Next Generation Materials for 112 GB/s

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AGC Nelco

TestConX™
Virtual Event • May 11-13, 2020

AGC
Your Dreams, Our Challenge

For Discussion Today

- New Base Materials for Prepreg and Laminate
- Material Elements of Insertion Loss
- New Developments in Laminate Technology

Advances in Fiberglass

Property	Units	E Glass	SI® Glass	NE-R Glass
Density	g/cm^3	2.6	2.3	2.3
Tensile Strength	GPa	3.2	3.1	2.4
Tensile Modulus	GPa	75	64	53
CTE (50 – 200°C)	$X10^{-6}/°C$	5.6	3.3	3.3
Dielectric Constant	10 GHz	6.6	4.7	4.3
Dissipation Factor	10 GHz	0.0060	0.0026	0.0018

Other Potential Substrates

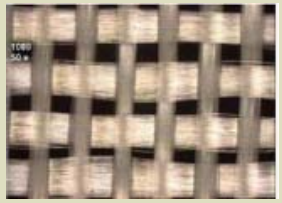
Substrate		SI® Glass	Nittobo NER	Hi-Silica Fabric	Ultra high density hydrocarbon	Hydrocarbon / E-glass	LCP	PTFE Web
Properties								
	Dk	4.4	4.4	3.7	2.25	≈ 4	3.0 @ 1 MHz	2.1
	Df	.0006	0.0009	0.0001	0.0002	≈ 0.0008	0.00018 @ 1 MHz	0.0004
Properties w/ M3K resin								
	Dk (AB)	3.44 (52%)		3.36 (40%)	2.67 (66%)		3.2 (47%)	2.56(85%)
	Df (AB)	0.0023 (52%)		0.0016 (40%)	0.0019 (66%)		0.0016 (47%)	0.0017 (85%)
	Dk (IPC)	3.44 (52%)		3.37 (40%)	2.67 (66%)		3.2 (47%)	2.54(85%)
	Df (IPC)	0.0023 (52%)		0.0024 (40%)	0.0023 (66%)		0.0018 (47%)	0.002 (85%)
	DMA Storage Modulus, Mpa			11,500	2500			1375

Advances in Fiberglass Weaving

106

1035

1080



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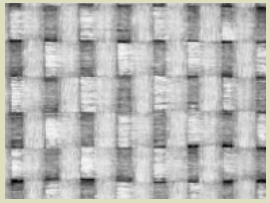

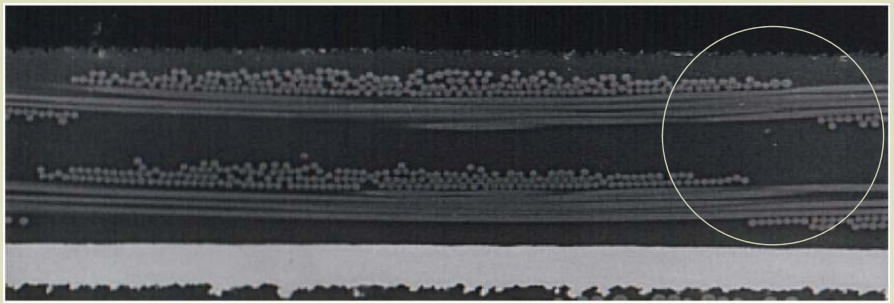

- More isotropic glass distribution
  - Lower skew due to local variation
  - Improved surface smoothness
  - Improved dimensional stability
  - Improved laser and mechanical drilling

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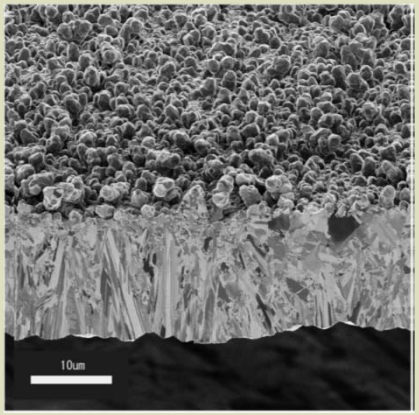
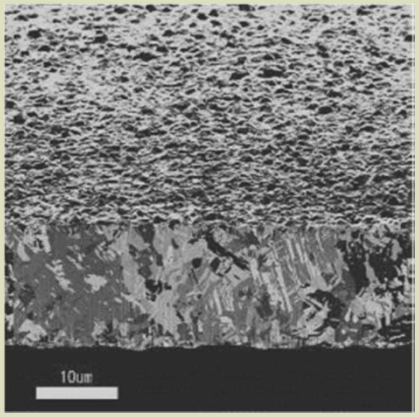
Advances in Copper

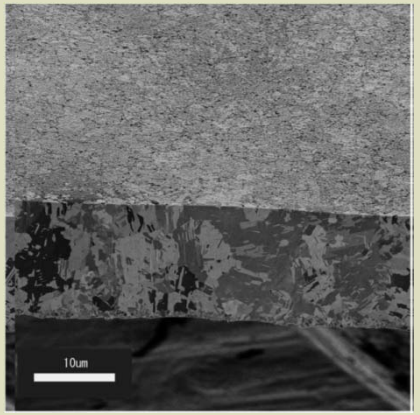
RTFOIL®
≈ 4.5 micron Rz



HVLP & VSP® type foil
≈ 0.8 - 1.5 micron Rz



SI foil
≈ 0.5 micron Rz



- Lower profile coppers (with acceptable peel strength) reduces skin effect on signal integrity and improves system attenuation

RTF = Reverse Treated Foil VSP® = Very Smooth Profile, is a registered trademark of Mitsui Mining & Smelting Co., Ltd.

SI = Signal Integrity Copper (in development)

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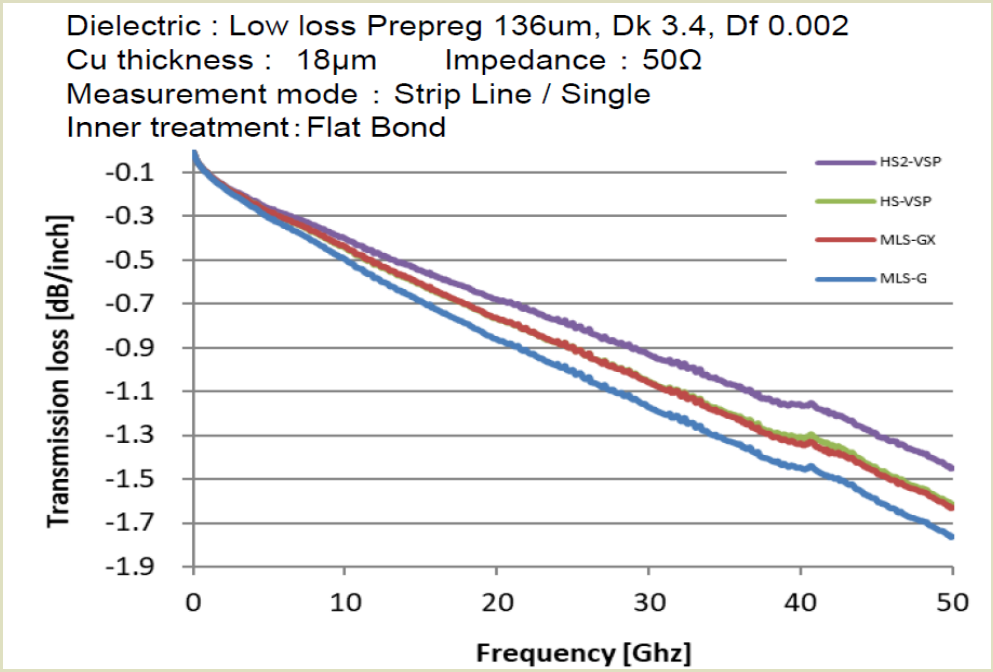
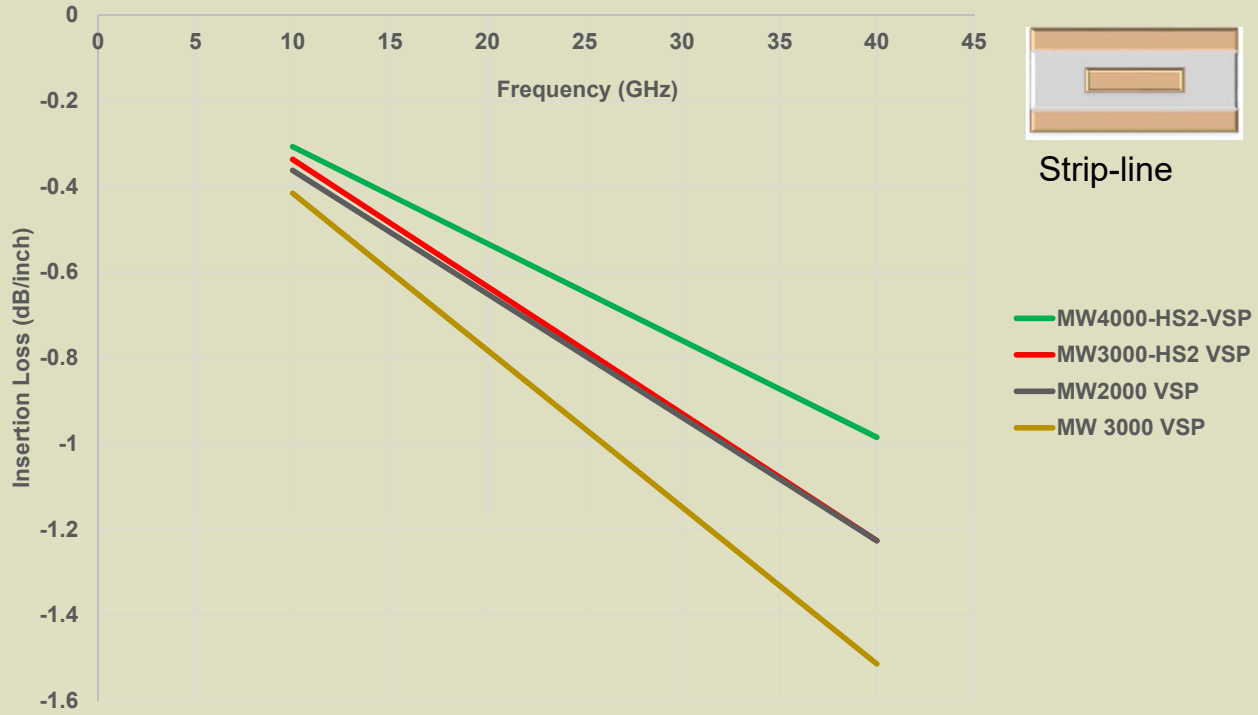
Copper Roughness vs Insertion Loss



Effects of Copper Roughness and Glass Style



Strip-line

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Putting It All Together

Laminate Properties	Meteorwave 8000	Meteorwave 8300	*ELL-10	*ELL-11	*ELL-12
Tg (DMA)°C	**185**	**190**	**190**	**190**	**190**
T288 (min)	**>120**	**>120**	**>120**	**>120**	**>120**
Dielectric Constant (Dk) 10 GHz Stripline (70% RC)	**3.2**	**2.8**	**3.0**	**3.2**	**2.8**
Dissipation Factor (Df) 10 GHz Open Resonator (70% RC)	**0.0017**	**0.0026**	**0.0014**	**0.0016**	**0.0013**
Z AXIS CTE (50°C to 260°C & 55% RC) Alpha 1 Alpha 2	 **35** **185**	 **33** **180**	 **35** **185**	 **35** **185**	 **35** **185**

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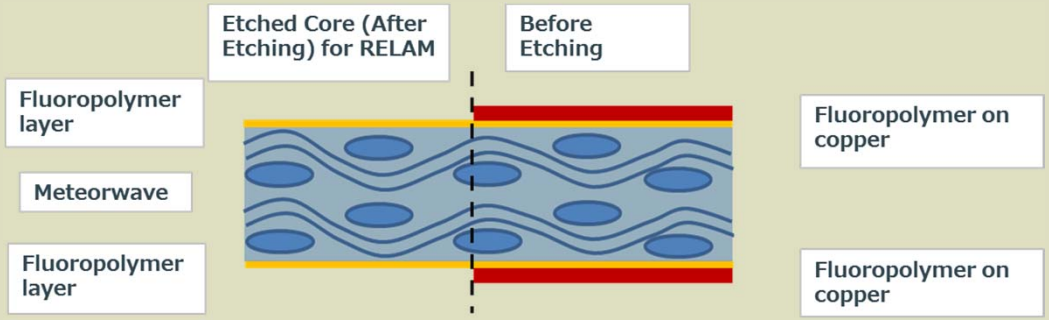
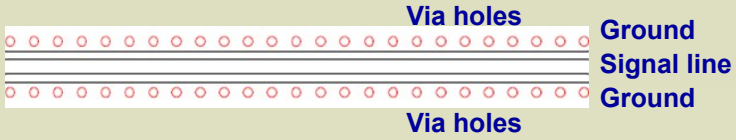
Addition of Fluoropolymer to Copper



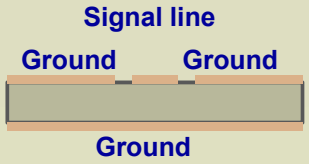
- AGC patented Fluoropolymer coated copper compatible with Meteorwave prepreg.
- This RCC can bind strongly to profile-free copper and the Meteorwave substrate enabling the reduction of insertion loss without a reduction of composite reliability.
- Dielectric properties of fluoropolymer enhance the Dk and Df of the laminate

Insertion Loss Testing to 100 GHz

Test Condition (slides 7 - 8)
- Boards: NL9300
  - Meteorwave 8300
  - Meteorwave EA (ELL-11)
  - Supplier R-3 (PTFE based)
  - Supplier I-A (Hydrocarbon based)
  - Supplier P-7N (PPE based)
- Transmission Line : Co-Planar Waveguide with Ground(CPW-G)
- Line length: 12.5 mm
- Instrument : E8361A+N5250, Keysight
- Calibration : Thru-Reflect-Line(TRL)
- Impedance : Designed 50 Ohm

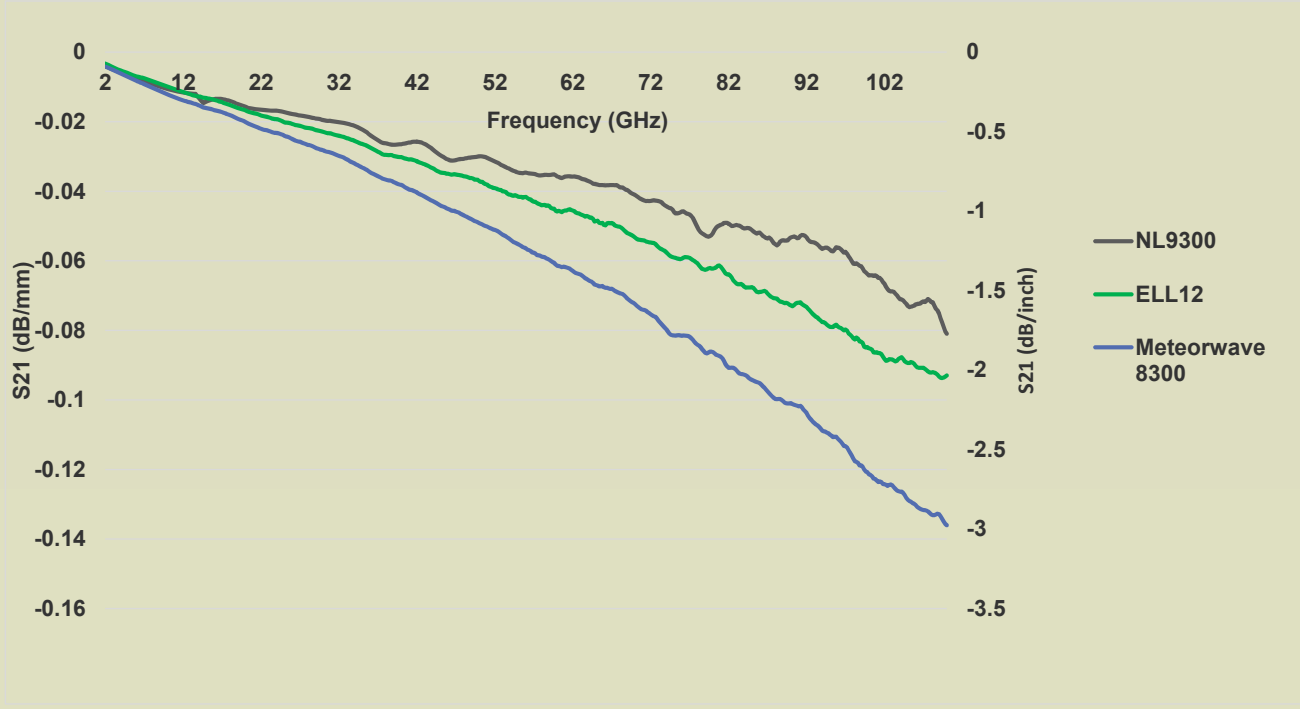


CPW-G (Top View)



CPW-G (Side View)

Insertion Loss



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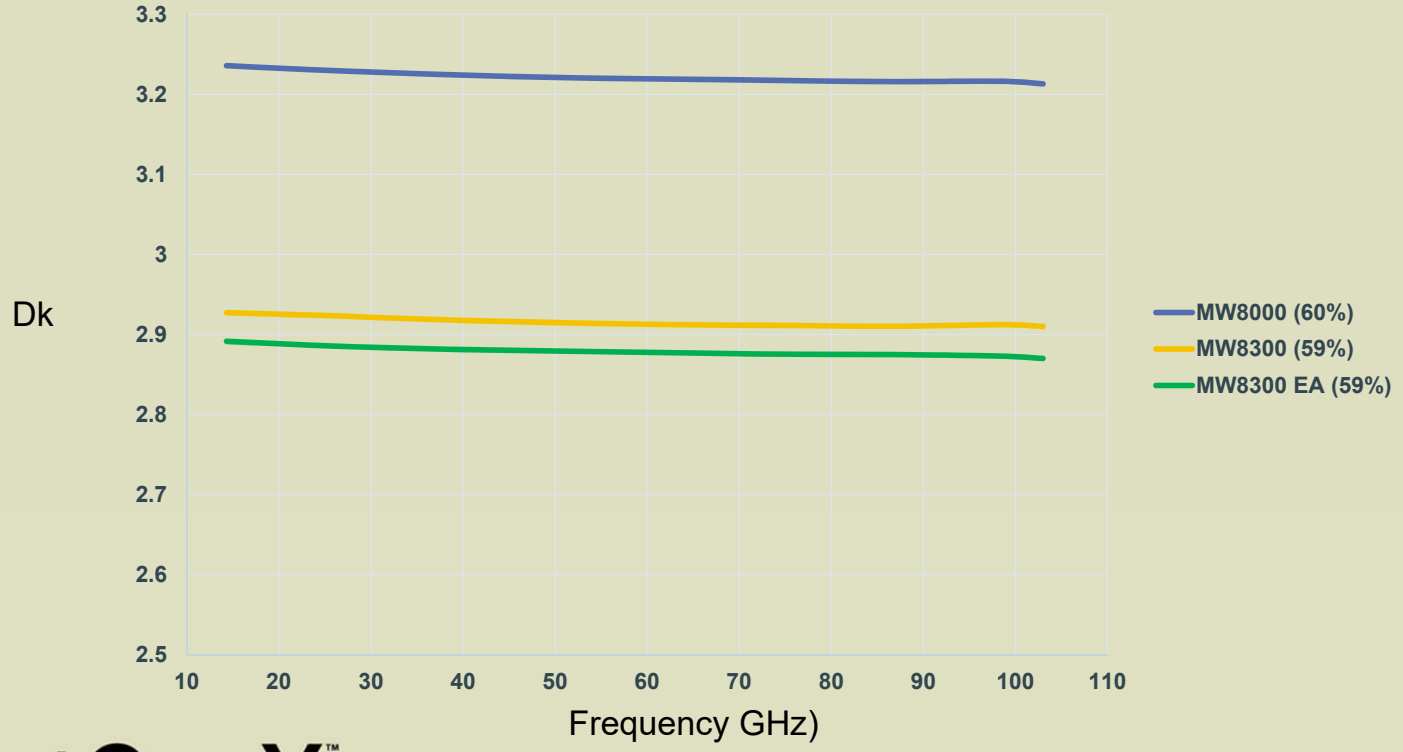
Dielectric Constant Frequency Response



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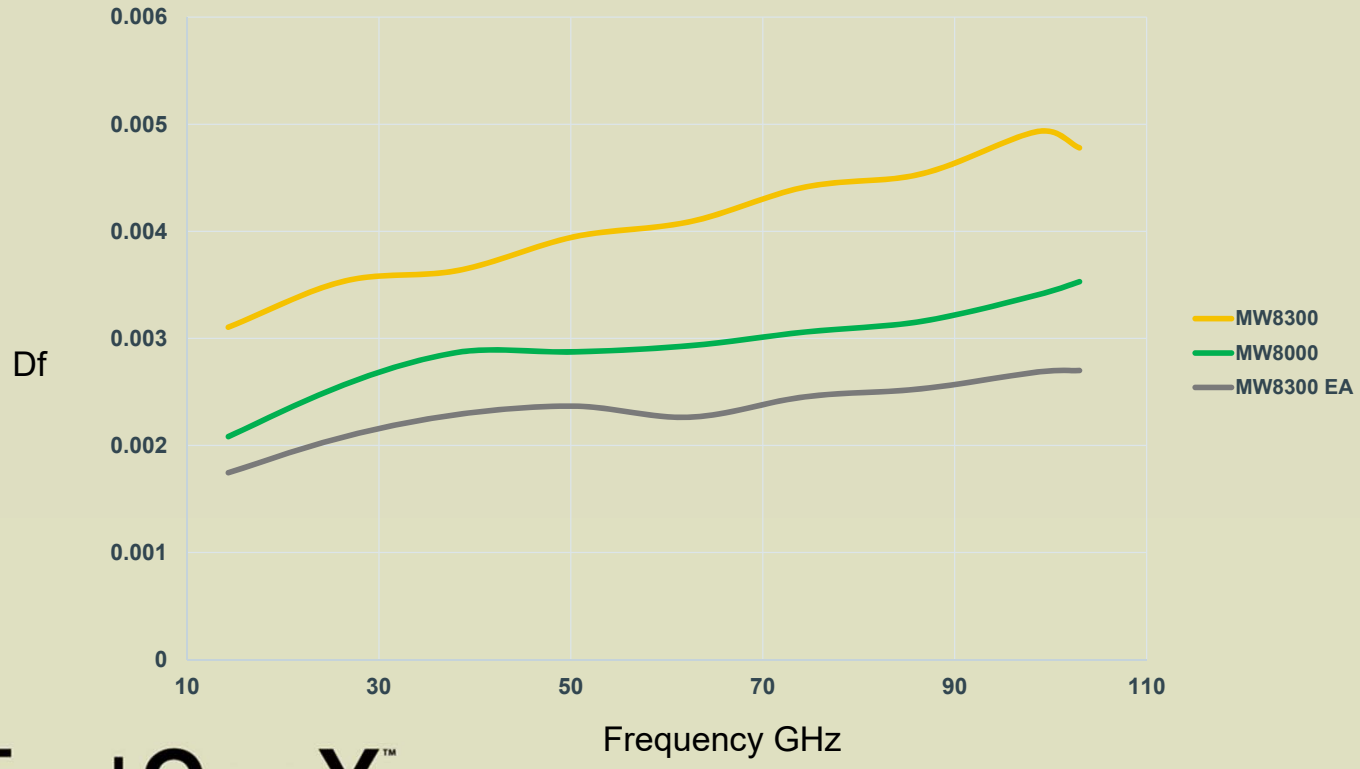
Dissipation Factor Frequency Response



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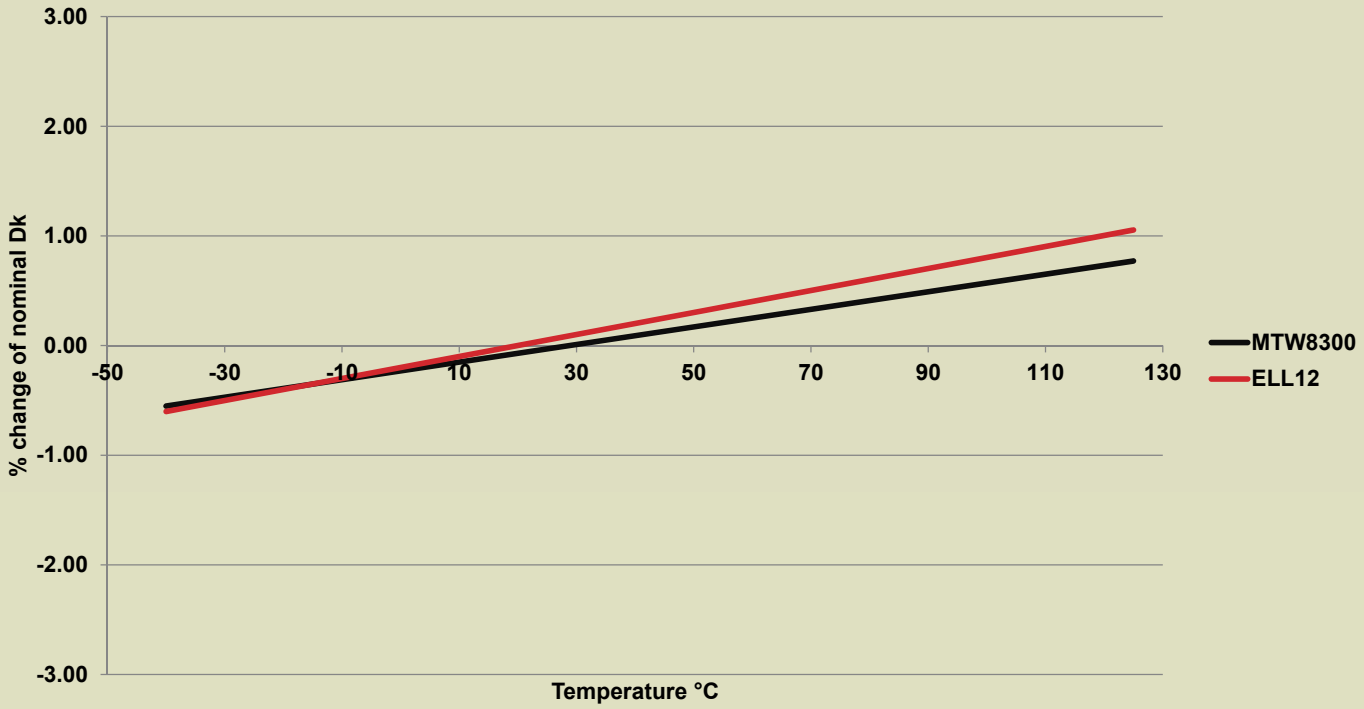
% Change of Dielectric Constant vs Temperature



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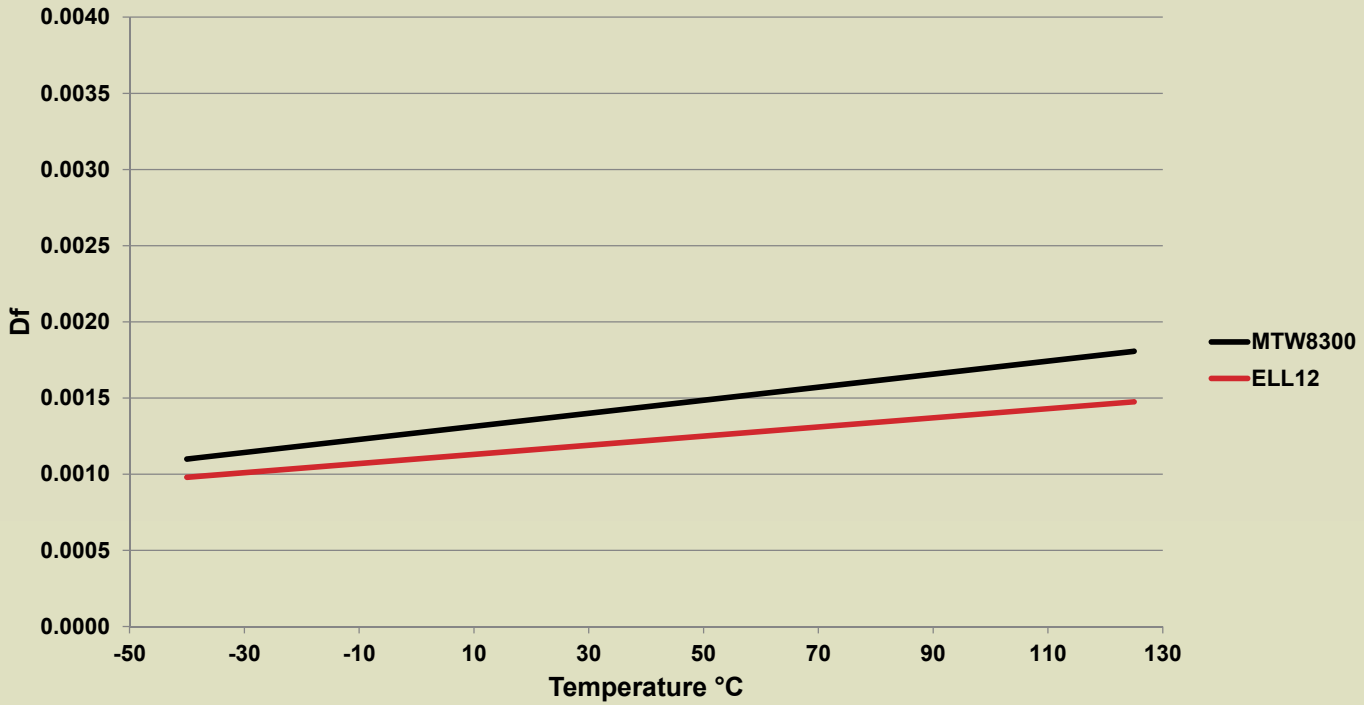
Dissipation Factor vs Temperature



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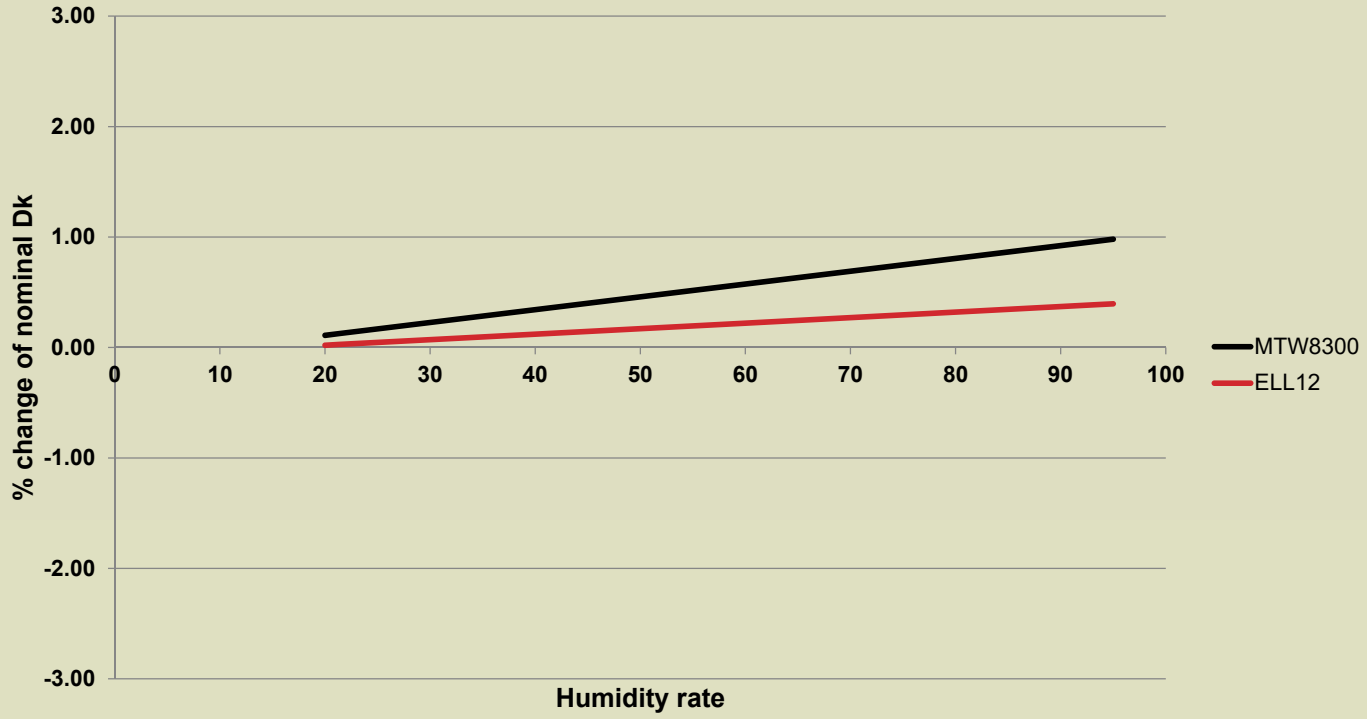
% Change Dielectric Constant vs Humidity



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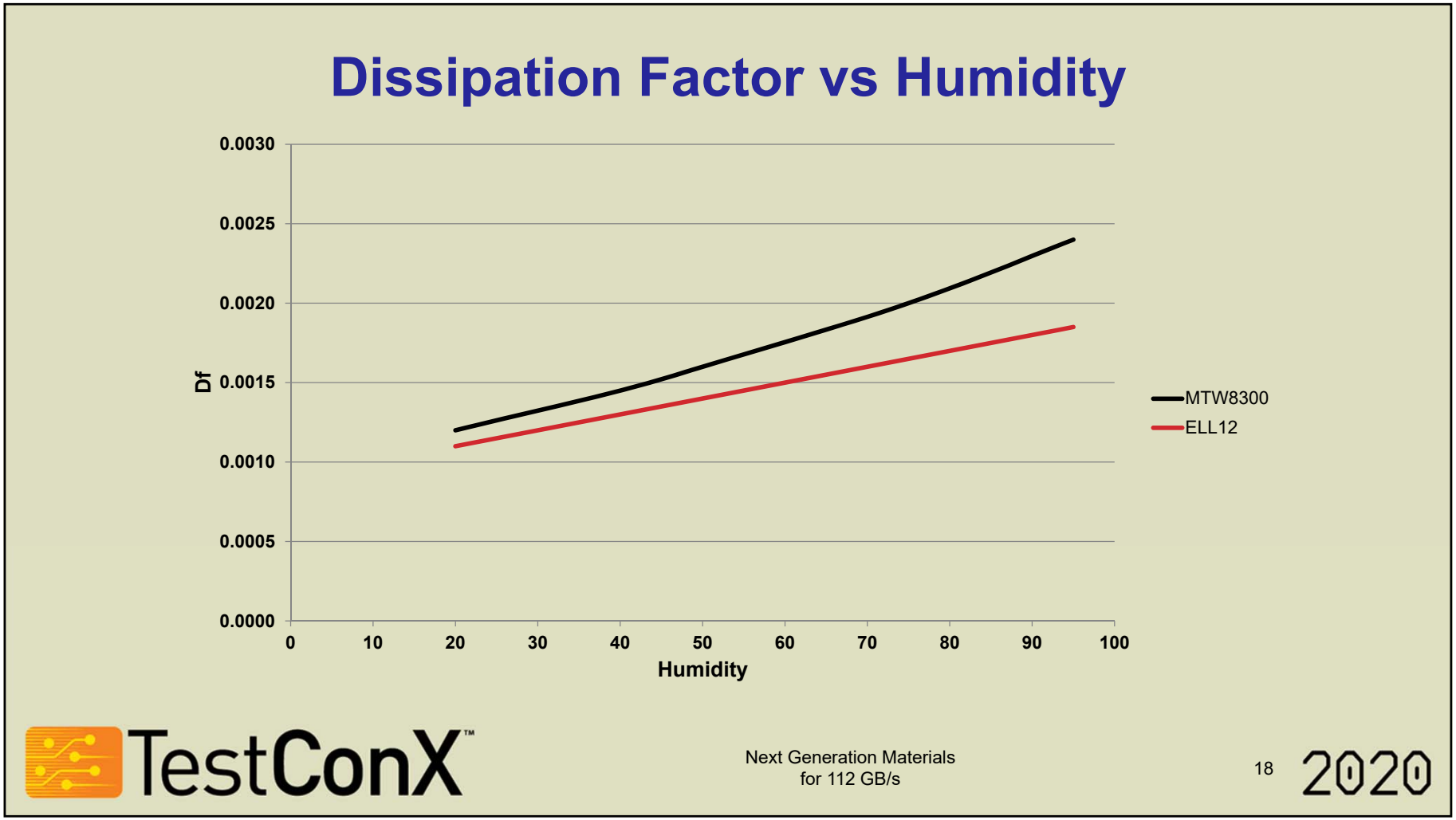
Dissipation Factor vs Humidity
0.0030
0.0025
0.0020
0.0015
0.0010
0.0005
0.0000
Df
0
10
20
30
40
50
60
70
80
90
100
Humidity
MTW8300
ELL12
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Summary

- Next Generation of Raw Materials will provide the Electrical Performance for Achieving 112GB/s
  - Low Loss, Low Dk Glass Fiber
  - "No Profile" Roughness Copper Foil
- Thermal, Environmental, Chemical, and Mechanical Reliability must be maintained, as well as Ease of Processing.
- Are we reaching the limits of Copper Clad Dielectrics?

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