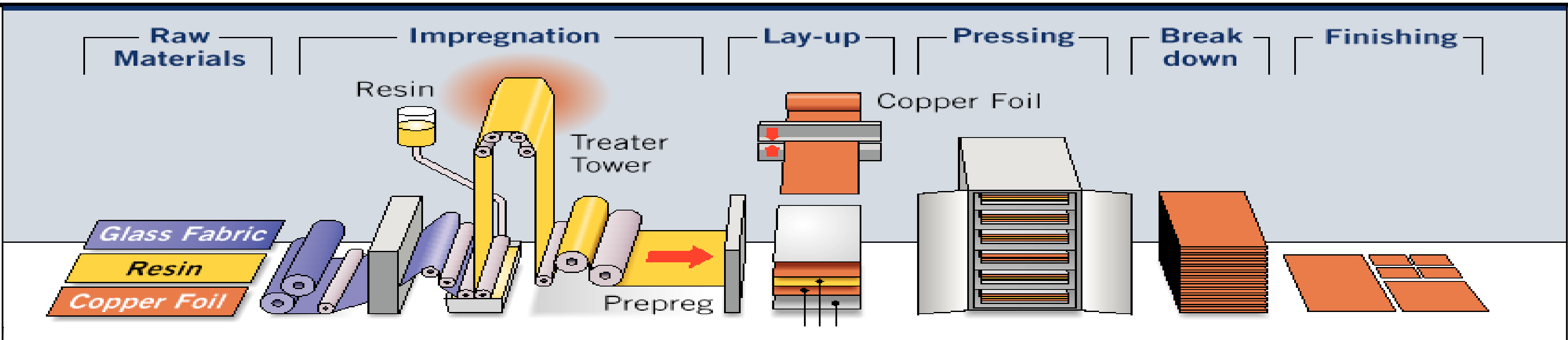
Laminate & Prepreg

Manufacturing

Manufacturing Technology Focus



- **Treating**
  - **Gamma Gauges for Resin content control**
  - **On line DCM's, MMV's, FTIR's**
  - **High Shear mixing equipment, Dedicated lines, Filtration systems**
- **Lay up**
  - **Sandwich copper concept, separate rooms.**
  - **Controlled Clean room environment with Humidity and static control.**
- **Press**
  - **High temperature pressing capability**
- **Finishing**
  - **High Speed and precise finishing capability.**

- **Manufacturing Focus**
  - **Internal contamination Reduction - Controlled environment, Treating technology, handling and lay up technology.**
  - **Prepreg Consistency - Resin content control, On Line cure monitoring, Redundancy with FTIR, Melt viscosity and Gelation**
  - **Surface quality - Lay up Technology**
  - **Controlled thickness .**
- **Cost**
  - **Productivity enhancement through lean manufacturing, Re engineered Processes**
- **QTA**
  - **Fast turn around capability through cycle time reduction, sophisticated scheduling and equipment capability**

Material Building Blocks

Glass

- Glass fabric is available in different roll widths and thicknesses
- Some glass fabrics are different between North America, Asia Pacific and Europe
- Core constructions are different depending on the region and OEM spec.

Resin

- The resin is determined by what properties are needed to make a particular MLB design function. ie. Tg, Dk, Df etc.
- The resin must be compatible with the glass fabric
- The resin must be compatible with the copper foil

Copper

- Copper is designated by wt and foil type i.e. Reverse Treat (RTF), HTE, Double Treat or std ED copper foil
- The copper used must be able to achieve good peel strengths so the copper does not pull away from the glass and resin.

Woven Glass Fabric

- OEM designs are calling out the number of plies of glass to be used per core layer and even calling out the glass fabric style when controlled impedance is critical.

- It is important that we understand the effect of the glass used in the construction of the core material we give to an OEM. A 2 ply construction vs. 1 ply will give you a different Dk and Df based on the retained resin % of the core.

- When programs move from one Region to the other please be aware of the constructions used in the other Regions. For critical OEM's and designs we need to try and keep the electrical properties of the material the same ie the same construction of core material

- On the next slide you will see the different glass styles used in North America Asia Pacific and Europe.

Glass Fabric

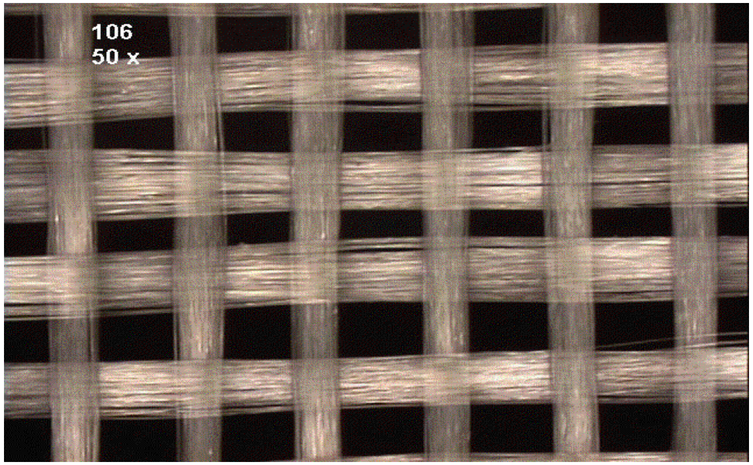
Glass Fabric

Glass Style	Weave	Warp Count	Fill Count	Warp Yarn	Fill Yarn	Fabric Thickness inches	Fabric Thickness mm	Fabric Nominal Weight OSY	Fabric Nominal Weight g/m2
1067	Plain	70	70	ECD 900-1/0	ECD 900-1/0	0.0013	0.032	0.91	31
106	Plain	56	56	ECD 900-1/0	ECD 900-1/0	0.0015	0.038	0.73	25
1086	Plain	60	60	ECD 450 1/0	ECD 450 1/0	0.0020	0.050	1.60	54
1080	Plain	60	47	ECD 450-1/0	ECD 450-1/0	0.0025	0.064	1.45	49
2113	Plain	60	56	ECE 225-1/0	ECD 450-1/0	0.0029	0.074	2.31	78
2313	Plain	60	64	ECE 225- 1/0	ECD 450-1/0	0.0032	0.080	2.38	81
3313	Plain	61	62	ECDE 300-1/0	ECDE 300-1/0	0.0032	0.081	2.43	82
3070	Plain	70	70	ECDE 300-1/0	ECDE 300-1/0	0.0034	0.086	2.74	93
2116	Plain	60	58	ECE 225-1/0	ECE 225-1/0	0.0038	0.097	3.22	109
1506	Plain	46	45	ECE110-1/1	ECE 110-1/0	0.0056	0.140	4.89	165
1652	Plain	52	52	ECG 150-1/0	ECG 150-1/0	0.0045	0.114	4.09	142
7628	Plain	44	31	ECG 75-1/0	ECG 75-1/0	0.0068	0.173	6.00	203

Fiberglass Yarn Nomenclature

1st Letter	E = E-glass (electrical grade)
2nd Letter	C = Continuous Filaments
3rd Letter	Filament Diameter D, E, DE, G
Ist number	Yardage in one pound
2nd number	Number of strands in a yarn/ strands plied or twisted

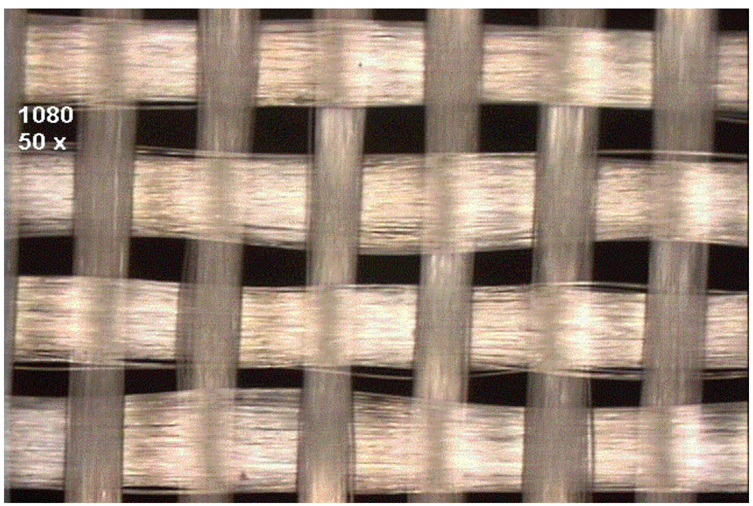
Woven Glass Fabric



106

Warp & Fill Count: 56 x 56 (ends/in)

Thickness: 0.0015” / 0.038 mm



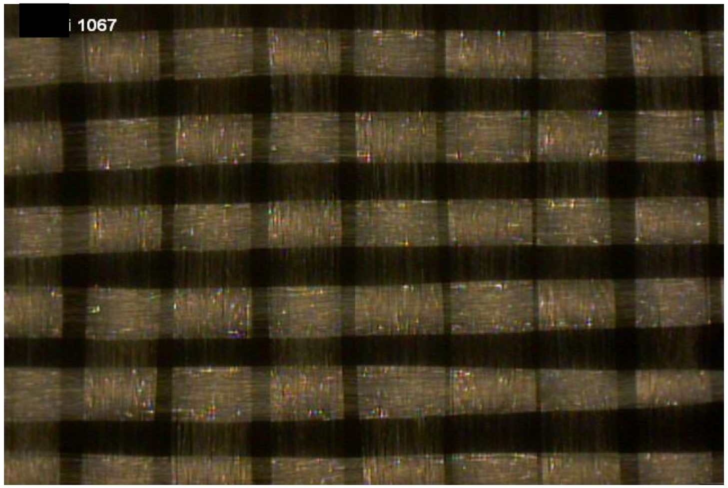
1080

Warp & Fill Count: 60 x 47 (ends/in)

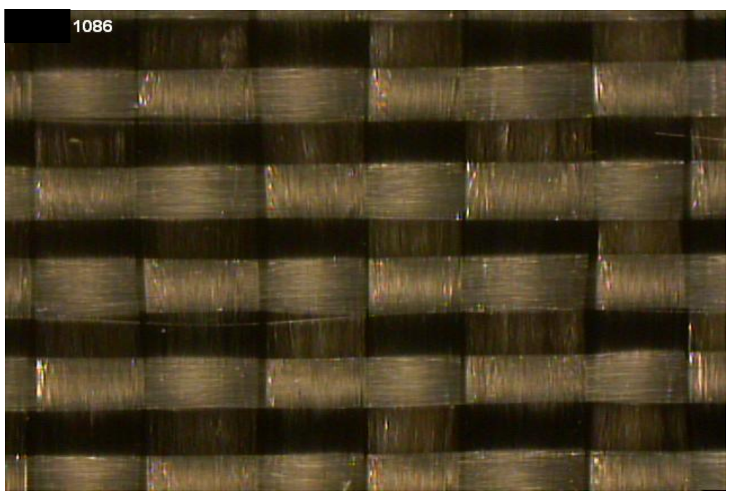
Thickness: 0.0025” / 0.064 mm

Photos courtesy of Isola R & D Laboratories

Woven Glass Fabric



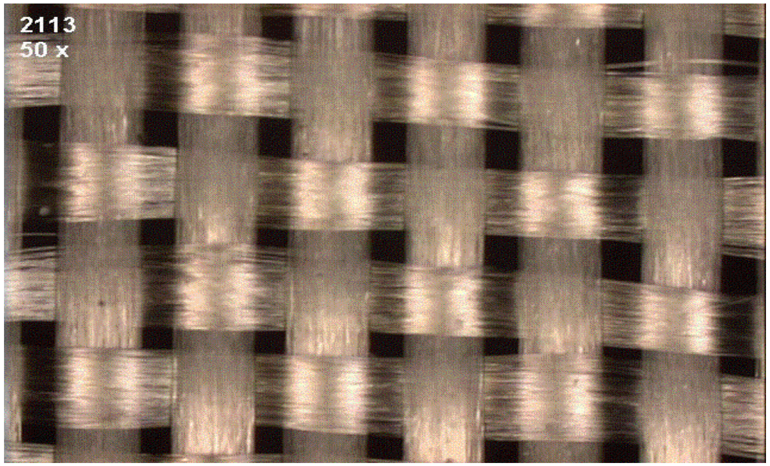
1067
Warp & Fill Count: 70 x 70 (ends/in)
Thickness: 0.0013” / 0.032 mm



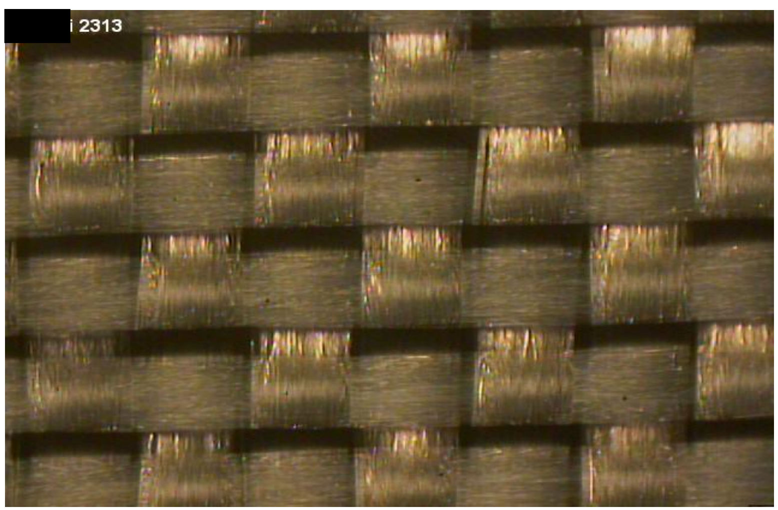
1086
Warp & Fill Count: 60 x 60 (ends/in)
Thickness: 0.002” / 0.050 mm

Photos courtesy of Isola R & D Laboratories

Woven Glass Fabric



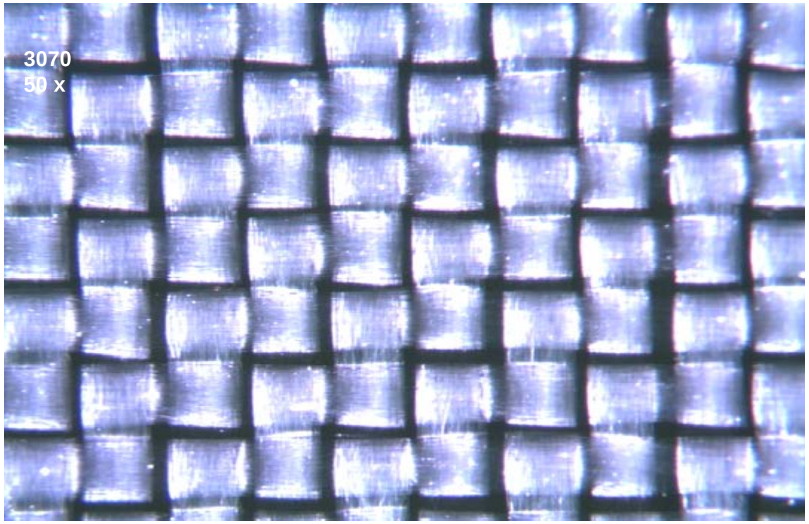
2113
Warp & Fill Count: 60 x 56 (ends/in)
Thickness: 0.0029” / 0.074 mm



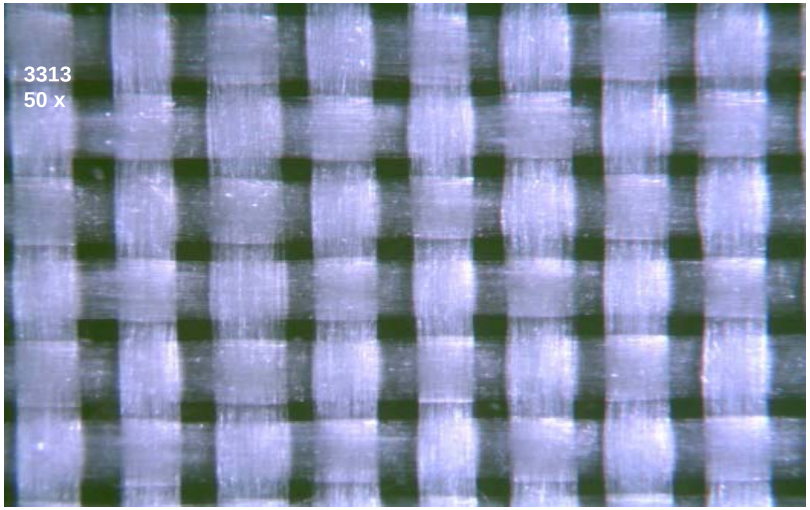
2313
Warp & Fill Count: 60 x 64 (ends/in)
Thickness: 0.0032” / 0.080 mm

Photos courtesy of Isola R & D Laboratories

Woven Glass Fabric



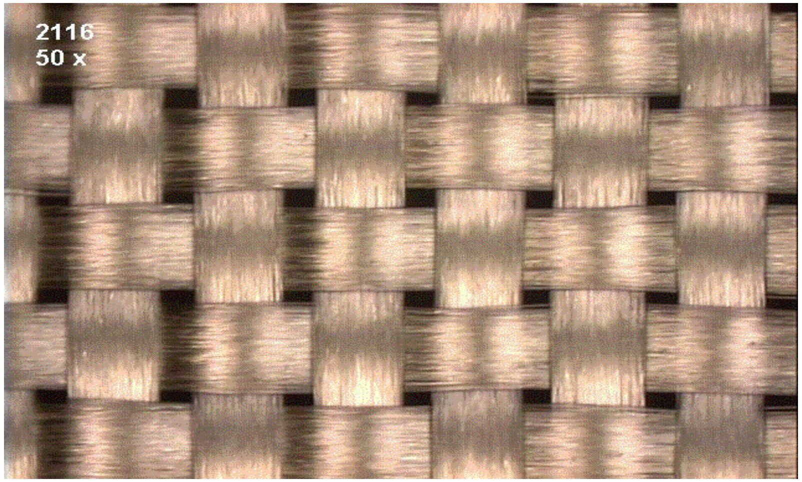
3070
Warp & Fill Count: 70 x 70 (ends/in)
Thickness: 0.0034” / 0.086 mm



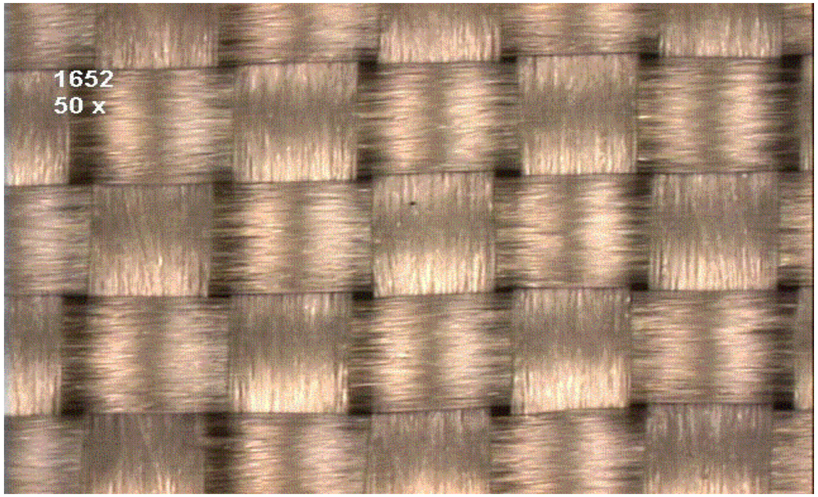
3313
Warp & Fill Count: 61 x 62 (ends/in)
Thickness: 0.0032” / 0.081 mm

Photos courtesy of Isola R & D Laboratories

Woven Glass Fabric



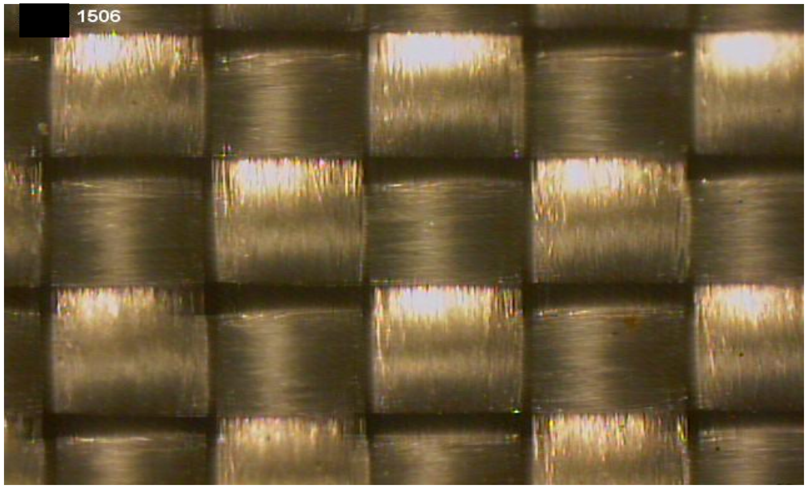
2116
Warp & Fill Count: 60 x 58 (ends/in)
Thickness: 0.0038” / 0.097 mm



1652
Warp & Fill Count: 52 x 52 (ends/in)
Thickness: 0.0045” / 0.114 mm

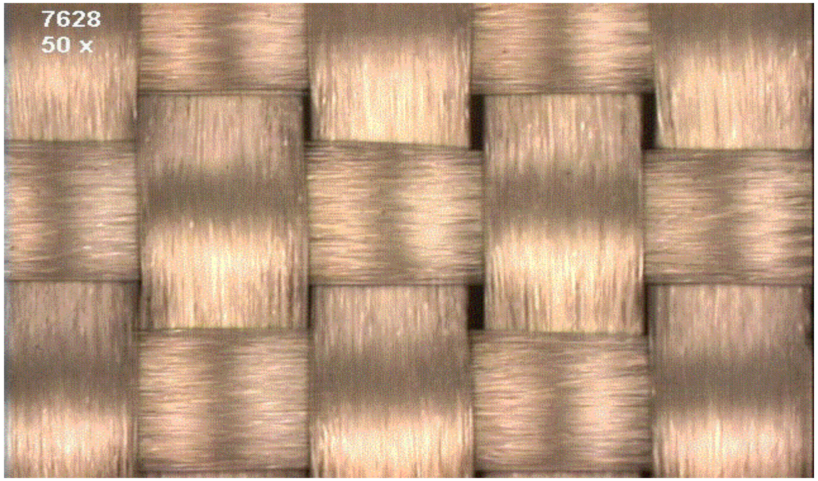
Photos courtesy of Isola R & D Laboratories

Woven Glass Fabric



1506

Warp & Fill Count: 46 x 45 (ends/in)
Thickness: 0.0056” / 0.140 mm



7628

Warp & Fill Count: 44 x 32 (ends/in)
Thickness: 0.0068” / 0.173 mm

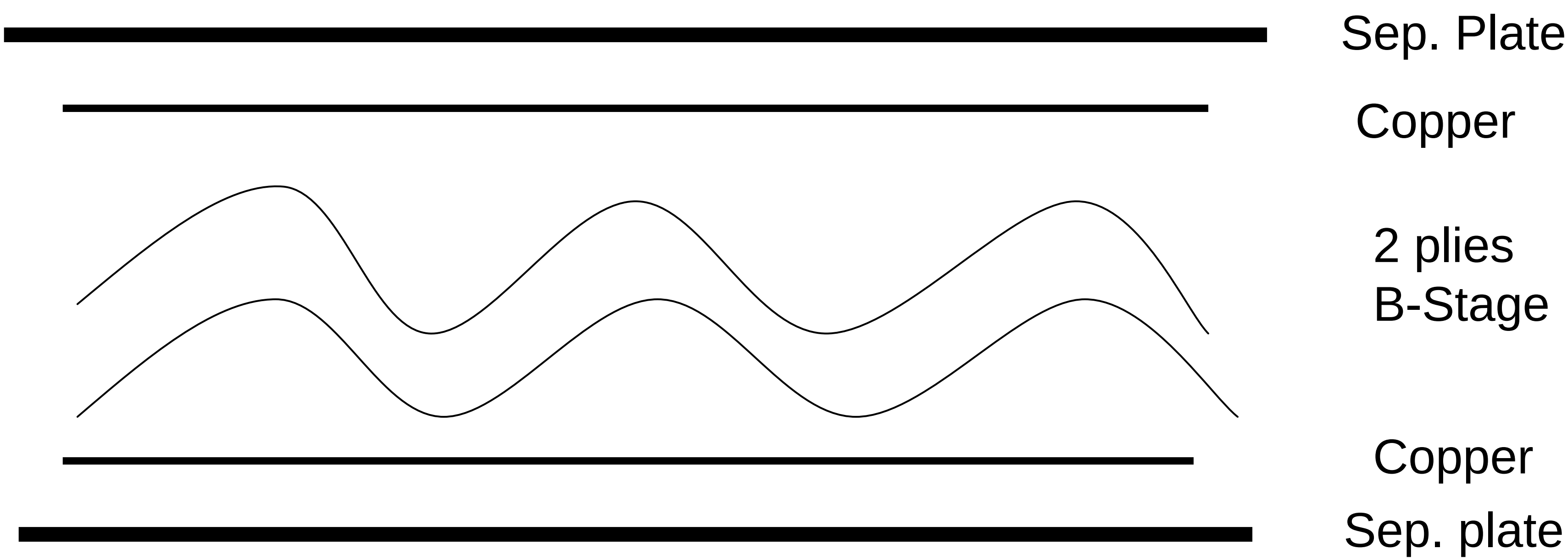
Photos courtesy of Isola R & D Laboratories

Regional Woven Glass Fabric Styles

North America	Asia-Pacific	Europe
106	106	106
1080	1035	1080
1067	1078	2113
1086	1080	3070
2113	1067	2116
3313	1086	1634
3070	2313	1647
2116	3313	1651
1652	2116	1501
7628	1501	2165
	1506	2157
	1652	7628
	7628	

Isola has Global Std Constructions on the High Performance Materials

Multilayer Core Manufacturing



Typical IS415 0.005" Core Constructions

Core/ Construction		Positives	Negatives
0.005"	Resin %		
1 x 1652	42 %	Cost/ Thickness/ DS	Low Resin/ thick glass
106 / 2113	54 %	DS/ Std 2 ply	Most Expensive
2 x 1080	56 %	Low Cost	DS/ Thickness
1 x 2116	54 %	Low Cost	DS/ Thickness

Dk / Df differences based on retained resin %. The difference can be up to 14 %

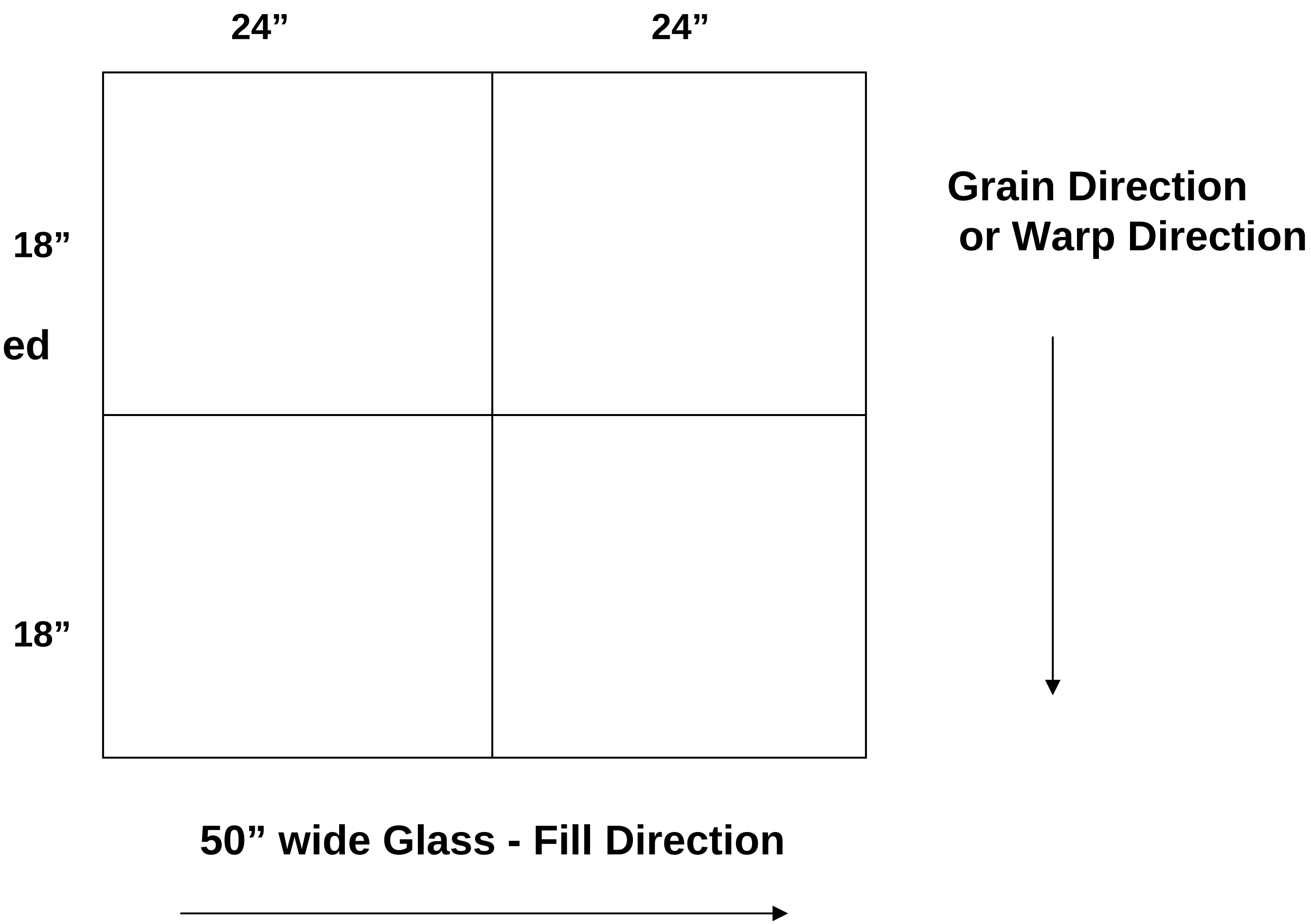
At 2 GHz Dk on 42 % = 4.12 Df on 42 % = 0.016
At 2 GHz Dk on 56 % = 3.79 Df on 56 % = 0.0198

Critical that the right core thickness is used by the OEM/ Designer to meet the impedance criteria.

Grain Direction

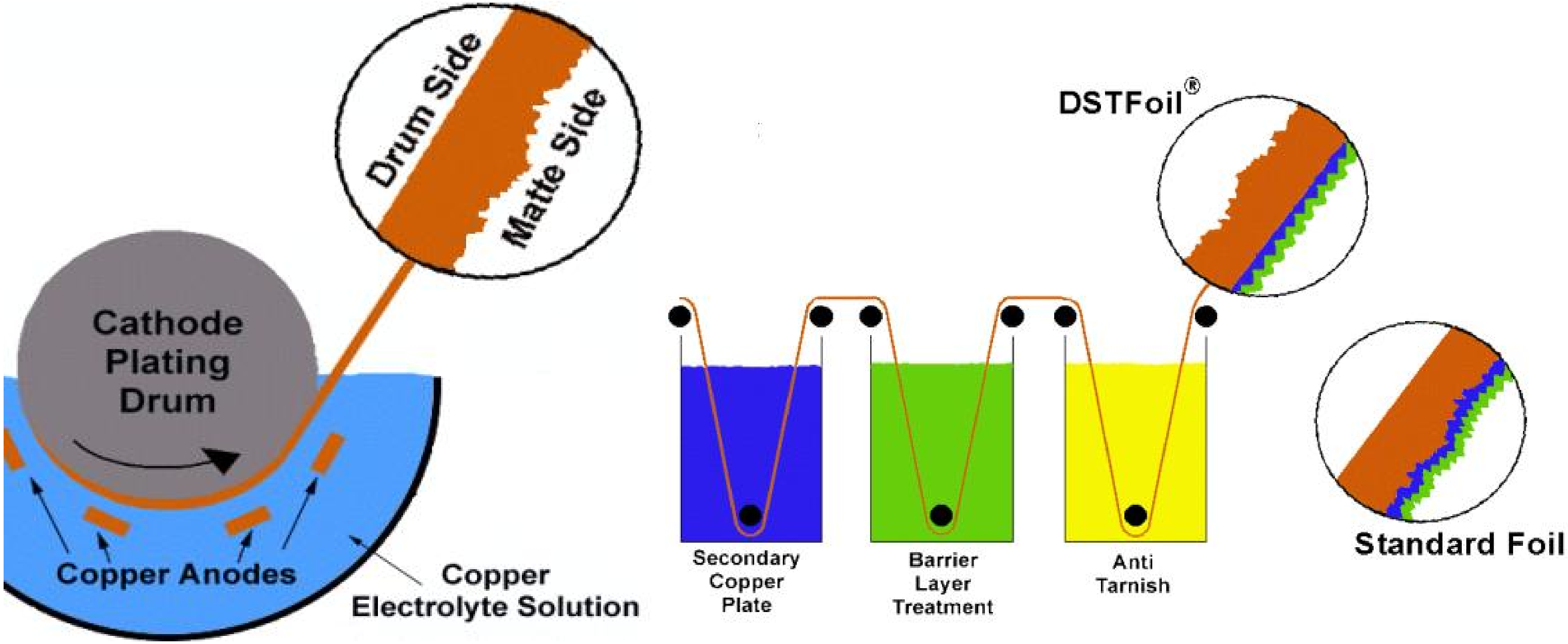
Grain Direction

- 50” wide glass
- 50” x 38” untrimmed
- 48” x 36” trimmed
- oversized panels available



Copper Foil

ED Copper Foil Manufacturing



- **Copper is electroplated onto a rotating drum.**
- **Treatments are applied to:**
  - Micro-roughen surface for adhesion
  - Plate barrier layer
  - Coat with anti-tarnish

Copper Foil

Copper Foil Types

ED = standard shiny copper, copper tooth
HTE = High temp elongation shiny copper, copper tooth
RTF = reverse treat, low profile copper tooth
DT = double treat copper, no black oxide needed

- The RTF copper foils offer benefits to the fabricator during processing – more defined etched line, ability for thinner lines and lower copper tooth profile.
- VLP foils are used for better impedance control
- 95+ % of NA is RTF foil. Very small percentage = DT
- Thicker cores still use some HTE or ED foil.

Copper wt

18 micron = H oz
35 micron = 1 oz
70 micron = 2 oz

Heavier copper such as 3, 4 and 5 oz foil used for power supply designs or ground planes in MLB designs

5 and 6 oz Cu for Automotive 4 – L designs

12 oz Cu used for Automotive 2 – L designs

Electrodeposited Copper Foil

- ED Foil is "Industry Standard
- Many thicknesses available
  - ½, 1 and 2 ounce the most common
  - 3+ available
  - 9, 5, 3 micron

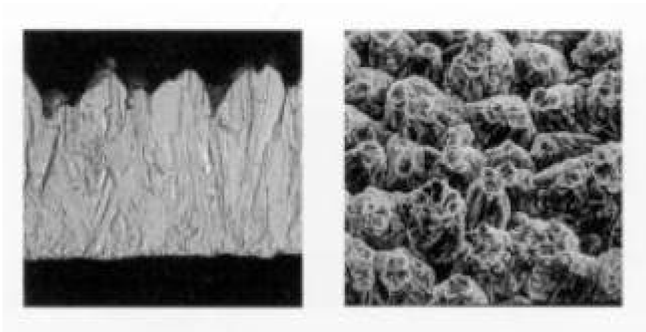
Grade	Foil Description
1	**Standard Electrodeposited**
2	High Ductility Electrodeposited
3	**High Temperature Elongation Electrodeposited**
4	Annealed Electrodeposited
5	As Rolled-Wrought
6	Light Cold Rolled-Wrought
7	Annealed-Wrought
8	As Rolled-Wrought Low-Temperature Annealable

Foil Profile Type	Max. Foil Profile (Microns)	Max. Foil Profile (μ Inches)
S – Standard	**N/A**	**N/A**
L – Low Profile	**10.2**	**400**
V – Very Low Profile	**5.1**	**200**
X – No Treatment or Roughness	**N/A**	**N/A**

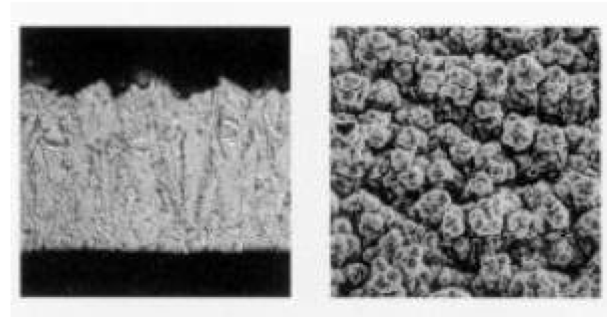
Foil Designator	Common Industry Terminology	Area Weight (g/m^2)	Nominal Thickness (μm)	Area Weight (oz/ft^2)	Area Weight ($g/254\ in^2$)	Nominal Thickness (mils)
E	5 μm	45.1	5.0	0.148	7.4	0.20
Q	9 μm	75.9	9.0	0.249	12.5	0.34
T	12 μm	106.8	12.0	0.350	17.5	0.47
H	**½ oz**	**152.5**	**17.2**	**0.500**	**25.0**	**0.68**
M	¾ oz	228.8	25.7	0.750	37.5	1.01
1	**1 oz**	**305.0**	**34.3**	**1**	**50.0**	**1.35**
2	**2 oz**	**610.0**	**68.6**	**2**	**100.0**	**2.70**
3	3 oz	915.0	103.0	3	150.0	4.05
4	4 oz	1220.0	137.0	4	200.0	5.40
5	5 oz	1525.0	172.0	5	250.0	6.75
6	6 oz	1830.0	206.0	6	300.0	8.10
7	7 oz	2135.0	240.0	7	350.0	9.45
10	10 oz	3050.0	343.0	10	500.0	13.50
14	14 oz	4270.0	480.0	14	700.0	18.90

Copper Surface Profiles

- Matte Side Surface Profile



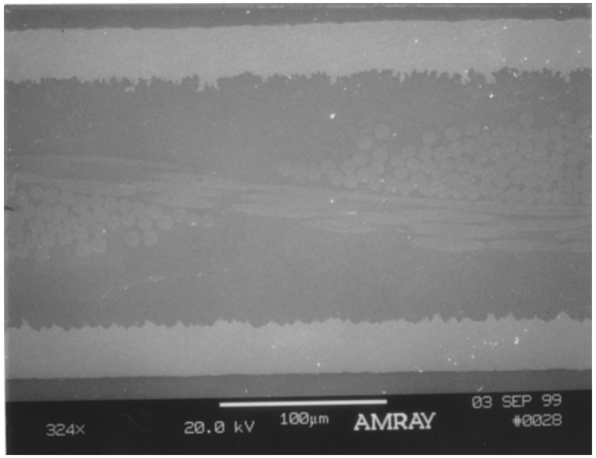
Matte Side of Standard Grade 1 Foil

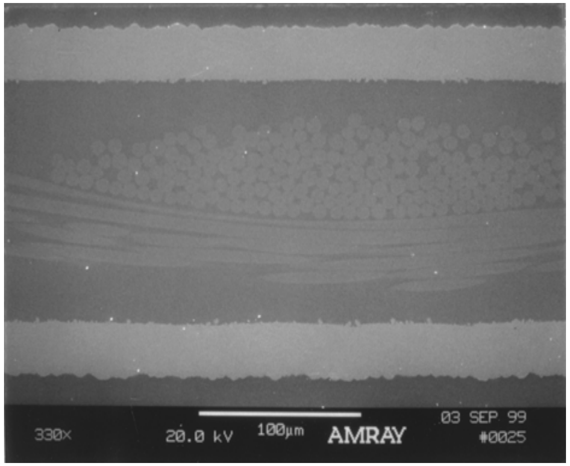


Matte Side of Low Profile Grade 1 Foil

- Standard vs Drum Side Treated Foil (DSTFoil)

Laminate With Standard Copper Foil



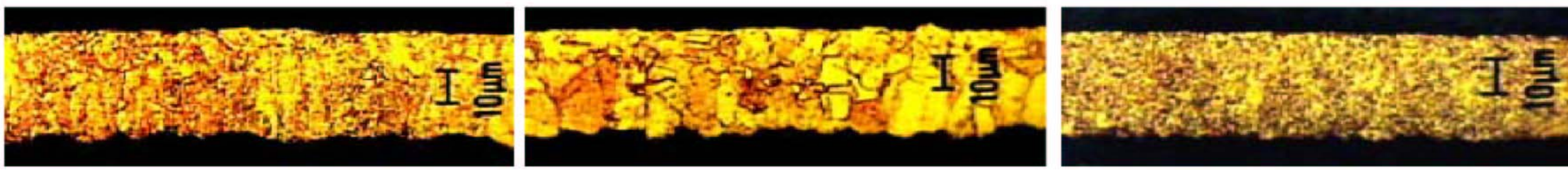


Laminate With DSTFoil® Copper Foil

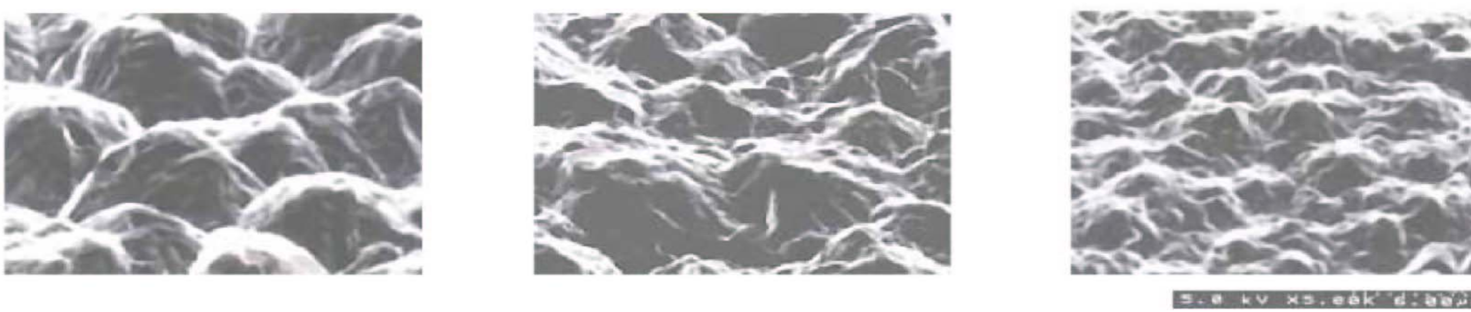
DSTF Process Introduction

Grain Structure and Surface Profile

Ⅲ (HTE) | Super-HTE | VLP



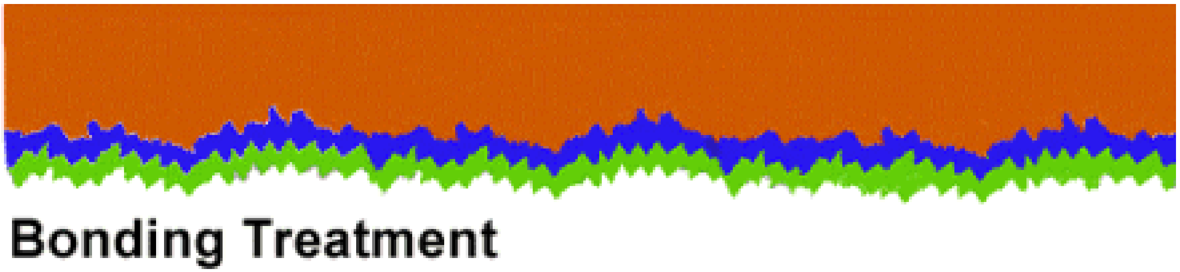
※After heated at 180℃,1hr



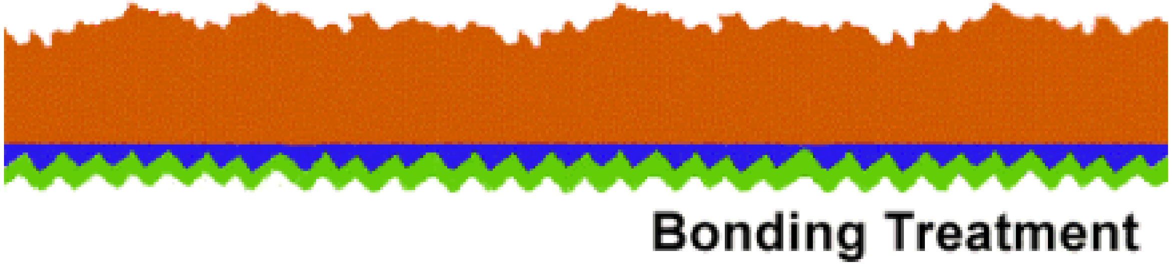
1oz Foil

DSTFoil® Comparison to Standard Copper Foil

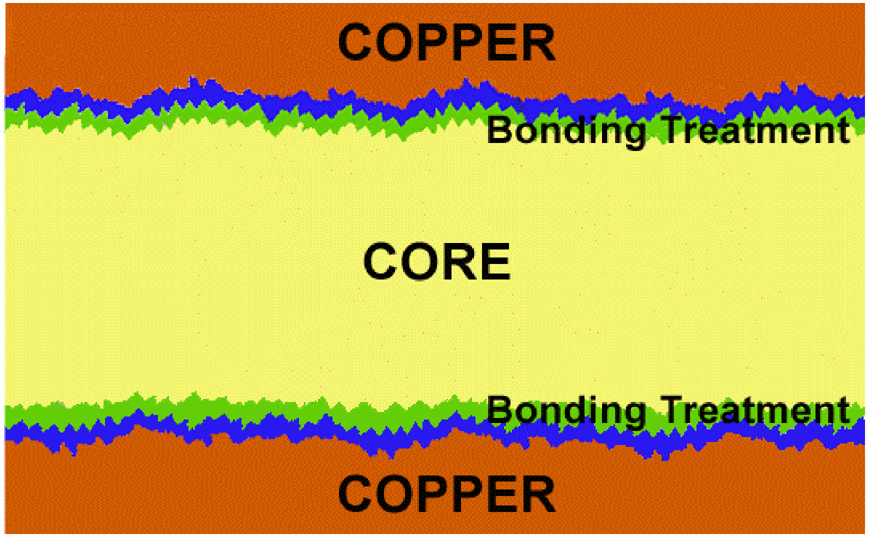
Standard Copper



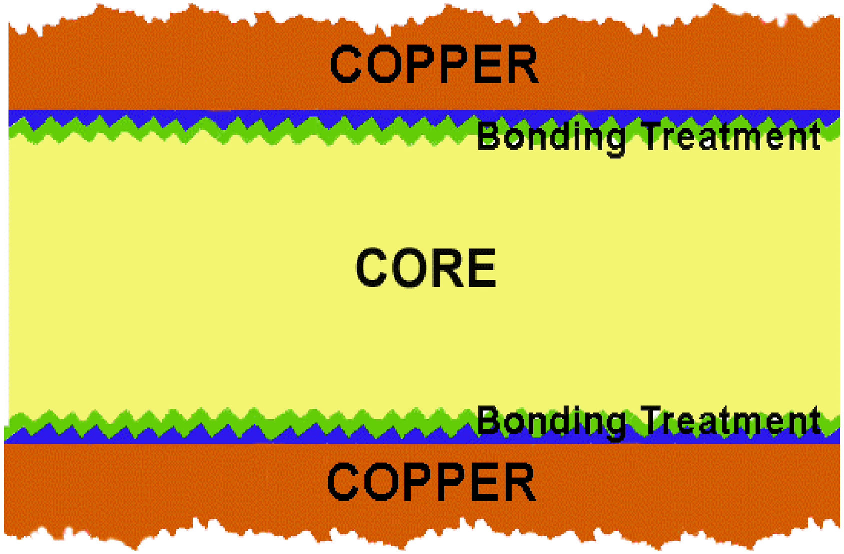
DSTFoil®



Standard Foil Clad Laminate

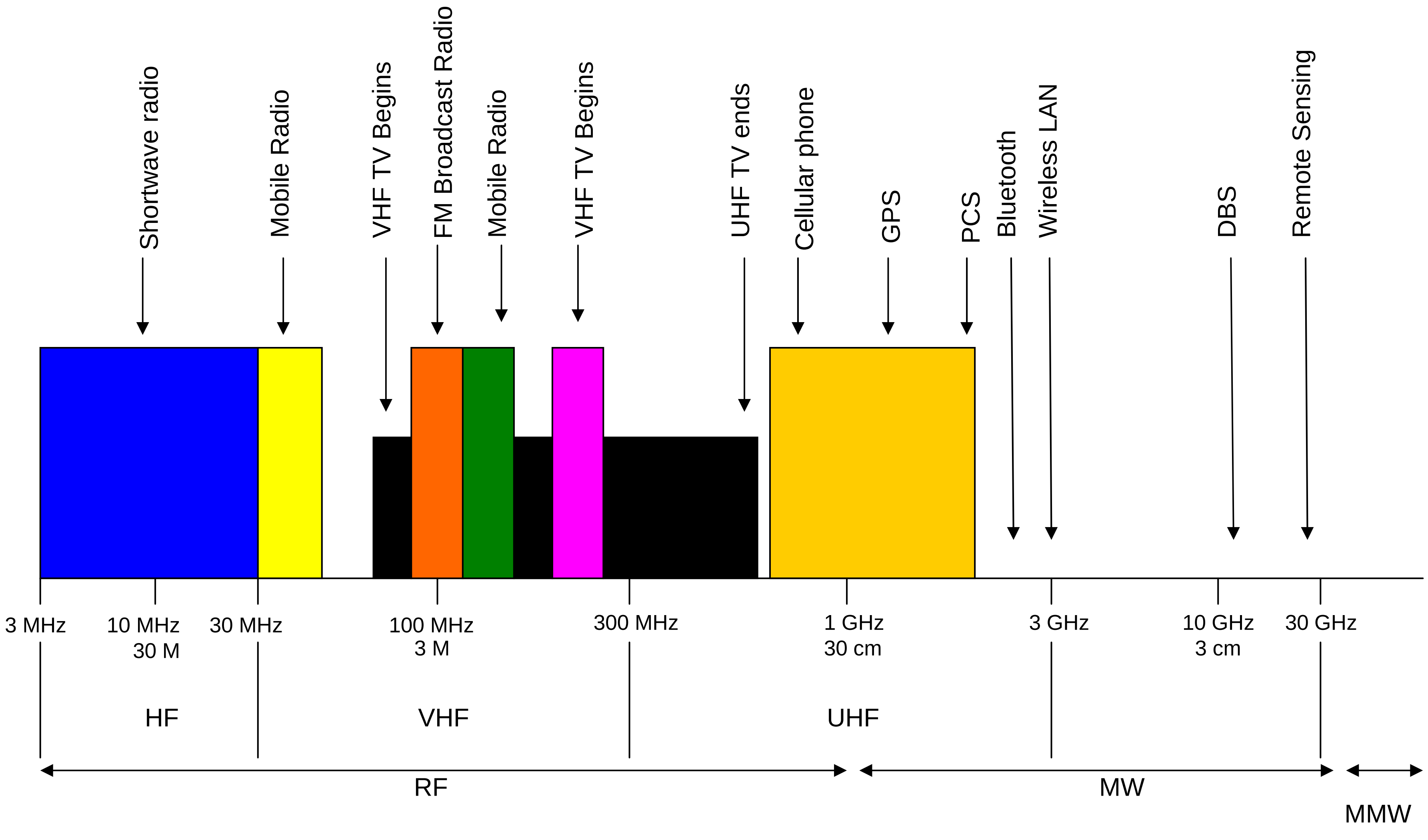


DSTFoil ® Clad Laminate



Definitions

The Electromagnetic Spectrum employed for RF & Microwave applications



Definitions

T_G – Glass Transition Temperature; *The temperature at which the resin changes from a glass-like state to an amorphous state changing its mechanical behavior, i.e. expansion rate*

DSC – Differential Scanning Calorimetry; *A measurement technique used to characterize the glass transition temperature of a resin by measuring the change in heat given off the resin.*

TMA – Thermal Mechanical Analysis; *A measurement technique used to characterize the glass transition temperature of a resin by measuring the changing in thermal expansion of a resin as a function of temperature.*

DMA – Dynamic Mechanical Testing; *A measurement technique used to characterize the glass transition temperature of a resin by measuring the change in modulus of a resin as a function of temperature.*

T_D – Decomposition Temperature; *The temperature at which the resin begins to decompose, measured by a weight change the resin sample.*

Definitions

TGA – Thermo-Gravimetric Analysis; *A measurement technique used to characterize the decomposition temperature of a resin by measuring the change in weight as a function of temperature.*

CTE – Coefficient of Thermal Expansion; *The rate of expansion of a laminate as a function of temperature change. Typically reported as PPM/°C or %.*

T_{260} – Time-to-Delamination @ 260°C; *A measurement conducted on the TMA apparatus in order to determine a laminate's resistance to Delamination at 260°C. Delamination is defined as an irreversible expansion in the z-axis. Measurements are noted in minutes at 260°C before failure.*

T_{288} – Time-to-Delamination @ 288°C; *A measurement conducted on the TMA apparatus in order to determine a laminate's resistance to Delamination at 288°C. Delamination is defined as an irreversible expansion in the z-axis. Measurements are noted in minutes at 288°C before failure.*

Dk – Permittivity, Relative Dielectric Constant; *The property of a material that impedes the transmission of a electromagnetic wave. The lower the relative dielectric constant, the closer the performance of the material to that of air. This property is critical to matching the impedance requirements of certain transmission lines.*

Definitions

Df – Loss Tangent; *The property of a material that describes how much of the energy transmitted is absorbed by the material. The greater the loss tangent, the larger the energy absorption into the material. This property directly impacts the signal attenuation at high speeds.*

Peel Strength; *This measurement is taken to evaluate the adhesion of the resin to the copper cladding, in units of lb_f/in or N/m. Measurements are taken after samples have been conditioned in the following manner: as received, after thermal stress, and after chemical processing*.

Thermal Stress; *This measurement is taken to evaluate the thermal integrity of laminates after short-term exposure to solder, 10 seconds at 550℉ (288℃). The samples are evaluated for evidence of blisters and delamination.*

Definitions

TCT – Thermal Cycling Test; *this type of reliability test is conducted in order to evaluate a PCB's resistance to plated-thru-hole failures when exposed to repeated temperatures extremes. Factors in this test that vary from OEM-to-OEM include temperature ranges, time at given temperatures, and medium used to heat and cool the PCB (i.e. liquid or air).*

IST – Interconnect Stress Test; *an accelerated thermal cycling test that utilizes DC current to heat the PTH and uses forced air to cool the PTH of a PCB coupon. The benefits of using IST in place of conventional TCT tests include lower cost, failure detection and results within days.*

CAF – Conductive Anodic Filament Growth Failure; *a PCB reliability issue related to the growth of copper containing filament along the resin-to-glass interface*

Isola

RoHS

Halogen Free

- **RoHS Compliancy** – Products that are RoHS compliant do not contain the 6 chemical substances listed on the following slide. These substances are not to be used in the base chemistry of laminates or prepregs.

A RoHS compliant resin system does not mean that it is Lead Free Assembly Compatible at 260 C.

ALL Isola Products are RoHS Compliant

EU RoHS Compliance

- Restriction of Hazardous Substances
- Legislation bans the following Six substances for shipment to EU countries effective July 1 -2006
  - Lead **(Pb)**
  - Mercury **(Hg)**
  - Hexavalent Chromium **(Cr^{6+})**
  - Polybrominated biphenyl **(PBB)**
  - Polybrominated diphenyl ether **(PBDE)**

  Max Conc. By Wt. < 0.1 %

  - Cadmium **(Cd**) **- - Max Conc. By Wt. < 0.01 %**
- High End Networking companies exempt until 2010 and beyond