A NONDESTRUCTIVE MICROWAVE BEAM LEAD DIODE MEASUREMENT

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ABSTRACT

Beam lead PIN diodes are commonly measured at 1 MHz or, on a sample basis destructively at microwave frequencies. This paper describes reproducible non-destructive microwave measurements using a vacuum hold down fixture.

INTRODUCTION

The problem with beam leads is that they're so small (about 35x12x5 mils, Figure 1) that the common practice previously has been not to measure their microwave parameters -- resistance (R_F) and capacitive reactance ($1/2\pi fC$) Figure 2 -- unless they were welded, soldered or epoxied into a transmission line. Such bonding precludes non-destructive removal of the beam lead from the test circuit. Consequently, beam lead diodes have been measured only on a sample basis at microwave frequencies, with 100% screening limited to 1 MHz C measurements.

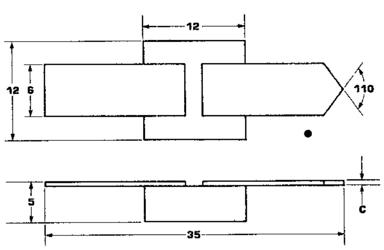

Figure 1. Outline drawing of the M/A-COM PIN beam lead diode.

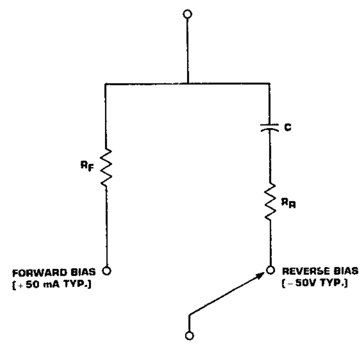

Figure 2. Beam lead PIN diode equivalent circuit

However, typically, different devices from the same wafer may vary from 3 to 8 ohms in forward biased resistance, R_F, and 0.027 to 0.035 pF in capacitance. Sample testing of R_F with such spreads is imprecise. Moreover, projecting 10 GHz isolation from a 1 MHz capacitance measurement is also imprecise. Finally, selecting devices with matched performance at microwave frequencies is only practical when a nondestructive measurement is possible.

This paper describes a beam lead vacuum test fixture useable at microwave frequencies and PIN diode measurements of insertion loss and isolation made with it at 10 GHz.

APPROACH

Figure 3 is a plan view showing three vacuum holes by which the beam lead device is held against the center conductor of a 0.010 inch thick, 50 ohm alumina substrate micro-strip transmission line. Figure 4 shows a photograph of the fixture. This circuit is useable from 100 MHz to 18 GHz, or more, provided that suitable bias tees are employed external to the microstrip fixture. A close up photograph of the beam lead in the microstrip fixture can be seen in Figure 5. A straight pin laid on the transmission line provides a size comparison.

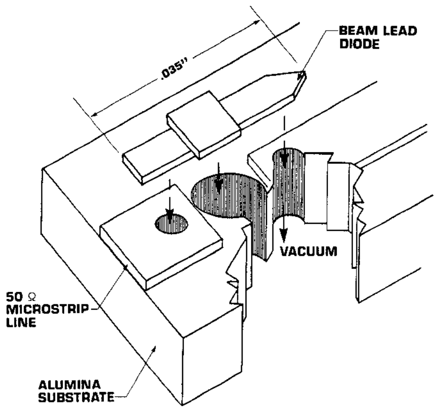

Figure 3. Beam lead diode and microstrip circuit with vacuum hold down

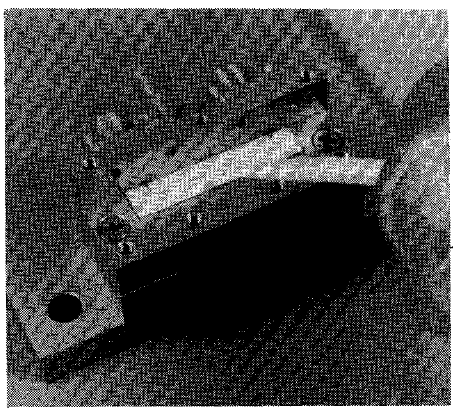

Figure 4. Overall view of the test fixture. A beam lead PIN, wetted with alcohol to the end of a plastic quill, is being conveyed to the gap in the line.

The small holes, beneath the diode's "beam leads" are 3 mils in diameter and are laser drilled through the alumina substrate. Similarly, a 7.5 mil diameter hole is bored at the gap in the center con ductor of the microstrip line. The center hole provides the brunt of the vacuum force to hold the body of the beam lead diode in place. It also serves to increase the isolation between the center conductor sections by reducing the gap capacitance of the fixture itself.

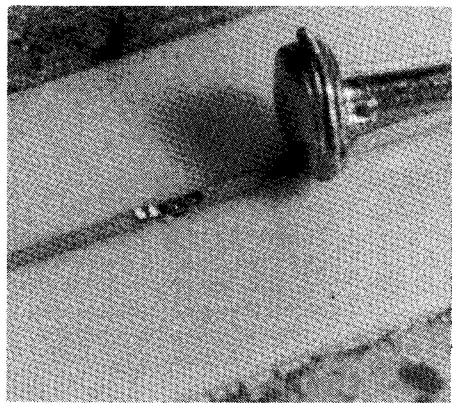

Figure 5. Close-up of a beam lead diode in the test fixture. A common straight pin rests on the 10 mil wide center conductor as a size comparison.

The transmission measurement test set-up is shown in Figure 6. The HP-438A dual head power meter was chosen to compensate for generator level drift. The low SWR of the power meter sensors (-30dB return loss) keeps mismatch uncertainties to a minimum. This and the drift compensation gives loss measurement with 0.001 dB resolution. The test frequency was selected to be 10 GHz to keep the isolation readings within the dynamic range of the test system.

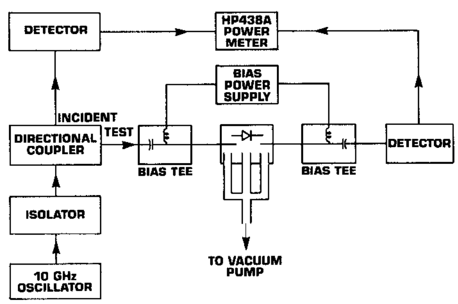

Figure 6. Beam lead diode transmission measurement test set-up

The zero loss reference is obtained by placing a short length of 10 mil wide gold ribbon across the gap. With the ribbon held in place by the vacuum, the input return loss of the test circuit was measured to be better than - 20 dB from 2-12 GHz. With the ribbon removed, the inherent isolation was measured to be 34 dB, which corresponds to only 0.003 pF of test circuit parasitic series capacitance.

RESULTS

A standard 0.02 pF capacitor having the dimensions of a beam lead diode does not exist. Therefore the efficacy of the vacuum jig was tested by a series of comparative measurements.

Figure 7 shows isolation versus frequency data for a single beam lead measured, first, in the vacuum fixture and, second, when thermocompression bonded into a microstrip line in a destructive measurement. The results are similar, with somewhat greater variations in the destructive fixture data from the expecation for a fixed capacitance. This may be due to larger mismatches present in the destructive fixture.

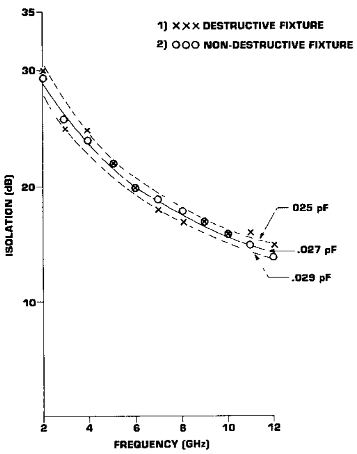

Figure 7. Isolation versus frequency measurements for a single beam lead in (1) the non-destructive fixture and (2) a destructive fixture.

The repeatability of the diode capacitance measured at 1 MHz is shown for two separate groups of ten measurements in Figure 8, demonstrating a reproducibility of ± 0.004 pF about a center value of 0.032 pF in the first measurement session. A similar spread in the data occurred in a second measurement session except the data were distributed about a center value of 0.030 pF. This shift is commonly experienced and is likely attributable to a shift in the zero capacitance calibration, a difficult step to perform more reproducibly with needle point probes.

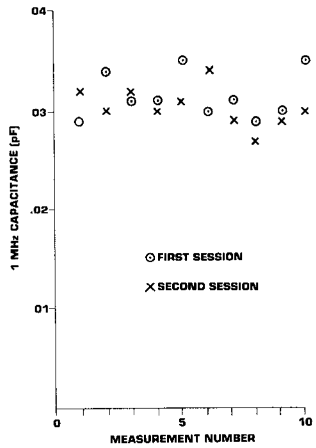

Figure 8. Reproducibility of 1 MHz capacitance measurement.

By contrast, the advantage of the vacuum microwave fixture is evident from the single frequency, 10 GHz data realized with it for the same diode, shown in Figure 9. First, both R_F and C are obtained from the same insertion of the diode in the measurement jig. The insertion is the most labor intensive portion of the beam lead's measurement.

Second, the capacitance data spread for all of the microwave measured values, are much narrower, ± 0.0015 pF, less than half the spread obtained in either 1 MHz session, giving a more consistent reading.

Third, the nominal microwave determined capacitance value, 0.020 pF, is shifted 55% from the 0.031 pF average obtained in the 1 MHz measurement sessions. As noted, this probably is attributable to the zero reference setting used for th 1 MHz measurement. The 1 MHz bridge was zeroed with the needle probes lifted just off of the diode. Since the beam lead C value is usually used to estimate microwave isolation, the 10 GHz isolation derived value of 0.020 pF could be considered the more reliable for microwave applications, an inherent advantage of the 10 GHz non-destructive measurement.

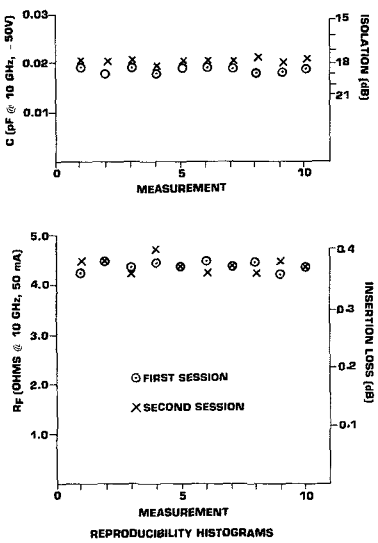

Figure 9. Reproducibility of 10 GHz measurement using vacuum mount test fixture.