Focusing in on W-band Absorbers

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Introduction

Originally designed for use in military applications to deter enemy radar, electromagnetic absorbing materials and the technologies with which they are often packaged have advanced considerably. Absorbers have now found use in countless applications—from reducing capacitive coupling between an integrated circuit and heat sink to attenuating common mode currents along a trace or cable. In particular, automotive technologies have improved significantly, with such features as collision avoidance, lane-changing assist, and automatic parking becoming integrated into platforms by nearly every major automobile manufacturer.

Assist features utilize a number of different systems to provide additional feedback to the driver. These include GPS, lidar (light detection and ranging), vehicle-to-vehicle communication, and radar (radio detection and ranging). Use of radar systems in vehicles is already prevalent, with many automotive manufacturers relying on radar units for environment object detection. Although 24 GHz systems have been widely used for mid-range detection systems, the use of 77 GHz in mid- and long-range radar units is becoming commonplace in automotive applications. Operation at these frequencies presents designers with new challenges in combating such issues as false positives and interference from surrounding structures, as well as transmitter and receiver antenna crosstalk. Electromagnetic absorbers designed by ARC Technologies Inc., including SB1006 and SB1009, are designed specifically for W-band (75 to 110 GHz) operation and address many of the above issues.

Material Design Challenges

There are many challenges associated with the design of W-band absorbers. With a free-space wavelength of 3.9 mm at 77 GHz, absorber thickness must be tightly controlled as this has a direct impact on far-field reflection loss performance. Designers of absorbing materials must also consider that the use of pressure sensitive adhesive (PSA) may contribute to shifting the reflection loss null due to the additional dielectric layer placed between the absorber and the mounting surface. Multilayer and gradient structures, allowing a gradual transition from free-space impedance, have the advantage of offering broadband performance over a wide range of frequencies. Although these structures aid in combatting changes in the reflection loss due to inconsistencies in material thickness and use of PSA, these solutions tend to be expensive and may be cumbersome for applications with limited space.

Using enhanced production techniques and taking into account the effects of the PSA's permittivity and thickness, ARC Technologies Inc. has designed absorbing materials specific to W-band applications.

ARC Technologies Inc. W-band Absorbers

ARC Technologies Inc. offers a variety of materials to meet the needs of applications operating at W-band frequencies. Thermoplastic-based materials, SB1006 and SB1009 are economical solutions that are proven effective in this frequency range.

SB1006

SB1006 is a 1-mm-thick, single-layer dielectric absorber that offers excellent far-field reflection loss at 77 GHz. As seen in Figure 1 below, the reflection loss is measured to be -16.78 dB at 77 GHz, with a better than -16 dB reflection loss from 76.73 to 78.51 GHz. The low profile of SB1006 also makes it suitable for use in applications where space is limited.

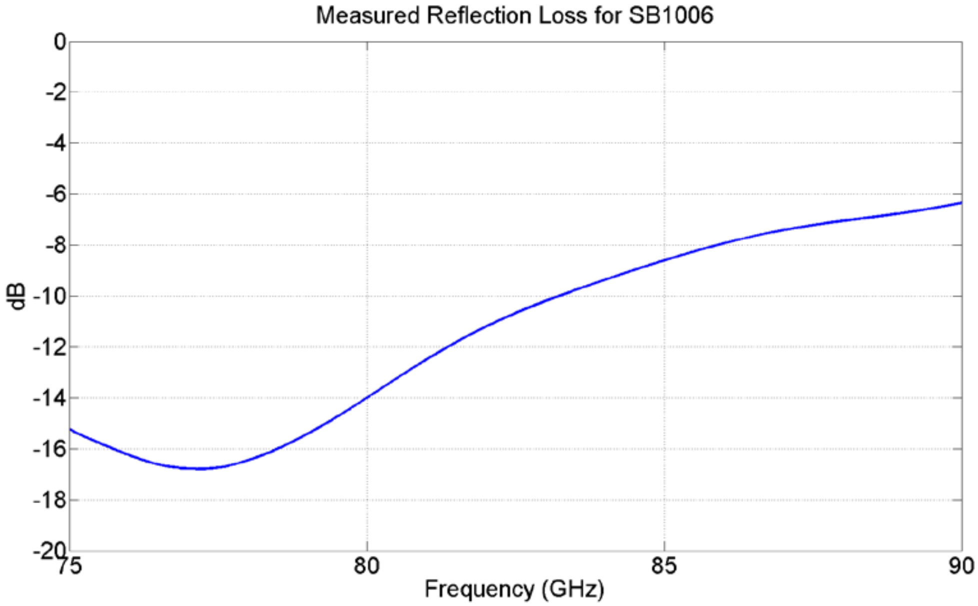

Figure 1 - Measured reflection loss for SB1006 at a 0° angle of incidence.

SB1009

SB1009 is a 2-mm-thick, single-layer, lightweight dielectric absorber that is ideally suited for 77 GHz systems. As shown in Figure 2 below, at 77 GHz, the reflection loss is measured to be -16.72 dB.

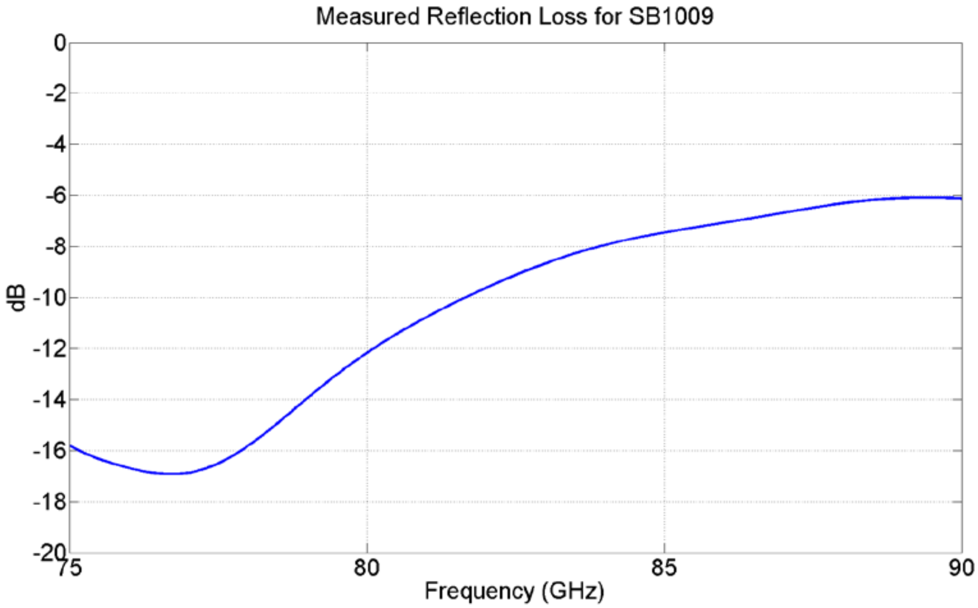

Figure 2 - Measured reflection loss for SB1009 at a 0° angle of incidence.

By tailoring material permittivity and permeability as well as thickness, interaction between the primary reflection wave and the outgoing wave results in destructive interference, suppressing the return signal. Reduction of scattering waves is critical for proper operation of automotive radar systems in which signals reflecting from chassis structures can result in false positives as well as deform radar antenna beam patterns, degrading radar performance. The electric field loss, related to ε'' of these materials, also allows them to be effective in suppressing surface currents, cavity resonances, and antenna crosstalk.

Validating W-band Performance

As detailed in [1], scattering parameter measurements allow for the extraction of the complex permittivity and permeability for a given material under test. Coaxial and waveguide test fixtures provide convenient ways to obtain scattering parameters; however, mounting samples in a W-band waveguide would be difficult and requires precise dimensions of such samples to reduce errors due to air gaps [2]. Quasi-optical systems can also be used to measure scattering parameters [3].

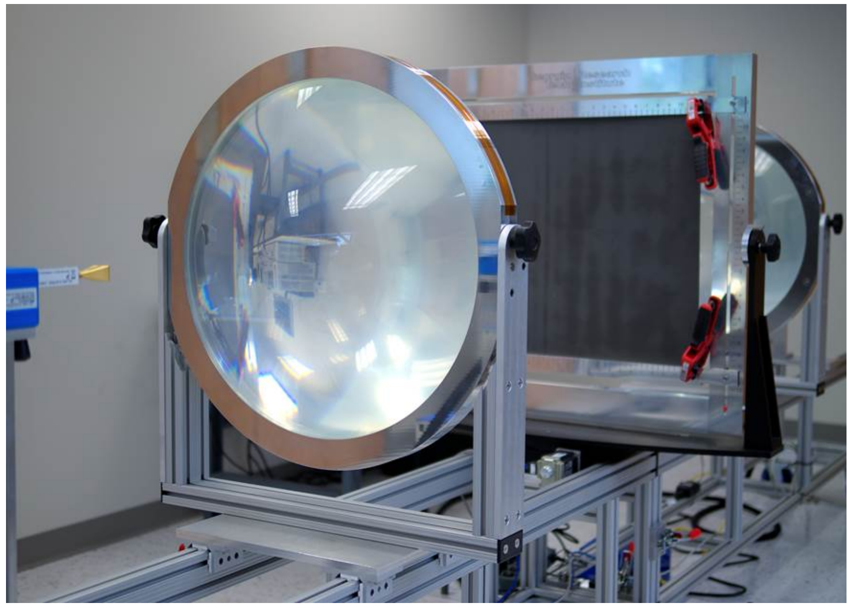

Figure 3 – ARC Technologies Inc. focused beam system setup for W-band measurements.

ARC Technologies Inc.’s focused beam system, shown in Figure 3, is a quasi-optical measurement system, consisting of specially designed lenses that are used to create a Gaussian beam. At the focal point of the lenses, the phase front of the beam is approximately planar, allowing for the characterization of a material’s permittivity and permeability, as well as insertion loss and reflection loss measurements. Metal-backed reflection loss measurements, as seen in Figures 1 and 2, are performed using a monostatic setup, with off angle measurements performed using an aluminum dihedral. ARC Technologies Inc.’s focused beam system is capable of measurements from 2 to 40 GHz and 75 to 110 GHz.

The comparison of modeled versus measured absorber performance using the focused beam system is key in not only validating simulated designs but also in the optimization of future W-band absorbers. Figure 4, below, shows a comparison of measured and modeled reflection loss from 75 to 90 GHz of SB1006 at a thickness of 0.040” (1.016 mm). The sample was adhered to a metal plate in the sample holder using 0.002” (0.051 mm) PSA. Modeling was performed using the measured permittivity of SB1006. The absorber layer was modeled at a thickness of 0.040” (1.016 mm) with a modeled PSA layer of 0.002” (0.051 mm).

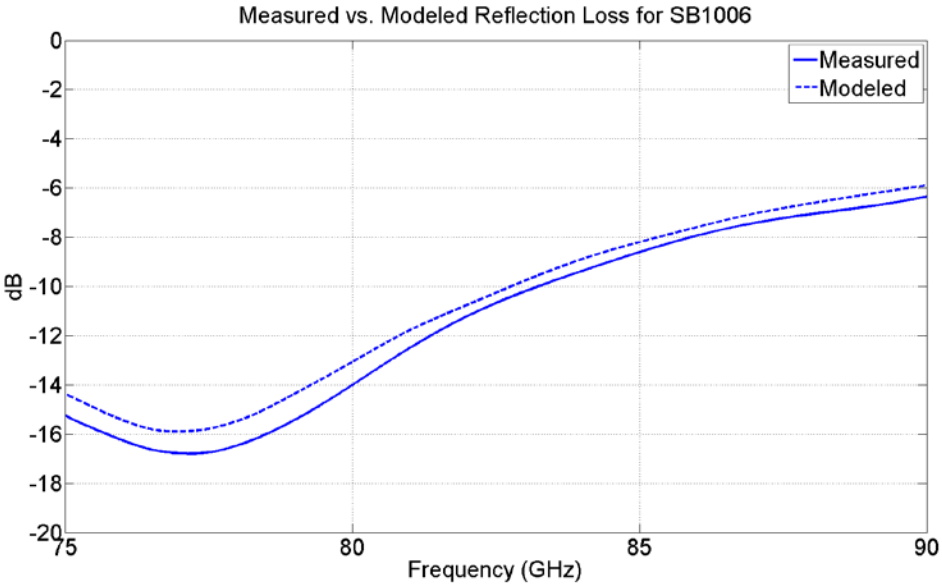

Figure 4 - Measured versus modeled reflection loss for SB1006. Modeled and measured at a 0° angle of incidence.

In comparing the two datasets, there is good agreement, less than 1 dB difference, between the modeled and measured data.

Conclusion

As more technologies emerge that operate in W-band, so will the need to integrate electromagnetic absorbers, such as SB1006 and SB1009, into these systems. By using focused beam measurements for material characterization, ARC Technologies Inc. can optimize and provide validation to absorber reflection loss and insertion loss performance. Additionally, understanding of parameters that may negatively alter absorber performance, such as use of PSA, material thickness, etc., can be considered early on in the absorber design phase, allowing for optimal performing absorbers.

References

[1] J. Baker-Jarvis, "Transmission/Reflection and Short-Circuit Line Methods for Measuring Permittivity and Permeability," NIST Technical Note 1355, 1992.

[2] Agilent, "Basics of Measuring the Dielectric Properties of Materials," Application Note, May 2014.

[3] J. Schultz, *Focused Beam Methods: Measuring Microwave Materials in Free Space*. CreateSpace, 2012.

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