Advanced Circuit Materials
High Frequency Laminates and Flexible Circuit Materials

QUESTION:

How Can I Build A Multi-layer Construction with RO4003™ High Frequency Circuit Material?

ANSWER:

Rogers new RO4003C™ material (part of the RO4000® family of high frequency materials) was developed in response to customer requests for a material with a low cost structure, high performance characteristics and fabrication ease similar to FR4. Use of RO4003 material allows the design and fabrication of high frequency circuits with superior electrical and mechanical properties at very competitive prices. Some applications will require the need for multilayer constructions consisting of RO4003 material and RO4003/FR4 hybrids.

There are many applications that require RO4003 material to be bonded, for stripline RF circuitry, as well as being bonded to FR4 for digital/DC signal processing. Several types of adhesives, as well as bond cycles, can be used depending on the interfaces to be bonded. Figure I shows a typical construction requiring an RO4003 stripline circuit bonded to an FR4 multilayer construction.

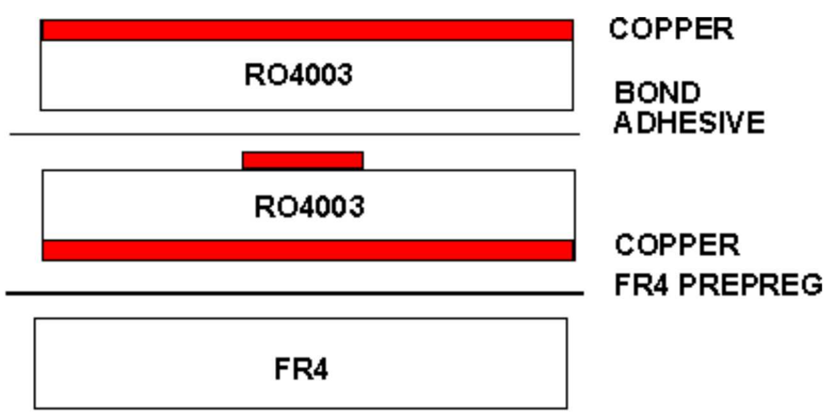

FIGURE 1. TYPICAL RF/DIGITAL MULTILAYER CONSTUCTION

RO4003 Bonding

RO4003 High Frequency Circuit Materials are glass reinforced hydrocarbon/ceramic laminates designed for performance sensitive, high volume commercial applications. RO4003 laminates are designed to offer superior high frequency printed circuit performance, ease of fabrication and a very low cost. The result is a high performance, low loss material which can be fabricated using standard epoxy/glass processes offered at competitive prices. The adhesive to use should be one that does not alter significantly the electrical loss of the bonded construction, while still providing ease of fabrication. Many of the films used for bonding PTFE based laminates do have low electrical loss (like FEP film from DuPont), thus not greatly affecting the loss characteristic of the stripline, but unfortunately would require the use of sodium etch to prepare the hole wall prior to PTH processing (RO4003 has no PTFE so this step would not be needed). FR4 prepreg can also be used to bond the RO4003 layers together and provide the simplest fabrication process. The possible problem in this case is the loss of the circuit is affected when using a prepreg whose loss can be an order of magnitude greater than that of the RO4003 material. Somewhere in the middle, there are prepregs based on PPO/epoxy material that have loss between the two as well as fabrication somewhat similar to FR4 (General Electric GETEK? prepreg).

An evaluation was performed to understand the difference in loss for bonded RO4003 material (two 0.032" layers) using the various adhesive option given above. For FR4 prepreg, Polyclad PCL-226 was selected. Typical properties for the materials used are presented in Table I while the measured insertion loss for each bond type is given in Figure I .

Table 1. Bond Film Properties

Film Type	Bond Temp, °C	Soak Time, min	Dielectric Const.	Loss Tangent	Thk.
FEP	295	50	2.1	0.0003	0.0020"
GETEK	190	90	3.9	0.012	0.0025"
FR4	177	60	4.5	0.018	0.0027"

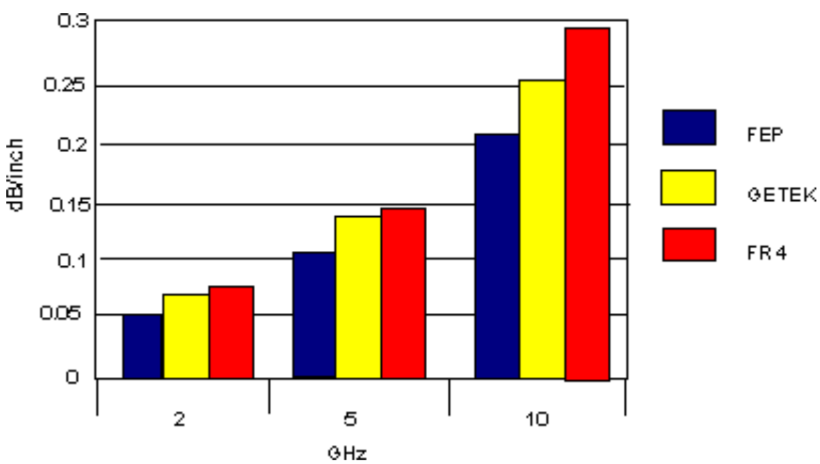

FIGURE I. Insertion Loss of RO4003 50W stripline

The difference in loss between the three adhesive types is not as great as one might have thought based on the difference of loss tangents, particularly for lower frequencies. In this case, FR4 prepreg constructions are 30 to 35% lossier than FEP constructions but the overall loss is still low (0.07 to 0.3 dB/inch compared to 0.2 to 0.8 dB/inch for an all FR4 stripline). This data illustrates that FR4 prepreg can be used to bond RO4003 material without drastically increasing the overall circuit losses while at the same time maintaining simplicity in fabrication.

The designer, however, needs to take into account how the bond layer will affect the overall effective dielectric constant of the system. This needs to be taken case by case since not only is the thickness of the board a factor, so is the circuitry itself. An edge coupled filter would be affected in a different manner as a standard through line due to the distribution of the electromagnetic fields. Figure II provides the measured values for the $e_{r,effective}$ of the bonded RO4003 striplines.

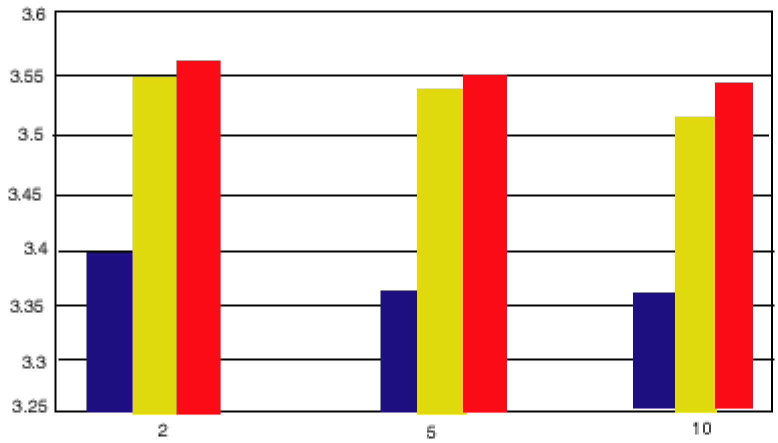

Figure II: Effective 4003/adhesive dielectric constant

RO4003-FR4 Bonding

RO4003 circuitry can be bonded to FR4 layers as if working with an all FR4 construction. As long as the copper ground plane on the RO4003 layer is being bonded to FR4 layers, standard FR4 prepreg is adequate. The ground plane on the RO4003 layer would isolate the circuit from whatever is below it, so FR4 hybrids can be built without deteriorating the performance of the RF/microwave circuitry on the RO4003 material. Copper surfaces need to be oxide treated, as is standard practice for FR4, in order to increase surface roughness. Red or brown oxides have been found to yield excellent results. Bonding of RO4003 to FR4 can be done in the same lamination cycle as bonding of RO4003 material to itself. Plated through hole processing between RO4003 and FR4 can go through the standard FR4 operations (desmear, plating) without harming the RO4003 material. Drilling of the hybrid boards should be done following the drilling guidelines for the RO4003 layer.

Following the guidelines presented here, RO4003 materials can be successfully bonded to form multilayer RF circuitry as well as being able to construct RO4003/FR4 hybrids for space saving requirements. RO4003 materials clearly provide the characteristics needed in a high performance commercial grade laminate, excellent electrical properties and low material/fabrication cost, to insure success in the expanding market of wireless communications.

The information and guidelines contained in this document are intended to assist you in designing with RO4000® materials. They are not intended to and do not create any warranties express or implied including any warranty of merchantability or fitness for a particular application. Results may vary as conditions and equipment may vary. The user should determine the suitability of Rogers materials for each application.

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