

Agilent PN 4291-5

Agilent 4291B RF Impedance/ Material Analyzer

Product Note

Dielectric Constant Evaluation of Rough-Surfaced Materials

Introduction

Among the various methods available for dielectric constant evaluations, the parallel plate method is widely used because of its ability to make accurate measurements using a simple setup. The system described here consists of the Agilent Technologies 4291B RF Impedance/Material Analyzer and the Agilent 16453A Dielectric Constant Fixture. This system uses the parallel plate method to provide easy measurements of the dielectric constant of the material under test (MUT).

The 4291B (Option 002) has a built-in function that reflects the electrode characteristics of the 16453A. This option is used to calculate and display all the dielectric constant parameters, such as complex dielectric constant ($\epsilon_r' - \epsilon_r''$) and loss tangent ($\epsilon_r' - \tan \delta$).

However, due to a theoretical constraint of the parallel method, the system may cause a measurement error if the MUT surface is not smooth enough. This Product note describes a technique to measure a MUT with rough surfaces more accurately using the 4291B and the 16453A.

The Parallel Plate Method

The parallel plate method derives the dielectric constant of the MUT by measuring the capacitance between the two parallel plates (electrodes) between which the MUT is sandwiched (Figure 1). The dielectric constant is determined by the area of the plates, A [m^2], the distance between the plates (that is, the thickness of the MUT), t , and the capacitance, C_p [F], as shown in Figure 1. (Note: the fringe capacitance of the plates should also be considered in practical applications.)

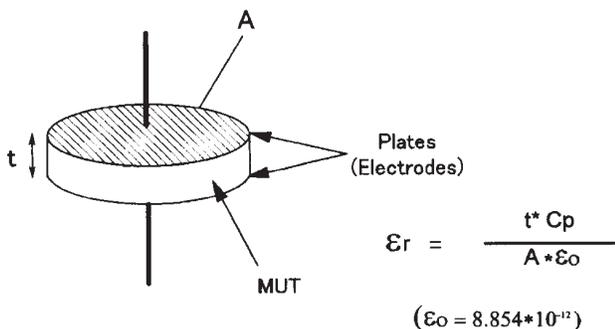


Figure 1. The Parallel Plate Method

Agilent 16453A

The 16453A Dielectric Material Fixture performs the dielectric constant evaluation at 1 MHz to 1GHz using the parallel plate method. The 16453A has a pair of electrodes (upper and lower) that are used as plates in this method. The upper electrode has a spring inside it that holds the MUT at an appropriate pressure to help provide stable and repeatable measurements.

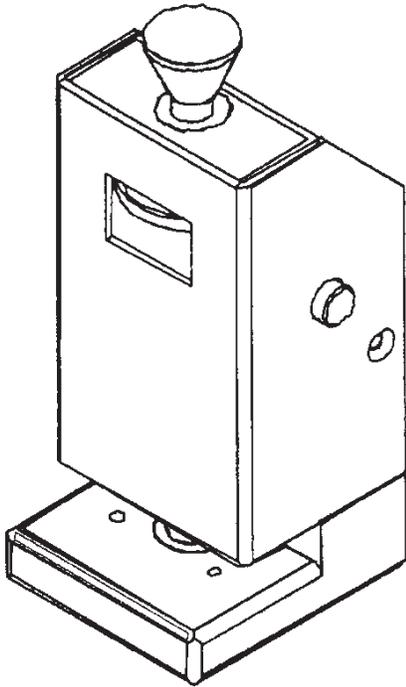


Figure 2. Agilent 16453A

As shown below, the 16453A allows easy measurements of dielectric constants. However, the system does not work well if the MUT surfaces are not smooth. This is because a rough-surfaced MUT tends to have a micro-air-gap between the MUT and the electrodes. This air gap causes a decrease in capacitance, resulting in a shifted measurement of the dielectric constant (Figure 3). For example, when $t = 1 \text{ } [\mu\text{m}]$, $\epsilon_r' = 4$, and the surface roughness $R_a = 12 \text{ } [\mu\text{m}]$, the measured dielectric constant (real part) will shift as much as 10%.

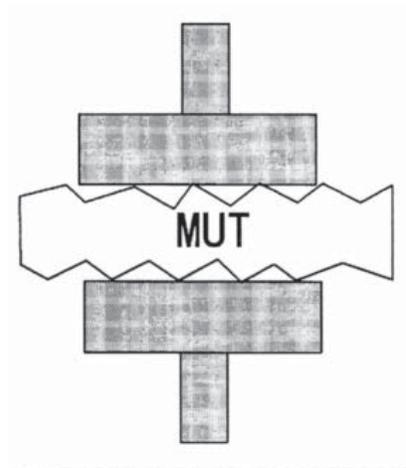


Figure 3. Error Caused by Air Gap

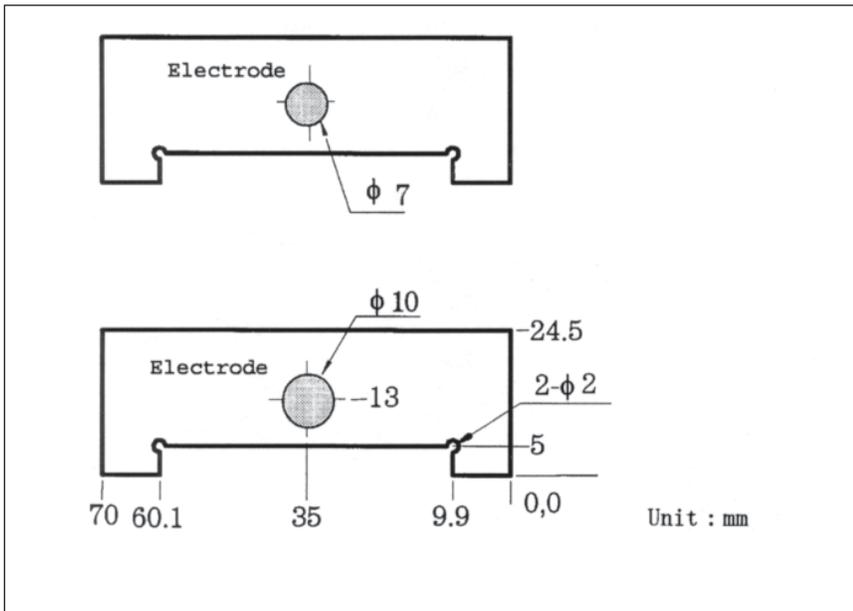


Figure 4. MUT Electrodes Shape and Position

Summary

By making electrodes for the MUT, a rough-surfaced MUT can be evaluated by the Agilent 4291B and 16453A without degrading the ease of use of the system.

Solution

For more accurate evaluation of the MUT, the air gap between the MUT and the electrodes must be reduced as much as possible. For this purpose, lapping the surfaces of the MUT can be very effective. However, it is not always practical to do this much preparation work on the MUT. Another technique is to make electrodes on the MUT surfaces. These electrodes will reduce the air gap significantly, and will provide more accurate measurements.

As shown in the Figure 4, the electrodes should be formed on both surfaces of the MUT so that each electrode matches the corresponding electrode on the 16453A in terms of position and shape. (The figure also shows a recommended shape for the MUT that makes positioning the MUT easier.) Because of the matched size and position of the electrodes, the measurement results on the 4291B (Option 002) can be used without any calculation or conversion.

Measurement Example

Figure 5 shows the measurement results of a rough-surfaced material. A complex dielectric constant was measured on the MUT without electrodes (left) and with electrodes (right) at 1 MHz to 1 GHz. At 100 MHz, there is a 10% improvement (from 4.447 to 4.96) in ϵ_r' (real part) on the MUT with electrodes. This technique provides results comparable to a test on a smooth-surfaced MUT of the same material.

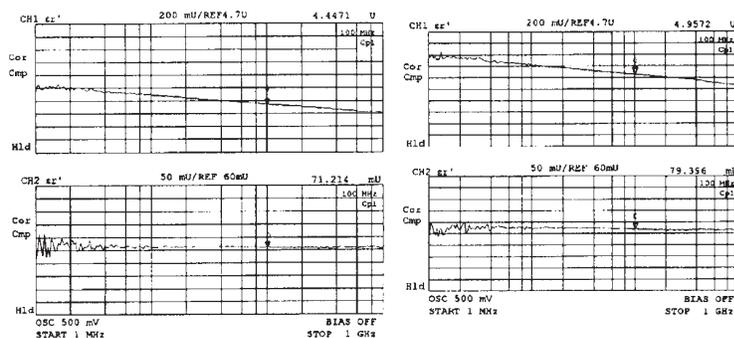


Figure 5. Measurement Example



Agilent Email Updates

www.agilent.com/find/emailupdates

Get the latest information on the products and applications you select.



Agilent Direct

www.agilent.com/find/quick

Quickly choose and use your test equipment solutions with confidence.

Remove all doubt

Our repair and calibration services will get your equipment back to you, performing like new, when promised. You will get full value out of your Agilent equipment through-out its lifetime. Your equipment will be serviced by Agilent-trained technicians using the latest factory calibration procedures, automated repair diagnostics and genuine parts. You will always have the utmost confidence in your measurements.

Agilent offers a wide range of additional expert test and measurement services for your equipment, including initial start-up assistance, onsite education and training, as well as design, system integration, and project management.

For more information on repair and calibration services, go to:

www.agilent.com/find/removealldoubt

www.agilent.com

For more information on Agilent Technologies' products, applications or services, please contact your local Agilent office. The complete list is available at:

www.agilent.com/find/contactus

Americas

Canada	(877) 894-4414
Latin America	305 269 7500
United States	(800) 829-4444

Asia Pacific

Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 112 929
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Thailand	1 800 226 008

Europe & Middle East

Austria	0820 87 44 11
Belgium	32 (0) 2 404 93 40
Denmark	45 70 13 15 15
Finland	358 (0) 10 855 2100
France	0825 010 700* *0.125 €/minute
Germany	01805 24 6333** **0.14 €/minute
Ireland	1890 924 204
Israel	972-3-9288-504/544
Italy	39 02 92 60 8484
Netherlands	31 (0) 20 547 2111
Spain	34 (91) 631 3300
Sweden	0200-88 22 55
Switzerland	0800 80 53 53
United Kingdom	44 (0) 118 9276201

Other European Countries:

www.agilent.com/find/contactus

Revised: March 27, 2008

Product specifications and descriptions in this document subject to change without notice.

© Agilent Technologies, Inc. 1998, 2000, 2008

Printed in USA, June 2, 2008
5966-1926E



Agilent Technologies