Agilent PN 4291-3

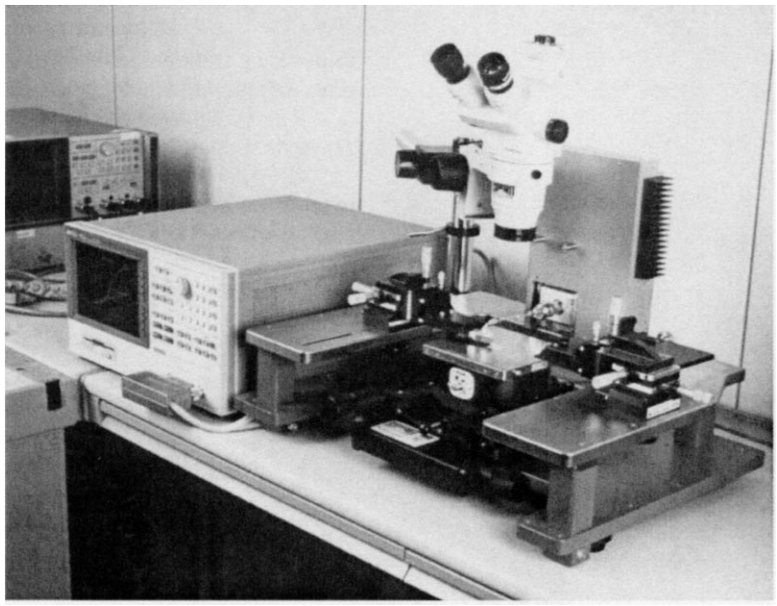
Impedance Measurements Using the Agilent 4291B and the Cascade Microtech Prober

Product Note

Agilent 4291B RF Impedance/ Material Analyzer

Introduction

There is an increasing demand and a need to make impedance measurements using a prober. One example would be making impedance characteristic evaluations of a narrow pitch transmission line at high frequency in order to evaluate the design of RF circuits and IC packages. Another example is performing a precise capacitance characterization of dielectric thin film up to the GHz range. In this product note, a new solution for this type of measurement is described in which the Agilent Technologies 4291B RF impedance/material analyzer and the Cascade Microtech prober are used.



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Agilent 4291B Capabilities

The 4291B 1 MHz-1.8 GHz RF Impedance/Material Analyzer can measure impedances covering a wide frequency range with great measurement accuracy by using the newly developed RF-IV method (basic measurement accuracy: 0.8%). Impedances that differ greatly from 50 are considered difficult to measure using the reflection coefficient method used in most Network Analyzers.

For example, inductors in nH, capacitors around 1 pF, etc., can be measured accurately using the 4291B. Also, regarding Q (quality factor), Q=100 can be measured at 1 GHz with an accuracy of 15% (typical value). In addition, a precise, stable probe system can easily be constructed using a standard 1.8 m connection cable as the test station. This station can be brought close to the probe without affecting the measurement accuracy.

Moreover, because parasitic elements like the residual inductance of the probe (which is considered to be one of the major error factors), can be removed by using the compensation function. These capabilities make it possible to evaluate the electrical characteristics of the DUT correctly.

System Composition

The 4291B can accurately measure the impedance of a narrow pitch transmission line using a Cascade Microtech prober. This system contains the following equipment:

Agilent Products:

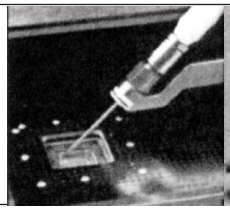
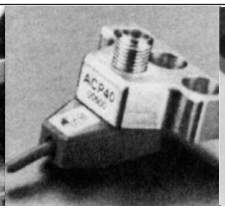
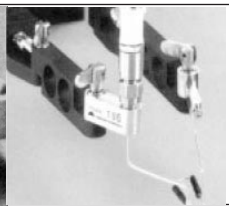
- 4291B RF Impedance/Material Analyzer (1 ea.)
- APC7®-SMA Adapter (Agilent P/N 1250-1746, 1 ea.)

Cascade Microtech Products:

- Summit series 9000 probe station (1 ea.)
- Positioner, microscope for probe station (1 ea.)
- Adapter kit for installation of 4291B test station (No. 106-768, 1 ea.)
- Cable with SMA (M)-(F) connector (No. HF-502-6, 6 inches long, 50, 1 ea.)
- Probe (1 ea.), see Table 1.
- Impedance standard substrate (choose suitable one for probe, 1 ea.)

There are three major different types of Cascade Microtech probes as shown in Table 1. The suitable probe for the measurement should be chosen from the table.

Table 1. Selection of Cascade Microtech Probe

	Compliance Probe (FPC series)	Wafer Probe (ACP, WPH series)	Fine-pitch Microprobe (FPM-1X)
			
Electrode Distance	Fixed: Selectable between 150–1250 um	Fixed: Selectable between 150–250 um	Variable: 0–18 mm
Main Features	Suitable for a device mounted on a PC board (or similar mount) because it contacts a device at a 45° angle. Can contact non-flat material using a spring-type probe tip.	Fixed: Selectable between 150–250 um	Variable: 0–18 mm
Measurement Stability	Best	Best	Good

System Selection and Measurement Procedures

Select the system and make the measurement according to the following procedures:

1. Choosing the 4291B test head

Good impedance measurement accuracy can be obtained by choosing an appropriate test head for the 4291B from two types of test heads depending on the impedance values being measured. Chose a suitable test head to achieve an accuracy of 10% at different frequencies. (See Figure 1.) See the 4291B data sheet for more details.

2. Installation of the 4291B test station

Fix the adapter kit to the left side of the probe station for the 4291B's test station installation. Then, place the test station vertically on the adapter kit. At that time, place the test head and DUT as close as possible. Fix steadily to the test station.

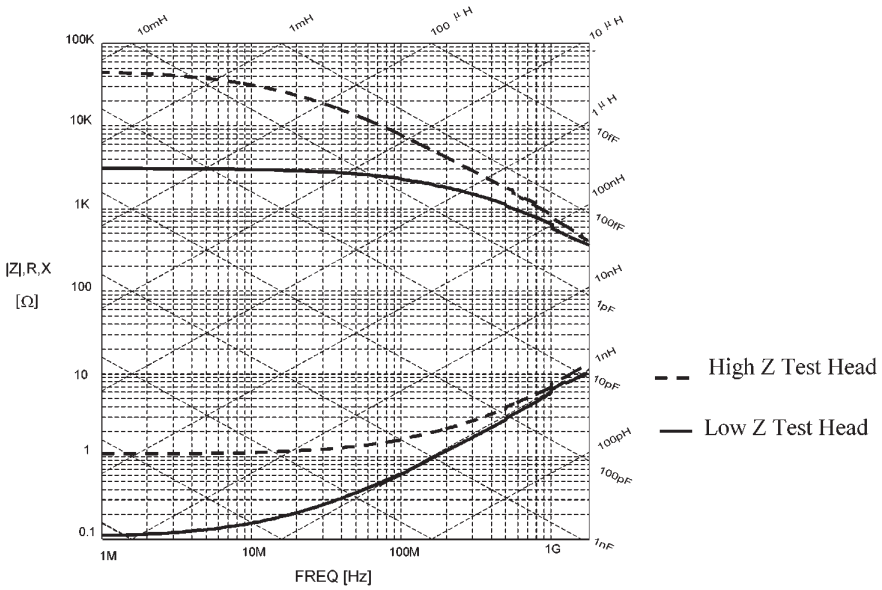


Figure 1. Agilent 4291B Accuracy (10%)

3. Setting Up the 4291B

Set the following measurement conditions:

- Start/stop frequency (when using frequency sweep)
- Test signal level
- Number of points (NOP)
- Number of points averaging
- Parameter for compensation kit

The test signal level is usually set as large as possible. For example, use 1 Vrms (for a measurement under 1 GHz) or 0.5 Vrms (for a measurement over 1 GHz) so that the measurement can be made under conditions where the signal-to-noise ratio is the largest.

The NOP, which is the number of points for one sweep, can be set to a maximum of 801. When data of a higher density is desired (for example, when evaluating the steep frequency characteristic precisely), set the number of points higher. If a short measurement time is desired, decrease the number of points. Usually, it is set to more than 201.

Point averaging reduces the random error of noise by averaging the data mathematically when calibrating, performing compensation, and measuring, according to the specified averaging time.

More than 32 averaging is usually recommended in order to remove as much noise as possible.

Table 2. Selection of Cascade Microtech Probe

	Input Value	
Agilent 4291B Compensation	**Value of Impedance Standard Substrate (FPC, ACP, WRH)**	**Ideal Value (FPM)**
OPEN: CONDUCT(G)	0	0
CAP.(C)	Copen	0
SHORT: RESIST.(R)	0	0
INDUCT.(L)	Lshort	0
LOAD: RESIST.(R)	50	50
INDUCT.(L)	Lterm	0

The compensation kit parameter is the actual impedance parameter of the impedance standard substrate for compensation. It's set in the Agilent 4291B in order to perform more accurate compensation in Step 6. Because these parameters (Copen, Lshort, and Lterm) are dependent on the probe used and the distance between the electrodes, they are supplied together with the probe. (However, as there are no parameters supplied for the FPM probe, the values under ideal condition are substituted.) Set the parameters according to Table 2. Once the input values are registered as USER COMPEN KIT, the appropriate data will be chosen the next time.

4. Calibration of the Agilent 4291B

The measurement accuracy of the 4291B is applicable when calibration is done on the APC-7® terminal test head. Calibration must be performed with the calibration kit (0, 0S, 50 and Low-loss Capacitor) attached to the 4291B.

There are two different types of calibration procedures called "FIXED" calibration and "USER" calibration. In FIXED calibration, the measurement is made at the specified frequency points in the analyzer for the calibration, and the internal data is calculated for the whole span frequency. Points other than the calibration measurement points are calculated by interpolation. The specification of the measurement accuracy will be satisfied even though the measurement frequency or the test signal level is changed. However, an interpolation error will occur. On the other hand, in USER calibration, the measurement can be done with good accuracy and without any interpolation error. This is true because the internal data for calibration is calculated at the same points as the frequency points. Perform the USER calibration when accurately measuring components or narrow pitch transmission lines. (Notice that it is necessary to perform USER calibration each time the frequency setting is changed.)

5. Connecting the Agilent 4291B and the prober

See Figure 2. Connect the APC7®-SMA adapter to the test head. Then connect the cable between the APC-SMA adapter and the Cascade Microtech prober.

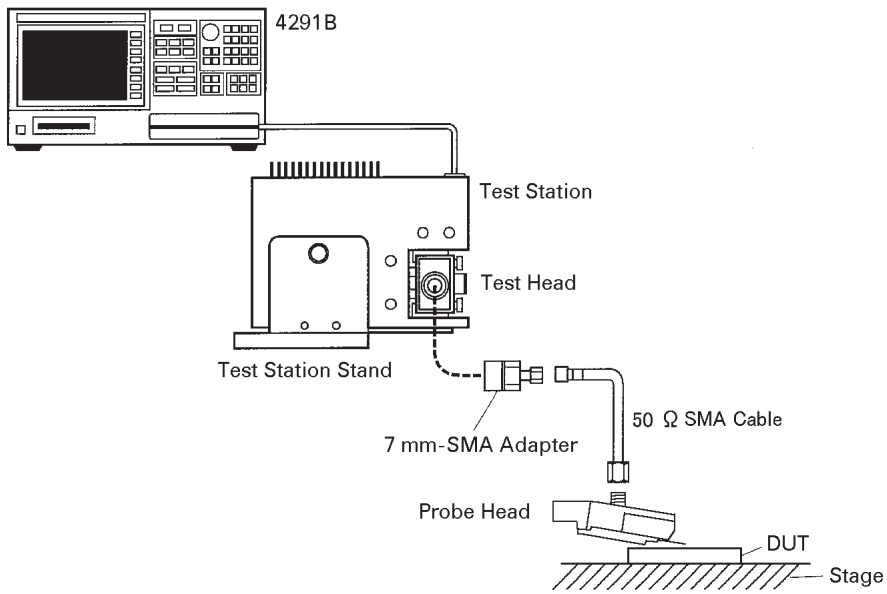


Figure 2. Connection between the 4291B and the Cascade Microtech Probe

6. Open/Short/Load compensation

The residual impedance of the cable and probe from the end of the test head can be removed by OPEN/SHORT/LOAD compensation. Perform OPEN compensation when the probe is not touching the DUT. Perform SHORT compensation by using the short standard substrate placed on the stage of the probe station. Perform LOAD compensation in the same way by using the 50 on the standard substrate. (Note: though there is a function to set appropriate electrical length for different types of test fixtures in the 4291B, it is not necessary to set the electrical length, as phase shift is also compensated for after load compensation. Set fixture to [none] mode.)

7. Measurement of the DUT

Place the DUT on the metallic stage of the probe station. Move the probe to the measurement position and make sure the probe is brought into contact with the device. Choose the applicable measurement parameter on the 4291B and make a measurement. One example of an Ls-Rs measurement of a transmission line is shown in Figure 3.

Summary

Impedance measurements of narrow pitch transmission lines and small capacitors on a wafer can be performed up to 1.8 GHz with good accuracy by using a combination of the Agilent 4291B impedance/material analyzer and the Cascade Microtech prober.

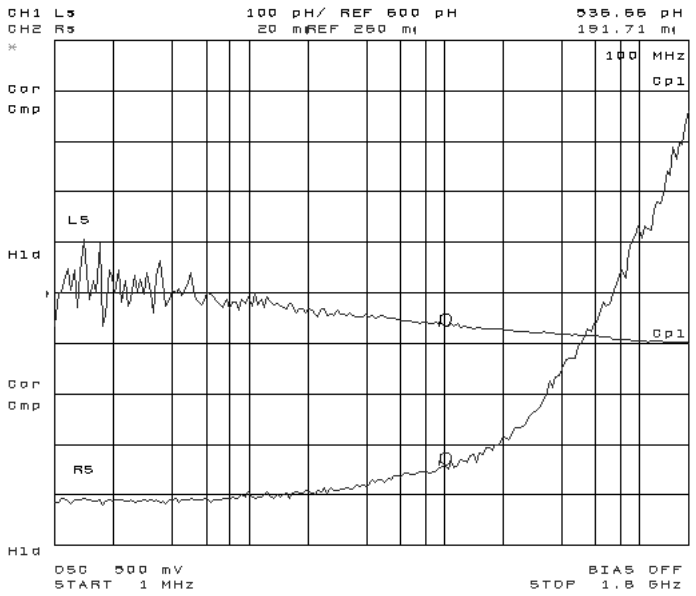


Figure 3. Ls-Rs Measurement Example of Transmission Line

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