Eurocircuits.com

From idea to professional

Online PCB platform

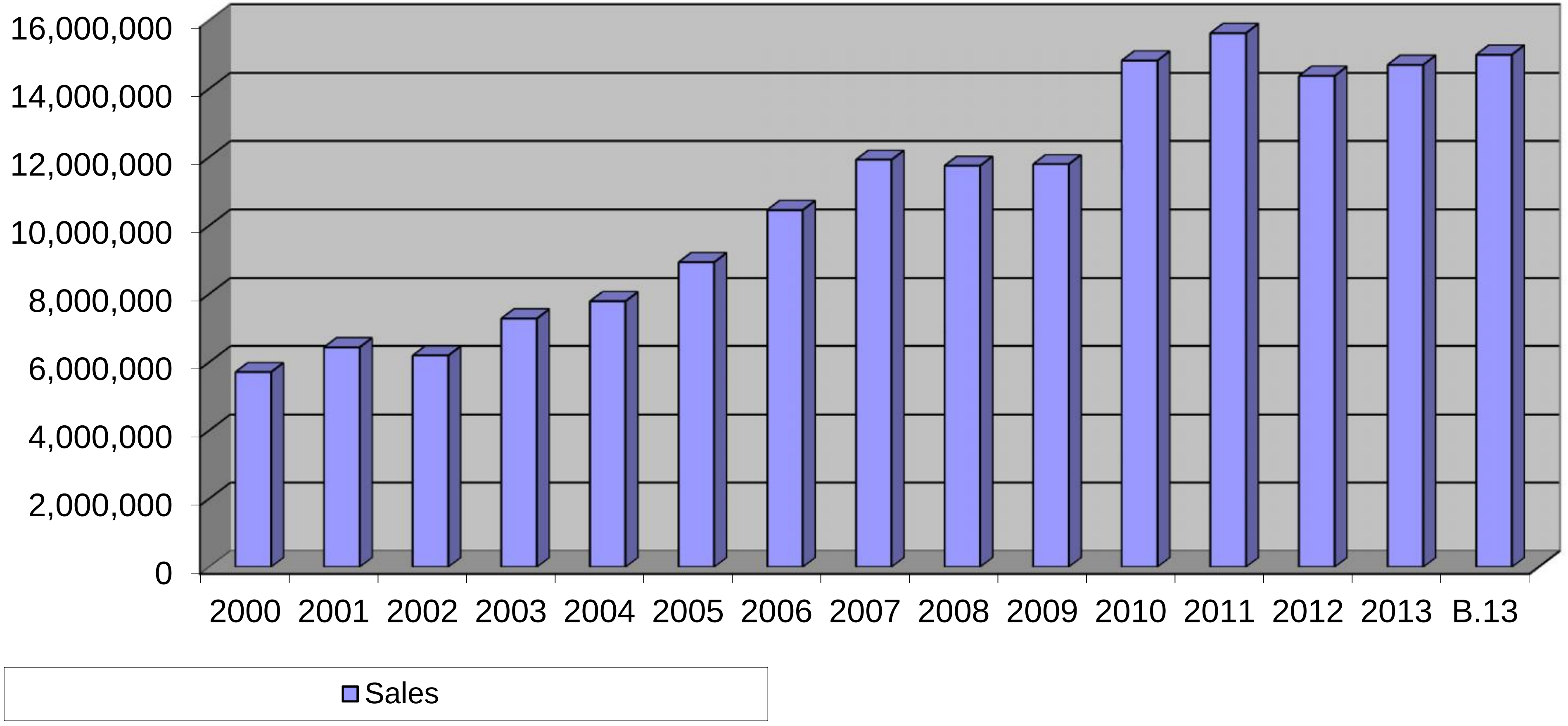
Eurocircuits – 23 years

- 1991 - Europrint NV – trade of PCBs
- 1993 - owner Hungarian factory - sales of own products
- 2000
  - first foreign sales office – Germany
  - first over seas activity – India (CAM)
  - first version of the Eurocircuits e-business platform
- 2004 - new factory in Eger Hungary
- 2006 - Group TO > 10M€
- 2007 - all group services online on eurocircuits.com
- 2008 - move head office to the new building
- 2009
  - Second factory in Aachen – Germany
  - first franchise site – elektorPCBservice.com
- 2010
  - new website – new services TECH pool and IMS pool
  - Group TO > 50.000 orders and +/- 15M€
- 2011
  - eC-equipment - SMD prototype soldering
  - second franchise site – element14.com
- 2012
  - Go social – engineering community – BLOGs, LinkedIn, Twitter, Facebook, Google+
  - Go visual – talk with images: PCB Image – PCB Visualizer
- 2013
  - Goes visual – PCB Checker – PCB Configurator – layout editor – buildup wizard - PCB PIXture - ...
  - Third factory in Ghandinagar – India
  - Serving +/- 8.000,- customers => +/-12.000 ,- users and +/- 70.000 orders

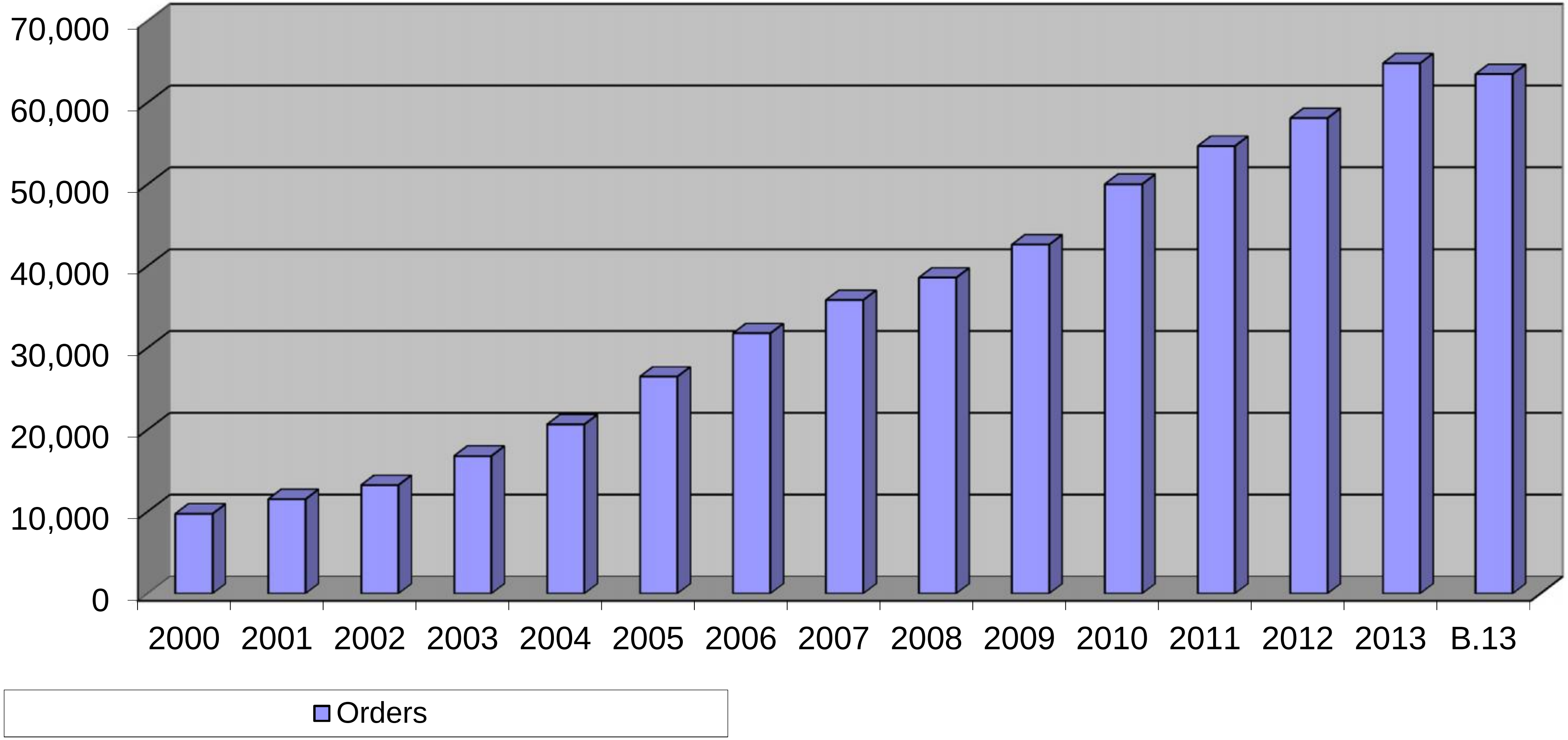
Eurocircuits - today

- Eurocircuits Group
  - Luc Smets – 50% partner
  - Dirk Stans – 50% partner
- Production and logistics
  - 4 logistic centers: B – D – HU - IN
  - 3 factories: HU– D - IN
- Sales & marketing
  - 7 subsidiaries: B – D – F – CH – HU – USA - IN
  - 2 local sales: UK - I
- CAM (front end preparation)
  - PCB Planet Ltd – India
- Eurocircuits own software teams
  - Website development & maintenance (India)
  - CAM-tools & database mgt (B)
  - ERP – Traceability – shop floor mgt (HU)

Eurocircuits Group PCB Sales YTD 2013



Eurocircuits Group PCB Orders YTD 2013



Eurocircuits – offer

- PCB proto’s & small series
- From 2 working days onwards
- On-line minimal administration
- Open 24/24 - 7/7D
- Free DFM-tools:
  - PCB Visualizer, PCB Checker, PCB Configurator
- Pooling until 8 layers
  - Services PCB proto, STANDARD pool, BINDI pool, RF pool and IMS pool
- Non-pooling until 16 layers
  - Services STANDARD- and RF pool
- Stencil service for prototypes
- eC-solutions
  - eC-equipment and eC-consumables for prototype soldering
  - EAGLE CAD software
  - eC-workshops & trainings

Next Generation Base Materials
High Reliability in Low Loss applications

Alun Morgan

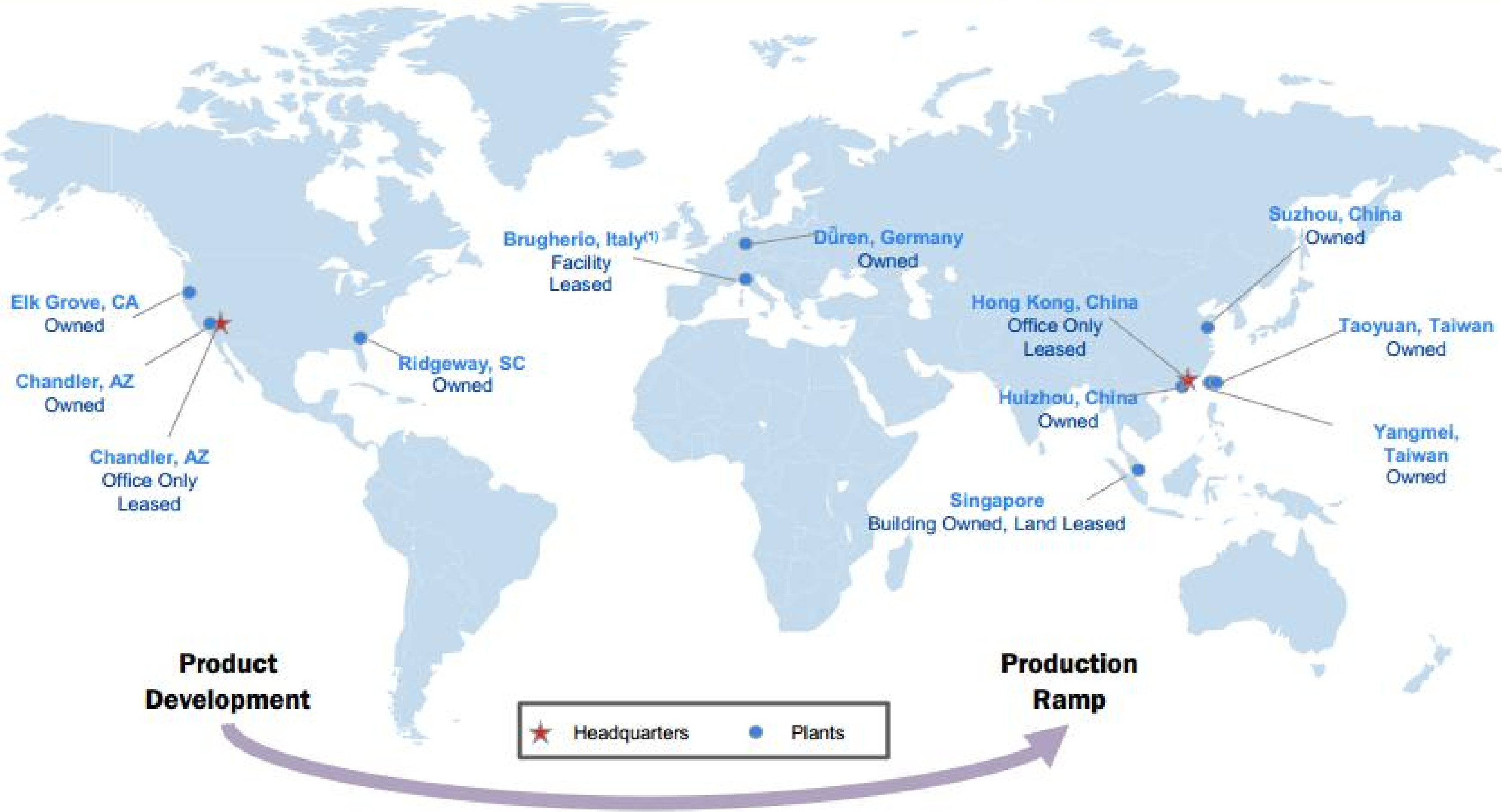
alun.morgan@isola-group.com

Global Product Development and Manufacturing Footprint

10 Manufacturing Facilities Across Three Continents

Three Strategic R&D Facilities with Headquarters in the US

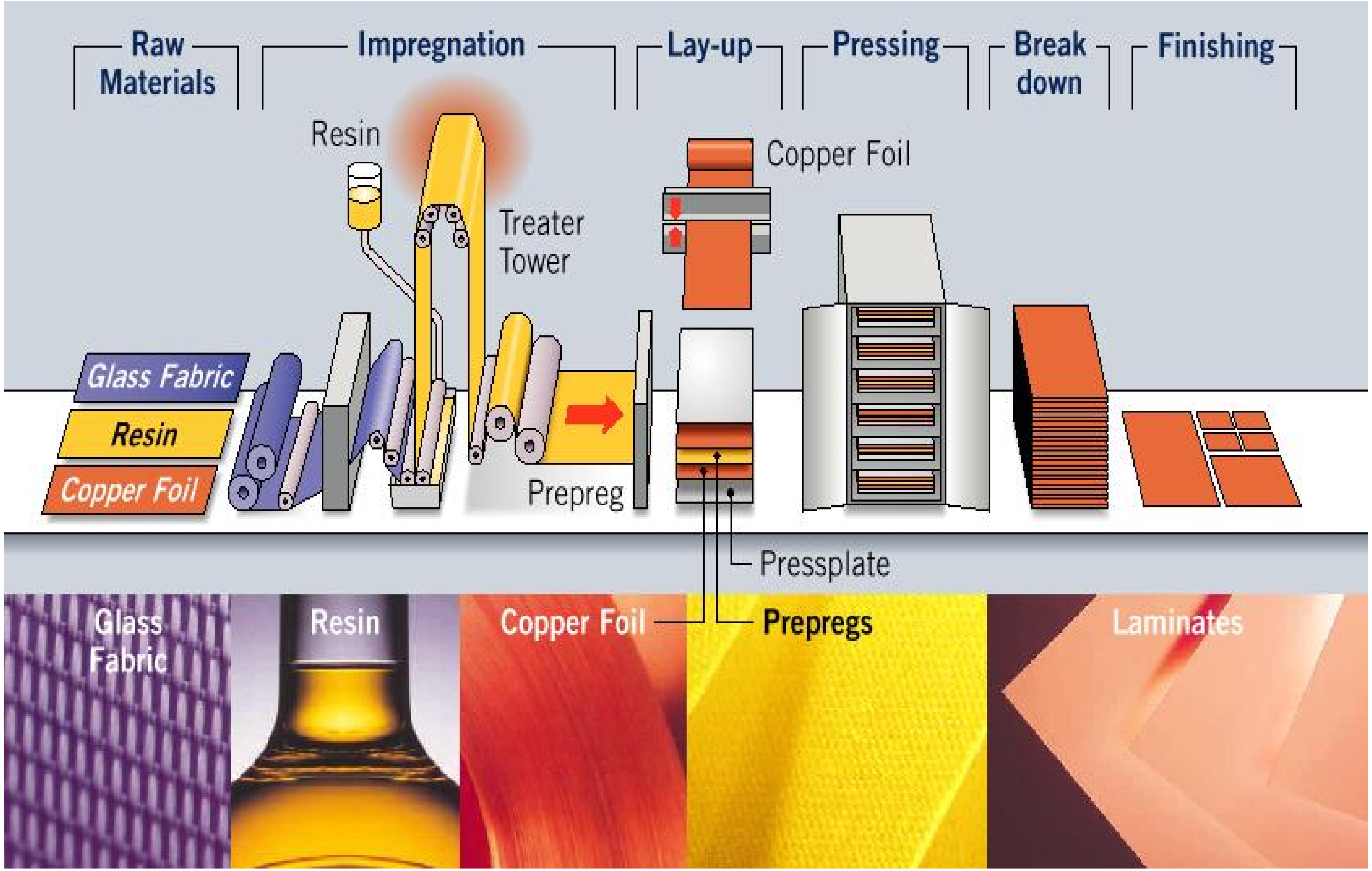
Global Quick-Turn Capability



Largest of only two specialized laminate providers with global capability to support development of high-performance products in the US / Europe and lower cost manufacturing in Asia

1. Brugherio facility is a glass fabric operation only

PCB Laminate Production Schematic



Lead free soldering- Migration from "dicy" to Phenolic Curing

Property	Units	Std Tg	High Tg	High Tg
Curing Chemistry		Dicy	Dicy	Phenolic
Tg, (DSC)	^{o}C	140	175	175
Td, (TGA - ASTM)	^{o}C	315	300	350
T-260 (TMA)	minutes	15	8	> 60
T-288 (TMA)	minutes	< 1	< 1	> 15

Comparison “dicyandiamide cured“ and “phenolic cured“ after thermal cycle

Mechanical and Electrical properties

Property	Units	Std Tg	High Tg	High Tg	Next Generation
Curing Chemistry		Dicy	Dicy	Phenolic	Non dicy /non phenolic
Tg, (DSC)	^{o}C	140	175	175	200
Td, (TGA - ASTM)	^{o}C	315	300	350	370
T-260 (TMA)	minutes	15	8	> 60	> 60
T-288 (TMA)	minutes	< 1	< 1	> 15	> 20
Dk, 2 Ghz	-	3.80	3.80	3.76	3.73
Dk, 5 Ghz	-	3.71	3.71	3.76	3.71
Dk, 10 Ghz	-	3.71	3.71	3.80	3.70
Df, 2 Ghz	-	0.020	0.020	0.025	0.015
Df, 5 Ghz	-	0.021	0.021	0.023	0.015
Df, 10 Ghz	-	0.021	0.021	0.023	0.016

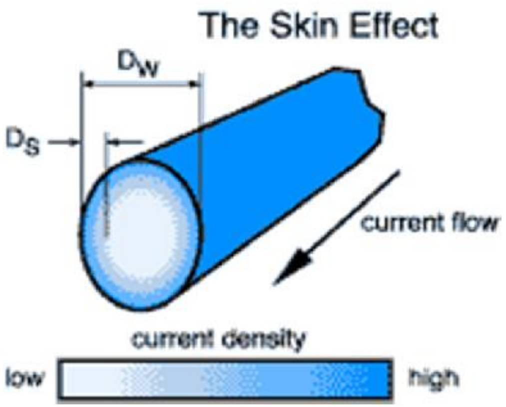
Where are the Losses ?

All PCB materials exhibit both conduction and dielectric loss.

- The conduction losses are primarily resistive (i^2r) losses in the conduction layers and leakage of charge through the dielectric.
- The dielectric losses result from the varying field produced from the alternating electric field causing movement of the material's molecular structure generating heat.

Skin Effect

Induced magnetic fields in a conductor affect the distribution of current forcing it to flow nearer and nearer the surface as frequency increases. This effectively reduces the current carrying cross section and hence increases the effective resistance



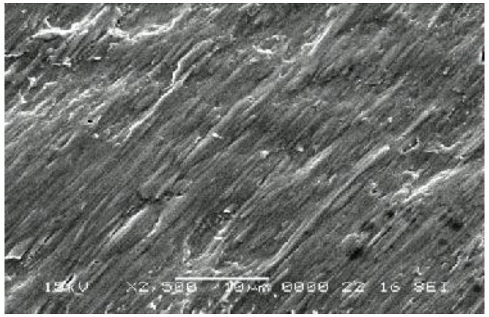
$$\delta = \sqrt{\frac{2}{\omega\,\mu\,\sigma}}$$

δ= skin depth (m)
μ= permeability (4π* 10-7 H/m)
π= pi
ρ= resistivity (Ω*m)
ω= radian frequency = 2π*f (Hz)
σ= conductivity (mho/m),

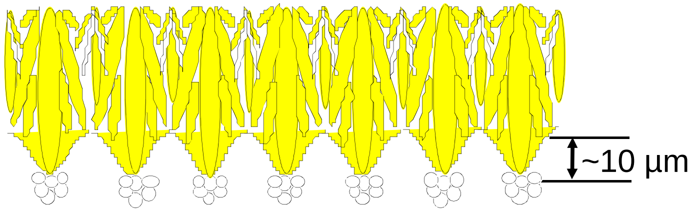
Frequency	Skin Depth (Copper)
50 Hz	9.3 mm
10 MHz	21 μm
100 MHz	6.6 μm
1 GHz	2.1 μm
10 GHz	0.66 μm

Copper Surface Profile

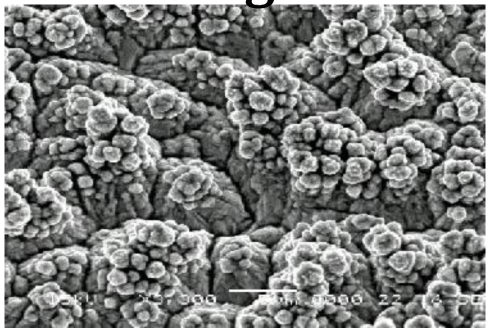
Resist side



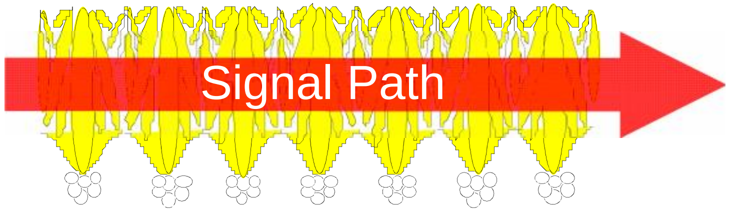
Standard foil



Bonding side

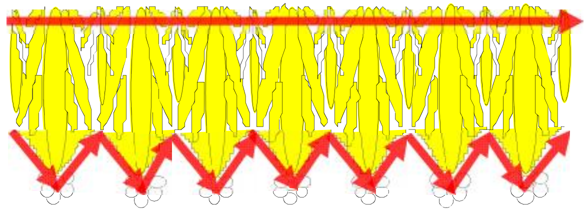


Frequency	Skin Depth
10 MHz	21 µm



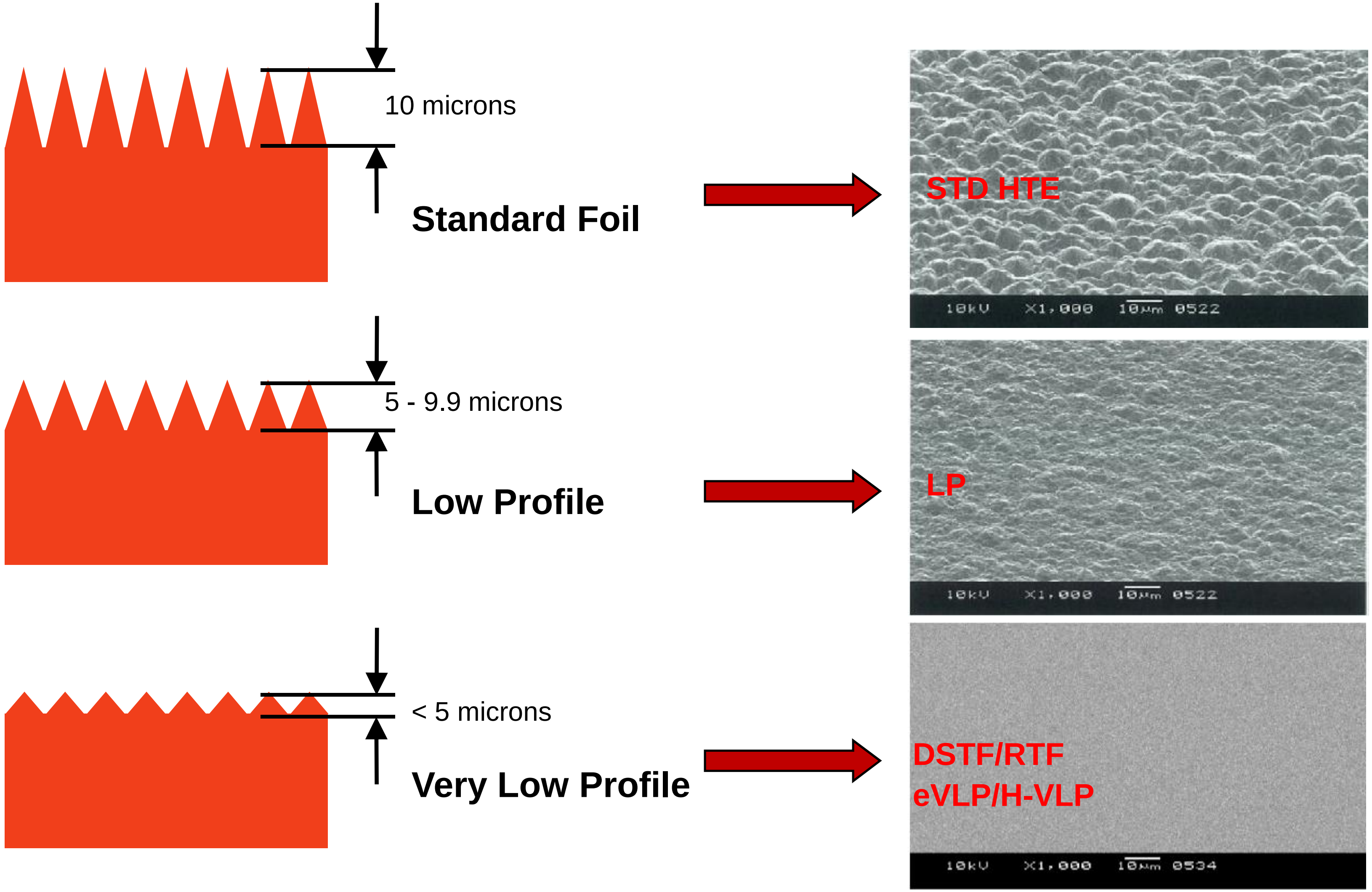
The current is able to tunnel below the surface profile and through the bulk of the conductor

Frequency	Skin Depth
100 MHz	6.6 µm



The current is forced to follow every peak and trough of the surface profile increasing path length and resistance

Copper Profile Specifications

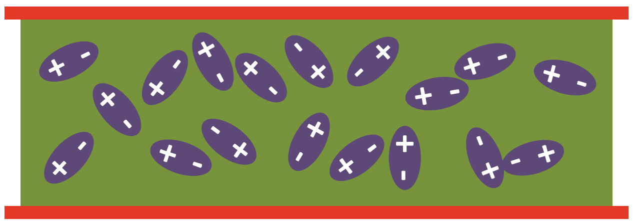


Dielectric Loss

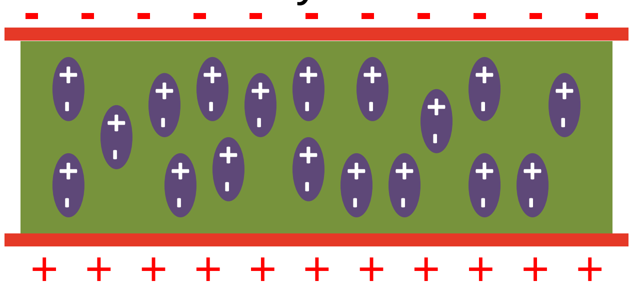
Dielectrics are materials which are poor conductors of electric current. They are insulators because they have few free electrons available to carry current.

However, when subjected to an electric field polarisation occurs whereby positive and negative charges are displaced relative to the electric field. This polarisation reduces the electric field in the dielectric thus causing part of the applied field to be lost

Unpolarised



Polarised by electric field

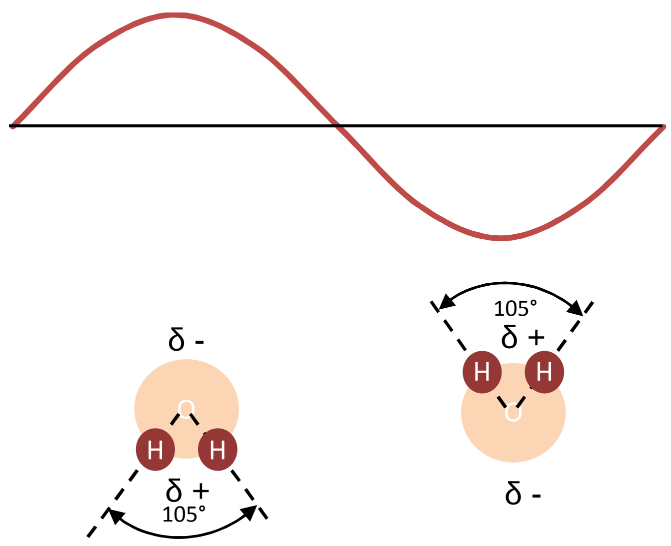


Dipole Moment

The amount of polarisation that can occur in a dielectric material depends on the symmetry of the molecular structure and can be quantified by the “Dipole Moment”. Within most molecular structures, although the overall charge is zero, the positive and negative charges do not overlap completely thus giving rise to a permanent Dipole Moment.

A good example of how this works is exhibited by water molecules in a microwave oven. As the field oscillates the molecules continuously rotate releasing kinetic energy as they collide with neighbouring molecules. The microwave frequency is 2.45GHz as this frequency allows the optimal time needed for the molecules to rotate exactly 180º.

The time delay is crucial to the process and explains why the dielectric loss reduces at higher frequencies for some advanced dielectrics where there isn’t enough time for the molecules to polarise before the charge reverses.



Loss Factor

The effect of the dipole moment in a dielectric is quantified as “loss tangent” and describes the dielectric’s inherent dissipation of an applied electric field. The loss tangent derives from the tangent of the phase angle between the resistive and reactive components of a system of complex permittivity. The property is dimensionless and is often referred to by the following synonyms;

- Loss Factor
- Dissipation Factor
- Dielectric Loss
- Loss angle
- Tan δ

Indicative Loss Factor Values

Material	Loss factor (1GHz)
Air	~ 0
Alumina	0.0002
Water	0.06
E-glass	0.0012
NE-glass	0.0006
Standard FR4	0.015
Phenolic cured FR4	0.020
Ceramic filled low loss substrate	0.003
PTFE based PCB substrate	0.002
New Generation PCB substrate	**0.003**

I-Tera MT

PTFE materials and more recently highly ceramic filled materials have been the standard choice for designers of high speed circuits

With the market growth and technological demands for multilayer circuits, new unfilled, non PTFE substrates have been developed enabling greater complexity, improved processability and offering a lower cost alternative to traditional solutions.

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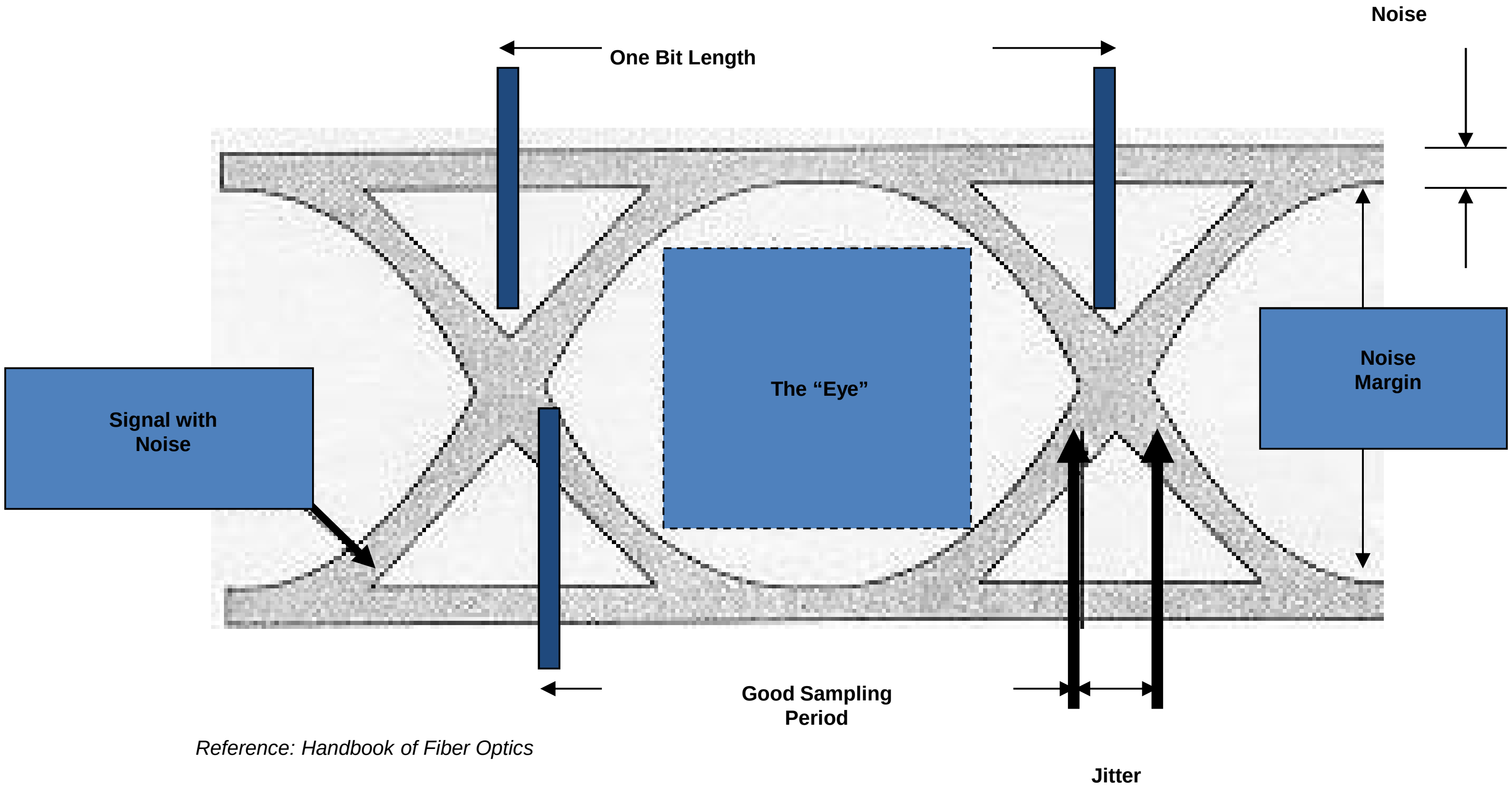
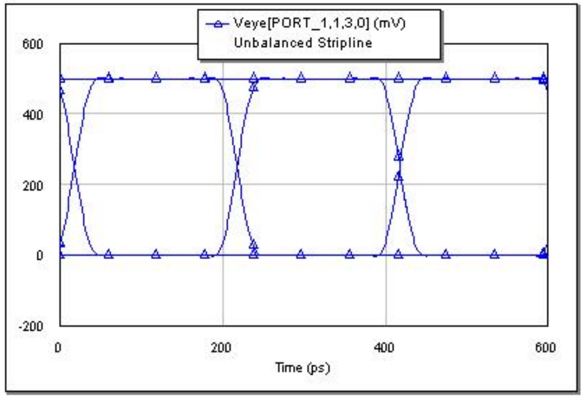
Eye Diagram



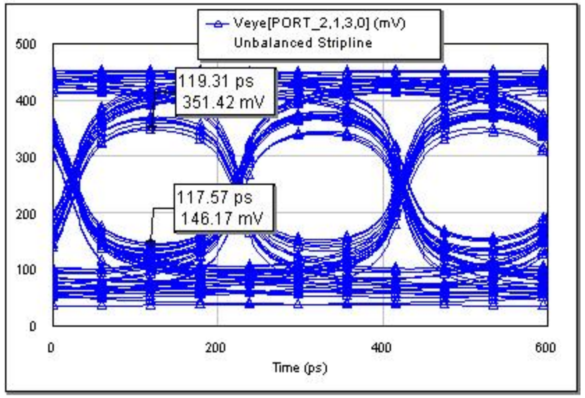
Reference: Handbook of Fiber Optics

Simulated Eye Diagrams

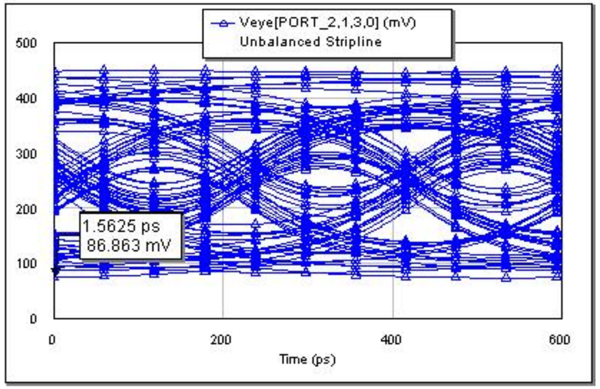
At Source



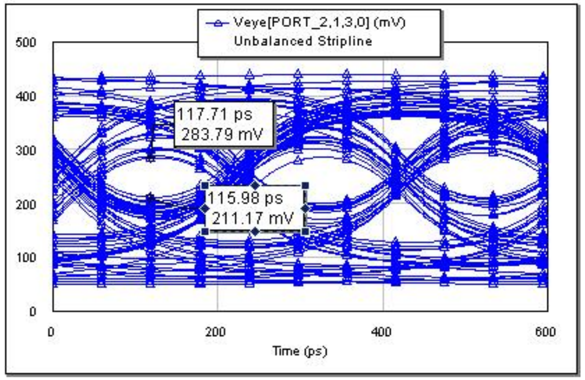
Zero Dielectric Loss



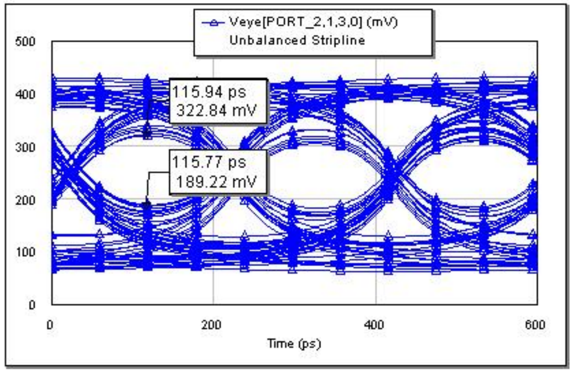
Standard FR4 DF =.020



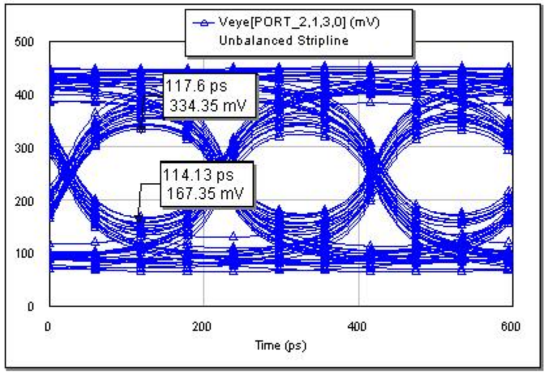
FR408 DF =.012



IS620 DF =.008



I=Tera MT® =.003



Simulated Eye Diagrams @ 5 Gbps -1 M -50 Ohms impedance
5 Mil Track width PRBS 35 PS Rise time

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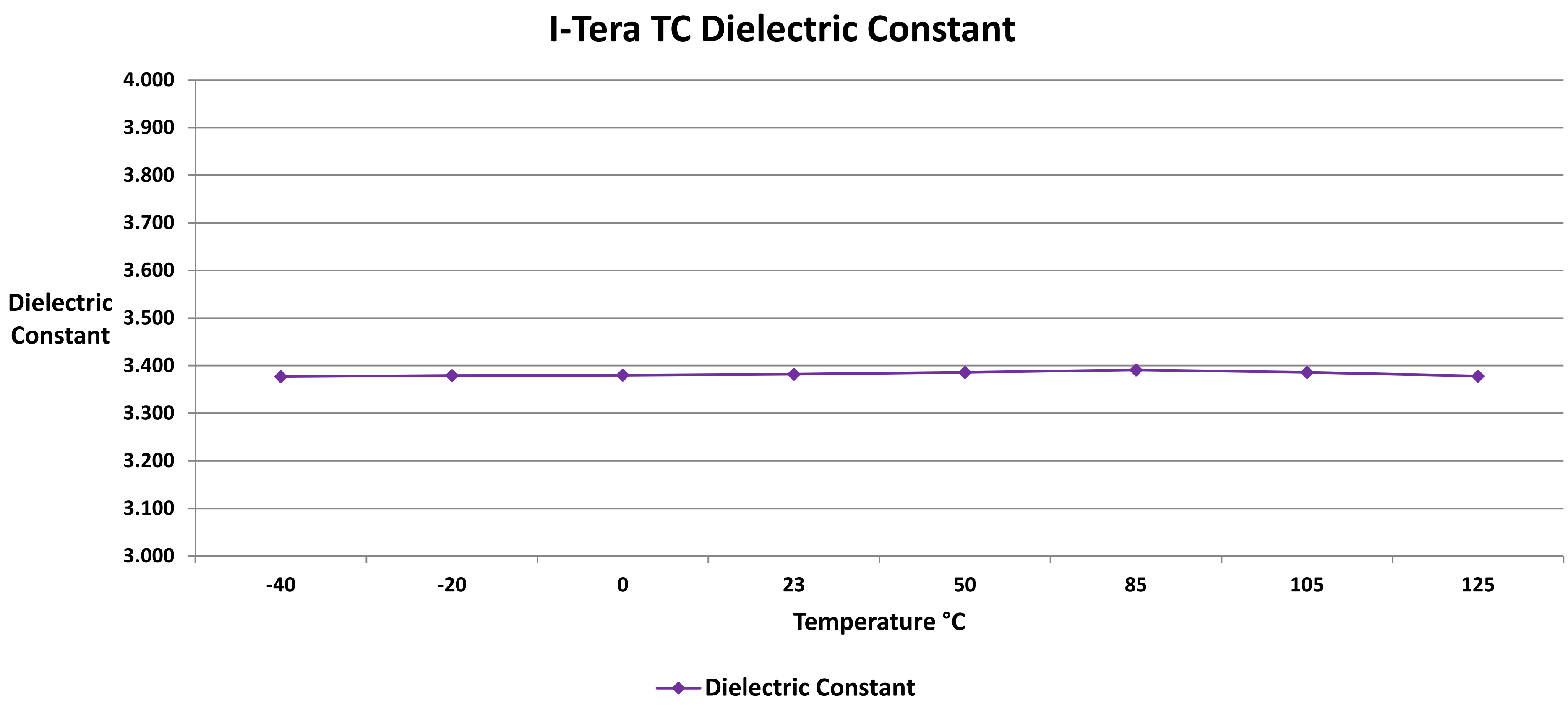
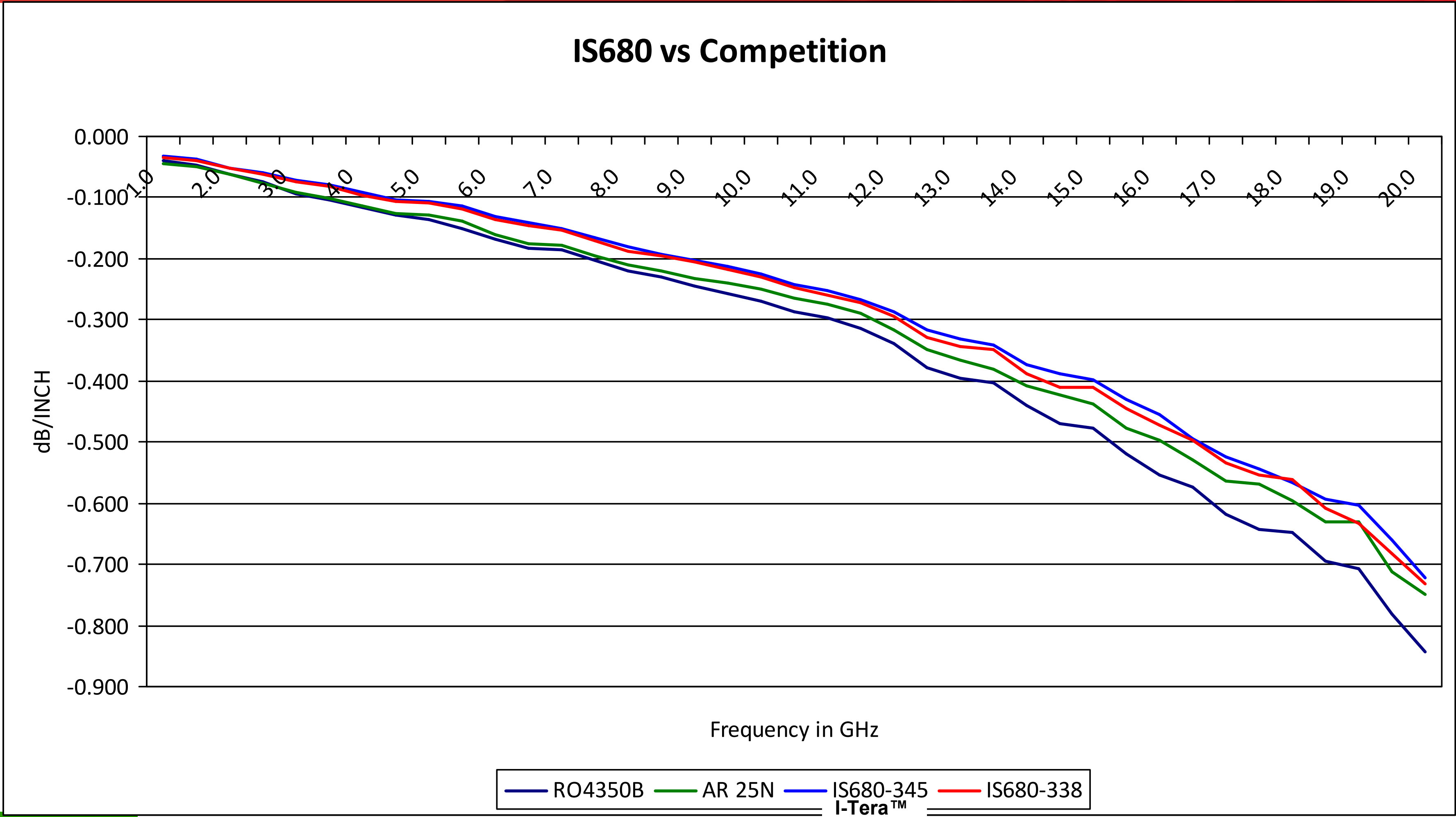
I-Tera® MT

- **Applications**
- **High Speed Digital**
  - Long Backplanes -20-30" – 10 Gbps/Channel
  - Daughter cards-10"- 20 Gbps/Channel
- **RF/Microwave**
  - Automotive Radars and Sensors
  - Antennas
  - Low noise block down converters (LNB) for Direct Broadcast Systems
  - Base Stations
  - Power Amplifiers
  - Point to Point Links
  - RFID's
- **Competitive products**
- **High Speed Digital**
  - **Megtron-6**
- **RF/MW**
  - **Rogers 4350**
  - **Taconic RF 35**

Thermal Coefficient of Dielectric Constant



I-Tera® MT and IS680 vs competitive products



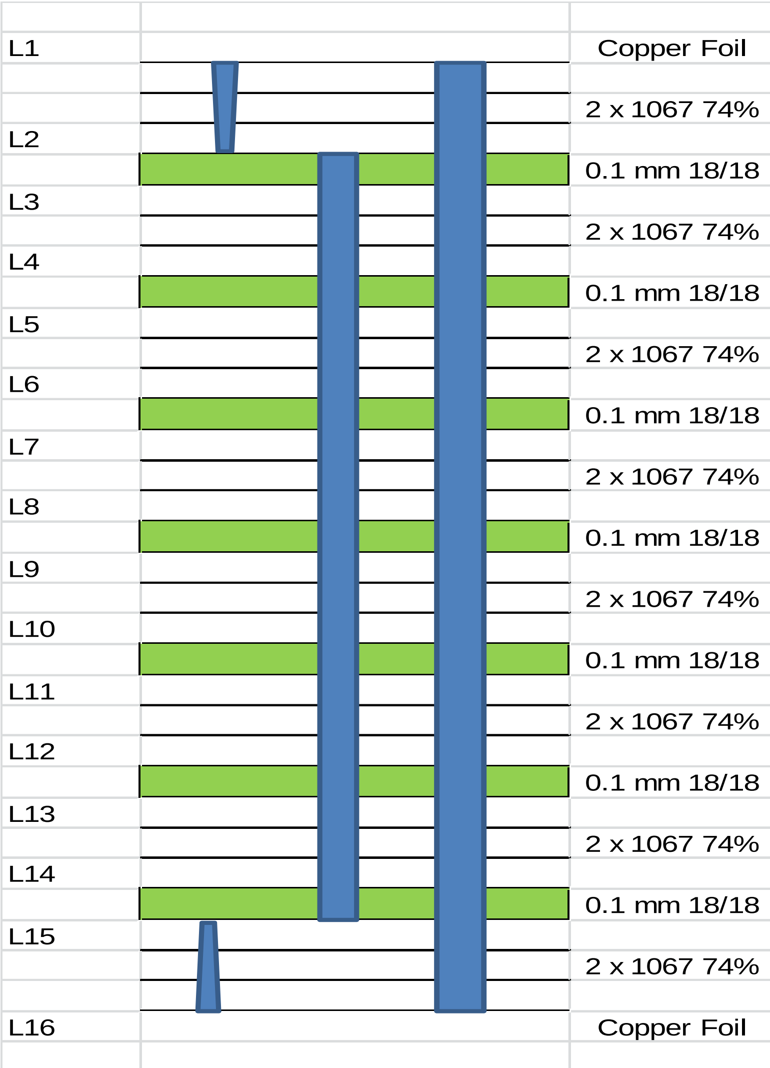
20-25 % Improved performance over competitive products

I-Tera® MT Product Strengths

- I-Tera MT uses **Standard E-Glass**
- **Standard Thicknesses** Available (nominal ± 5% for 0.020" and above)
- **Full Thin core offering from 0.0020** (non ZBC) to 0.018" for multilayer designs
- **Square and MS Spread glass** weaves used - 1035, 1067, 1086, 1078
- Very low loss material for backplane, high data rate daughter cards, hybrid applications
- **Superior Drilling Performance** – I-Tera MT does not contain a ceramic filler
- Processing to date - **Plasma desmear not required**
- I-Tera **has passed 10x 370˚C re-work simulation testing.**
- Compatible with Isola **185HR, 370HR and IS415 for hybrid constructions**
- **I-Tera MT prepreg** can be **stored** at **standard FR4 conditions**
- I-Tera MT = UL 94 V- 0
- UL MOT 130 C , I-Tera MT is the UL designation

I-Tera® MT IST Testing

IST Test Structure



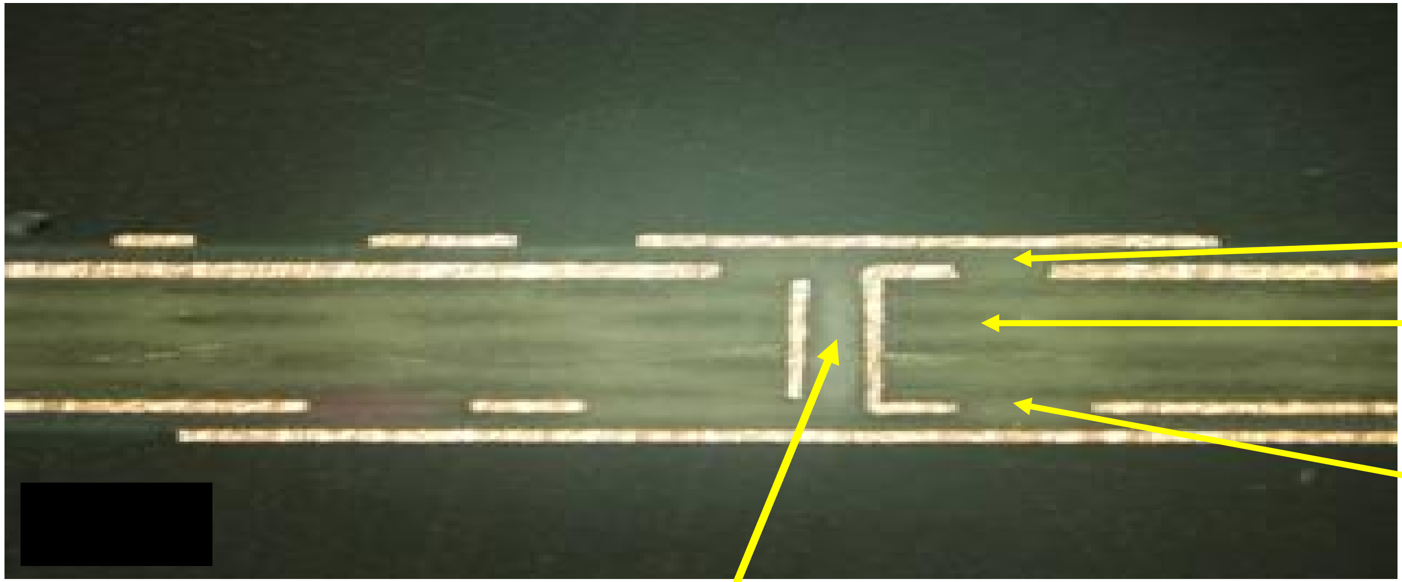
- IST Test Structure
  - 16 Layers, 2 mm thick
  - PTH = 300 um drilled dia.
  - Buried Via = 250 µm mm drilled dia.
  - Microvia = 125 µm drilled dia.
- IST Test
  - Pre-Condition 5 x 230 C
  - PTH = RT to 150 C
  - Buried Via's = RT to 150 C

I-Tera® MT IST Testing

IST Test Results

- Initial test results indicated exceptional thermal performance of I-Tera.
- Six initial IST test coupons were tested : -
  - PTH Holes (indicative of material performance)
    - The IST test was **stopped** after **2,800 cycles** of the PTH with **no failures** and no real sign of resistance increase being measured.
    - Customer commented that this type of performance was what would be typically expected of a **Polyimide** material.
    - In comparison, **370HR** (Customer's "standard" FR4 material) would have been expected to "fail" at **1,000 to 1,500 cycles** on such a PCB structure.

I-Tera® MT – Via Filling



- I-Tera Prepreg has shown the ability to fill vias
- I-Tera 0.020 H/H 3.45 Dk and 1 x 1078 72 % both sides
- Competitive Product would not fill the via, pre-fill had to be used
- Isola continues to work on **hybrid applications** with
  - 185HR, IS400, 370HR and IS415

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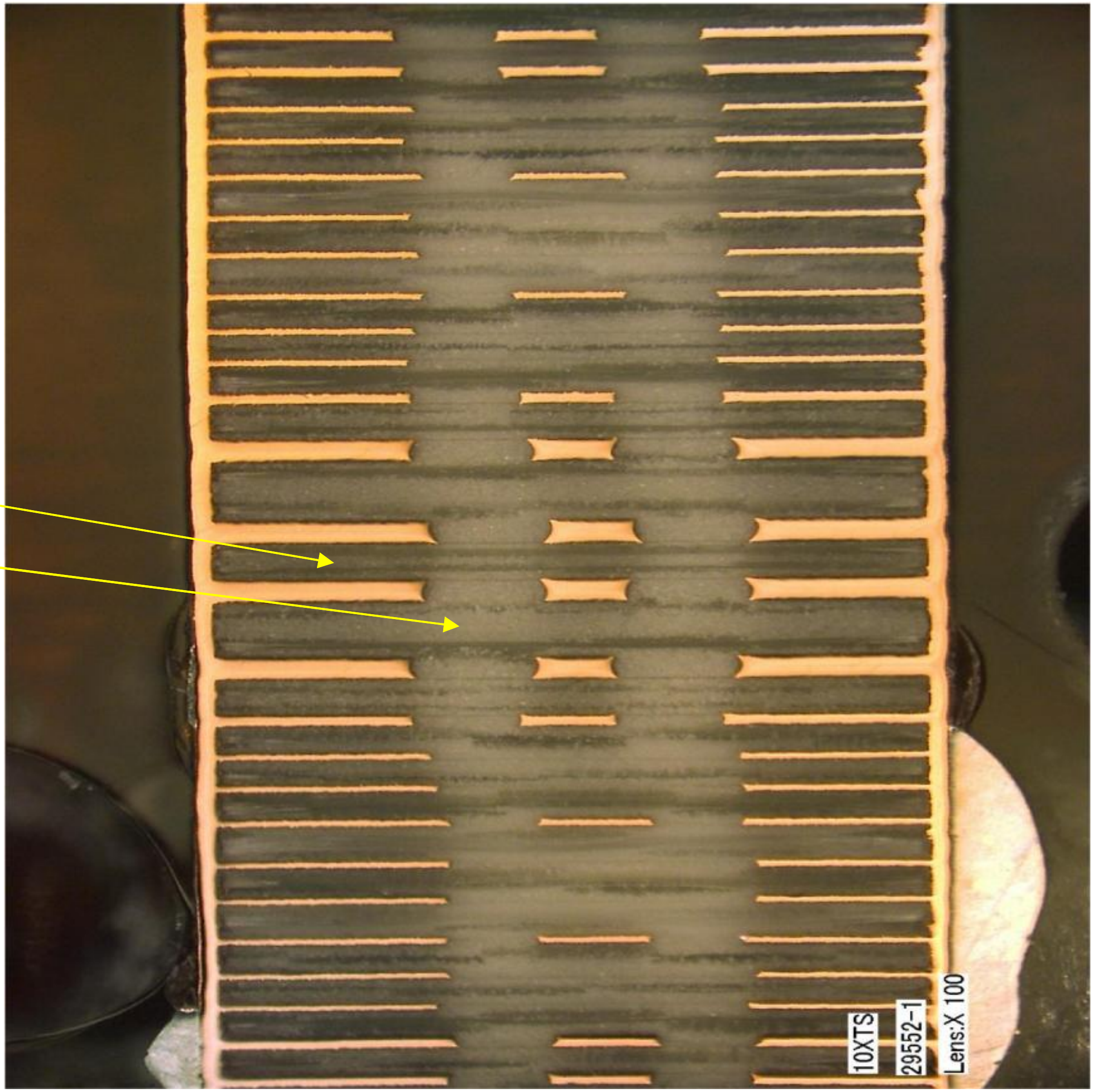
I-Tera® MT TV with 2 oz planes

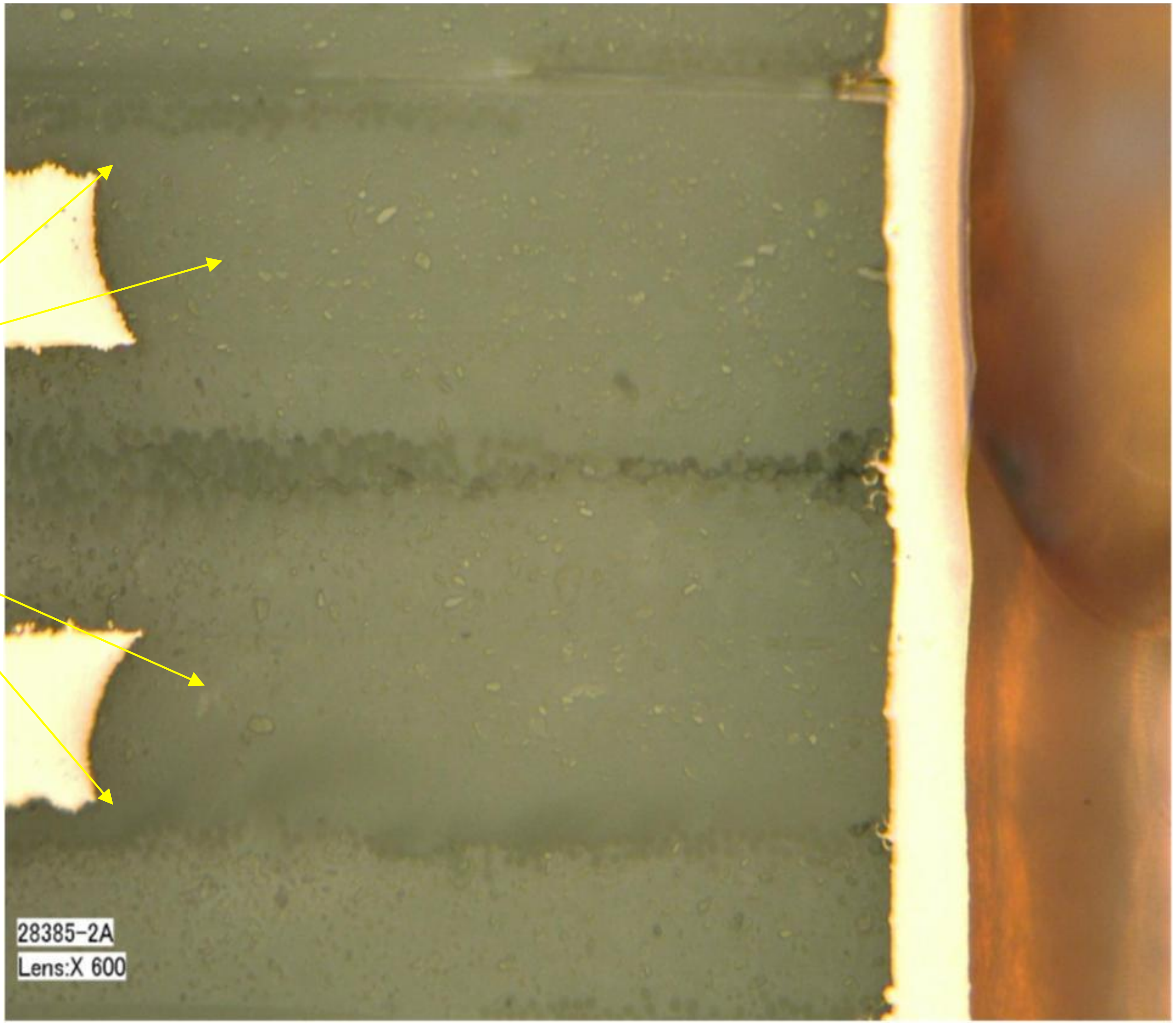
10X Lead Free Reflow @ 260°C shows complete fill of the 2oz copper areas and no de-lamination.



I-Tera® MT TV with 2 oz planes

10X reflow at 260 C

2 oz planes. Cross sections show fill area of 2 oz copper noting no glass stop on copper surface and no de-lamination



I-Tera® MT

Hybrid PWB

Processing Data

I-Tera® MT Hybrid Processing

Lamination Process	185HR	370HR	IS415	FR408HR
ROR				
(180 -280 Deg F)	6 to 10	3 to 6	3 to 6	3 to 6
(80-140 Deg C)	3.3 to 5.6	1.7 to 3.3	1.7 to 3.3	1.7 to 3.3
Cure Temperature				
Deg F	370	370	390	370
Deg C	188	188	198	188
Cure Time (mins)				
full pressure	45	45	45	50
reduced pressure	45	45	45	50
Pressure(psi) *				
full from start of cycle	375	375	375	375
reduce for stress relief	50 -100	50 -100	50 -100	50 -100
Cooling Rate				
initial rate (from cure temp for first 15 deg F 10 deg C)	less than 3 F / 1.7 C	less than 3 F / 1.7 C	less than 3 F / 1.7 C	less than 3 F / 1.7 C
balance of cooling	6 to 10	6 to 10	6 to 10	6 to 10
	3.3 to 5.6	3.3 to 5.6	3.3 to 5.6	3.3 to 5.6

* Lamination pressure can range from 300 - 500 based on part design, panel thickness etc
Pre lamination vacuum is advised reference standard process for FR4 material

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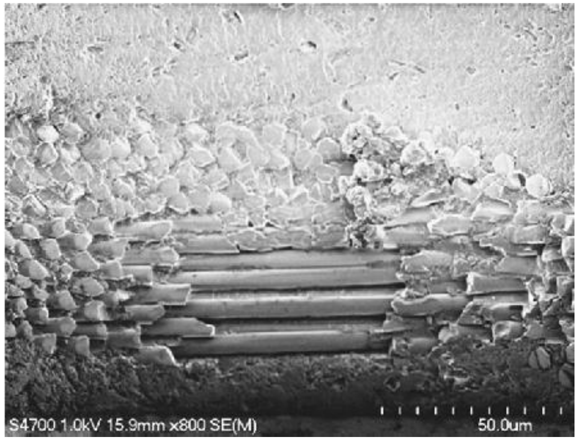
I-Tera® MT MT Hybrid Processing

Desmear

In Hybrid processing it is recommended to use the current process of the FR-4 component. I-Tera does very well with both chemical or plasma desmear processes with a weight loss similar to that seen with FR4 180 Tg type products.

In the case where a hybrid using a more chemically resistant material you will expect to see an increased etch back on the I-Tera creating a stepped difference in the two materials.

I-Tera® MT plasma vs chemical desmear

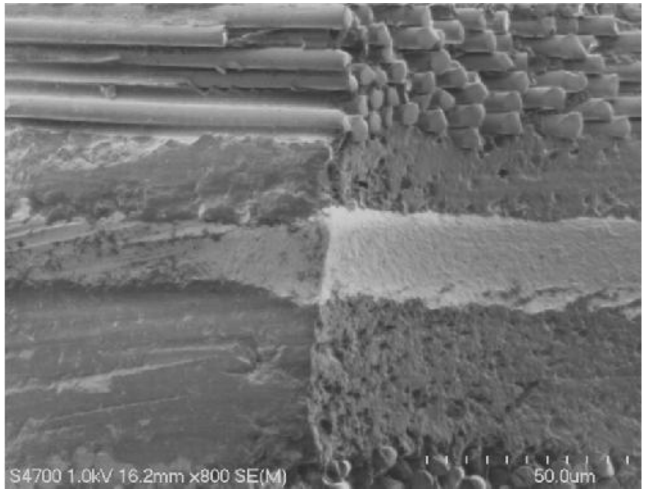


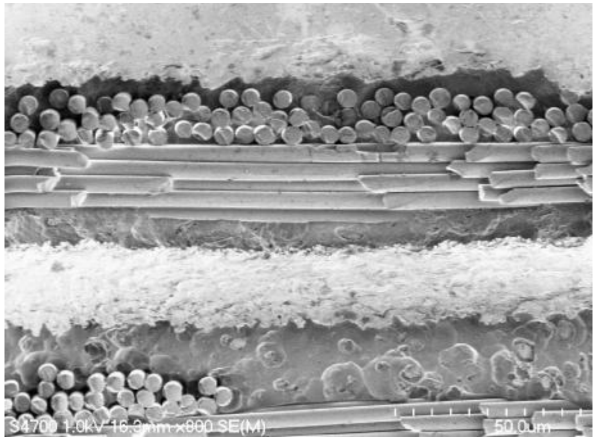
Plasma

Even toward outer edge of board there is no sign of positive etch back.

Dielectric surface looks improved

Glass looks cleaner.



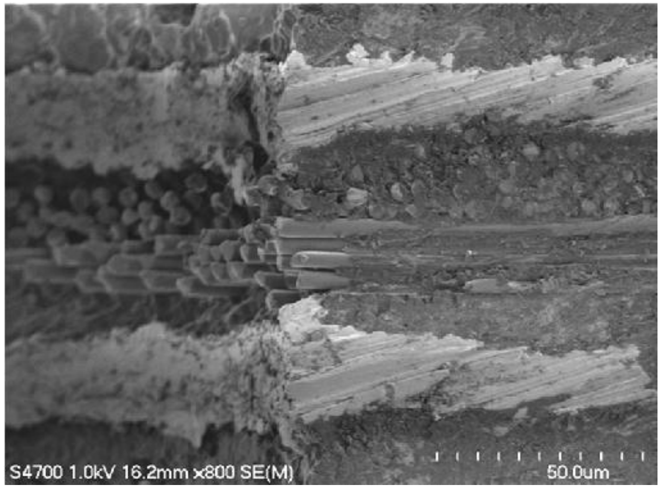


Chemical Desmear

Outer regions of holes show increased resin removal. Positive etch-back more apparent.

Glass is very clean.

Resin shows some texturing.



800 X

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I-Tera® MT Dk Data

Core Thickness (in)	Core Thickness (mm)	Standard Constructions	Resin Content	Dk at 100 MHz	Dk at 500 MHz	Dk at 1 GHz	Dk at 2.0 GHz	Dk at 5.0 GHz	Dk at 10.0 GHz
0.002 (non-ZBC)	0.0500	1 x 1067	63	3.21	3.21	3.21	3.21	3.21	3.21
0.0025	0.0625	1 x 1078	56	3.34	3.34	3.34	3.34	3.34	3.34
0.0030	0.0750	1 x 1080	62	3.22	3.22	3.22	3.22	3.22	3.22
0.0030	0.0750	1 x 1078	62	3.22	3.22	3.22	3.22	3.22	3.22
0.0033	0.0825	1 x 1086	61	3.24	3.24	3.24	3.24	3.24	3.24
0.0035	0.0875	1 x 1086	63	3.21	3.21	3.21	3.21	3.21	3.21
0.0040	0.1000	1 x 3313	54	3.38	3.38	3.38	3.38	3.38	3.38
0.0040	0.1000	2 x 1067	63	3.21	3.21	3.21	3.21	3.21	3.21
0.0040	0.1000	2 x 1035	64	3.19	3.19	3.19	3.19	3.19	3.19
0.0045	0.1125	1 x 3313	58	3.30	3.30	3.30	3.30	3.30	3.30
0.0045	0.1125	2 x 1067	66	3.15	3.15	3.15	3.15	3.15	3.15
0.0050	0.1250	1 x 2116	53	3.39	3.39	3.39	3.39	3.39	3.39
0.0050	0.1250	1 x 3313	61	3.24	3.24	3.24	3.24	3.24	3.24
0.0050	0.1250	2 x 1078	56	3.34	3.34	3.34	3.34	3.34	3.34
0.0050	0.1250	2 x 1067	69	3.09	3.09	3.09	3.09	3.09	3.09
0.0055	0.1375	1 x 2116	57	3.32	3.32	3.32	3.32	3.32	3.32
0.0055	0.1375	2 x 1078	59	3.28	3.28	3.28	3.28	3.28	3.28
0.0060	0.1500	1 x 2116	60	3.26	3.26	3.26	3.26	3.26	3.26
0.0060	0.1500	2 x 1080	62	3.22	3.22	3.22	3.22	3.22	3.22
0.0060	0.1500	2 x 1078	62	3.22	3.22	3.22	3.22	3.22	3.22
0.0066	0.1650	2 x 1080	65	3.17	3.17	3.17	3.17	3.17	3.17
0.0066	0.1650	2 x 1078	65	3.17	3.17	3.17	3.17	3.17	3.17
0.0070	0.1750	2 x 1086	63	3.21	3.21	3.21	3.21	3.21	3.21
0.0080	0.2000	2 x 3313	54	3.38	3.38	3.38	3.38	3.38	3.38
0.0090	0.2250	2 - 3313	58	3.30	3.30	3.30	3.30	3.30	3.30
0.0100	0.2500	3313/ 1652	50	3.45	3.45	3.45	3.45	3.45	3.45
0.0100	0.2500	2 x 2116	53	3.39	3.39	3.39	3.39	3.39	3.39
0.0100	0.2500	2 x 3313	61	3.24	3.24	3.24	3.24	3.24	3.24
0.0120	0.3000	2 - 3313 / 1067	61	3.24	3.24	3.24	3.24	3.24	3.24
0.0130	0.3250	2 - 3313 / 1080	61	3.24	3.24	3.24	3.24	3.24	3.24
0.0133	0.3325	2 - 3313/ 1086	61	3.24	3.24	3.24	3.24	3.24	3.24
0.0140	0.3500	3 - 3313	59	3.28	3.28	3.28	3.28	3.28	3.28
0.0150	0.3750	3 - 3313	61	3.24	3.24	3.24	3.24	3.24	3.24
0.0150	0.3750	3 - 2116	53	3.39	3.39	3.39	3.39	3.39	3.39
0.0160	0.4000	2 - 3313 / 2116	58	3.30	3.30	3.30	3.30	3.30	3.30
0.0160	0.4000	2 - 3313 / 2 - 1078	61	3.24	3.24	3.24	3.24	3.24	3.24
0.0166	0.4150	2- 3313 / 2 - 1078	62	3.22	3.22	3.22	3.22	3.22	3.22
0.0180	0.4500	2- 3313 / 2 - 3313	58	3.30	3.30	3.30	3.30	3.30	3.30
0.0200	0.5000	2 - 3313/ 2 - 1652	50	3.45	3.45	3.45	3.45	3.45	3.45
0.0200	0.5000	4 - 2116	54	3.38	3.38	3.38	3.38	3.38	3.38
0.0300	0.7500	5 - 1652	50	3.45	3.45	3.45	3.45	3.45	3.45
0.0300	0.7500	6 - 2116	54	3.38	3.38	3.38	3.38	3.38	3.38

I-Tera® MT Df Data

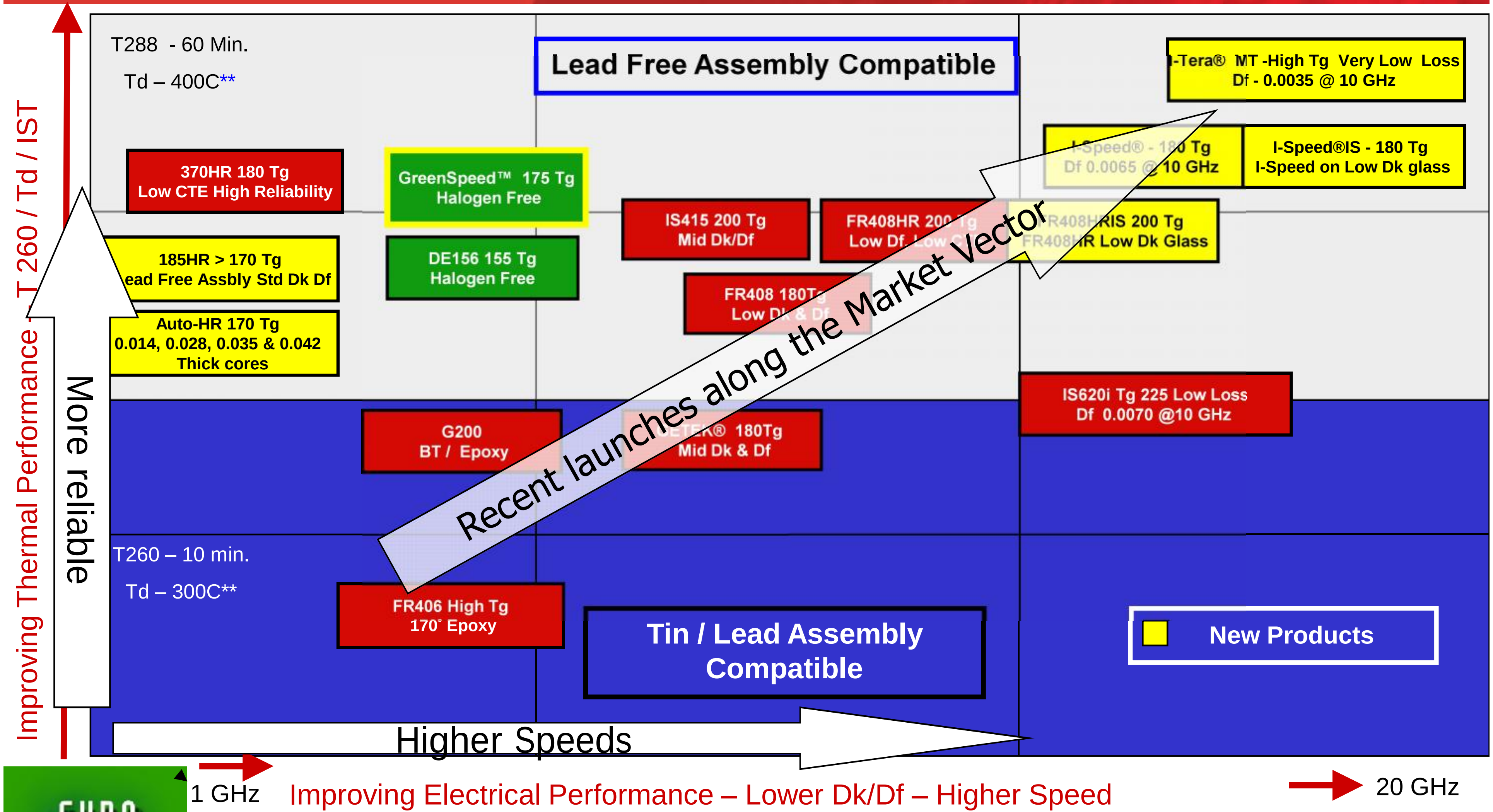
Core Thickness	Core Thickness (mm)	Standard Constructions	Resin Content	Df at 100 MHz	Df at 500 MHz	Df at 1 GHz	Df at 2.0 GHz	Df at 5.0 GHz	Df at 10.0 GHz
0.002 (non-ZBC)	0.0500	1 x 1067	63	0.0032	0.0033	0.0034	0.0034	0.0034	0.0034
0.0025	0.0625	1 x 1078	56	0.0034	0.0035	0.0036	0.0036	0.0036	0.0036
0.0030	0.0750	1 x 1080	62	0.0032	0.0033	0.0034	0.0034	0.0034	0.0034
0.0030	0.0750	1 x 1078	62	0.0032	0.0033	0.0034	0.0034	0.0034	0.0034
0.0033	0.0825	1 x 1086	61	0.0033	0.0034	0.0035	0.0035	0.0035	0.0035
0.0035	0.0875	1 x 1086	63	0.0032	0.0033	0.0034	0.0034	0.0034	0.0034
0.0040	0.1000	1 x 3313	54	0.0035	0.0036	0.0037	0.0037	0.0037	0.0037
0.0040	0.1000	2 x 1067	63	0.0032	0.0033	0.0034	0.0034	0.0034	0.0034
0.0040	0.1000	2 x 1035	64	0.0032	0.0033	0.0034	0.0034	0.0034	0.0034
0.0045	0.1125	1 x 3313	58	0.0034	0.0035	0.0036	0.0036	0.0036	0.0036
0.0045	0.1125	2 x 1067	66	0.0031	0.0032	0.0033	0.0033	0.0033	0.0033
0.0050	0.1250	1 x 2116	53	0.0035	0.0036	0.0037	0.0037	0.0037	0.0037
0.0050	0.1250	1 x 3313	61	0.0033	0.0034	0.0035	0.0035	0.0035	0.0035
0.0050	0.1250	2 x 1078	56	0.0034	0.0035	0.0036	0.0036	0.0036	0.0036
0.0050	0.1250	2 x 1067	69	0.0030	0.0031	0.0032	0.0032	0.0032	0.0032
0.0055	0.1375	1 x 2116	57	0.0034	0.0035	0.0036	0.0036	0.0036	0.0036
0.0055	0.1375	2 x 1078	59	0.0033	0.0034	0.0035	0.0035	0.0035	0.0035
0.0060	0.1500	1 x 2116	60	0.0033	0.0034	0.0035	0.0035	0.0035	0.0035
0.0060	0.1500	2 x 1080	62	0.0032	0.0033	0.0034	0.0034	0.0034	0.0034
0.0060	0.1500	2 x 1078	62	0.0032	0.0033	0.0034	0.0034	0.0034	0.0034
0.0066	0.1650	2 x 1080	65	0.0031	0.0032	0.0033	0.0033	0.0033	0.0033
0.0066	0.1650	2 x 1078	65	0.0031	0.0032	0.0033	0.0033	0.0033	0.0033
0.0070	0.1750	2 x 1086	63	0.0032	0.0033	0.0034	0.0034	0.0034	0.0034
0.0080	0.2000	2 x 3313	54	0.0035	0.0036	0.0037	0.0037	0.0037	0.0037
0.0090	0.2250	2 - 3313	58	0.0034	0.0035	0.0036	0.0036	0.0036	0.0036
0.0100	0.2500	3313/ 1652	50	0.0038	0.0038	0.0038	0.0038	0.0038	00038
0.0100	0.2500	2 x 2116	53	0.0035	0.0036	0.0037	0.0037	0.0037	0.0037
0.0100	0.2500	2 x 3313	61	0.0033	0.0034	0.0035	0.0035	0.0035	0.0035
0.0120	0.3000	2 - 3313 / 1067	61	0.0033	0.0034	0.0035	0.0035	0.0035	0.0035
0.0130	0.3250	2 - 3313 / 1080	61	0.0033	0.0034	0.0035	0.0035	0.0035	0.0035
0.0133	0.3325	2 - 3313/ 1086	61	0.0033	0.0034	0.0035	0.0035	0.0035	0.0035
0.0140	0.3500	3 - 3313	59	0.0033	0.0034	0.0035	0.0035	0.0035	0.0035
0.0150	0.3750	3 - 3313	61	0.0033	0.0034	0.0035	0.0035	0.0035	0.0035
0.0150	0.3750	3 - 2116	53	0.0035	0.0036	0.0037	0.0037	0.0037	0.0037
0.0160	0.4000	2 - 3313 / 2116	58	0.0034	0.0035	0.0036	0.0036	0.0036	0.0036
0.0160	0.4000	2 - 3313 / 2 - 1078	61	0.0033	0.0034	0.0035	0.0035	0.0035	0.0035
0.0166	0.4150	2- 3313 / 2 - 1078	62	0.0032	0.0033	0.0034	0.0034	0.0034	0.0034
0.0180	0.4500	2- 3313 / 2 - 3313	58	0.0034	0.0035	0.0036	0.0036	0.0036	0.0036
0.0200	0.5000	2 - 3313/ 2 - 1652	50	0.0038	0.0038	0.0038	0.0038	0.0038	00038
0.0200	0.5000	4 - 2116	54	0.0035	0.0036	0.0037	0.0037	0.0037	0.0037
0.0300	0.7500	5 - 1652	50	0.0038	0.0038	0.0038	0.0038	0.0038	00038
0.0300	0.7500	6 - 2116	54	0.0035	0.0036	0.0037	0.0037	0.0037	0.0037

I-Tera® MT Dk Df - Prepreg

Prepreg	Resin Content	Thickness (in)	Thickness (mm)	Dk at 100 MHz	Dk at 500 MHz	Dk at 1 GHz	Dk at 2.0 GHz	Dk at 5.0 GHz	Dk at 10.0 GHz
1035	61	0.0018	0.0450	3.24	3.24	3.24	3.24	3.24	3.24
1035	64	0.0020	0.0500	3.19	3.19	3.19	3.19	3.19	3.19
1067	66	0.0023	0.0575	3.15	3.15	3.15	3.15	3.15	3.15
1067	69	0.0025	0.0625	3.09	3.09	3.09	3.09	3.09	3.09
1067	74	0.0031	0.0775	3.00	3.00	3.00	3.00	3.00	3.00
1078	66	0.0035	0.0875	3.15	3.15	3.15	3.15	3.15	3.15
1078	70	0.0040	0.1000	3.07	3.07	3.07	3.07	3.07	3.07
1078	72	0.0044	0.1100	3.04	3.04	3.04	3.04	3.04	3.04
1086	63	0.0035	0.0875	3.21	3.21	3.21	3.21	3.21	3.21
1086	66	0.0039	0.0975	3.15	3.15	3.15	3.15	3.15	3.15
1086	69	0.0044	0.1100	3.09	3.09	3.09	3.09	3.09	3.09
1080	67	0.0035	0.0875	3.13	3.13	3.13	3.13	3.13	3.13
1080	71	0.0040	0.1000	3.05	3.05	3.05	3.05	3.05	3.05
3313	54	0.0040	0.1000	3.38	3.38	3.38	3.38	3.38	3.38
3313	58	0.0045	0.1125	3.30	3.30	3.30	3.30	3.30	3.30
3313	61	0.0050	0.1250	3.24	3.24	3.24	3.24	3.24	3.24
2116	57	0.0055	0.1375	3.32	3.32	3.32	3.32	3.32	3.32
2116	60	0.0060	0.1500	3.26	3.26	3.26	3.26	3.26	3.26

Prepreg	Resin Content	Thickness (in)	Thickness (mm)	Df at 100 MHz	Df at 500 MHz	Df at 1 GHz	Df at 2.0 GHz	Df at 5.0 GHz	Df at 10.0 GHz
1035	61	0.0018	0.0450	0.0033	0.0034	0.0035	0.0035	0.0035	0.0035
1035	64	0.0020	0.0500	0.0032	0.0033	0.0034	0.0034	0.0034	0.0034
1067	66	0.0023	0.0575	0.0031	0.0032	0.0033	0.0033	0.0033	0.0033
1067	69	0.0025	0.0625	0.0030	0.0031	0.0032	0.0032	0.0032	0.0032
1067	74	0.0031	0.0775	0.0029	0.0029	0.0030	0.0030	0.0030	0.0030
1078	66	0.0035	0.0875	0.0031	0.0032	0.0033	0.0033	0.0033	0.0033
1078	70	0.0040	0.1000	0.0031	0.0031	0.0032	0.0032	0.0032	0.0032
1078	72	0.0044	0.1100	0.0030	0.0030	0.0031	0.0031	0.0031	0.0031
1086	63	0.0035	0.0875	0.0032	0.0033	0.0034	0.0034	0.0034	0.0034
1086	66	0.0039	0.0975	0.0031	0.0032	0.0033	0.0033	0.0033	0.0033
1086	69	0.0044	0.1100	0.0030	0.0031	0.0032	0.0032	0.0032	0.0032
1080	67	0.0035	0.0875	0.0031	0.0032	0.0033	0.0033	0.0033	0.0033
1080	71	0.0040	0.1000	0.0030	0.0030	0.0031	0.0031	0.0031	0.0031
3313	54	0.0040	0.1000	0.0035	0.0036	0.0037	0.0037	0.0037	0.0037
3313	58	0.0045	0.1125	0.0034	0.0035	0.0036	0.0036	0.0036	0.0036
3313	61	0.0050	0.1250	0.0033	0.0034	0.0035	0.0035	0.0035	0.0035
2116	57	0.0055	0.1375	0.0034	0.0035	0.0036	0.0036	0.0036	0.0036
2116	60	0.0060	0.1500	0.0033	0.0034	0.0035	0.0035	0.0035	0.0035

Product positioning map



Speed is a function of design such as line length etc.

** Laminate Data - IST performance is a function of Hole diameter, board thickness, plating parameters and laminate attributes.