



Revolutionary Polymer for Metal Replacement in Automotive Applications

**Dr. Mike Zimmerman
Quantum Leap Packaging, Inc.**

**Mr. Charles Buehler and Dr. William Rodgers
General Motors Corporation**



Outline

- Introduction
 - Material needs in the automobile industry
- QLP Materials
 - Basic Material Concepts and Relevance to Automotive Applications
- Material Properties & Comparison
- Computer simulations of Fascia Bracket
- Materials roadmap for automotive industry



Materials Needs

- Very Low CLTE = to steel
- Stiffness > 10,000 MPa
- Tensile Elasticity, +/- aluminum, approaching steel
- Paint-ability – Class “A” Surface
- Compatibility w/metals, high bond strength
- Chemical resistant
- Injection moldable, thermo formable, extrusion
- High Heat Resistant, >250°C



QLP Background

- **Founded in December 2002**
- **Headquartered in Wilmington, Massachusetts**
 - 32,000 sq. ft. manufacturing facility in Massachusetts
 - 16,000 sq. ft. manufacturing facility in California
- **Venture Capital:**  A History of Success in Building Market Leaders
- **Strategic Investor:**  **SUMITOMO CHEMICAL**
- **Strategic Partnerships**
 - DuPont  The miracles of science™
 - CMC Interconnect Technologies
- **Materials Company with first products in semiconductor packaging**



Quantech™

Material Innovation



- Semiconductor Assembly - High Reliability
- Technology focused on Solving Current LCP Limitations

Traditional LCP Limitations	<i>QLP Materials</i>
<ul style="list-style-type: none">▪ Orientation Issues<ul style="list-style-type: none">• TD CLTE > 80 ppm/C▪ Temperature Limitations▪ No Adhesion	<ul style="list-style-type: none">▪ <i>Isotropic Properties</i>▪ <i>High Temperature (>400°C)</i>▪ <i>Adhesion to Metals</i>
Traditional Structural Materials	<i>QLP Formulations</i>
<ul style="list-style-type: none">▪ Reinforced with long fibers (glass/carbon)▪ Anisotropic properties	<ul style="list-style-type: none">▪ <i>Micro and nano fillers for reinforcement</i>▪ <i>Isotropic structural properties</i>

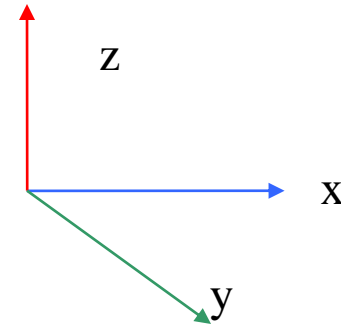


Quantech™

Material Innovation



- High Performance Polymer For Ceramic/Metal Replacement: **Semiconductor Packaging**
- Next generation Polymer Technology solves **current LCP Limitations**
 - Tailor-able Material Properties
 - CTE Matching Metals
 - Isotropic Mechanical Properties
 - Dimensional Stability
 - High Temperature Stability
 - Outstanding Moisture Resistance
 - Excellent Adhesion to Metals





CLTE



Tailorable and Isotropic

Product		Mold Direction (ppm/°C)	Transverse Direction (ppm/°C)
Traditional LCP Materials	SCX-072C1	6	104
	E7008	9	83
Quantech™ Materials	QLP -1	27	32
	QLP-2	19	20
	QLP -3	9	3

4X6” Plaque—Example Properties

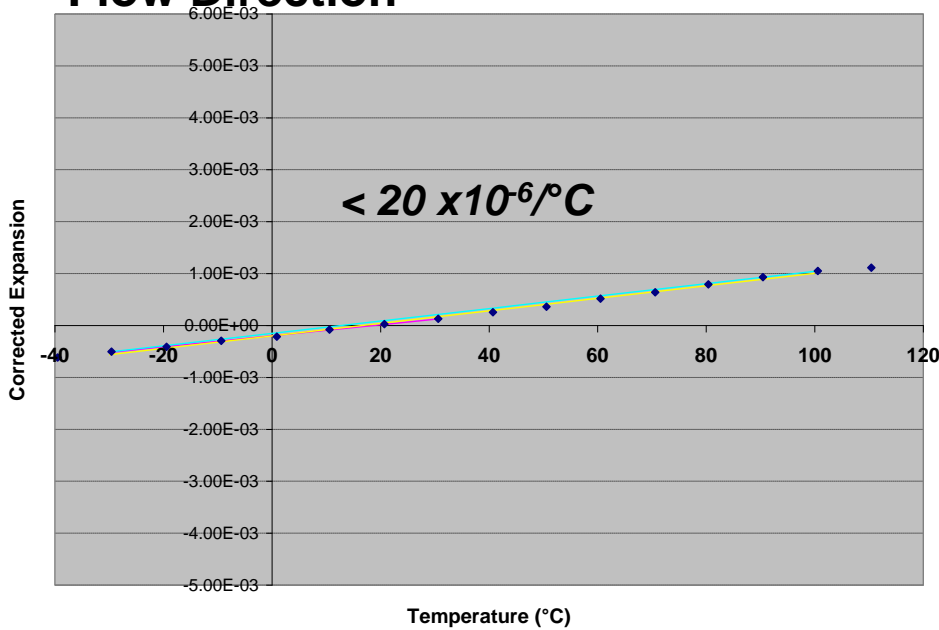


Linear and Low CLTE matching steel



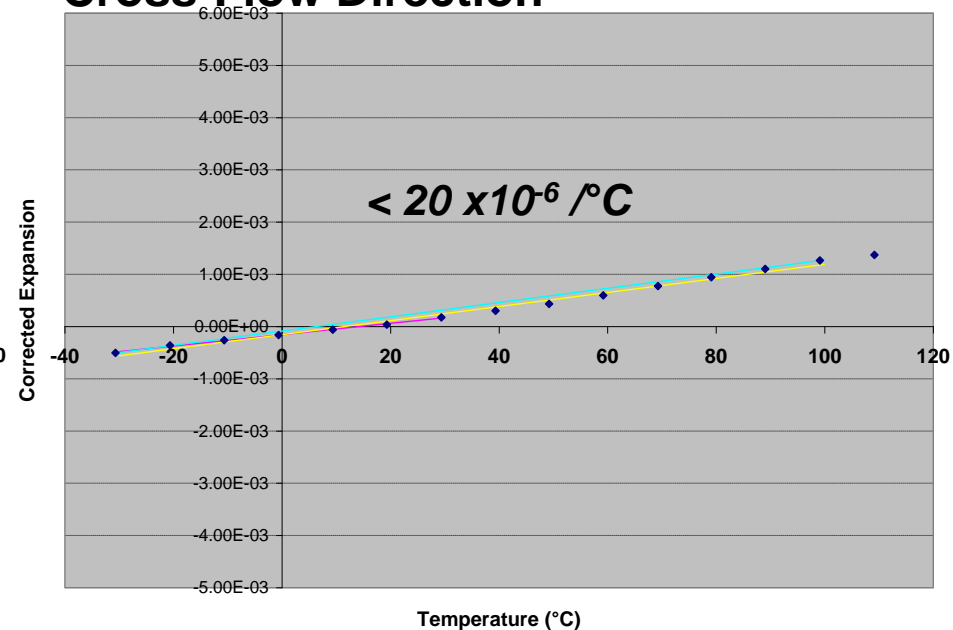
- Steel CLTE = $14 \times 10^{-6}/^{\circ}\text{C}$ to $19 \times 10^{-6}/^{\circ}\text{C}$
- End gated plaque, 3" x 5"

Flow Direction



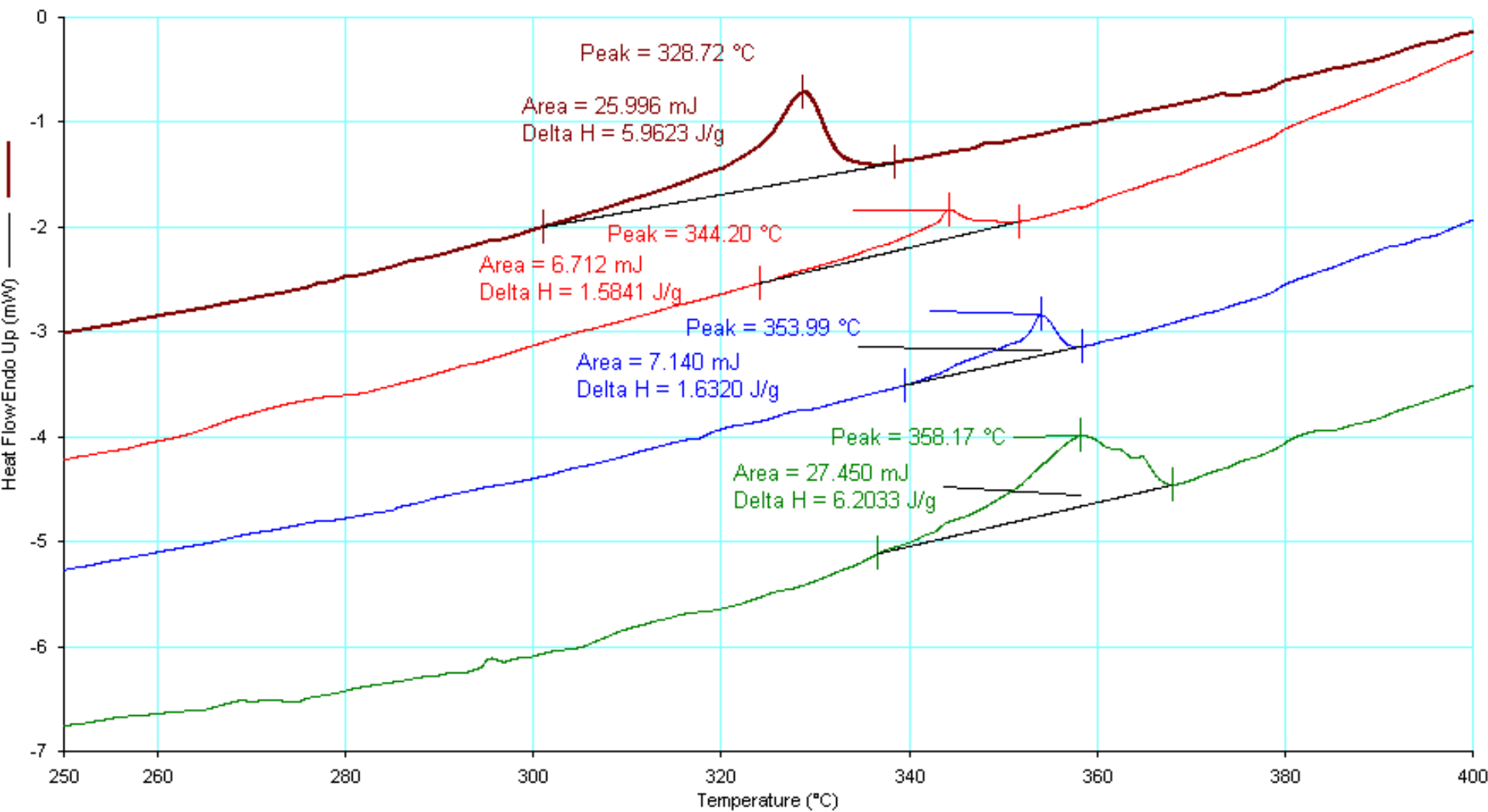
	-30 to 30	-30-100	Pts
CLTE	1.07E-05	1.21E-05	1.19E-05

Cross-Flow Direction



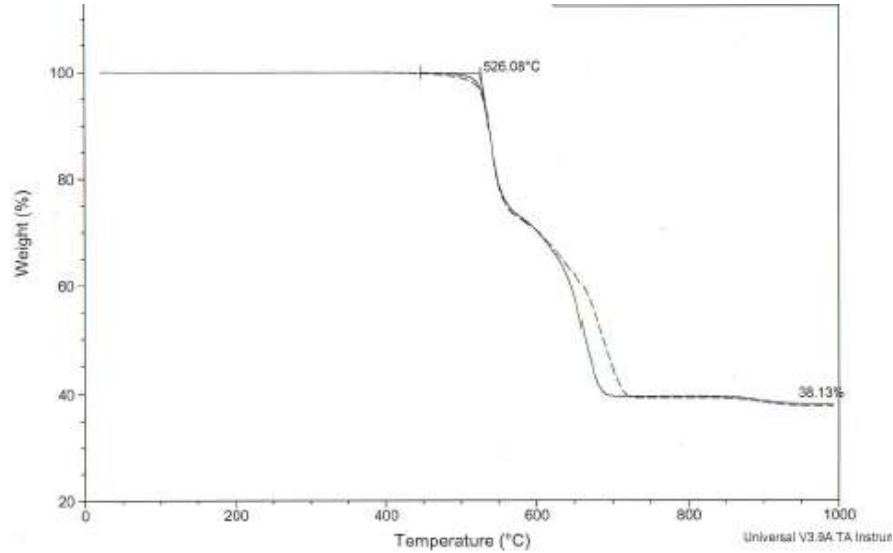
	-30 to 30	-30-100	Pts
CLTE	1.09E-05	1.35E-05	1.36E-05

320°C – 360°C



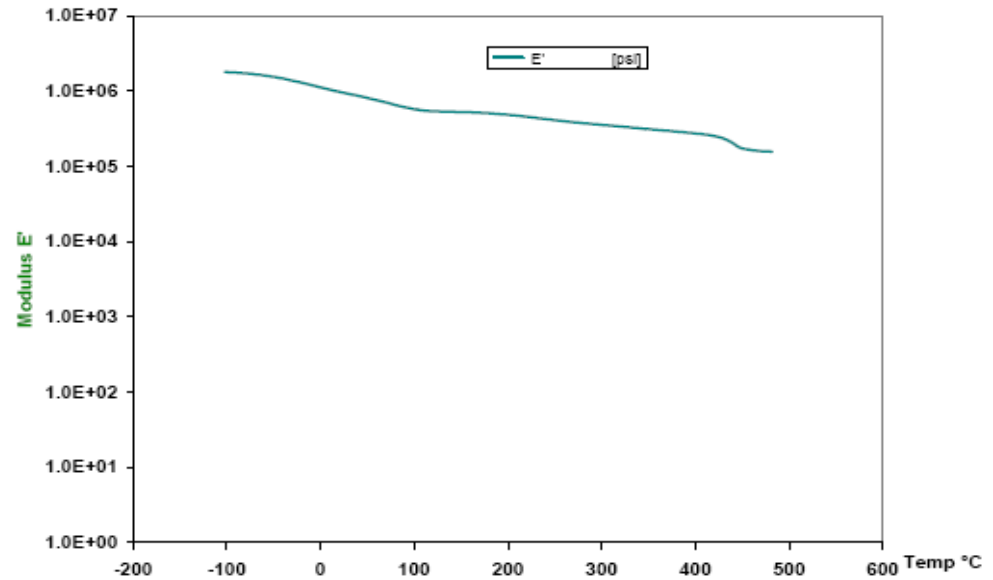
TGA

(Low Outgassing: Stability to 500C)

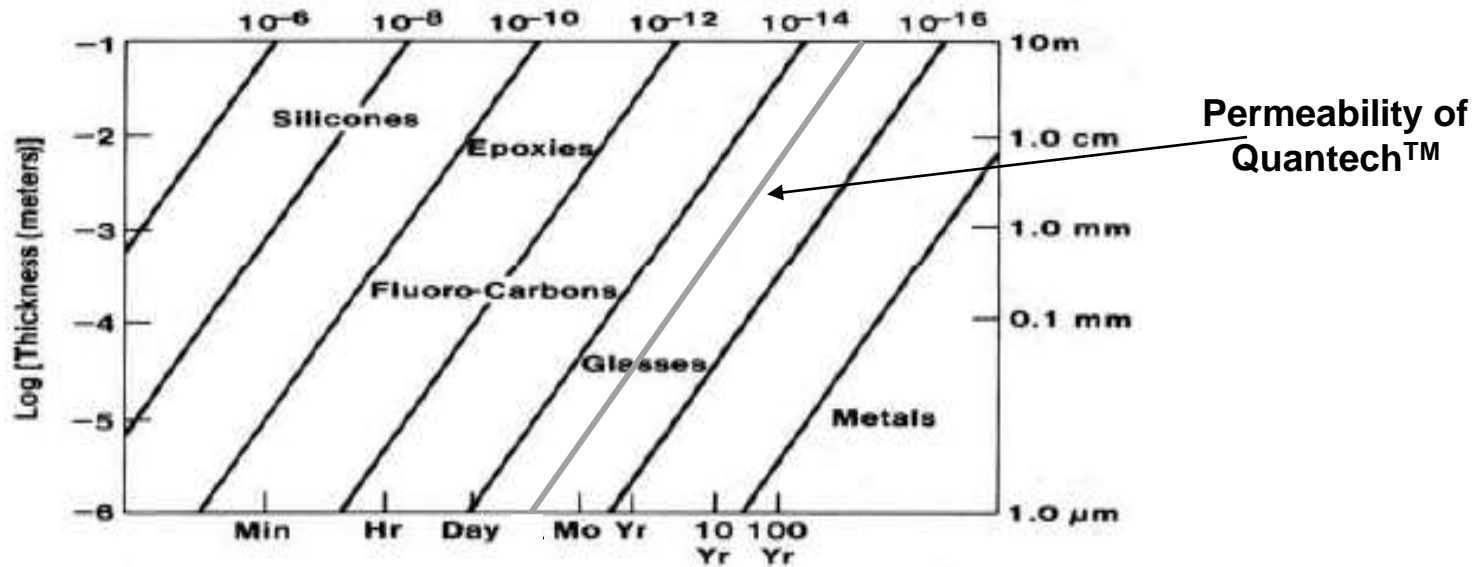


No discernable Tg

DMA (-200C – 500C)



Permeability Comparable to Glass



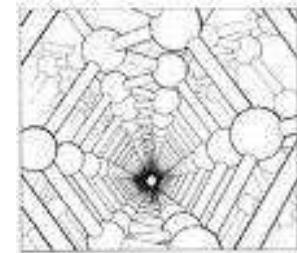
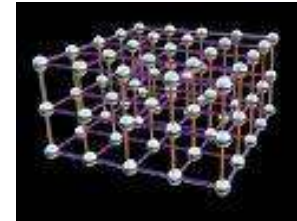


Quantech™ Suitability

Manufacturing Structural Parts

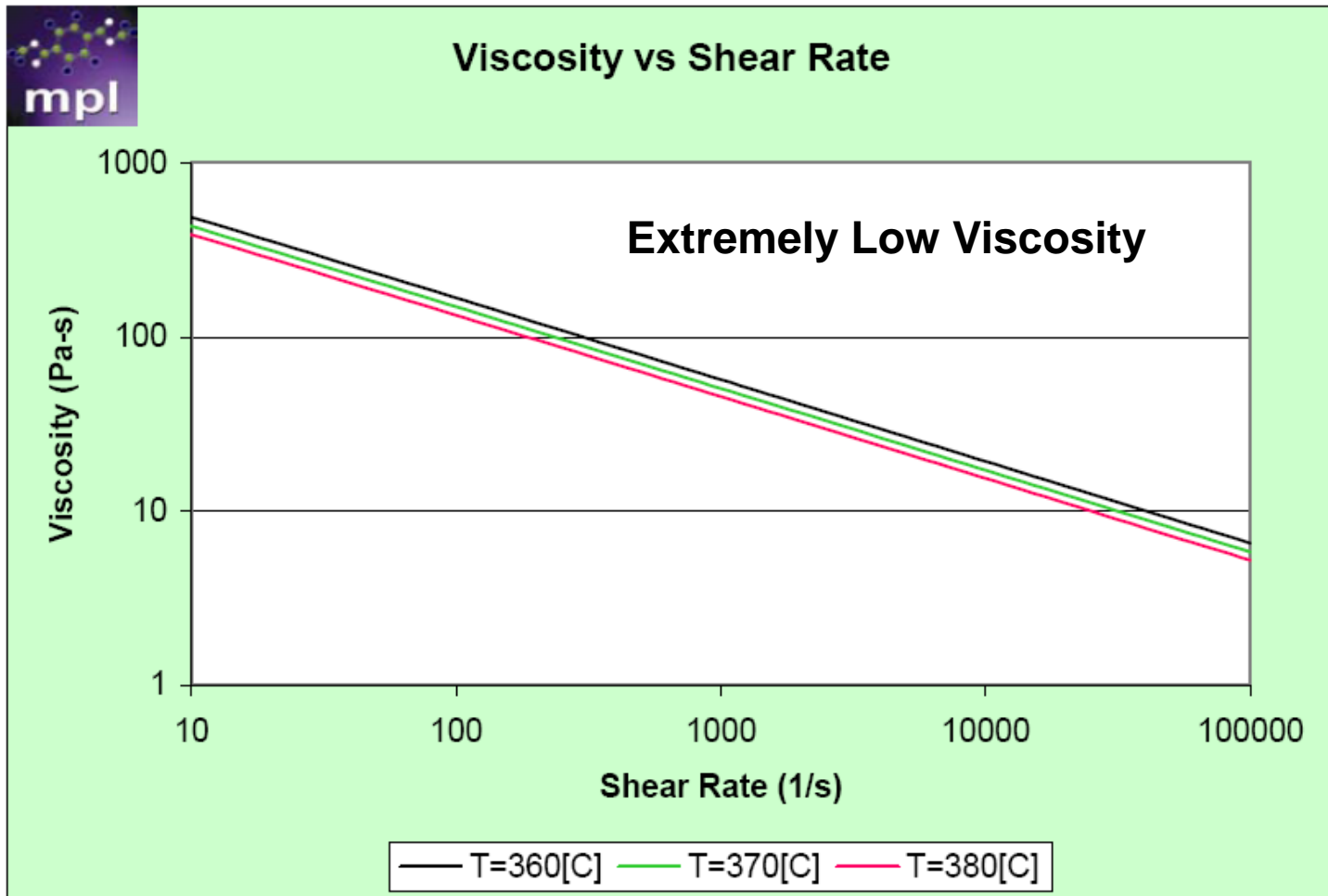


- 100% Crystalline material
- Extremely low heat of fusion
 - Fast Cycle Times
 - Excellent dimensional stability
- Very Low Viscosities
 - Can fill complex geometries
- Very Low Shrinkage
 - Minimum sink marks



Rheology

Extremely Low Viscosity





Quantech™



Low Density <ul style="list-style-type: none">• <i>Lighter Weight vs Al and Steel</i>• <i>Weight Savings >30%</i>	1.75 g/cc
CTE Matching metals <ul style="list-style-type: none">• <i>Minimizes Gaps up on Expansion</i>	10-40 ppm
Near-Zero Shrinkage <ul style="list-style-type: none">• <i>Dimensionally stable</i>• <i>Improves alignment during assembly processes</i>• <i>No Warpage</i>	<0.05%
High Stiffness <ul style="list-style-type: none">• <i>Excellent structural strength and rigidity</i>	>1GPa
High Temperature Stability <ul style="list-style-type: none">• <i>Under-the-hood applications</i>	420 C HDT
Extremely Fast Injection Cycle Time	<90s
Environmentally Friendly	ROHS and Green Compliant



Quantech™ Key Properties



Property	Unit	QLP Quantech™ Material	
CLTE - isotropic <i>Tailorable $10 - 40 \times 10^{-6} / ^\circ C$</i>		X13017 (electronics)	X13094 (High Stiffness)
X	$10^{-6} / ^\circ C$	13.5	15.9
Y	$10^{-6} / ^\circ C$	14.2	22.2
Flexural Modulus	Mpa	13,620	22,274
Tensile Modulus	Mpa	14,177	24,629
Density	g/cc	1.75	1.72
Water Uptake	%	0.08	0.05
Shrinkage	%	<0.05	<0.05
Heat Deflection	$^\circ C$	320	370



Quantech™ Suitability

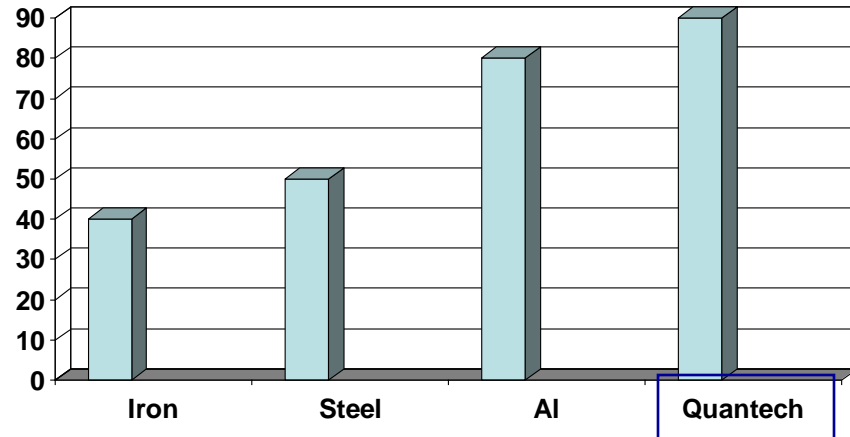
Lightweight Structural Applications



Strength/Weight (s.g.) Ratio

- Quantech™ 90
- Cast Aluminum 80
- Cast Steel 50
- Cast Nodular Irons 39-42

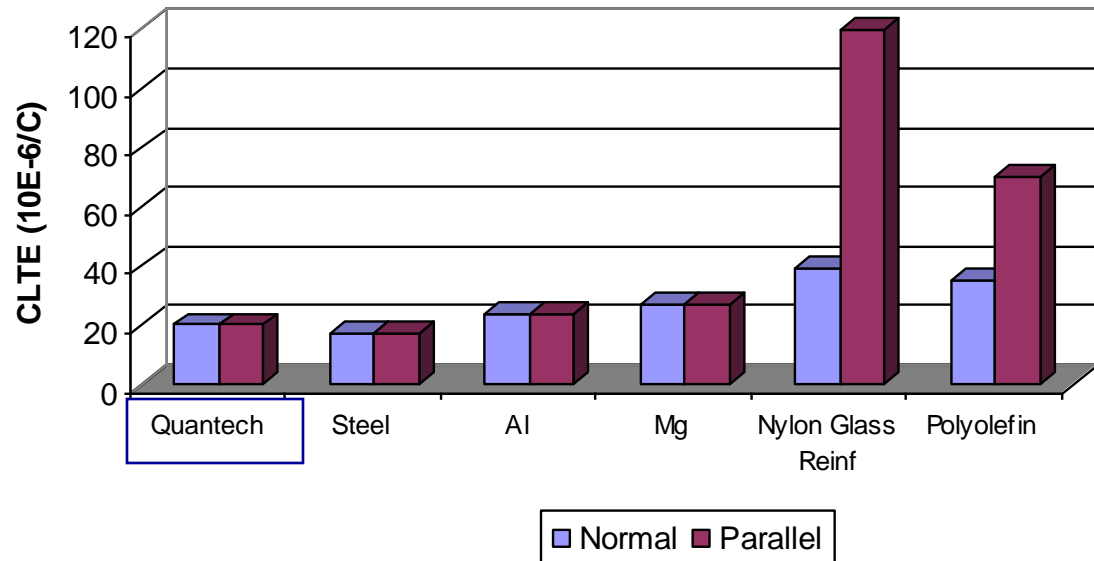
Strength/weight Ratio vs. Material



CLTE

- Tailored to match Metals
- Isotropic

CLTE vs. Material





Quantech™ Suitability

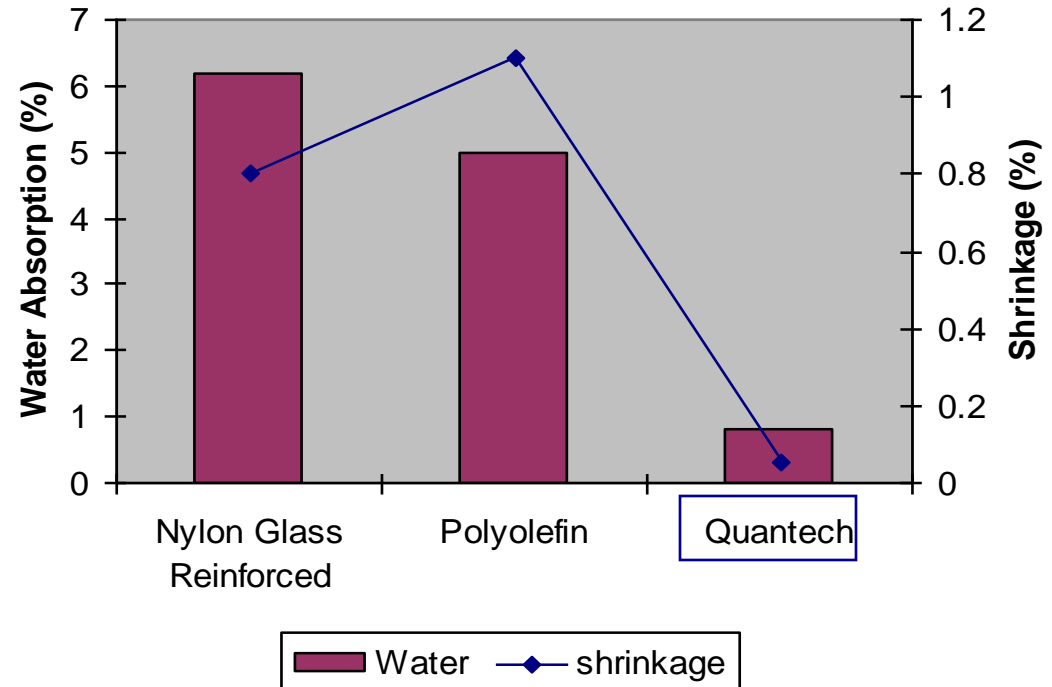
Lightweight Structural Applications



Quantech™ Addresses

- Moisture Issues with Current Plastics
- Shrinkage and Dimensional Stability
- Anisotropy
- Warpage

Water Absorption vs. Material





Potential Applications & Material Studies



Potential Applications

- Structural parts, support brackets, etc.
- High heat applications, under hood
- Painted applications, exterior
- Very low CLTE applications, gap control

Bracket Moldflow studies - Glass Filled Nylon vs Quantech™

- Warpage
- Cycle Time
- Ability for thin walls
- Part Weight
- Clamp Tonnage

Warpage Comparisons

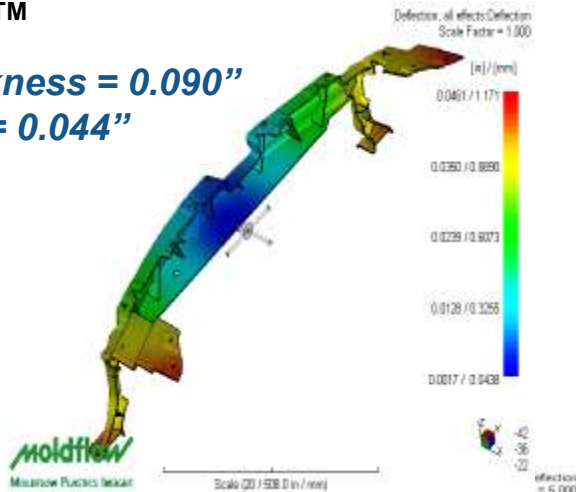
Glass Filled Nylon vs Quantech™

Lower wall thickness and warpage 1/10 of Nylon

Quantech™

Wall Thickness = 0.090"

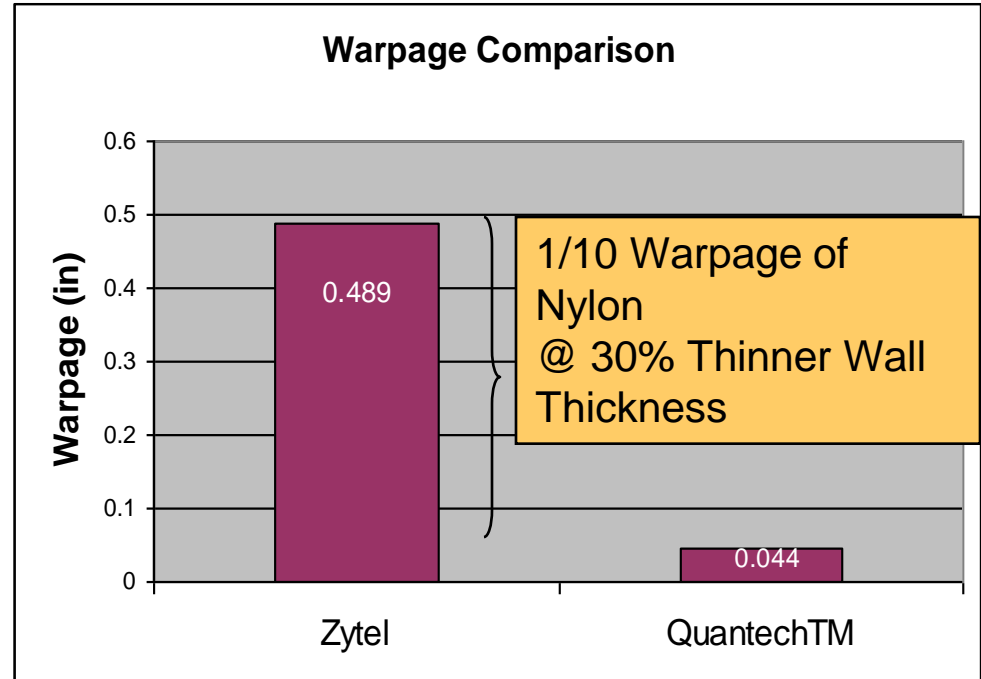
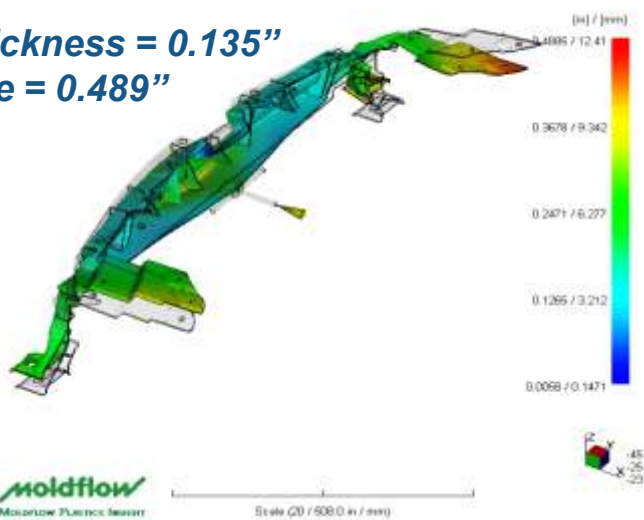
Warpage = 0.044"



Nylon

Wall Thickness = 0.135"

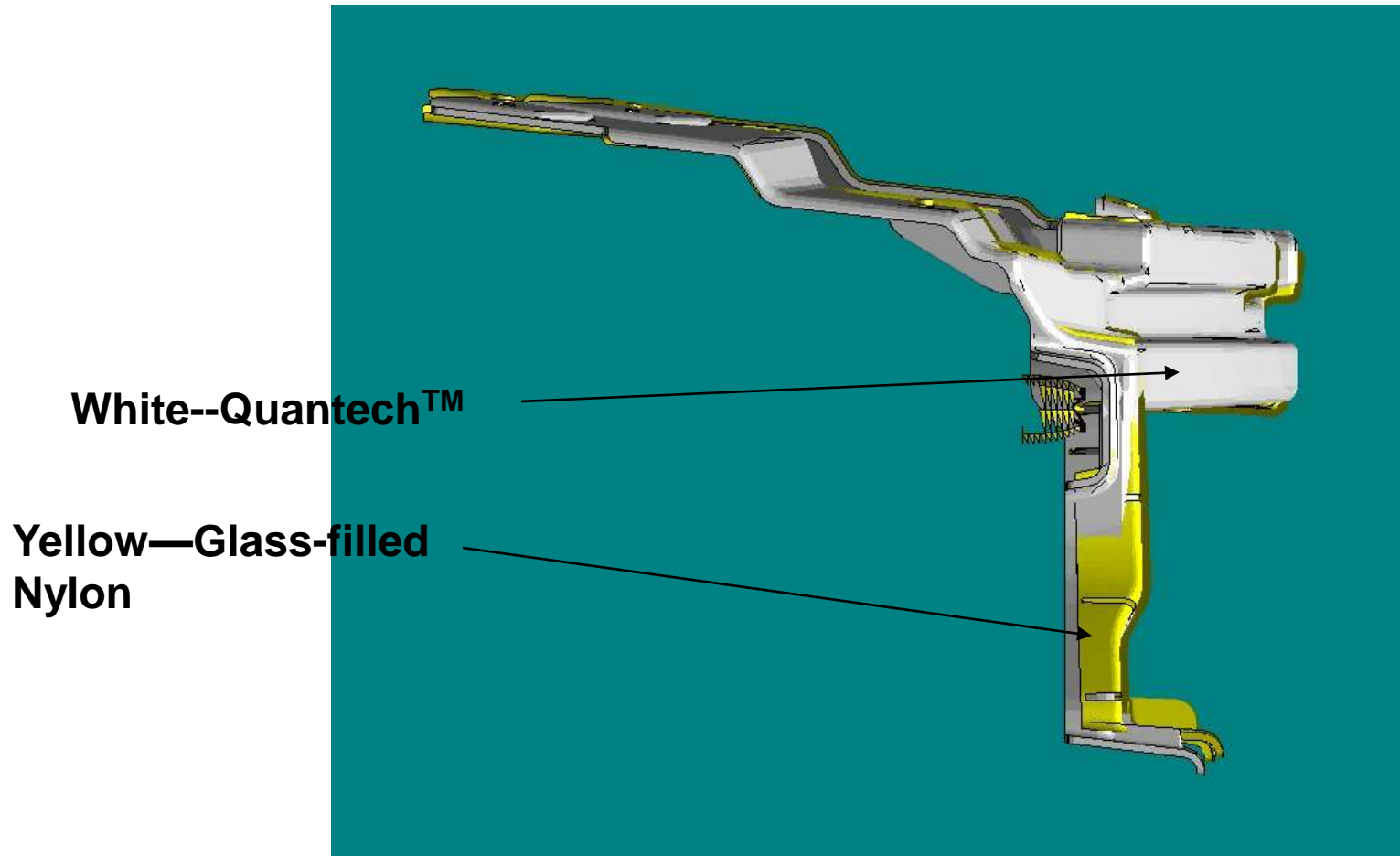
Warpage = 0.489"





Warpage Comparison

Glass Filled Nylon vs Quantech™





Summary of Bracket

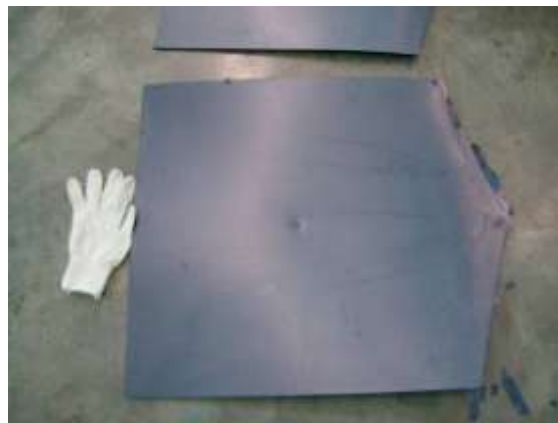
- Warpage is 1/10 that of glass filled nylon.
- Molding pressure < 50% of molding pressure of Nylon.
- Thinner wall (0.090") vs Zytel 0.135".
- Part weight is 15% (minimum) less than Nylon.
- Cycle time is 1/2 of glass filled nylon
 - Nylon 20 seconds
 - Quantech™ 10 seconds
- Clamp Tonnage
 - Nylon 800 tons
 - Quantech™ 525 tons



QLP/GM Molded World's Largest LCP Part



- Husky Molding Facility
 - Novi, Michigan
- 1350 Ton Molding Press
- 24X24 Inch x 3 test plaque
 - 4.1 lb part
 - Largest LCP part ever molded





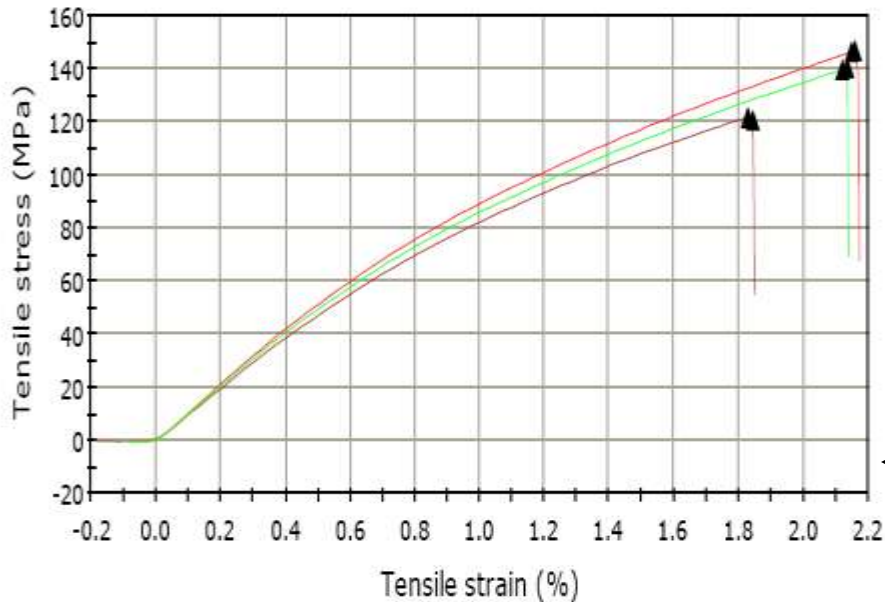
Materials Roadmap



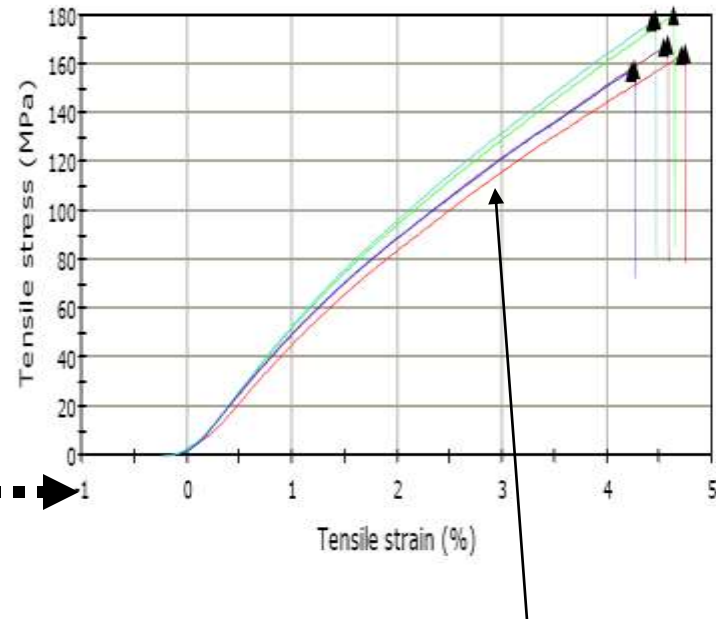
- Impact Resistance
 - High Elongation Materials
 - Greater Ductility
- Paint-ability
- Very Low CLTE

Stress-Strain Characteristics

Current Elongations ~ 2.0%



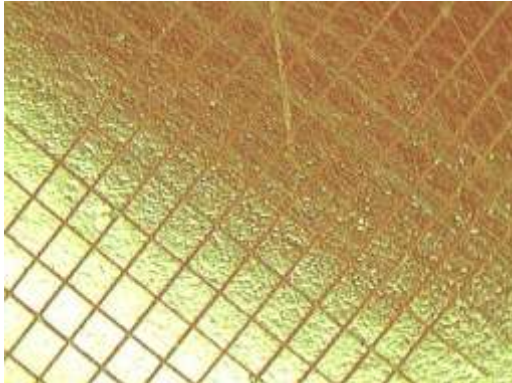
Future Goal $\geq 8.0\%$



Improved Ductility-
Quantech™

Paintability

Substrate After Tape Test



- QLP paint-able LCP technology
 - *Typical LCPs are not paint-able*
- Cross-Hatch Test Results
 - Excellent Adhesion

Tape Cross Hatch View



Tape on White Paper



Cross Hatch Detail



Substrate removed with paint

Non-Scored Areas Clean



SUMMARY

Unique material properties of Quantech™ enables direct metal replacement and weight reduction

- Tailored CTE—Matching Metals
- Excellent Strength and Stiffness
- Low Density
- Outstanding Moisture Resistance
- High Temperature Stability
- Excellent Chemical Resistance/Permeability
- Materials Roadmap for automobile Industry