Low Loss Laminate Trends and Performance - Taiwan Supply Perspective

IBM Symposium

GCE

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Overview of Discussion

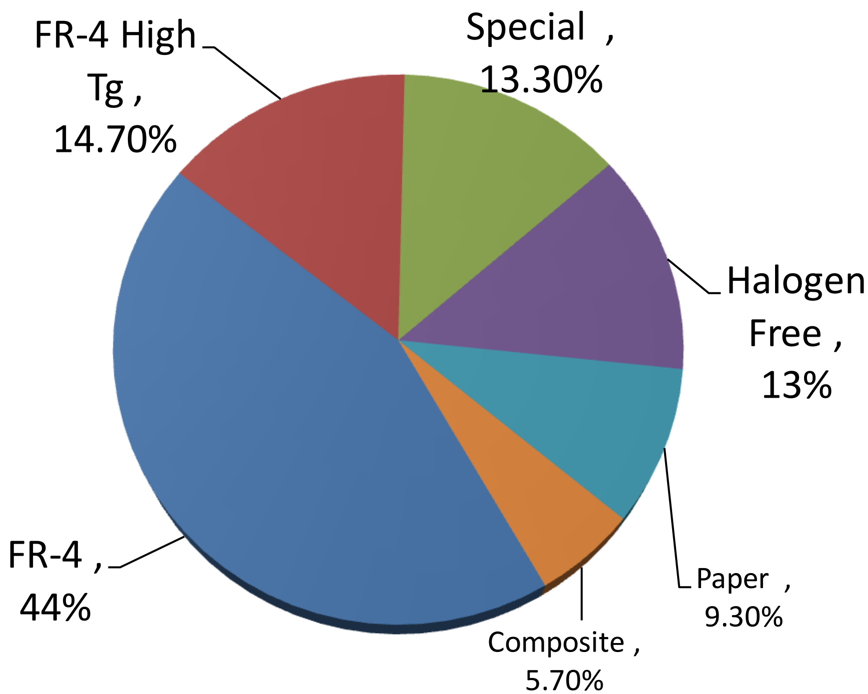
- Introduction
- Low Loss Material Development, Taiwan region
  - Status of Supply
    - Market and Availability
    - Manufacturability
      - Process Window
      - Material Properties

Introduction

- Product Evolution at a rapid pace is increasing the need to quickly drive "maturity" in the low loss laminate supply

- "Maturity" can be defined as
  - Available regionally, including samples
  - Competitive
  - Capable with a wide "design, process and assembly" range of implementation
  - Able to meet all appropriate qualification tests

Supplier Material Market Status

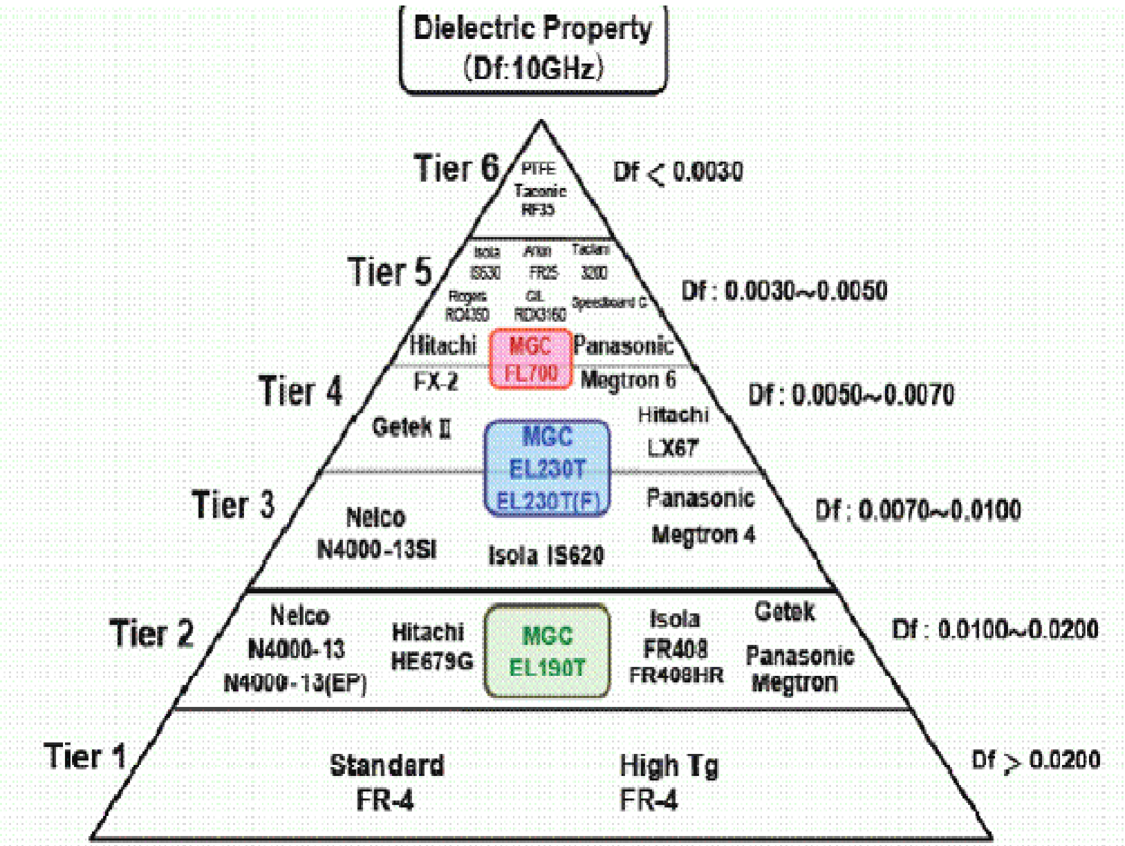


Material	Estimated % of market based on market data
FR-4	44%
FR-4 High Tg	14.7%
Special	13.3%
Halogen Free	13%
Paper	9.3%
Composite	5.7%

Current Situation: Low + Ultra Low, less than 13% of total market

Material Availability Trend

- Common representation of performance vs cost in the market, but will the pyramid is getting “flatter”?



Possible/likely evolution?

	Cost now	2013 (est)	2015 (est)
Tier 1	Std	Std	
Tier 2	100%	150%	100%
Tier 3	150%		
Tier 4	350%	200%	150%
Tier 5	450%	450%	300%
Tier 6	600%		

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Material Review

1. Raw Material "Data Sheet"
2. Post PCB processing Result
3. Customer specific Output

- Efficient data collection and marriage between these 3 collection points tantamount

Laminate Material Name	
Data Source:	PCB Supplier Name

Electrical Properties	1 GHz		3 GHz		10 GHz	
	Low	High	Low	High	Low	High
Loss Tangent - SE SPP						
Resin Content						
Cu Foil Type						
Oxide Treatment						
Loss Tangent - Differential SPP						
Trace Width/Space						
Resin Content						
Cu Foil Type						
Dielectric Constant SPP						
Resin Content						
Cu Foil Type						
Oxide Treatment						

Thermal Reliability	5X, 245C		5X, 260C		7X, 260C	
	Cracks	Delam.	Cracks	Delam.	Cracks	Delam.
HOP31B - 110 mils thickness						
HOP31B - 130 mils thickness						

Long Term Reliability	300 hrs - CAF 600 Cycles - ATC	600 hrs - CAF 900 Cycles - ATC
ATC - 110 mils thickness		
CAF (Via-Via) - 110 mils thickne		
CAF (Via-Via) - 130 mils thickne		

Qualification Requirements Summary

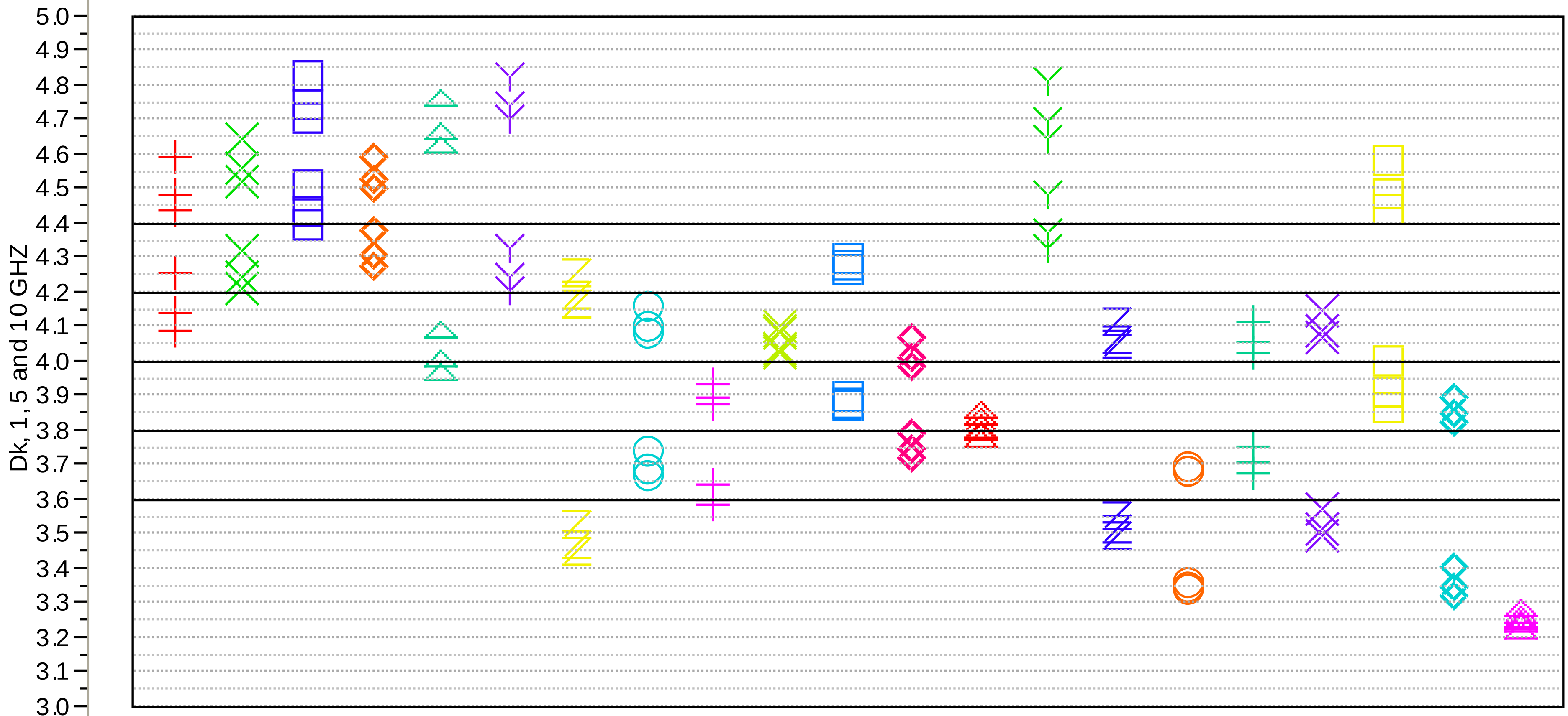
OEM	TV	Condition	Thermal reliability	CAF testing
IBM	0.130” 26L	6x 245C or 6x 260C	ATC (300, 600 or 900 cycles)	CAF (IBM dedicate 10K risk sites 0.8 mm -300/600 hrs min, testing down to 0.6 mm)
B	0.220 “ 34L	5x 260C	IST - cycle to 150C (test to fail, plot lognormal failure probability plot)	CAF (modified IPC – 0.8 mm) - 500 hrs min
C	0.150” 30L	10x 260C	Thermal cycle, -35 to 125C (400 cycles –air to air)	CAF (modified IPC – 0.8 mm) - 500 hrs min
D	0.125” 22L	6 x 260C	Thermal cycle, -40C to 125C (3000 cycles –air to air) or IST 2000 cycles min (cycle to 150C)	CAF (modified IPC – 0.8mm pitch) – 500 hrs min

Significant differences in “total” energy/heat resistance within the industry

Status of Supply - Dissipation Factor, SPP Method, 1, 5, 10 GHz Stacked Chart

More availability and capability in the low and ultra low loss space at 10 GHz needed and being pursued vigorously

Status of Supply - Dielectric Factor, SPP Method, 1, 5, 10 GHz Stacked Chart



Dk below 4 at 10GHz coincident with Df requirements needed

material

Material Characterization Comment

- "Best process window" for meeting qualification and reliability requirements for introducing new materials
- Material Properties Typically reviewed:
  - Td, Tg, T260, T288, CTE, Df, Dk, Moisture
  - Assess Data sheet, then manufacture "material screening" tests
    - SPP, HOPMIX, Hollow fiber, Triple Point
- Additional properties of interest to speed up learning.
  - Moisture resistance of finished PCB
  - Plasma/De-Smear weight loss
  - Specific heat capacity

Supplier Status - Manufacturability

GCE testing – Material Characteristics Summary

Supplier	MTL	Loss	% CTE 25-260	T288	3 day H20	22 Min Plasma Mg/dm2
		<0.005	2.80%	120		
		0.0038 to 0.0051	2.48%	>20	0.04%	95.15
		<0.005	1.50%	30		
		0.0042 to 0.0051	1.86%	24.5	0.07%	60.97
		<0.007	2.60%	30		
		0.006 to 0.007	2.58%	16.4	0.10%	35.64
		<0.008	2.30%	20		
		0.007 to 0.008	2.85%	13.5	0.13%	16.28
		<0.010	2.80%	20		
		0.0097 to 0.0109	2.83%	14.7	0.16%	38.32
		<0.010	2.90%	30		
		0.0058 to 0.0088	3.08%	8.416	0.07%	95.15
		<0.011	2.80%	15		
		0.012 to 0.0132	3.89%	13.88	0.15%	44.61

Laminate Data sheet - TOP ROW

Post PCB Fabrication Results - BOTTOM ROW – Various TV

Supplier Status - Manufacturability

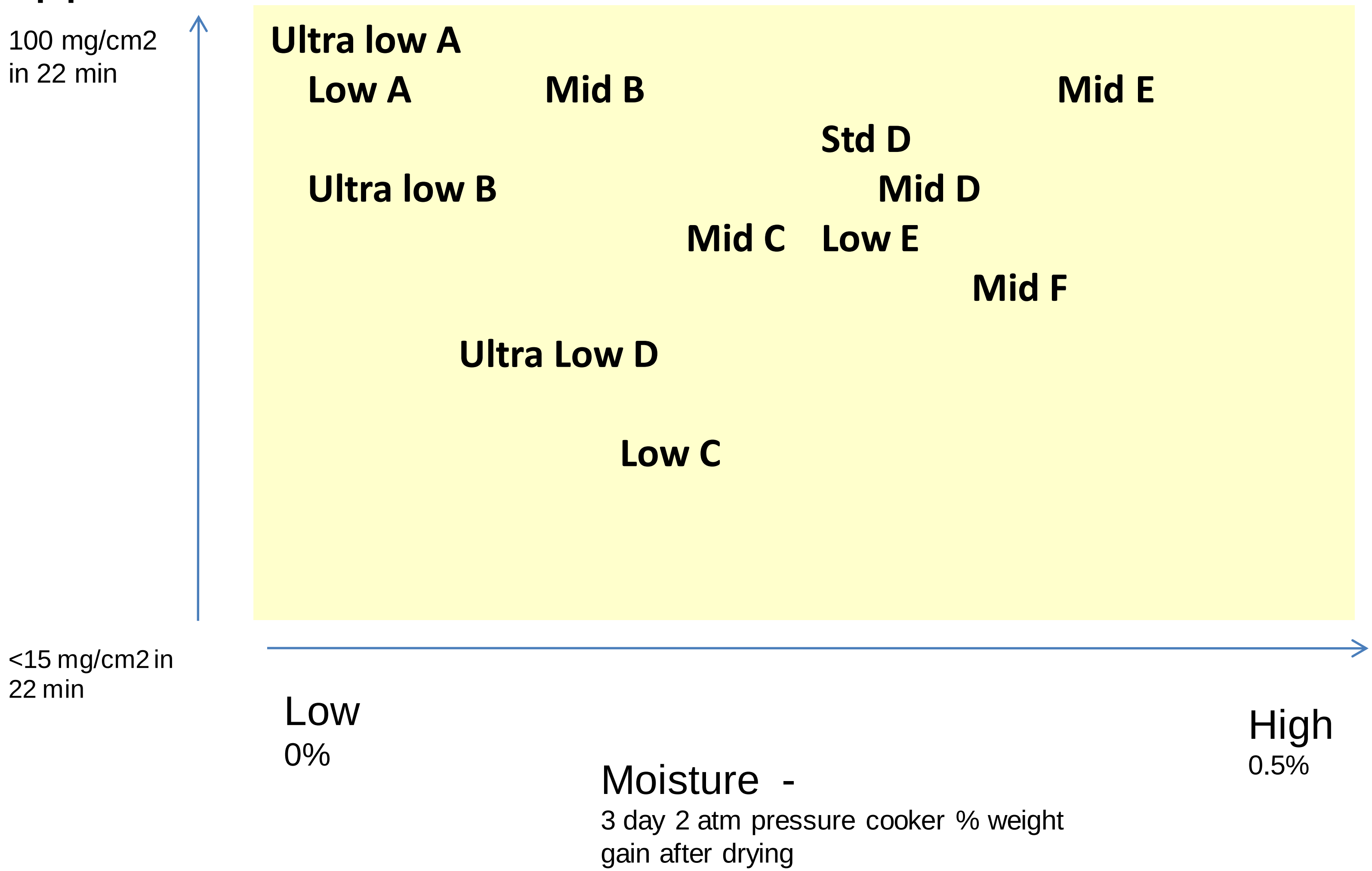
GCE Testing – Material Characteristic Summary

Supplier	MTL	Loss	% CTE 25-260	T288	3 day H20	22 Min Plasma
		<0.011	2.60%	60		
		0.0123 to 0.0145	3.77%	10	0.20%	42.09
		<0.012	2.50%	30		
		0.0132 to 0.0157	3.00%	12	0.22%	70.44
		<0.012	2.70%	25		
		0.010 to 0.0107	3.24%	12	0.25%	61.83
		<0.015	3.00%	30		
		0.0137 to 0.0155	3.39%	15.9	0.46%	75.95
		<0.015	3.00%	25		
		0.0164 to 0.0172	2.73%	11.8	0.33%	59.85
		<0.020	2.50%	25		
		0.0192 to 0.0212	2.47%	8.7	0.18%	56

Laminate Data sheet - TOP ROW

Post PCB Fabrication Results - BOTTOM ROW – Various TV

Plot of Moisture holding maximum versus Plasma weight loss
Upper Left is desired condition



Specific Heat Monitor - How Formulations impact result

- Formulations refined to improve Df tend to lower heat capacity.
- Polymer mobility equates to higher specific heat but also higher loss.
- Side chain, co-polymer composition and polymer back bone "design" also effects Df and mobility
- Use of Specific Heat measurement can further identify formulation (material type) AND stack up differences (design and test vehicles)

Specific Heat Monitoring

- Best method is using DSC with sapphire standard in the reference cell, method well established and documented by Thermal analysis equipment makers.
- All laminate makers are familiar with this method (simple and do-able)
- Applying this method to each "new stack up" can be a way to confirm if actual application is vulnerable to higher heat environments

Substance	Specific Heat J/kg per C
Water	4184
Air	1050
Copper	385
Laminate low A (supplier data)	850
Laminate U low A (supplier data)	880
Sapphire Std	916

Specific Heat Review

Sample	Below Tg J/kg/C median value 3 runs 100C value	Material	Layers	Thick
Std TV	932	A	20	110
Std TV	960	A	26	130
Mid PN	971	B	12	75
Mid PN	1051	B	16	100
Mid PN	1090	B	8	62
Low PN	865	C	24	93
Low PN	867	C	20	80

•Samples taken in laminate area only.
•% Resin drives the specific heat result
•Significant differences between material types confirmed. (20% range)

Next steps:
Perform tests in copper areas of board
Create stack up model and specific heat threshold confirmation of stack up
Ascertain a direct relationship, feasibly, between a PN specific heat and ability to withstand Reliability testing.

Summary

- PCB Fabrication process window assessment to assure reliability can speed up new material introduction

- GCE will continue to assist in the regional growth of low and ultra low loss materials and explore/refine analyses that allow for successful launching of new materials

- Additional material property testing to assist in process window confirmation and drive success