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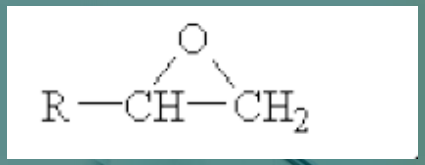

THE IMPORTANCE OF THE MIX RATIO, GLASS TRANSITION TEMPERATURE & STRESS ON EPOXY ENCAPSULATION

Webinar on 26th Mar 2021 , 4:00pm (MY Time)

Speaker: TC Loh (Msc Material Engineering)

WT Tham (Msc Chemistry)

Organized by: Penchem Technologies Sdn. Bhd.

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Outline

Session 1:

- Topic 1: Effect of Wrong Mix Ratio & Mixing
- Topic 2: Effect of Tg of Epoxy Encapsulant
- Topic 3: Thermal stress of Epoxy Encapsulant

Session 2:

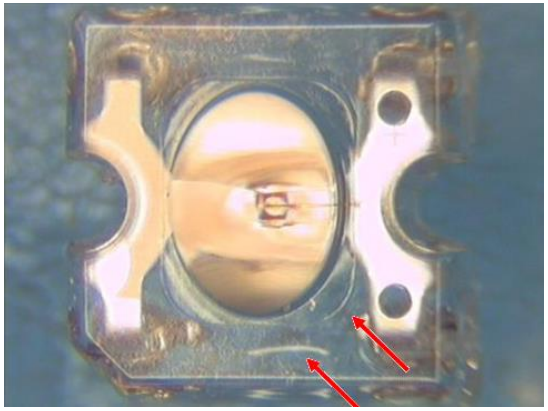
- Products Introduction

Topic 1: Effect of Wrong Mix Ratio & Mixing

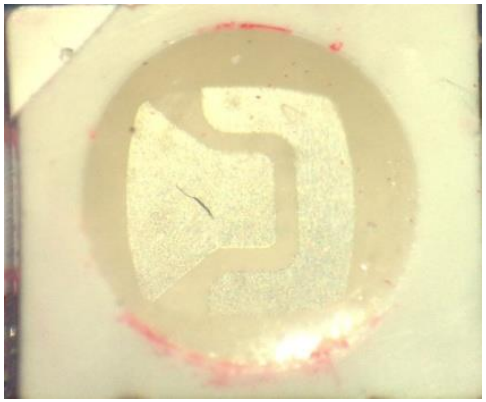
- 2 Part Epoxy Encapsulant / Potting / Adhesives (Epoxy/anhydride, Epoxy/polyamine, etc.)

Wrong mix ratio / improper mixing:

a) Weighing out of recommended mix ratio
b) Un-optimized formulation
c) Poor dispersion



Encapsulant yellow & crack



Encapsulant yellow

What will happen?

a) Yellowing
b) Cracking
c) Double exotherm / abnormal curve from DSC analysis
d) Tg out of control range
e) Stability of the epoxy (viscosity, pot life, heat & moisture resistance)

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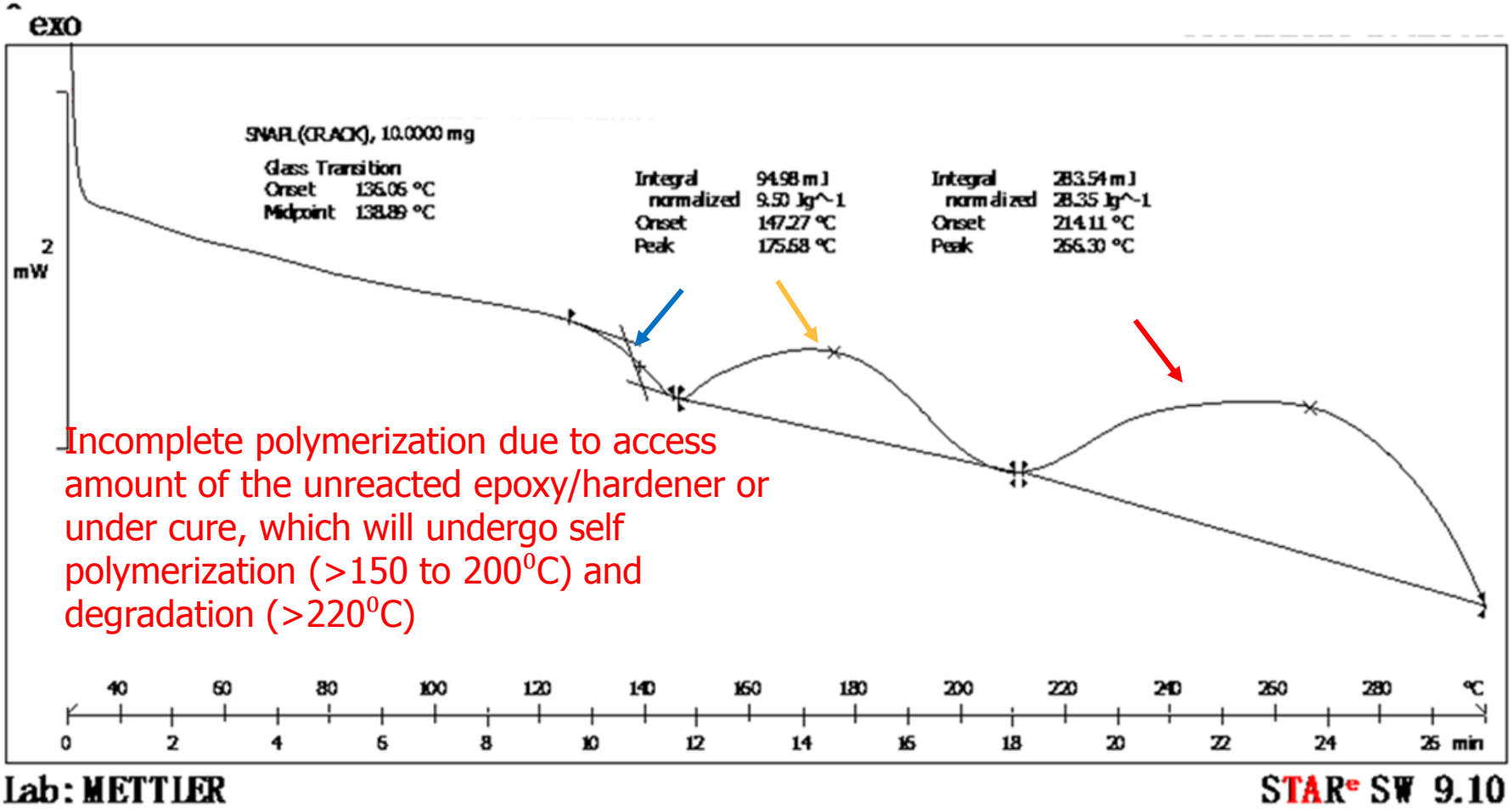
How do we ensure good and homogenous mixing?

- Make sure there is no wavy line in the mixture.
- Scrap the inner wall and bottom of the mixture.
- Recommended mixers: Planetary centrifuge mixer (preferred with vacuum)
- Eg. Mazerustar mixer (Kurabo) and Thinky mixer.
- Suitable for low to ultra high viscosity mixture.

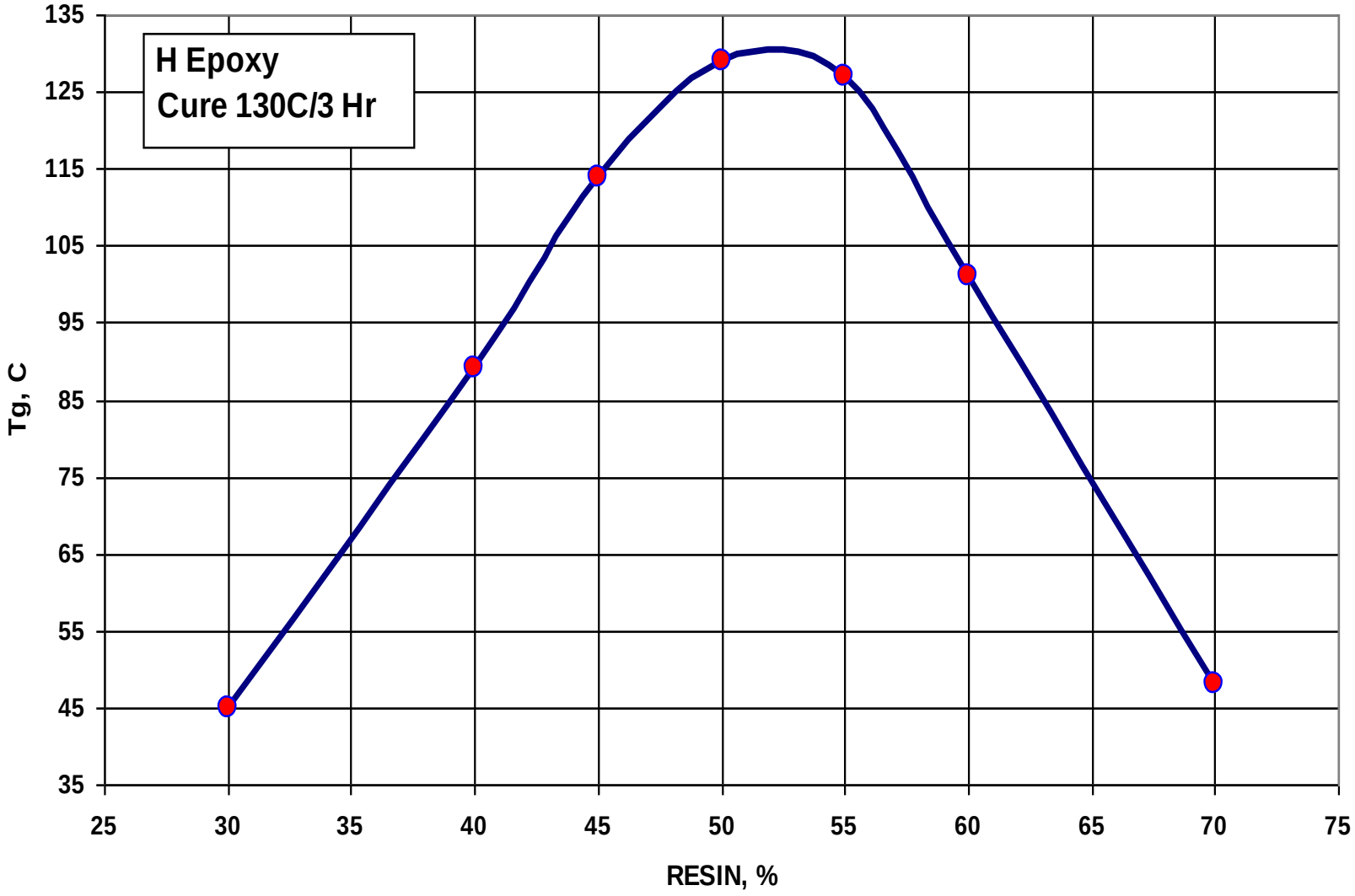
Initial

After mixing and deaeration by Mazerustar (Kurabo) KK-250 mixer (channel C10 x1)

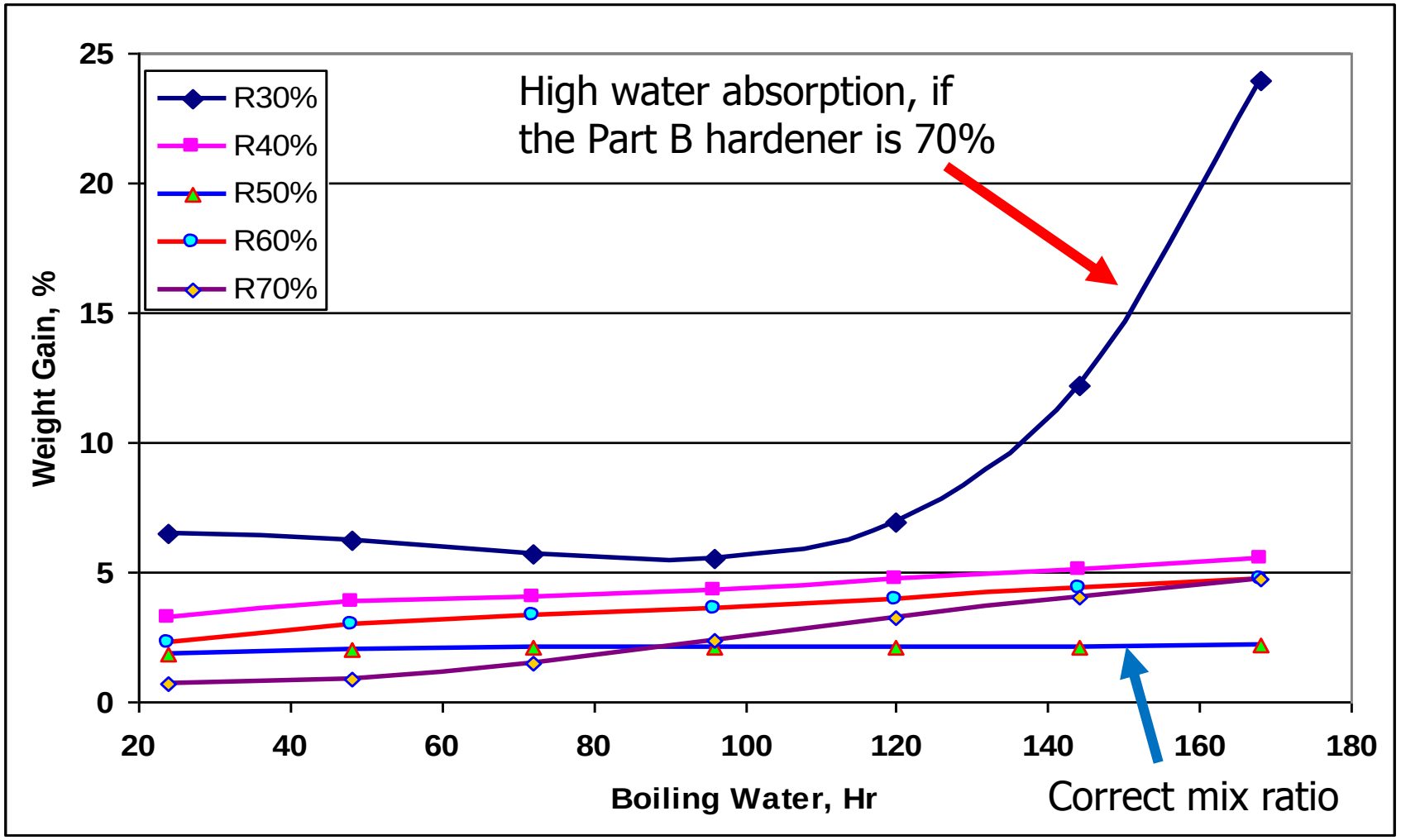
Double Exotherm from DSC (Differential Calorimetry Scan)



Mix Ratio vs. Tg



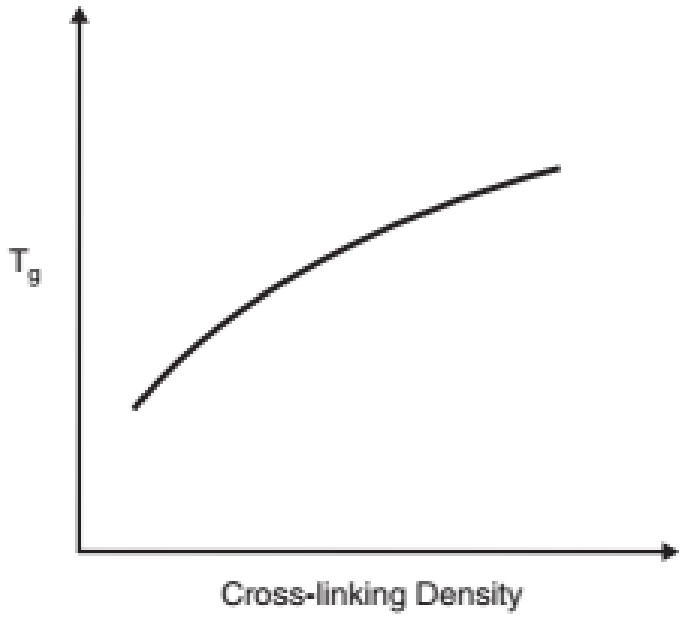
Mix Ratio vs. Water Absorption



Remark:
Specimens: Epoxy/anhydride system
R50 = 50 % of Part A epoxy resin, 50% of Part B hardener

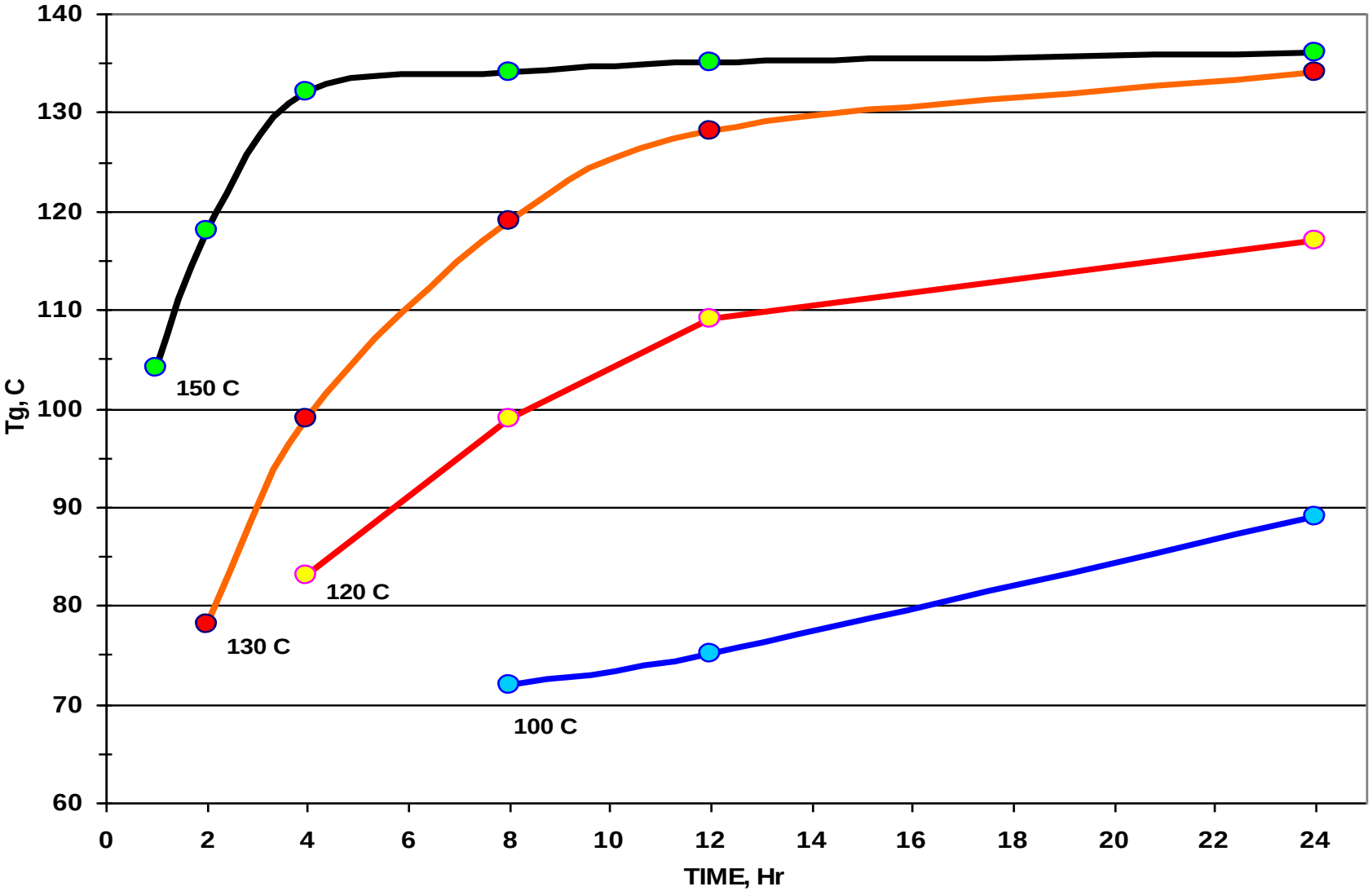
Topic 2: Effect of Tg of Epoxy Encapsulant

- Glass transition temperature, Tg, is one of the important properties for the epoxy encapsulant.
- Tg is the transition temperature of the polymer from the glassy state to the rubber-like state.
- It is marking a region of dramatic changes in the physical properties, such as hardness and elasticity of the epoxies.

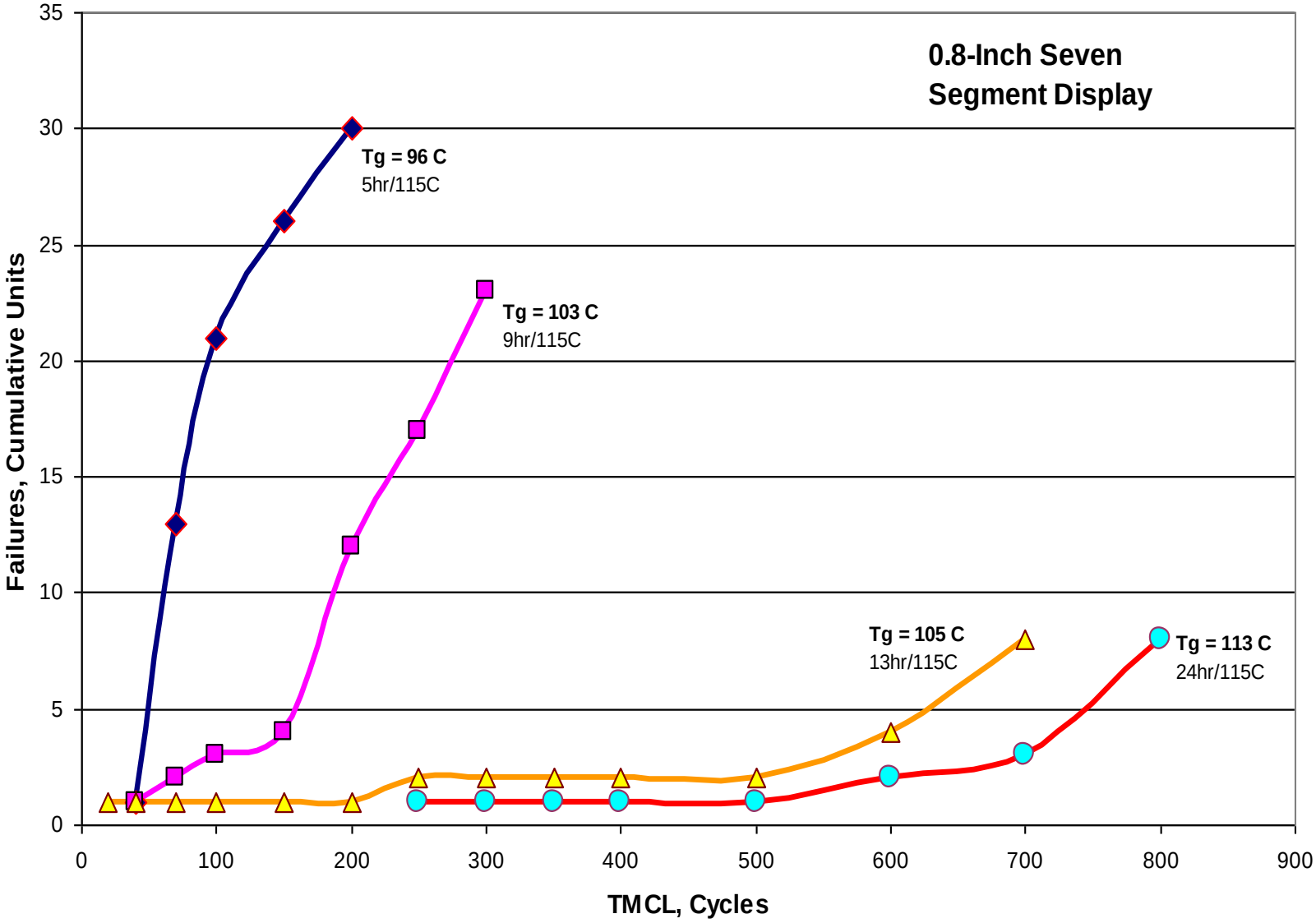


If the Tg is above or below the typical operating temperature range, there will not be drastic changes in the material.

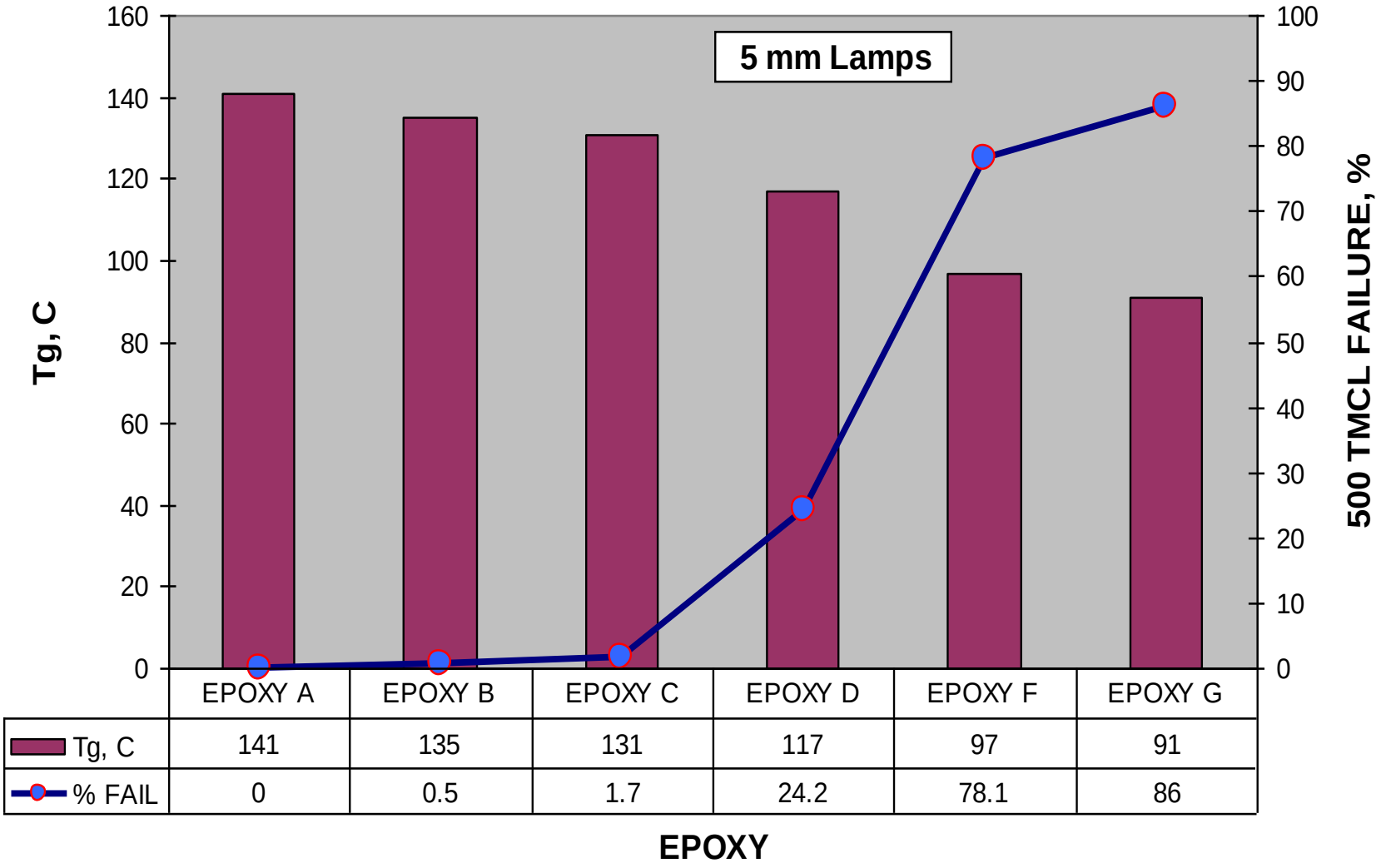
Epoxy cure vs. Tg



Tg vs. TMCL (-40 to 85°C) Failure



Tg vs. TMCL (-40 to 125^{0}C) Failure



	EPOXY A	EPOXY B	EPOXY C	EPOXY D	EPOXY F	EPOXY G
Tg, C	141	135	131	117	97	91
% FAIL	0	0.5	1.7	24.2	78.1	86

EPOXY

Topic 3: Thermal Stress of Epoxy Encapsulant

1) The total stress of the epoxy is calculated by using equation below

$$S = \int_{T_1}^{T_2} E_{(T)} \cdot \alpha_{(T)} dT$$

S = Total stress
$\alpha_{(T)}$ = Coefficient of thermal expansion of epoxy
$E_{(T)}$ = Storage modulus of epoxy
T = Temperature

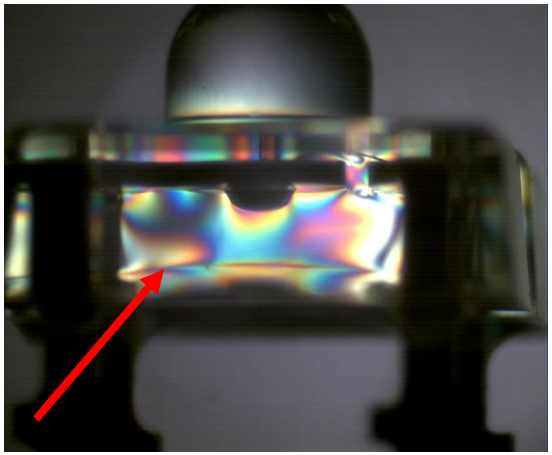
- **Coefficient of thermal expansion (CTE)** is represents the change of dimension of the material per unit change in temperature (ppm/^{0}C). Generally, CTE will be higher after the Tg. Mismatches in coefficients of thermal expansion (CTEs) can often cause local stresses that can lead to failure of the package structure.

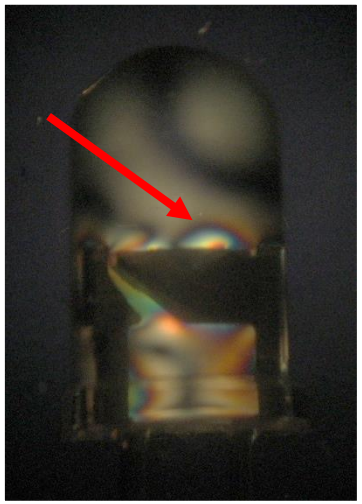
- **Storage modulus (E')** is a measure of elastic response of a material, which it reflects the total mobility of a polymer (also known as how stiff of the polymer material).
- **Residual stresses** are often introduced as a result of temperature dependent elastic modulus and CTE mismatches in adhering materials.

Materials	CTE (ppm/°C)
Unfilled epoxies	45 - 200
Filled epoxies	20 - 125
Polyimide	28
Silicone	~200 - 1000
FR-4	14 - 17
Silicon	2-5
Sapphire	5.3
Copper	16 - 17
Aluminum	21 - 24
Gold	14
Silver	19

2) By photoelastic method (polarization image)

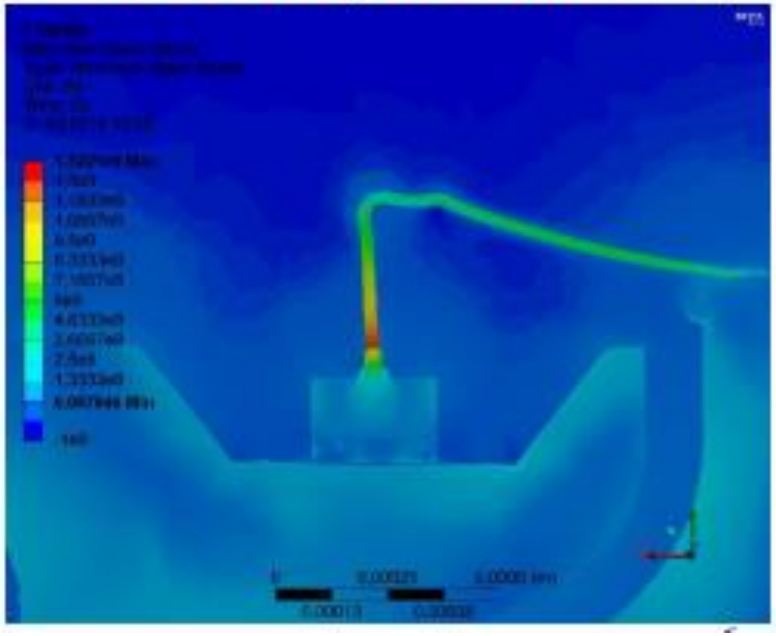
- By using an optical microscope, specimens can be examined in reflected light, or transmitted light if the specimen is made of transparent material.
- The residues stress or thermal stress of the cured epoxy can be revealed by using the polarized light.
- Thermal stress is created when a change in size or volume is constrained due to a change in temperature.



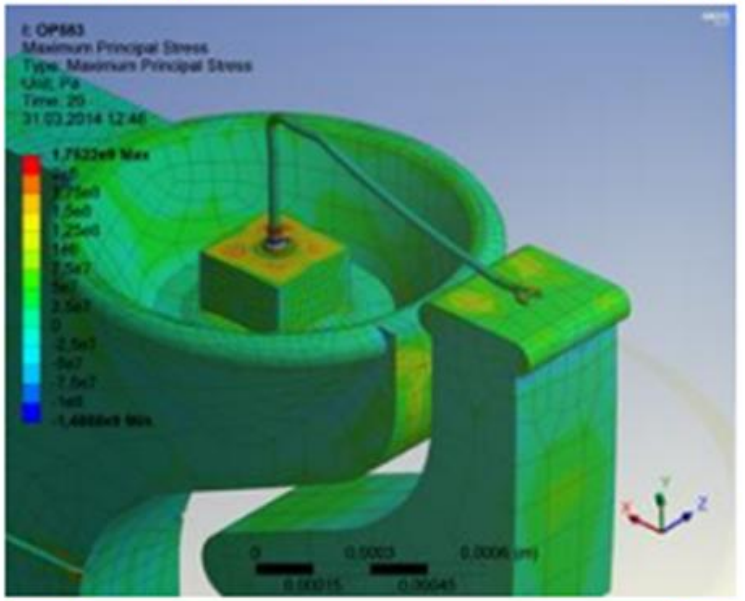


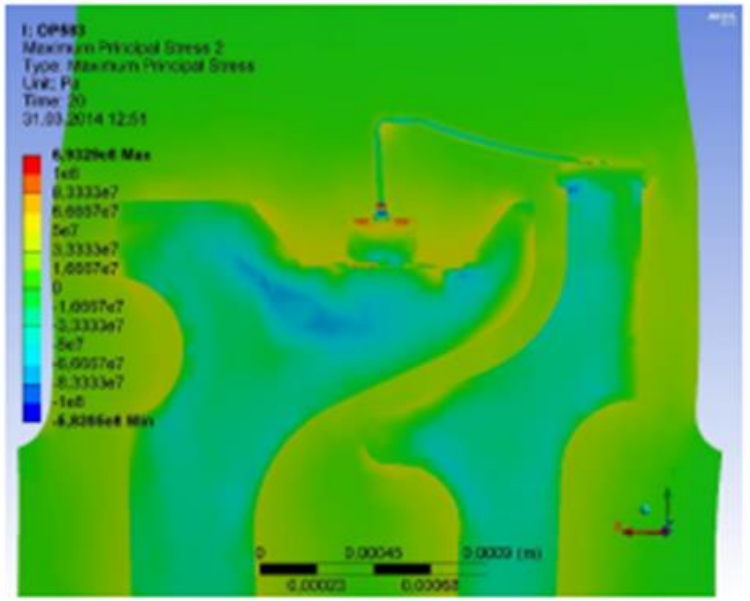
3) By FEA simulation

Max. Shear Stress (parallel to finite element)



Max. Principle Stress (perpendicular to finite element





- High stress area always happen in the wire neck area which will cause broken wire.

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4) Penchem solution

- Theoretically, we **need low CTE, Low Modulus material** in order to perform better in situation where stress is critical.
- Depending on the design, lower modulus might be a more dominant factor if compare to lower CTE.
- To provide a low stress solution to customer, Penchem has launch OP583-20 a low stress epoxy for encapsulation of device where leadframe ratio to encapsulation is high and involve high stress geometrical design like rectangular shape.

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Product Launching:

OP583 Series for Color Filter Receiver

DA669-4 Low Stress, Low antimony Encapsulation and Dam & Fill Application

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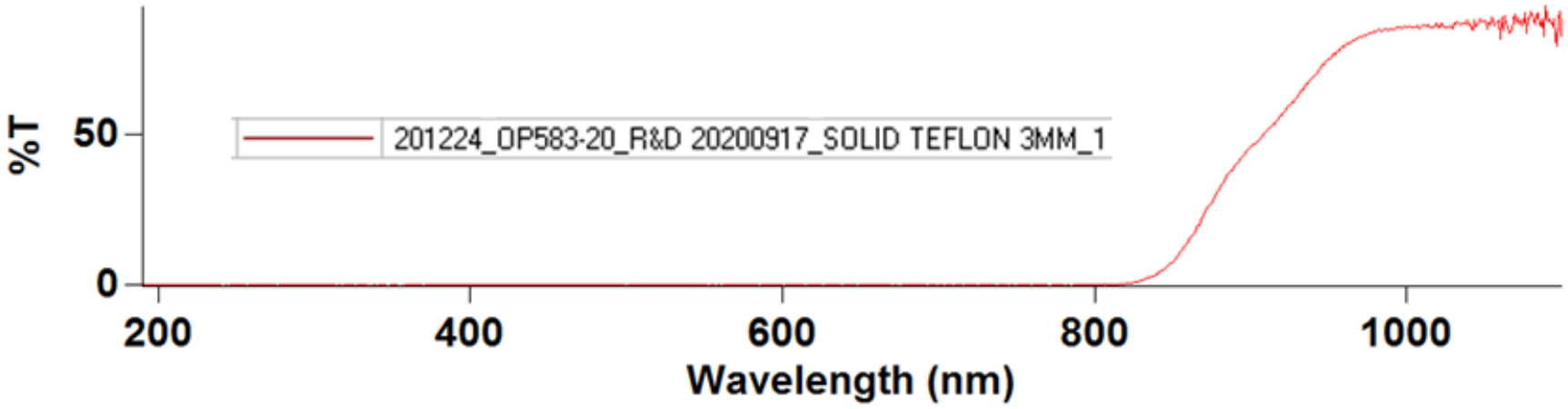
Technical Data Sheet OP583-20

Properties	Unit	Typical Value		
		Part A Resin	Part B Hardener	Mixed
Chemical type		Epoxy	Anhydride	
Appearance		Dark Liquid	Clear Liquid	
Mix ratio, by weight		1.0 ± 0.02	1.0 ± 0.02	
Shelf life, 25°C	Month	12	12	
Pot life, 25°C	Hour			2
Viscosity, CAP 2000+ Viscometer, 25°C	cP	4829	71	613
Specific gravity, 25°C		1.15	1.15	1.15
Refractive index, 25°C		1.55	1.48	1.51
Hardness	Shore D			80
Tg, DSC	°C			115
Thermal expansion coefficient, alpha 1 (30 ~ 120°C)	ppm/K			42.43
Thermal expansion coefficient, alpha 2 (120 ~ 220°C)	ppm/K			195.66
Storage Modulus, MPa @ -39.85 ^{0}C @ 40 ^{0}C		2021 1690		

Transmission OP583-20



Special Features OP583-20

- Able to pass 1000 cycle TMCL at -25 to 85°C on high stress package.
- Low stress epoxy (low modulus and good adhesion on Ag/Cu LF) that can be used for high metal to epoxy ratio package.
- Halogen Free, meet RoHS and Reach requirement.
- Heat stability colour filter at 150°C
- Can be customize to various colour filters depending on the requirement. Ranging from IR region, red, green, yellow to blue filter.

Technical Data DA669-4 Series

		Condition	R7	R8	(X1)	R11
Viscosity, cPs		Cap1, 6rpm	12890.0	10719.0	3500	13610.0
Adhesion strength YC on glass		165C/1H	4.412	5.127	5.1	3.33
Adhesion strength YC steel on stainless steel		165C/1H	9.526	16.429	NA	NA
Hardness shore D		SHORE D	89	82	83	90
Density		g/cm3	1.68	1.62	1.40	1.76
Tg (TMA)		C	159	153	94.3	128.4
CTE α1			26.3	28.2	72.5	34.8
CTE α2			50.5	45.1	170.6	78.3
Modulus	-40^{0}C	MPa	7731	5675	2845	5652
	40^{0}C	MPa	6731	4837	2422	4661
	120^{0}C	MPa	5400	3961	533	2483

Special Features DA669-4 Series

- Able to pass 1000 cycle TMCL at -25 to 125°C on high stress package.
- Low antimony, RoHS and Halogen free compliance.
- Good adhesion on various substrate including metal, PCB, ceramic, plastic and epoxy lens.
- Suitable to be used as gold wire encapsulation.
- Can customize to white colour for better reflectivity.

Thank You

You can't reach for tomorrow, if you have your arms wrapped around yesterday.

Any enquiries please consult us at

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