CERN | IRRAD Proton Facility

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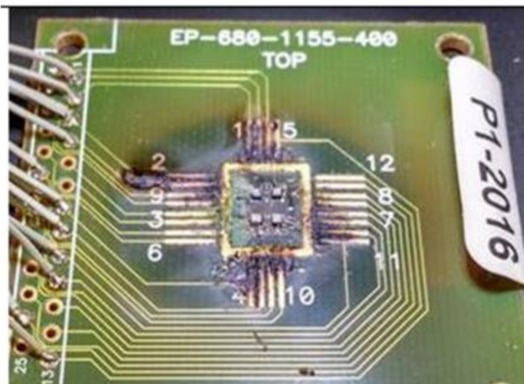
Information about Halogen-free PCB materials

The DS-7402 is, so far, the only substrate we tested as suitable to be used for a very hash radiation environment (up to 10^{17} p/cm^{2}). Besides the standard FR4 substrate, we also tested the DS-7409S (not Halogen-free). Here below you can find a short summary of what we noticed during our tests:

The figures below show a comparison between the use of a standard FR4 PCB and a so-called Halogen-free PCB (ref.: Doosan DS-7402) devoid of chlorine and phosphorus. The traces of corrosion observed on the standard FR4 in Figure 1 would be Al(OH)3 (aluminum hydroxide ≡ acid), produced by a reaction with chlorine as a catalyst. The irradiation, the presence of chlorine, a humid atmosphere, and the absence of solder mask on the tracks led to this result. It's not obvious in the pics but some wire bonds have been ejected from the pads of the card.

Figure 2 shows a possible solution, asking the manufacturer to choose as a substrate a type FR4 Halogen-free. This does not mean that the substrate is devoid of chlorine but that it contains some residual. To have the "Fire Retardant" properties, the use of chlorine is always present in the process.

Standard FR4. Corrosion on VDD lines, burnt and swollen substrate.



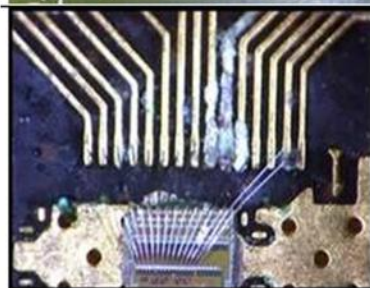


Figure 1

Halogen Free DS-7402, at same levels of radiations doesn`t show any considerable damage.

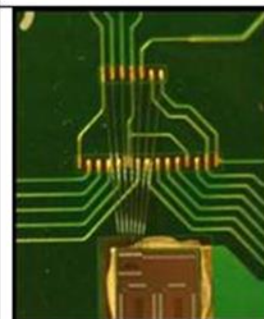
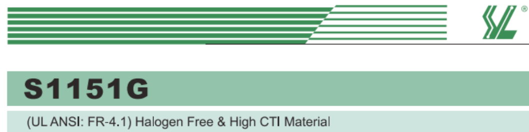


Figure 2

The finishing for the SMD and bonding is in Palladium-Gold ENEPIG to be compatible with "chip on Board" and connect the wire bonds correctly on the reception pads. Adding solder mask to protect the tracks is a plus as shown in Figure 2. The disadvantage is that the use of such a process is approximately twice as expensive as the standard one.

Here it follows the datasheet of the tested PCB substrate: https://www.mclpcb.com/wp-content/uploads/2021/05/doosan-ds-7402.pdf

Another possible solution, that we didn't test yet, is the substrate S1151G, proposed by the French company https://www.pcbelectronics.fr/



S1151G

(UL ANSI: FR-4.1) Halogen Free & High CTI Material

FEATURES

- Lead-free compatible.
- Constituents free of halogen free, antimony, and red phosphorus
- UV Blocking/AOI compatible.
- High CTI, CTI≥600V.

APPLICATIONS

Communication equipment, mobile phone, computer, instrumentation, VCR, TV, electronic game machine, and etc.

GENERAL PROPERTIES

Test Items		Treatment Condition	Unit	Property Data	
				SPEC	Typical Value
Tg		DSC	℃	≥140	150
Flammability		C-48/23/50,E-24/125	Rating	UL94 V-0	UL94 V-0
		E-24/125+des			
Volume Resistivity		After moisture resistance	MΩ-cm	$\geq 10^6$	6.4×10^7
		E-24/125		$\geq 10^3$	5.3×10^6
Surface Resistivity		After moisture resistance	MΩ	$\geq 10^4$	4.8×10^7
		E-24/125		$\geq 10^3$	2.8×10^6
Arc Resistance		D-48/50+D-0.5/23	S	≥60	140
Dielectric Breakdown		D-48/50+D-0.5/23	KV	≥40	45+KV NB
Dielectric Constant (1MHz)		C-24/23/50	-	≤5.4	5.1
Dissipation Factor (1MHz)		C-24/23/50	-	≤0.035	0.010
Thermal Stress	Unetched	288℃, solder dip	-	>10s No Delamination	Pass
	Etched				
Peel Strength	1OZ Cu.Foil	288℃/10s	N/mm	≥1.05	1.4
		125℃		≥0.70	1.3
		After process solutions		≥0.80	1.3
Flexural Strength	LW	A	Mpa	≥415	600
	CW			≥345	450
Water Absorption		D-24/23	%	≤0.5	0.10
CTE Z-axis	Before Tg	TMA	PPM/℃	≤60	36
	After Tg	TMA	PPM/℃	≤300	220
	50-260℃	TMA	%	≤3.5	2.8
Td		10℃/min, N_2, 5%Wt Loss	℃	≥325	360
T288		TMA	min	≥5	15
T260		TMA	min	≥30	>60
CTI		IEC60112	Rating	PLC 0(≥600)	PLC 0(≥600)

Specimen thickness: 1.6mm. Test method is according to IPC TM-650.

Remarks: 1. All the typical value listed above is for your reference only, please turn to Shengyi Technology Co.,Ltd. for detailed information,and all rights from this data sheet are reserved by Shengyi Technology Co.,Ltd.

2. All the typical value is based on the 1.6mm specimen.

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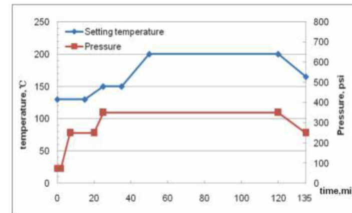
S1151GB PREPREG

(UL ANSI: FR-4.1) Halogen Free & High CTI Material

PREPREG PARAMETERS

Glass fabric type	Resin content (%)	Cured Thickness (mm)	Standard size (Roll type)
2116	54%	0.125	1.260m x 250m
	58%	0.137	
7628	45%	0.200	1.260m x 150m
	48%	0.218	
	50%	0.229	

HOT PRESSING CYCLE



- Heat up rate: 1.0-2.5℃/min (80-140℃)
- Curing time: >60min (180-190℃)
- The hot pressing parameter is for your reference only, please turn to Shengyi Technology Co., Ltd for detailed information.

STORAGE CONDITION

- Three months when stored at < 23℃ and <50% RH
- Six months when stored at <5℃. Normalize in room temperature for at least 4 hours before using.
- Beware of moisture, always keep wrapped in damp-proof material. Were kept in normal condition, prepreg might absorb moisture and its bonding strength would be weakened.
- Avoid UV-rays and strong light.

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We found interesting also the table available at this reference: https://www.pcbdirectlab.com/wp-content/uploads/2018/05/Materials.html