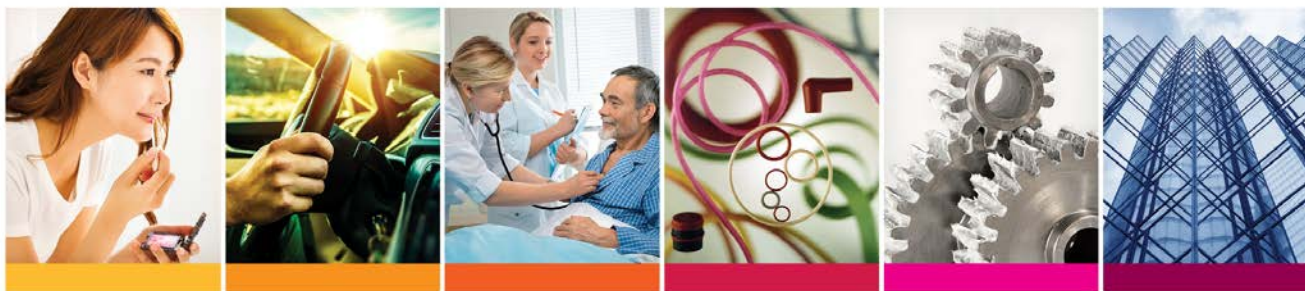




Consumer Solutions



High Temperature Gels

DOWSIL™ EG-3810 Dielectric Gel

DOWSIL™ EG-3896 Dielectric Gel



consumer.dow.com

Agenda

- Applications
- Positioning
- Portfolio
- Technical Content
- Packaging and Collateral
- Conclusion

■ Meeting Changed Market Needs

DOWSIL™ EG-3810 Dielectric Gel

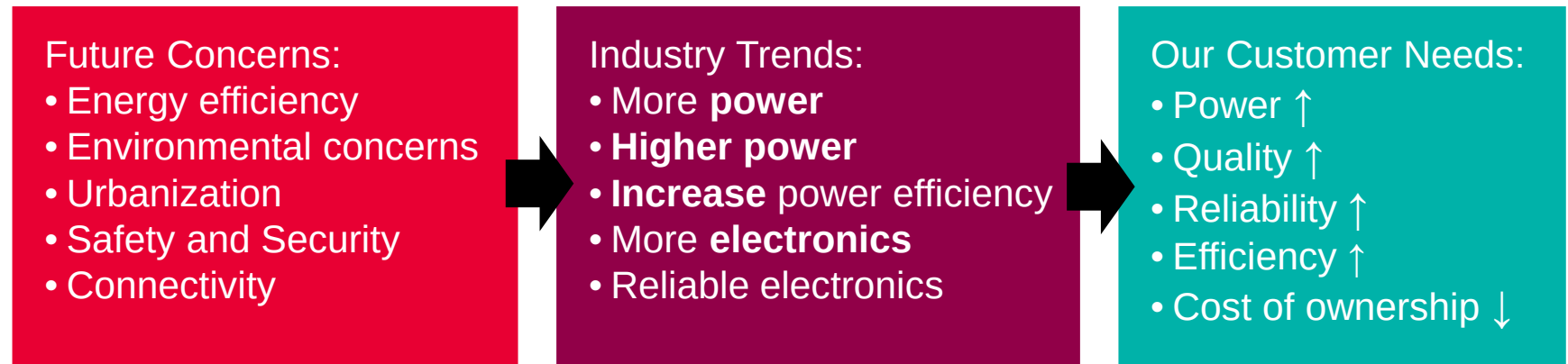
DOWSIL™ EG-3896 Dielectric Gel

Enable our customers to provide protection of power modules and of other applications requiring gel protection

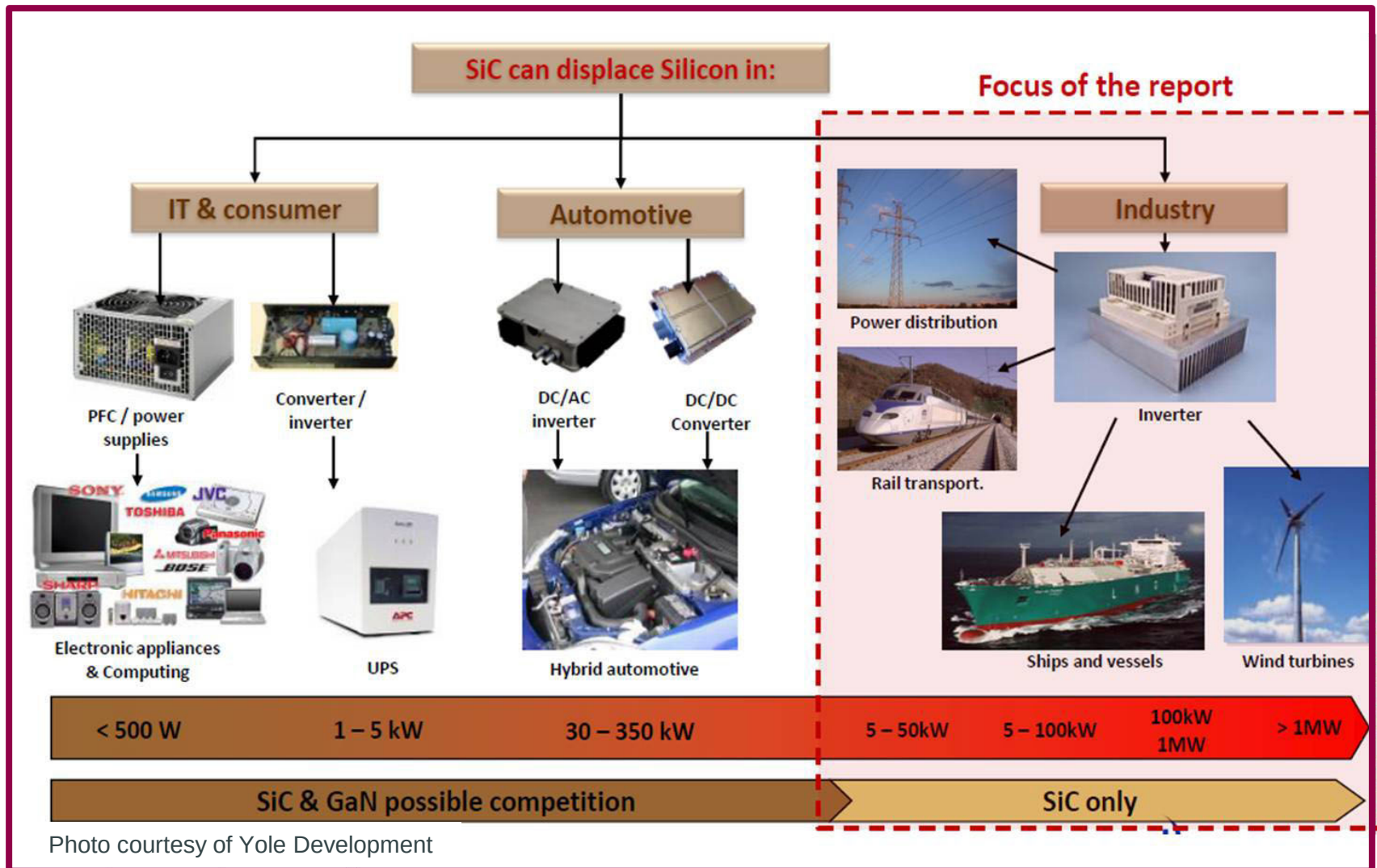
- Over a large temperature range of -60°C to +200°C (essential feature of DOWSIL™ EG-3810 Dielectric Gel)
- With improved reliability thanks to the built-in toughness and adhesion capability (essential features of DOWSIL™ EG-3896 Dielectric Gel)

Industry trends

- Various applications in power electronics
- (Uninterruptible) power supplies and inverters to various external markets



Market – What is Power Electronics?

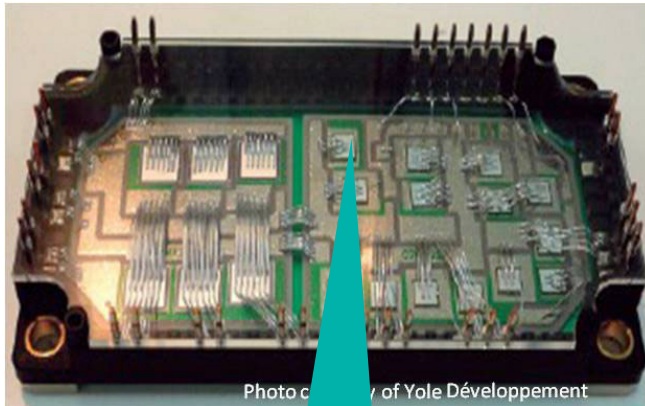


Technology Drivers – Impact on Assembly Techniques

- Pushing Silicon (Si) based power semiconductors toward their limits
- Adoption of Silicon Carbide (SiC) and Gallium Nitride/Silicon (GaN/Si) based power semiconductors
- Consequences on assembled modules and discrete devices
 - Increase of operating temperatures, theoretically well above 300°C (200°C for Si)
 - Increase of power density, hot spots creation, high stress
 - Increase of lifetime, stretch on materials capabilities
 - Increase of reliability

Power Devices – What is it all about?

Primary Target: IGBT Modules



Gel Potting

Second Target



Discrete Power
Semiconductors

Photos courtesy of Yole Development

Other Market Segments/Applications

Automotive

- Car inverter/converter for hybrid and electric vehicles



Photo courtesy of Yole Développement

- Power modules for fuel efficiency systems (stop and start systems)

Other Applications

Sensors and actuators for both cold and hot applications

Photos courtesy of Yole Development

Applications

DOWSIL™ extended temperature gels allow wider operating range and longer design life.

- DOWSIL™ EG-3810 Dielectric Gel offers a unique extended temperature range on both the low end as well as high temperature performance (-60°C ~ 200°C) versus standard gels (-40°C ~ 180°C).
- DOWSIL™ EG-3896 Dielectric Gel, because of its toughness, offers a unique crack resistance and void formation resistance, and it shows better stability on vertical surface compared to standard gels.

DOWSIL™ EG-3810 Dielectric Gel

1-part gel

- Clear
- Gel Hardness (measured at 10mm): 78 grams
- Penetration 1/10 mm: 80
- Penetration $\frac{1}{4}$ cone: 84
- Heat cure only
 - 15 min at 125°C
 - 10 min at 150°C
- Temperature stability: -60°C to 200°C
- Best thermal stability among the two new gels
- UL flammability testing: upon request

DOWSIL™ EG-3896 Dielectric Gel

2-part gel

- Toughened gel → crack resistance and void formation resistance
- Self-priming → improved protection of modules
- Slightly hazy
- Gel hardness (measured at 10 mm): 220 grams
- Penetration 1/10 mm: 30
- Penetration 1/4 cone: 55
- Heat cure only
 - 30 min at 70°C
 - 10 min at 100°C
 - 5 min at 150
- Temperature stability: -40°C to 185°C
- UL 94 V-1 flammability classification

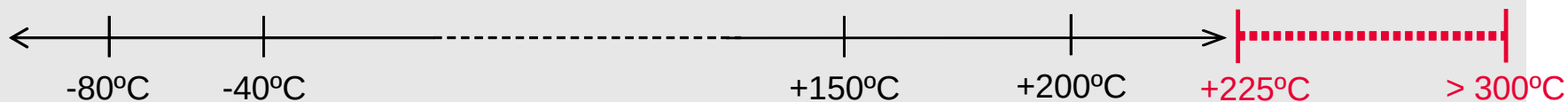
Gels Portfolio

	Unit	SYLGARD™ 527 Silicone Dielectric Gel	DOWSIL™ 3-4155 HV Dielectric Gel	DOWSIL™ 3-6635 Dielectric Gel	DOWSIL™ Q3-6575 Dielectric Gel	DOWSIL™ 3-4170 Dielectric Gel	DOWSIL™ EG-3896 Dielectric Gel	DOWSIL™ EG-3810 Dielectric Gel
Description		Dielectric gel	Dielectric Low T gel	Dielectric Low T gel	Dielectric Low T gel	Dielectric gel		
		2-part	2-part	1-part	2-part	2-part	2-part	1-part
Viscosity	Mixed (mPa·s)	500	1875	700	750	473	520	690
Penetration	¼ cone method (cured)						55	84
	1/10 mm	45	90	85	80	65		
Dielectric Strength	kV/mm	17	16	20	18	20	22	21
Cure Schedule		100°C/120 min 150°C/35 min	25°C/1 hr	100°C/120 min	25°C/24 hr 100°C/20 min	100°C/9 min 150°C/3 min	70°C/30 min	125°C/15 min
Working T Low/Hi	°C	-40/150	-80/175	-80/175	-80/175	-40/150	-40/185**	-60/200**

Ideal Gel for the Market

SYLGARD™ 527 Silicone Dielectric Gel

SYLGARD™ type with High T resistance



Operating Temperature (°C)

■ Challenges for Power Modules Encapsulation

- Physical protection with soft gel
- Moisture protection
- Dielectric insulation
- Temperature stability
 - Down -60° C
 - Up 200° C to 300° C
- Adherence
- Modules versus discretes, two different environments
 - Need to ensure all these functions along all service life of module (15-20 years)
- High volume availability at right cost

Specification for Silicone Gels

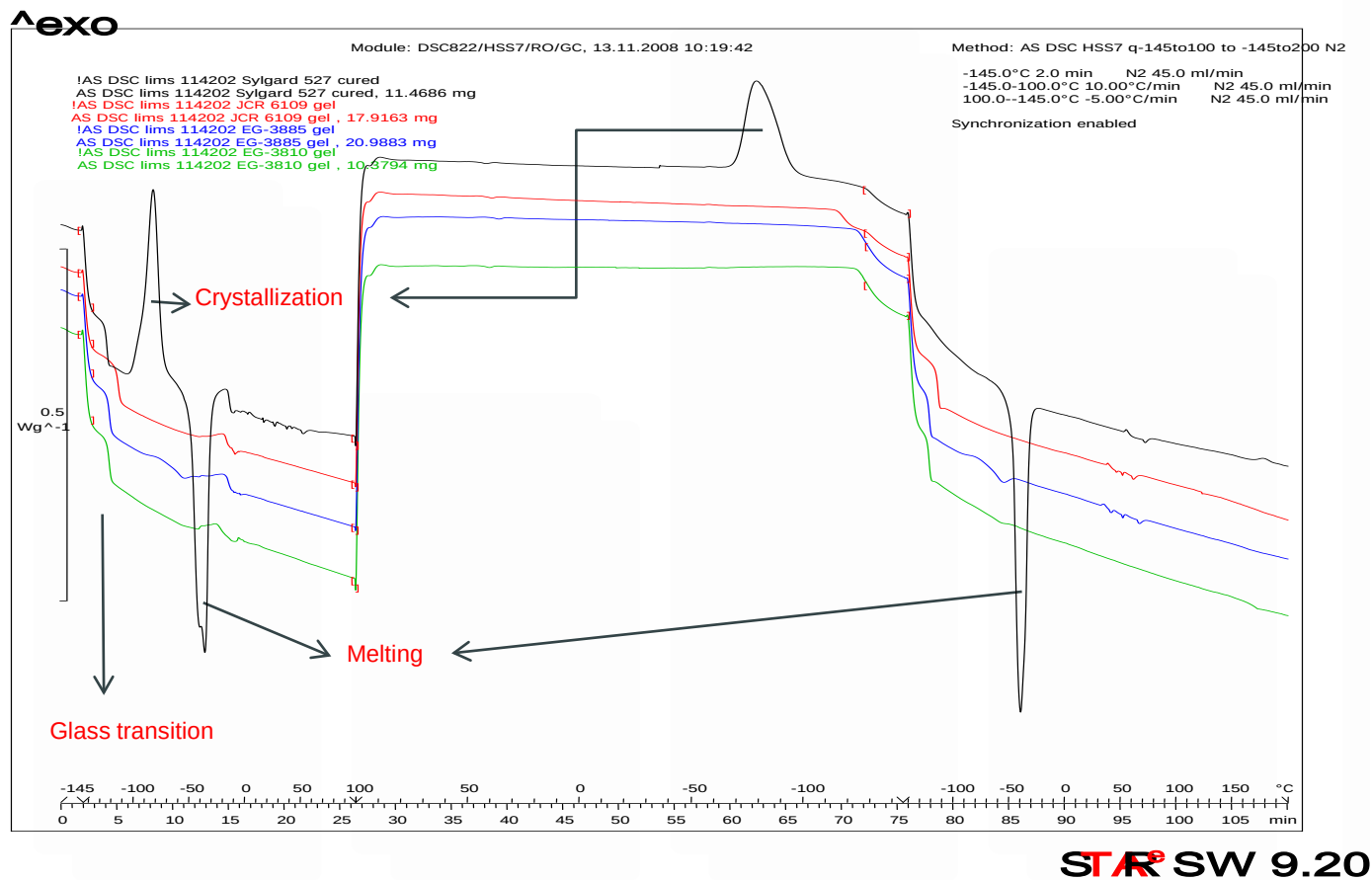
Typical Failure Mechanism:
Cracking with Delamination



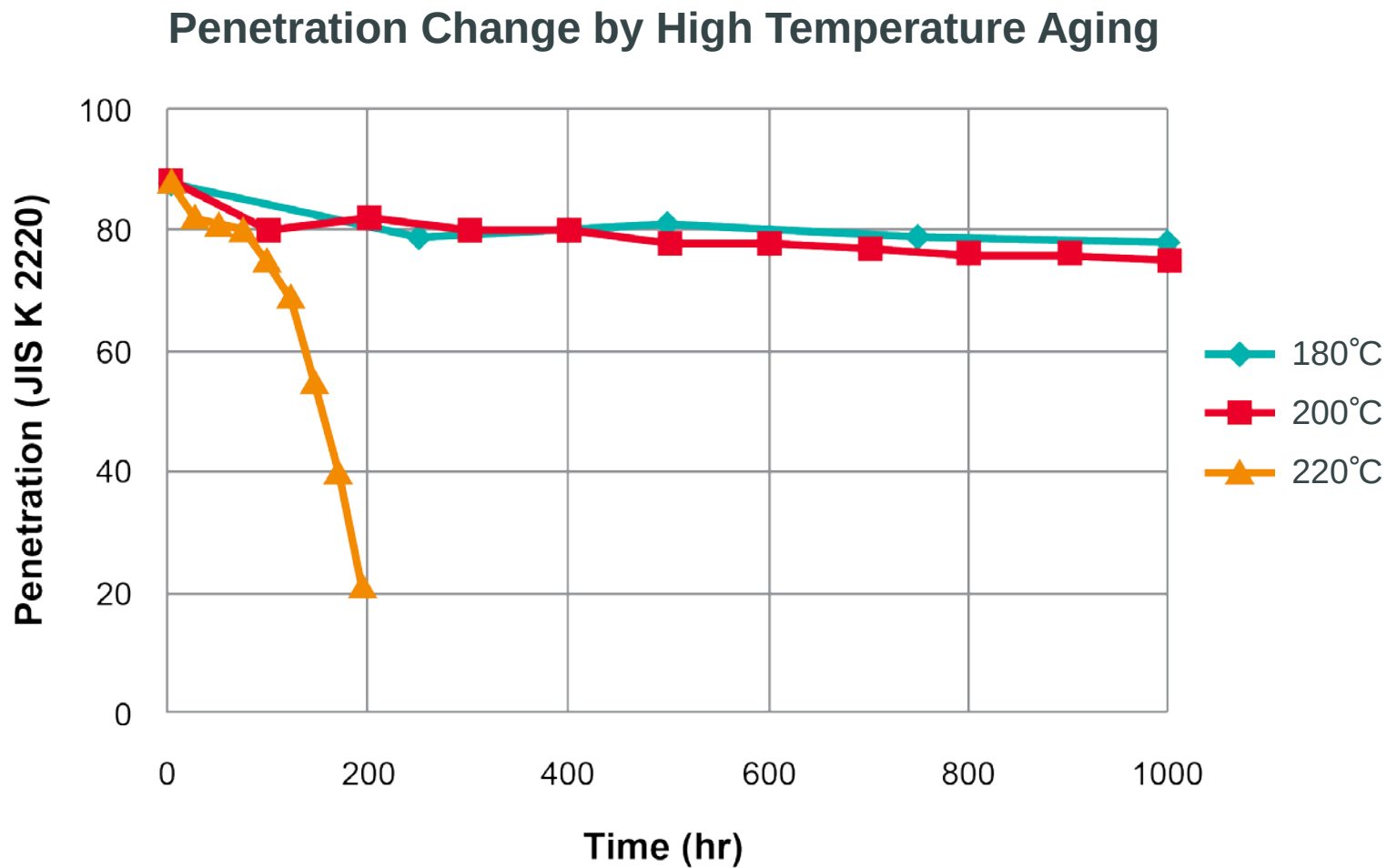
What's in the Toolbox?

- **Standard Polymers** that impart limited temperature stability to formulated gels.
 - SYLGARD™ 527 Silicone Dielectric Gel is one such gel
- **Tool to Extend Both Low and High Temperature Limits**
 - New DOWSIL™ EG-3810 Dielectric Gel is such a gel
- **Tool to Built-in Toughness**
 - New DOWSIL™ EG-3896 Dielectric Gel is such a gel
- **Phenyl Groups Containing Polymers:** addition of phenyl groups permit to achieve best temperature performances but at elevated cost
 - DOWSIL™ JCR 6109(N) Gel is such a gel

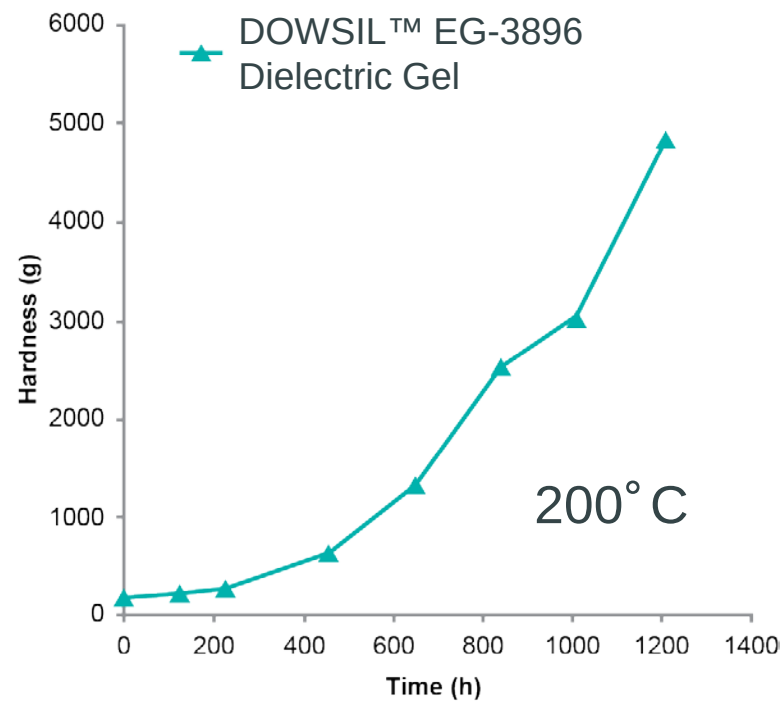
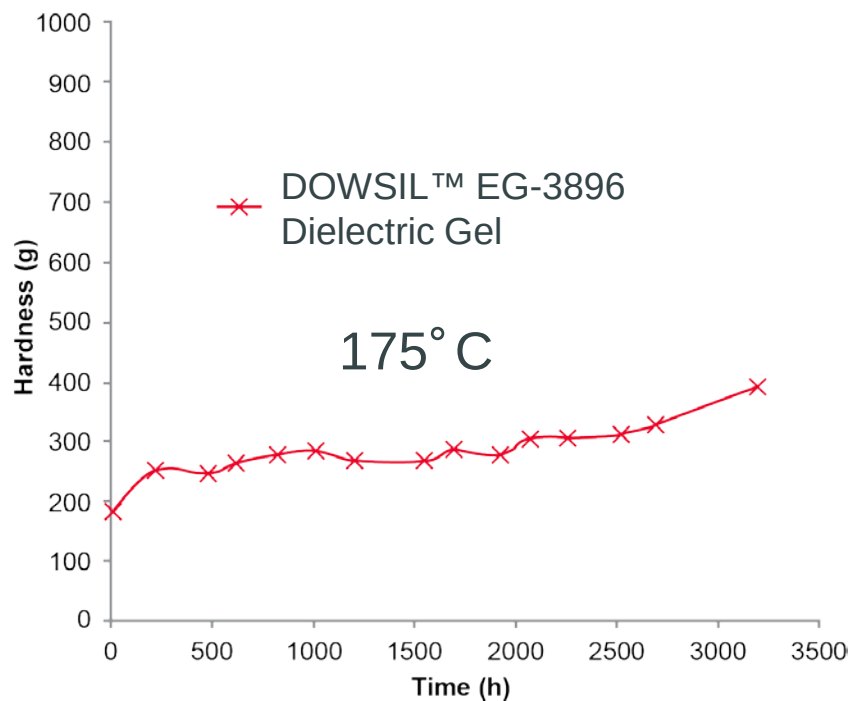
Low Temperature Behavior



DOWSIL™ EG-3810 Dielectric Gel – Reliability Status



DOWSIL™ EG-3896 Dielectric Gel - Reliability Status



Packaging Options, Documentation

- Packaging Information
 - DOWSIL™ EG-3810 Dielectric Gel: currently available in 1 kg plastic bottles (as sample), 18 kg pails, and 190 kg drums
 - DOWSIL™ EG-3896 Dielectric Gel: currently available in 2 kg plastic bottle kits (as sample) and in 36 kg pail kits
- Documentation Available
 - DOWSIL™ EG-3810 Dielectric Gel Data Sheet
 - DOWSIL™ EG-3896 Dielectric Gel Sell Sheet
 - DOWSIL™ EG-3810 Dielectric Gel Data Sheet
 - DOWSIL™ EG-3896 Dielectric Gel Sell Sheet

Conclusions

- These new gels, DOWSIL™ EG-3810 Dielectric Gel and DOWSIL™ EG-3896 Dielectric Gel, enable improved protection of:
 - Power modules such as IGBT modules
 - Automotive power modules
 - Sensors and actuators
- Over a large temperature range of -60°C to +200°C (essential feature of DOWSIL™ EG-3810 Dielectric Gel)
- With improved reliability thanks to the built-in toughness and adhesion capability (essential features of DOWSIL™ EG-3896 Dielectric Gel)
- *Advanced formulations* enabling 225 operating temperatures are being worked on.



— Thank You

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