Circuit and Terminal Board Laminates

Printed Circuit Reliability Starts With Design

In the final analysis, no matter how well a printed circuit is manufactured, it will be reliable in direct proportion to the care exercised during the design stage in matching materials specification with required physical and electrical characteristics. Hints for selecting dielectric base materials appropriate to your requirements are found in Table 1. Table II provides specific data on the function of various plated coatings on printed circuits.

TABLE 1
TYPICAL PROPERTIES OF INDUSTRIAL LAMINATES

Base Material	Nema Grade	Military Designation (Laminate only)	Military Designation (Copper Clad)	PROPERTIES OF BASE MATERIAL: Dielectric Constant 10^6 Cycles	Dissipation Factor 24 hrs. in H_2O 10^6 Cycles	Moisture Absorption 1/16" % 24 hrs.	Flexural Strength Face-Lengthwise PSI	Maximum Oper. Temp. °C Continuous	COPPER CLAD PROPERTIES: Copper Bond Strength lbs. to pull 1" Strip 1 oz	2 oz	Hot Solder Resistance Secs. to Blister 1" Sq. Greater than	Punching Quality	CHARACTERISTICS AND APPLICATIONS
Phenolic Paper	XX	MIL-P-3115C PBG		5.4	0.040	1.30	18,000	120	6	8	10@450°F	Excellent	General purpose, low cost, high mechanical strength for panels, contactors, and terminal blocks.
	XXP			4.9	0.034	0.5	20,000	120	8	11	10@475°F	Excellent	Hot punching grade, a good mechanical strength, not recommended for severe humidity conditions.
	XXX	MIL-P-3115C PBE		4.8	0.038	0.8	18,000	120	6	8	10@475°F	Poor	High resin content, excellent moisture resistance, superior electrical properties, - used for high voltage and high frequency applications.
	XXXP	MIL-P-3115C PBE-P	MIL-P-13944 PP	4.0	0.030	0.4	20,000	120	8	11	10@475°F	Excellent	Best quality paper base-most widely used. Excellent cold punching. Especially suited for printed circuits requiring close registration of circuits and punched holes. Several modifications available.
Phenolic Nylon	N-1	MIL-P-15047 NPG		3.7	0.030'	0.3	15,000	120	8	11	10@450°F	Excellent	Highest insulation resistance under humid conditions. High impact strength with excellent electrical properties.
Melamine Glass	G-5	MIL-P-15037C GMG		6.8	0.018	0.2	55,000	120	8	11	10@450°F	Fair	Highest mechanical strength, superior arc and fire resistance. Difficult to machine.
Silicone Glass	G-7	MIL-P-997 GSG		4.1	0.013	0.1	40,000	160	3	4	10@450°F	Fair	Best heat resistance, excellent electrical properties. Difficult to machine. Used in high temperatures and for arc resistance.
Epoxy Paper	FR3	MIL-P-22324 FR3		3.8	0.032	0.40	27,000	120	8	11	10@450°F	Excellent	Easy machining, self extinguishing, surpasses any XXXP grade. Best cold punching and machining properties, high insulation resistance and superior electrical characteristics.
Epoxy Glass	G-10	MIL-P-18177B GEE	MIL-P-13949 GE	4.6	0.025	0.15	65,000	130	10	15	30@500°F	Good	Excellent electrical grade-best surface resistivity, high mechanical strength, low dimensional change, cold punching. Stands up under cyanide plating and at very high temperatures. Excellent for missiles and computers.
	G-11	MIL-P-18177B GEB	MIL-P-13949 GB	4.4	0.015	0.09	60,000	150	10	15	30@500°F	Good	Exceptional arc and surface resistivity, electrical properties, heat resistance, dimensional stability and mechanical strength. Self-extinguishing grade. Ideal for computer circuits and military electronic uses.
	FR4		MIL-P-13949 GF	4.5	0.024	0.08	60,000	130	10	15	30@500°F	Good	Flame resistance G10
	NC8175			5.1	0.029	0.35	48,000	130	7	9	20@500°F	Good	Commercial Grade G10

WHY PLATE?

At LAKE, we consider the electroplating of printed circuits to be sufficiently vital to high reliability to have installed the most modern plating facilities available. Although it is becoming increasingly less common, many well designed and produced circuits still fail in use because of oxidation of the copper conductor pattern. More common is the additional work necessary to prepare a circuit, which has oxidized, for subsequent manufacturing operations. Failure in-use, and increased manufacturing costs to remove oxidation products, can be almost entirely eliminated if an electroplate of a precious metal is specified at the outset.

Of course there are many different types of metals which can be plated onto the conductor pattern of the printed circuit, and each has its own particular advantage to recommend it. The most common types of plating include silver, gold, lead-tin solder, nickel-gold, rhodium and nickel rhodium. Table II shows typical applications of the plated circuits.

TABLE II
APPLICATIONS OF PLATED COATINGS ON PRINTED CIRCUITS

COATING	THICKNESS	PROPERTIES AND APPLICATIONS
Copper	0.0005 — .002"	Used to build up circuitry in thru hole Plating.
Gold — Immersion	.005-.010 mil.	Fair corrosion resistance; improves solderability after long storage.
Gold — Electroplated	0.0001 — .0002"	Corrosion and wear resistance, low contact resistance, used on plug-in contacts, switches and connectors.
Nickel-Gold	0.0002 — .001" Ni 0.00001 — .0001" Au	Hard, wear-resistant, low contact resistance; used on plug-in boards, switches and connectors.
Nickel-Rhodium	0.0003 — .001" Ni 0.00001 — .0001" Rh	Very hard, wear resistant, wiping contact surface, non-corrosive; recommended for continuous and intermittent operation on switches and plug-in contacts.
Silver — Electroplated	0.0003 — .002"	Long term protection against oxidation, used mainly in contact switches.
Silver — Immersion	.005-.010 mil.	Short term protection against oxidation, improves solderability if soldered shortly after coating is applied.
Silver — Rhodium	0.0005 — .002" Ag 0.00001 — .0001" Rh	Non-corrosive, wear resistant. Used where nickel cannot because of its magnetic properties.
Solder — Electroplated	0.0005 — .002"	Extends shelf life, permits use of mild fluxes, and improves solderability. Used widely in plated-thru holes where two-sided soldering is accomplished by fusing, or solder dipping one side.