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1798 Technology Drive
Suite 246
San Jose, CA 95110
Phone:408-573-1325
Fax :408-573-0575
Email:esi1@en-solutions.com

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# Report on dielecric measurement of wirebond coating material using TDR.

Prepared for the exclusive use of Microbonds, Inc.

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**Introduction:** Time domain Reflectometer measurements were performed on samples with coated and uncoated wirebonds. Impedance and propagation delay were measured for the wirebond discontinuity. Effective dielectric constant seen by the electromagnetic wave traveling through the coated and uncoated wirebond was calculated from the propagation delay. This is an indirect method of measuring effective dieletric constant and gives a value of effective dielectric constant which will be close to the actual effective dielectric constant.

**Theory:** From electromagnetic theory propagation delay for an EM (electromagnetic wave) is ~ 0.033*sqrt(Er)ns/cm. Where Er is the effective dielectric constant of the material surrounding the conductor. Using TDR, propagation delay of a discontinuity of wirebond can be easily measured. Using the above equation the effective dielectric constant can then be calculated. As shown in figure 1 below this effective dielectric constant will depend on the thickness of dielectric material surrounding the conductor since this thickness will determine the extent to which the field lines are enclosed by the dielectric. If this thickness is sufficient that all the field lines are enclosed within the same dielectric then the effective dielectric is equal to the dielectric of the material. If all the field lines are not enclosed by a single dielectric material then the effective dielectric constant is some combination of dielectric constant of the various materials.

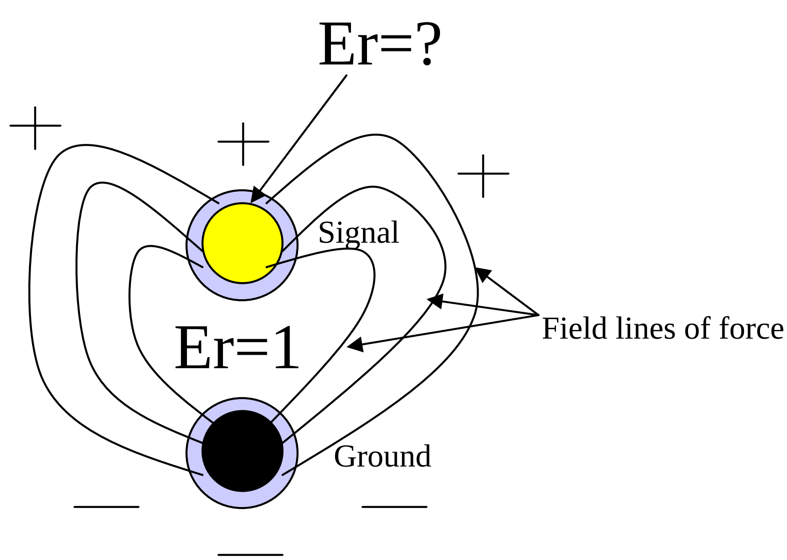


**Figure1**: Cross section of measurement sample with the field lines.

In figure 1 above the effective dielectric constant will be some combination of dielectric constant of the coating compound and air (Dielectric constant of air =1).

**Measurement methodology**: An 11801 Tektronix sampling oscilloscope along with SD24 TDR head was used to generate the TDR pulse and capture the reflection from the discontinuity. The rise time of TDR pulse is ~25ps. The probe used for measurement was a cascade microprobe with Signal-Ground configuration at a pitch of 1000 microns and signal bandwidth of 40GHZ. Measurement was done on three samples provided by Microbonds, Inc. Typical sample is shown in figure 2.

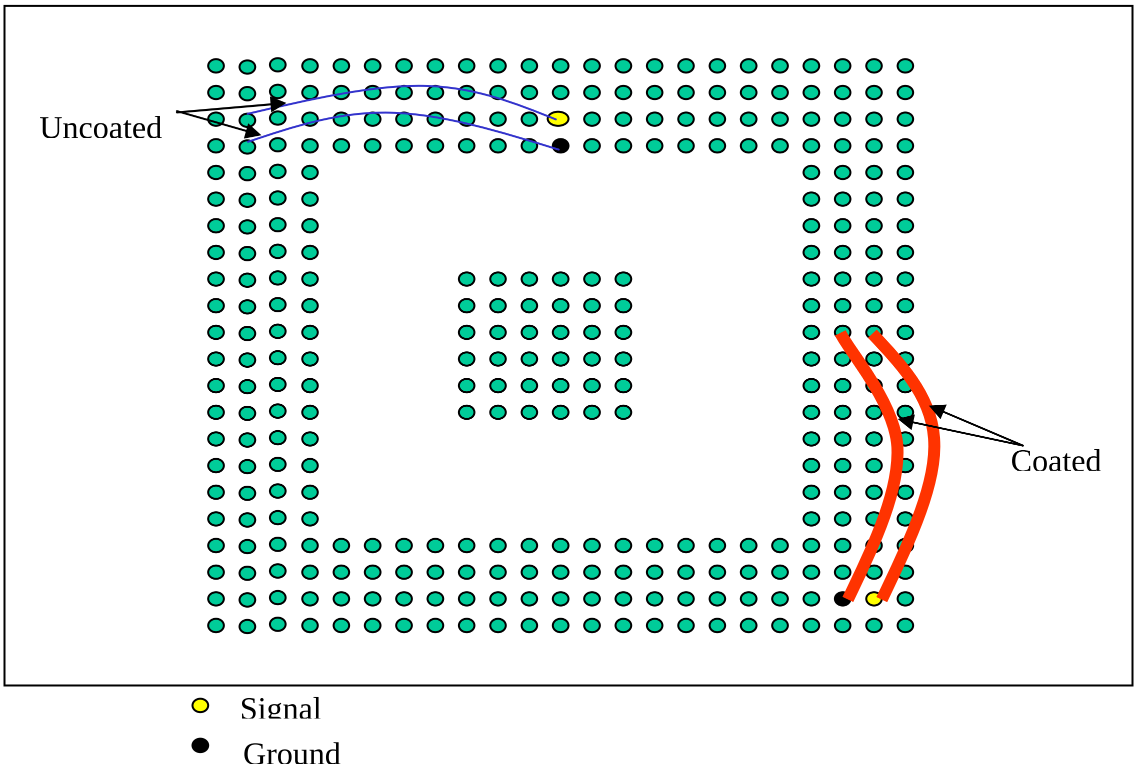


Figure2: Typical sample wirebonded configuration.

Results:

| Sample | Td (ps) | Z(Ohms) | L(Henrys) | C(farads) | Er |
|---|---|---|---|---|---|
| S6_uncoated | 3.40E-11 | 248 | 8.43E-09 | 1.37E-13 | 1.06E+00 |
| S5_coated | 4.20E-11 | 197 | 8.27E-09 | 2.13E-13 | 1.62E+00 |
| S5_uncoated | 3.30E-11 | 248 | 8.18E-09 | 1.33E-13 | 1.00E+00 |
| S4_uncoated | 3.40E-11 | 247 | 8.40E-09 | 1.38E-13 | 1.06E+00 |

Table1: Measurement/calculated data for the various wirebonds.

**Discussion**: For the uncoated case the effective dielectric constant calculated is 1.06, while the dielectric constant for air is 1. In the uncoated case all the field lines are surrounded by air as dielectric hence the effective dielectric cocnstant seen by EM wave is ~1. In the coated case the effective dielectric constant is 1.62 and is closer to that of air since most of the field lines are in air and only a small proportion of them reside in the coated material. The coating material also increase the capacitance of the bond wire as seen in the result for S5_coated. The inductance has decreased for the coated case as compared to the uncoated case. This could be due to the fact that the distance between the signal and ground wire bonds is less than that in the uncoated case. The capacitance is higher for the coated case due to the coating material itself as well as for the above reason of signal being closer to ground wirebond.

**Conclusion**: For the coated case the effective dielectric constant seen by the EM wave traveling thru the wirebond is 1.62. **THIS IS NOT THE DIELECTRIC CONSTANT OF THE COATING MATERIAL.** Since the coating is very thin, the dielectric constant is dominated by the dielectric material outside the coating. In actual applications the wirebonds will be glob topped or encapsulated by molding compound, whose dielectric constant is ~3.4. Therefore the effective dielectric constant seen by EM wave will be ~3.4. For modeling and simulation purposes therefore the dielectric constant of 3.4 should be used**.** At the frequencies of interest (< 3 GHZ) and for the wirebond length of interest in actual application (<5mm) this values of effective dielectric constant can be used for modeling and simulation without any loss in accuracy.

For the case where the coated wirebond is not encapsulated in glob top material but surrounded by air, the effective dielectric constant of 1.62 should be used upto a distance of 2.5microns around the wire .