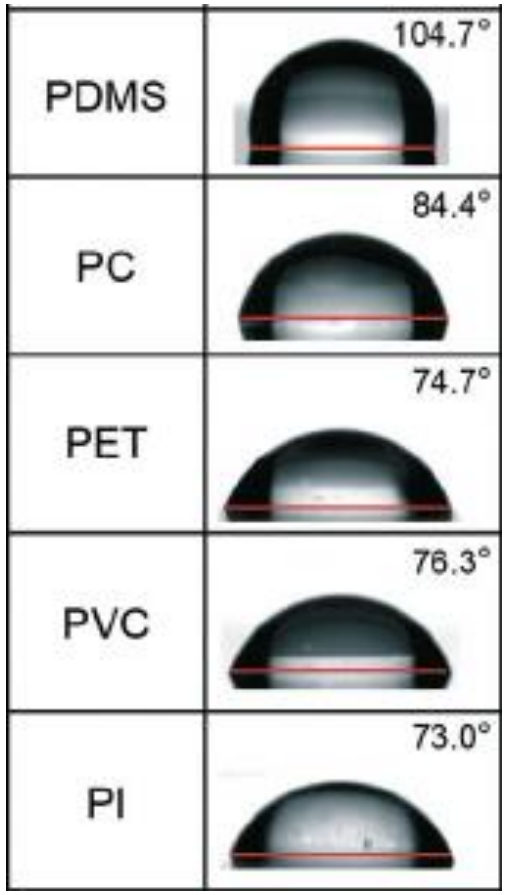


Superior improved tensile set and recovery

Silicones are Heat Resistant



Challenges with Silicone

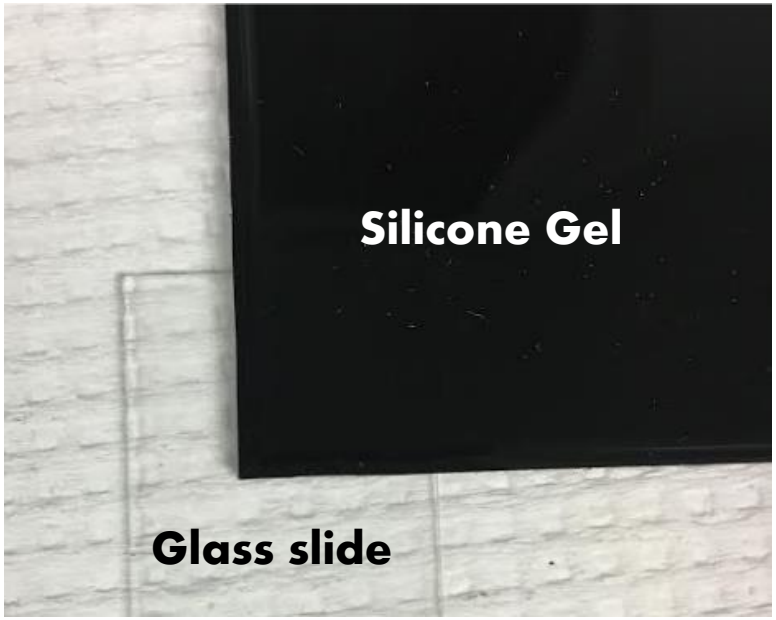


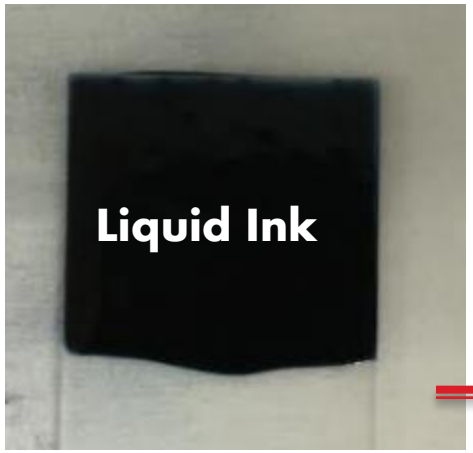
- Low Energy
- Low Energy Residue

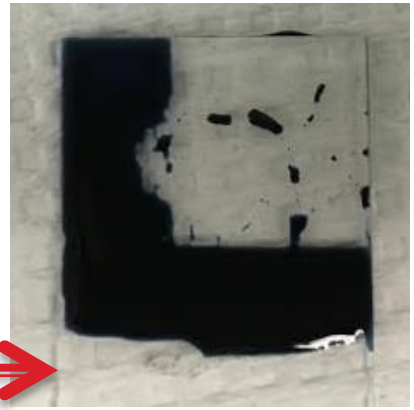
- Poor surface wetting
- Poor ink adhesion
- Poor device bonding

Wu, Jing & Yoon Lee, Nae. (2014)

Silicone Residue Induces Dewetting

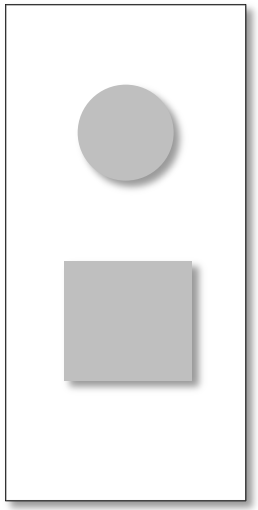






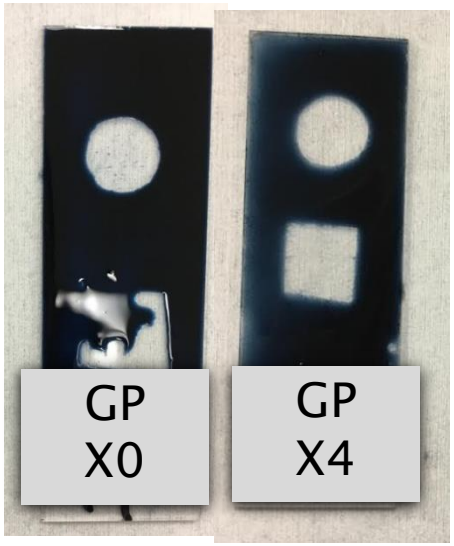
Ink dewets

Ultra-Clean Silicone

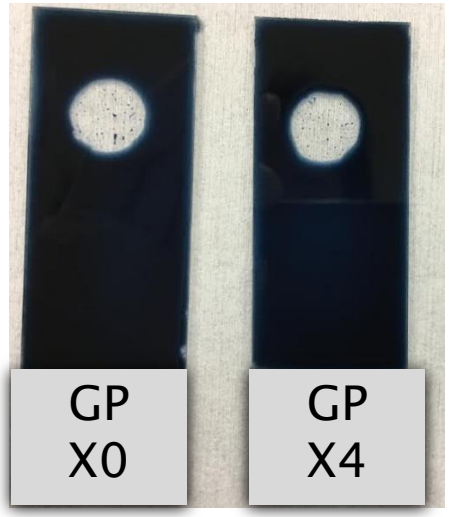


Positive control

Test sample



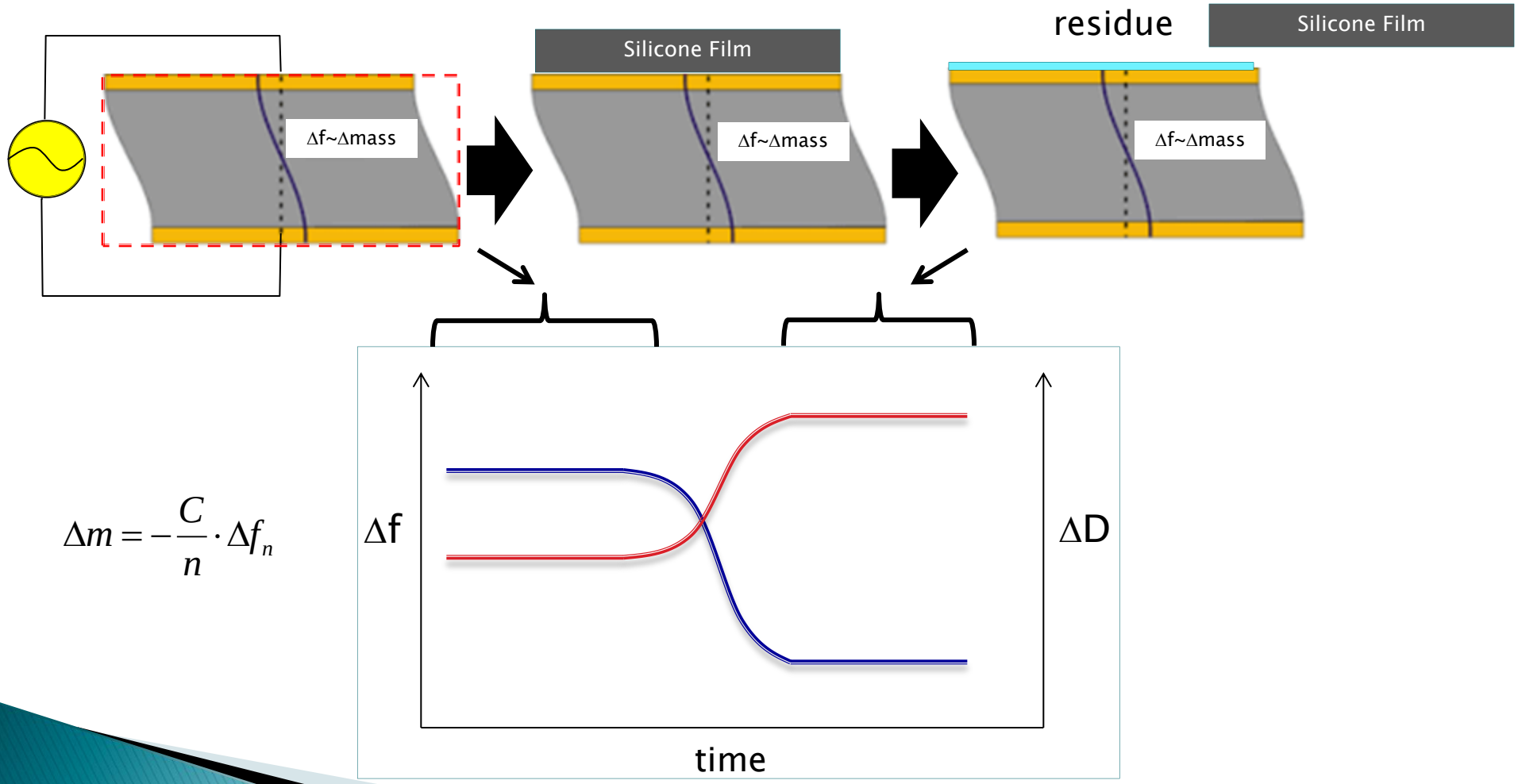
Standard Silicone



DGL film

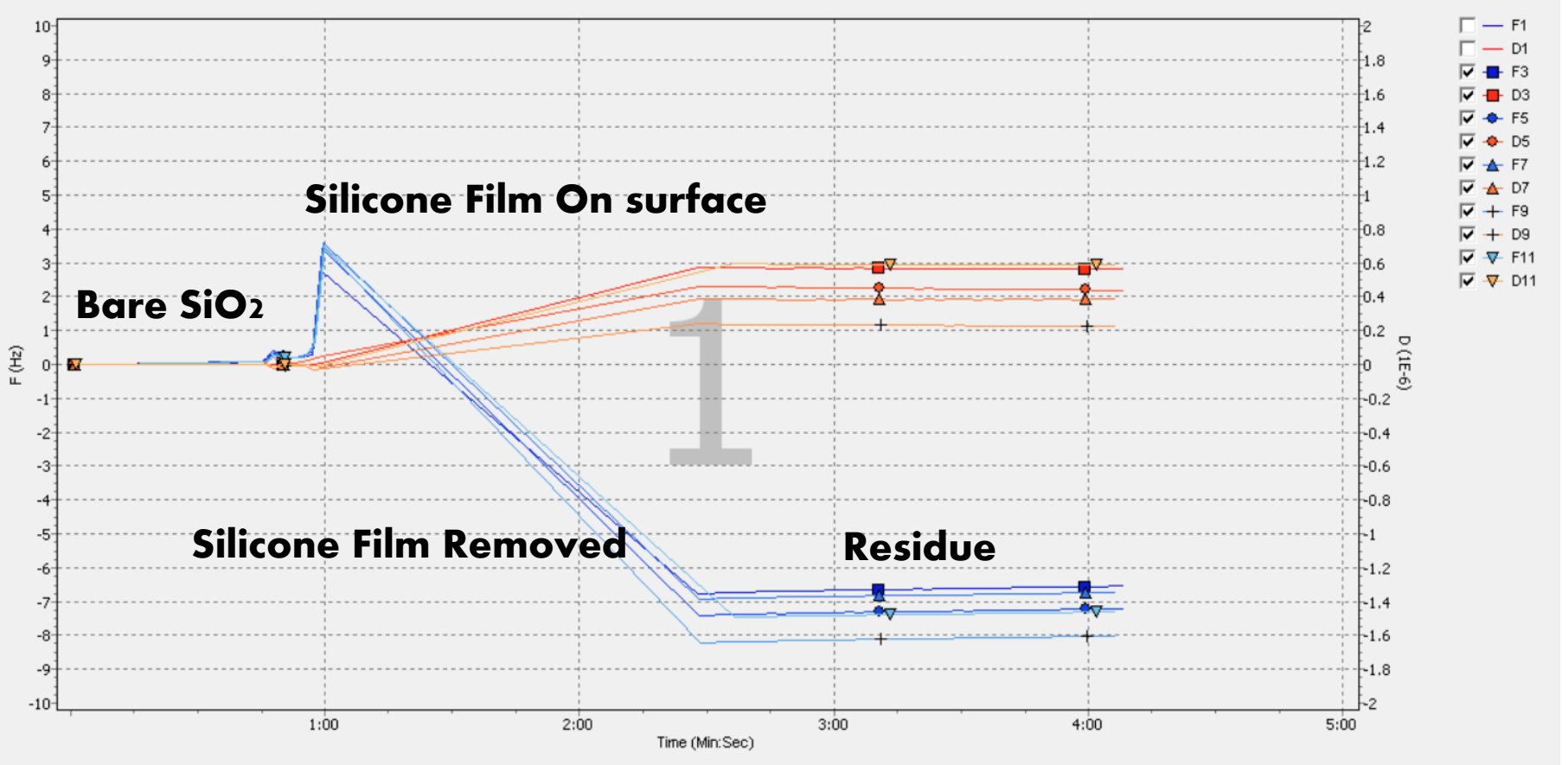
- DGL film minimizes ink dewetting due to residue
- Can we quantify how much residue induces dewetting?

QCM for Residue Analysis

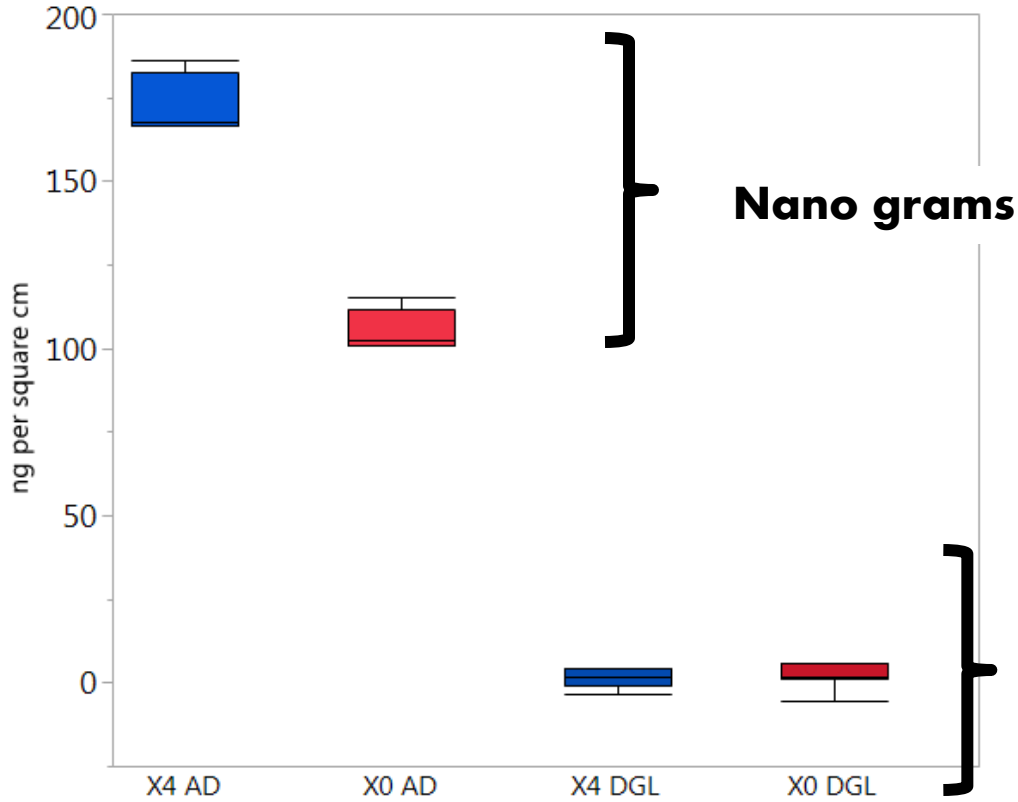


$$\Delta m = -\frac{C}{n} \cdot \Delta f_n$$

QCM for Residue Analysis



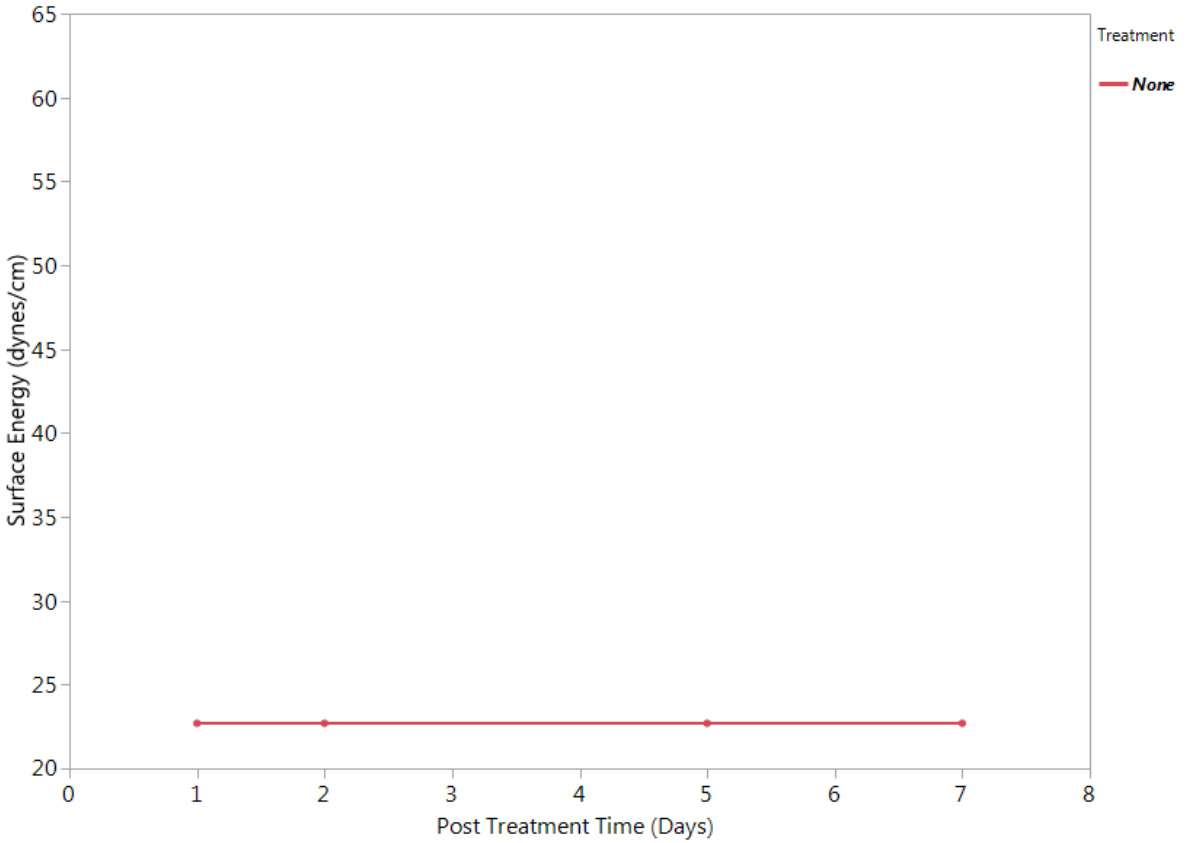
No Residue with DGL Films



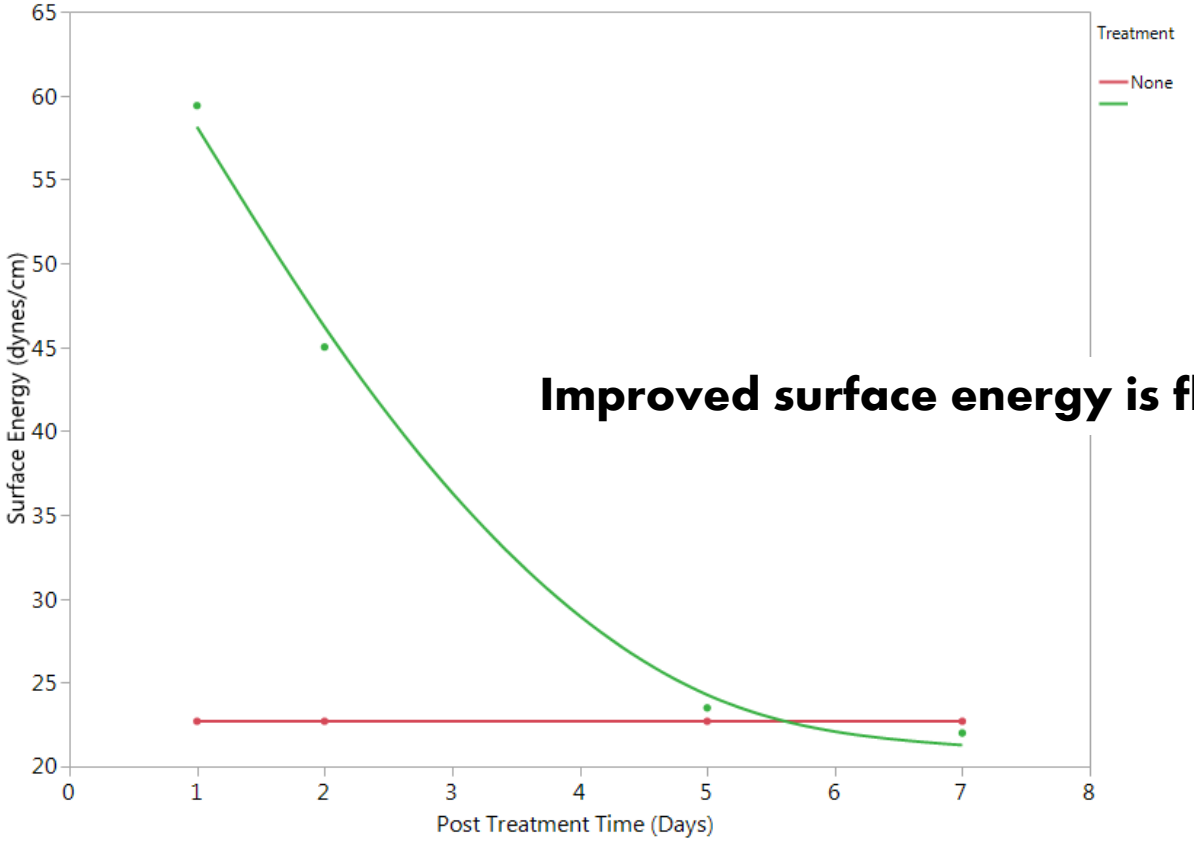
Nano grams of residue detected

No residue detected

Surface Energy – Silicone

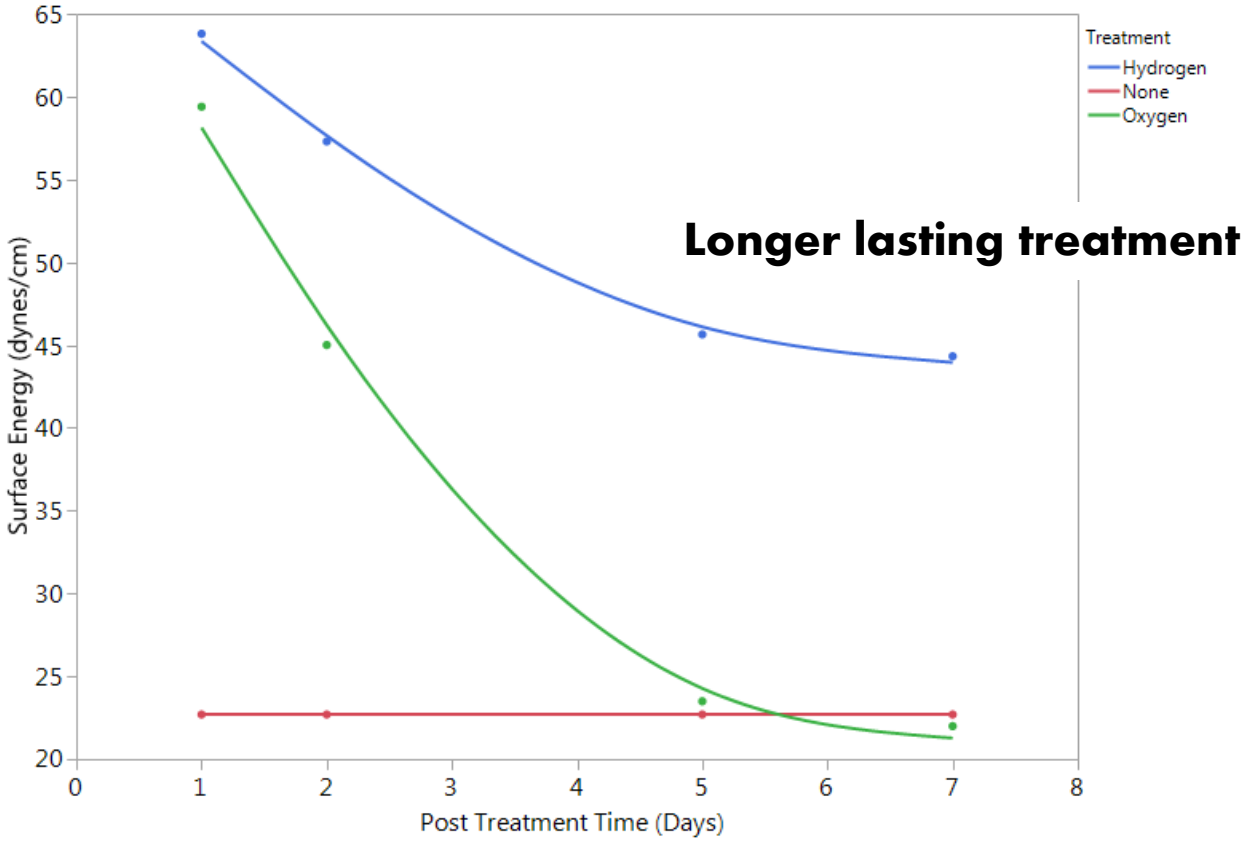


Oxygen Plasma Treatment



Improved surface energy is fleeting

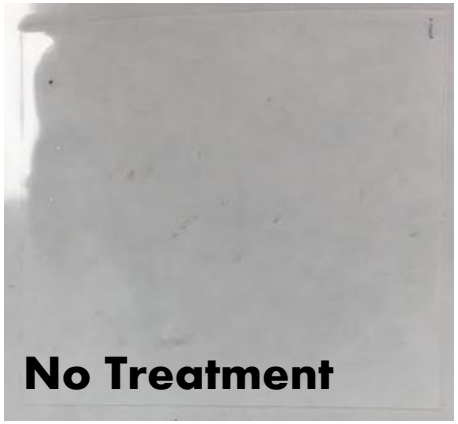
H_2 Plasma Treatment

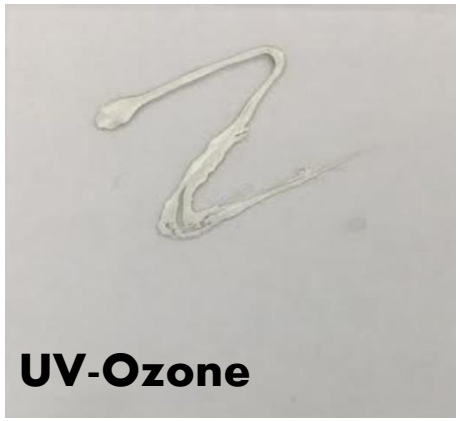


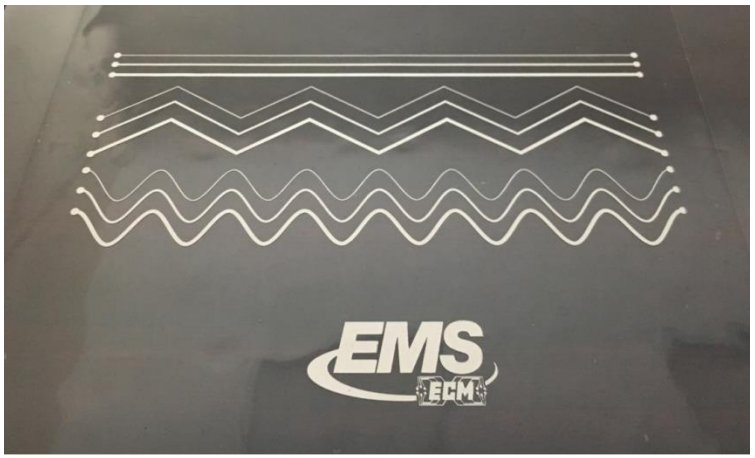
Longer lasting treatment

Ink Adhesion

Post Stress Testing With Tape







Screen Printed

No Ink Adhesion

Good Ink adhesion

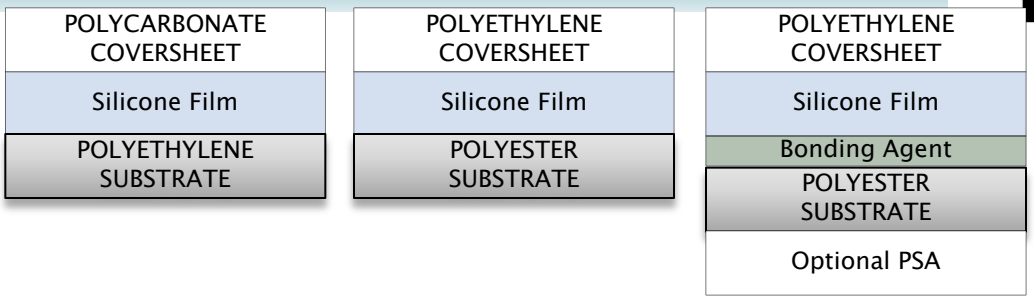
Ink Adhesion Summary

Treatment	Days of treatment Effectiveness	Ink Adhesion (EMS-CI-1036)	Comments
UV Ozone	1	Good	Treatment not effective after ink cure
O_2 Plasma	3	Good	Treatment not effective after ink cure
H_2 Plasma	>7	Good	Treatment remains effective after ink cure

Continued Challenges

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

Delphon Silicone Offerings



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

Summary

- 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

- Joey Flores – Automation specialist
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- Contacts:
  - Victoria Tran – Research and Development Director – vtran@delphon.com
  - Darby Davis – VP of Sales & Marketing – darby@gelpak.com
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Thank you