

Paricon Technologies

CSP socket

Cycling Test
DC Measurement Results

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Objective

The objective of these measurements is to determine the DC performance of a Paricon Technologies CSP socket when subjected to a series of mechanical and electrical load cycles. Measurements are focused on current voltage relation, contact resistance, and leakage as a function of voltage.

Methodology

A four terminal (Kelvin) measurement setup is used that includes a computer controlled voltage source as well as a current source capable of delivering 10 A. The voltage developed across the contact is recorded in a Kelvin (four terminal) measurement at separate terminals.

Leakage testing relies on acquisition of a number of data points as a function of applied voltage. Voltage is increased in small steps and the associated current is recorded. From these values, resistance is computed. The setup is capable of resolving leakage currents on the order of a few pA. A normalization is performed to remove the effects of the setup without the socket under test.

Current handling measurements are carried out by driving the contact under test from a current source. Simultaneously, voltage is recorded with a second set of terminals (see setup).

Contact resistance is recorded as a function of mechanical position of an Au plated brass plunger that serves as a termination. A four terminal (Kelvin) measurement method is employed.

Repeatability is established by subjecting the CSP socket to four successive mechanical actuations and data acquisitions. After this sequence, the DUT is

subjected to cycling with surrogate devices in a mechanical cycler that is adjusted and adapted to the DUT characteristics. After a prescribed number of actuations the above test sequence is repeated.

Test procedures

A first set of tests was performed without having subjected the DUT to any prior surrogate device insertion. A sequence of 4 successive tests was performed with a mechanical actuation of the DUT before each of these tests. For this actuation, the shorting plunger (see setup) was withdrawn until it cleared the contacts completely. It was then re-inserted to the previous position and the appropriate electrical parameters recorded.

The cycling program selected was 0, 8192, 65536, 262144 and 1048576 surrogate device insertions with the above sequence of 4 tests performed after achieving each of these levels. Surrogate chips were changed after each of the program steps or 100,000 cycles. If specified, cleaning of the DUT was performed at the requested intervals.

For leakage testing the DUT subjected to a voltage applied to one contact, while all other pins are grounded. Applied voltage is raised from 0 to 10V in 0.25V steps while leakage current is recorded. Exponential averaging is used to reduce noise.

This contact is also used for testing the socket performance under load. For this, however, the Au plated shorting plunger is used as a DUT. It is introduced into the socket and brought to a position commensurate with nominal operating position or a bottomed out condition. Drive current is then applied and increased in binary steps up to the specified maximum level of 4 A for the socket under test. Simultaneously, the voltage developed across the drive terminals is recorded. The dwell time for each current step is 0.5 s for V/I curves.

Contact resistance is recorded as a function of mechanical position of an Au plated brass plunger that serves as termination. The test is performed by first bringing the plunger toward the socket under test until first contact is achieved. This is the starting position. Displacement is then adjusted until the plunger bottoms out in the socket. This is the second datum for the test sequence. The plunger is retracted until it no longer touches the contact, indicated by an open circuit condition. The plunger is then brought forward again toward the socket. Data are recorded from the start position to the end position. After reaching the end position, the cycle is repeated. This procedure is performed four times to illuminate any inconsistency in contact quality. This does not exactly represent the recommended procedure of applying a specific force to this particular type of socket. The test was nevertheless carried out in this fashion since it was found that force measurement with the existing test fixtures was not reliable because of friction. Results will show that no negative effects existed because of this process.

Setup

To avoid any cross-effects from dc testing on rf characterizations, a different contact is used for this program. As shown in Fig. 1, the contact under test is on the side of the DUT, typically the second from the top. The same contact will be used for all dc measurements, shown here in white.

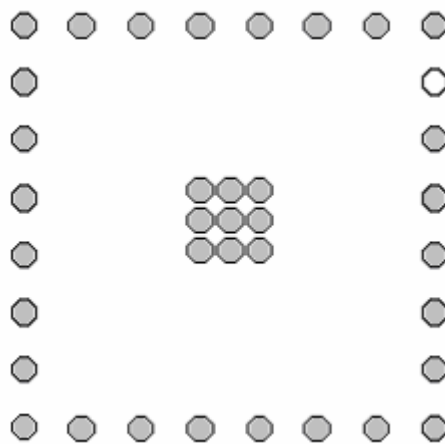


Figure 1 QFP socket test arrangement

The CSP socket is mounted on a brass plate similar to the one shown in Fig. 2. This plate has a small hole through which a probe is inserted for the dc testing. Since this plate is also used for mechanical cycling with surrogate devices, the probe bore is plugged with a metal plug during this procedure.

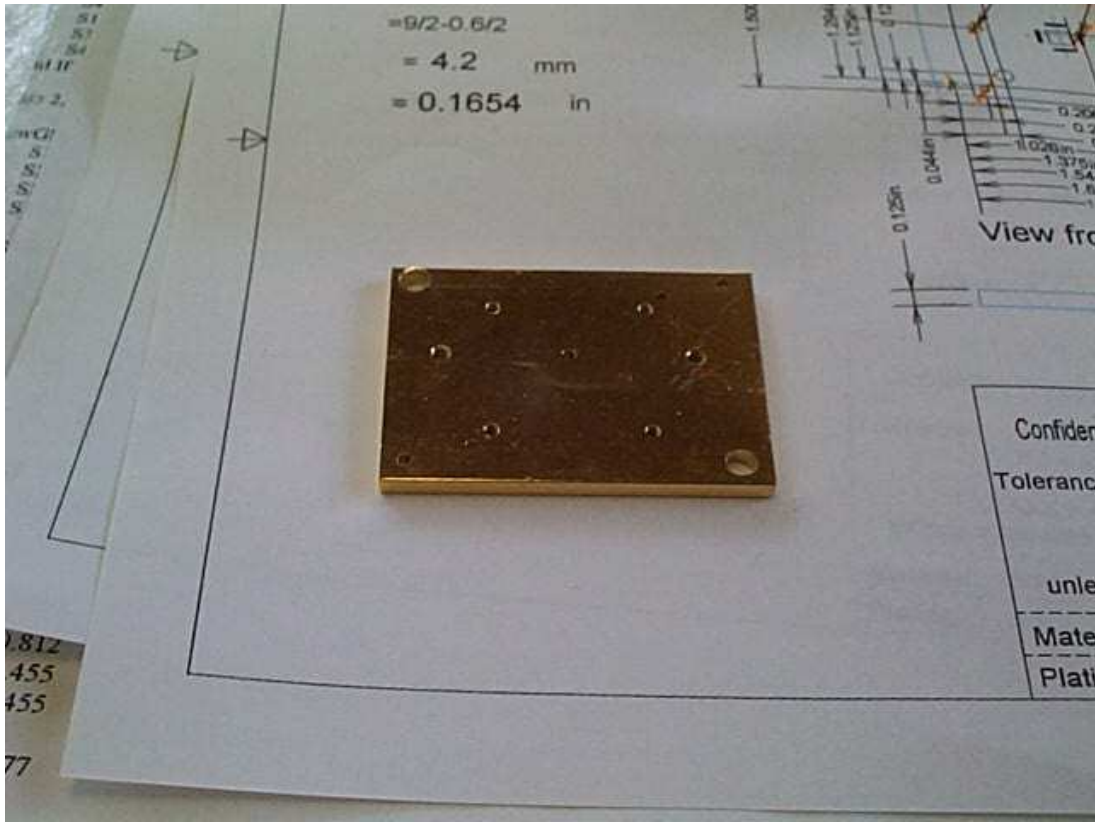


Figure 2 CSP socket mounting plate example

Au over Ni plating was applied to the surfaces of the brass plate. Material type and thickness specifications were identical to those used for PCBs.

The current/voltage probe consists of a copper post with suitably shaped surface. This surface is Ni and Au plated. The post has two connections, thus allowing for a four terminal measurement with very low residual resistance (about 1 milliOhm).

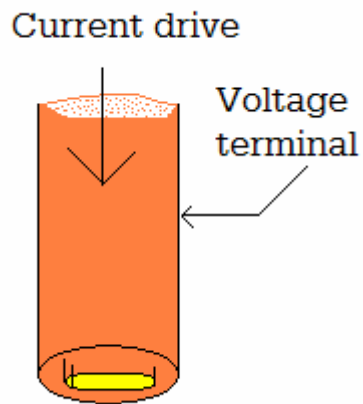


Figure 3 Current drive probe

The socket with its plate is mounted in a test stand with XYZ adjustment capability (Fig.4).

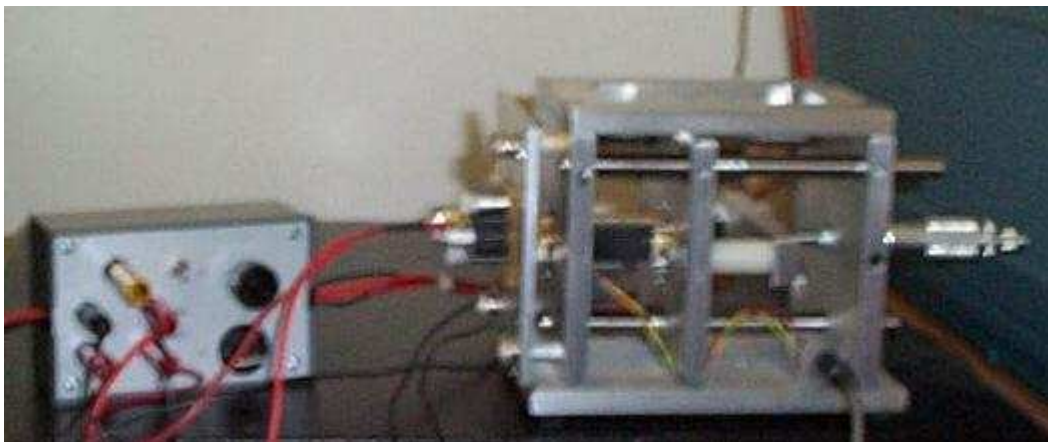


Figure 4 Test stand

This setup has a micrometer screw that allows repeatable adjustments in the Z direction. Also included is a transducer that converts Z position to an electrical signal for the data acquisition.

For leakage measurements an excitation is applied to the test probe. The DUT side of the socket is left open circuited. Leakage testing is performed via computer controlled voltage source (10V max.) and HP 3456A DMM.

For current handling tests, all contacts are grounded except for one. The CSP socket is placed into the test setup. A brass plunger shaped like an actual test IC is pressed against the contacts on the DUT side of the socket. Au over Ni plating was applied to the surface of the plunger. A four terminal (Kelvin) measurement setup is used that included a computer controlled current source capable of delivering 10 A. The voltage developed across the contact is recorded at separate terminals with an HP3456A digital voltmeter. Once the data are available, they are processed to reveal the resistance and power dissipation as a function of drive current.

The same setup is used for contact resistance measurements. In this case, connections are made only to an HP3456A DMM. It is operated in 4 wire mode for this measurement. A precision linear potentiometer serves as a distance transducer. Its resistance is recorded by a second HP3456A DMM.

Two different types of cycling apparatus were used. Depending on the socket type either a mechanical cyler with parallel plates moving by a small amount or a solenoid based cyler were used. Displacement was typically established such that the surrogate test devices reach a position close to bottoming out in the socket.

For the parallel plate setup force limiting was accomplished by inserting a thin hard rubber sheet between the DUT and the moving plates. Parameters were selected such that under maximum deflection and normal cycling conditions the surrogate device touches the bottom of the socket. Where necessary, pressure sensitive paper was used to verify this condition. Maximum speed of this setup was 3 cycles per second.

When a solenoid based cycler was used, force limiting was via solenoid drive current when necessary. Force measurements were performed with a pressure indicating paper that is capable of determining the magnitude of the applied pressure and hence the force. This method is necessary because of the dynamic situation that exists with the solenoid plunger / surrogate chip holder assembly entering the DUT with some speed and hence contributing to the maximum force. Maximum operating speed was 10 cycles per second.



Figure 5 Parallel plate cyclers

Measurements

Resistance

The contact resistance as a function of displacement is one of the parameters recorded during the dc characterization. Its absolute level and variations give a measure of repeatability and reliability for the socket under test.

The resultant data for this socket under test are shown below:

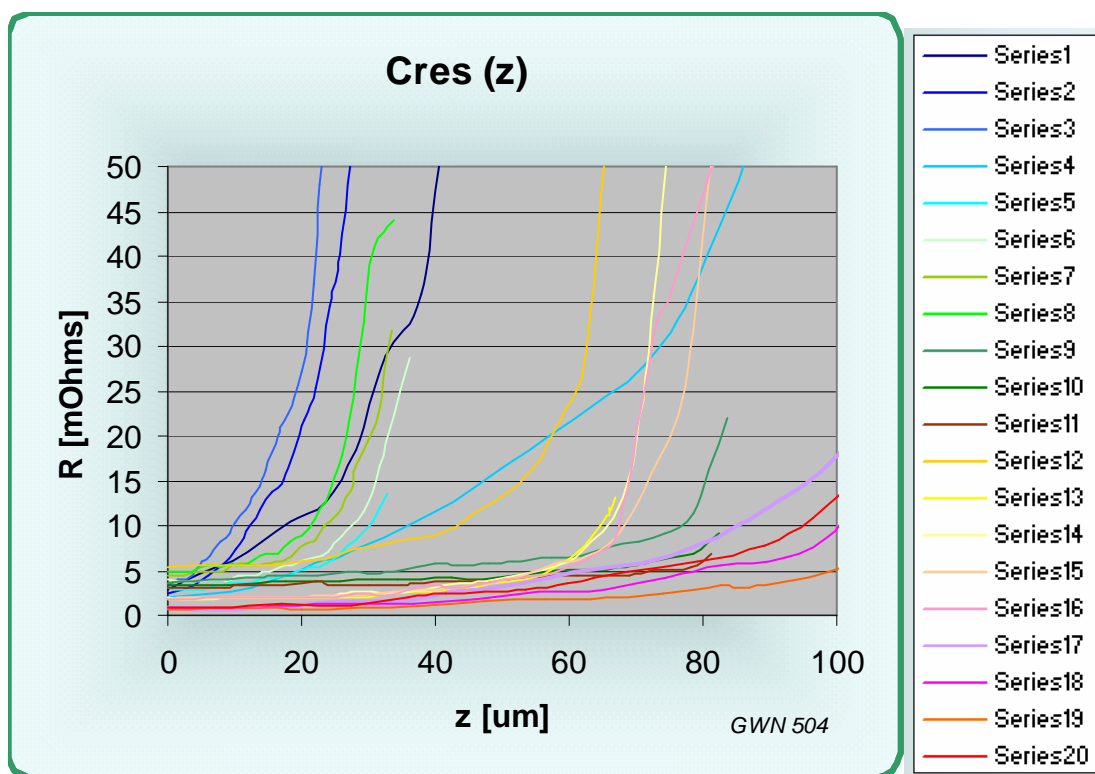


Figure 6 Contact resistance as a function of displacement

For this graph, the value $z=0$ represents the maximum compression in operation, i.e. with the DUT fully inserted. There are no anomalies in the observed response. Onset of contact is judged by when a reading is obtained on the DMM. Since readout update

time is about ½ second, the exact point is not always repeated and therefore is subjective and not consistent. This in no way reflects negatively on the socket. Thus, a more appropriate way of data presentation was selected by curtailing the range displayed:

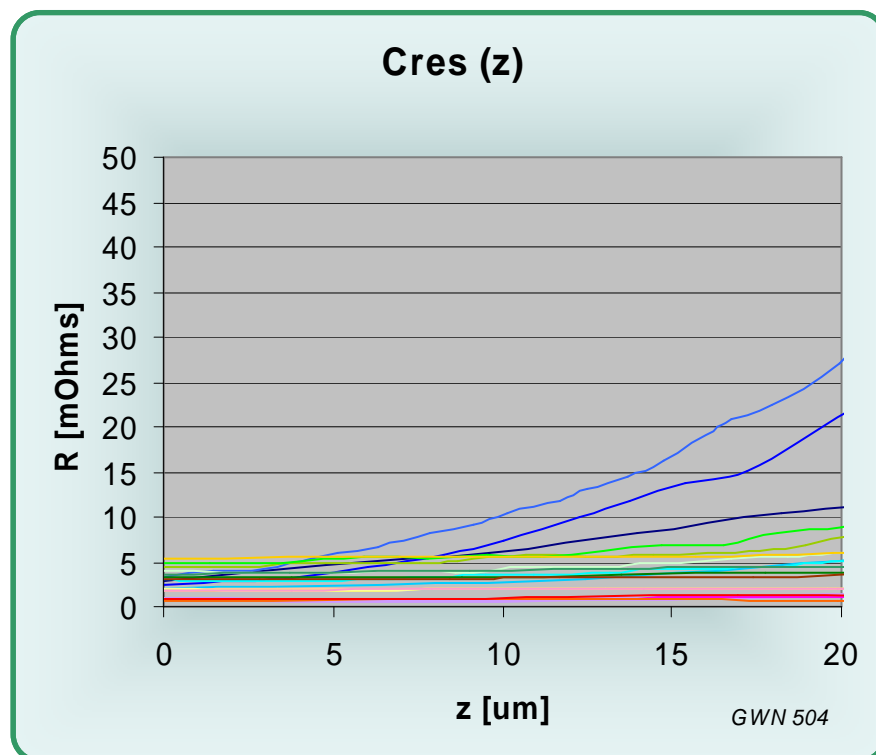


Figure 7 Contact resistance as a function of displacement

This is thought of to be more likely to be the actual range of operation, since DUTs to be tested will be inserted with a constant force. As cycle numbers increase (\Rightarrow series#), the overall resistance actually decreases.

As a measure of change throughout the cycles, the average resistance for the last 5 data points before the plunger reaches full insertion are plotted as a function of cycle number:

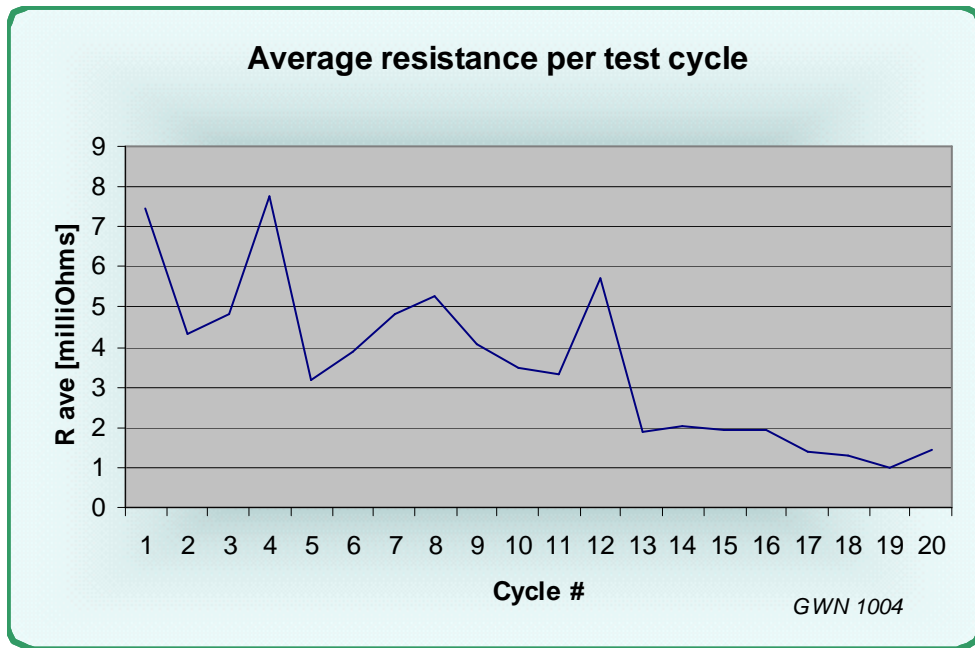


Figure 8 Contact resistance as a function of cycle number

While there is some variation, the overall level is extremely low and actually decreases as the number of cycles moves up toward the one million mark.

Also offered as a measure of contact performance are the deviations of the resistance as a function of displacement (plunger position, see graph below). Not surprisingly, average and variability increase when less displacement (force) is applied by the plunger.

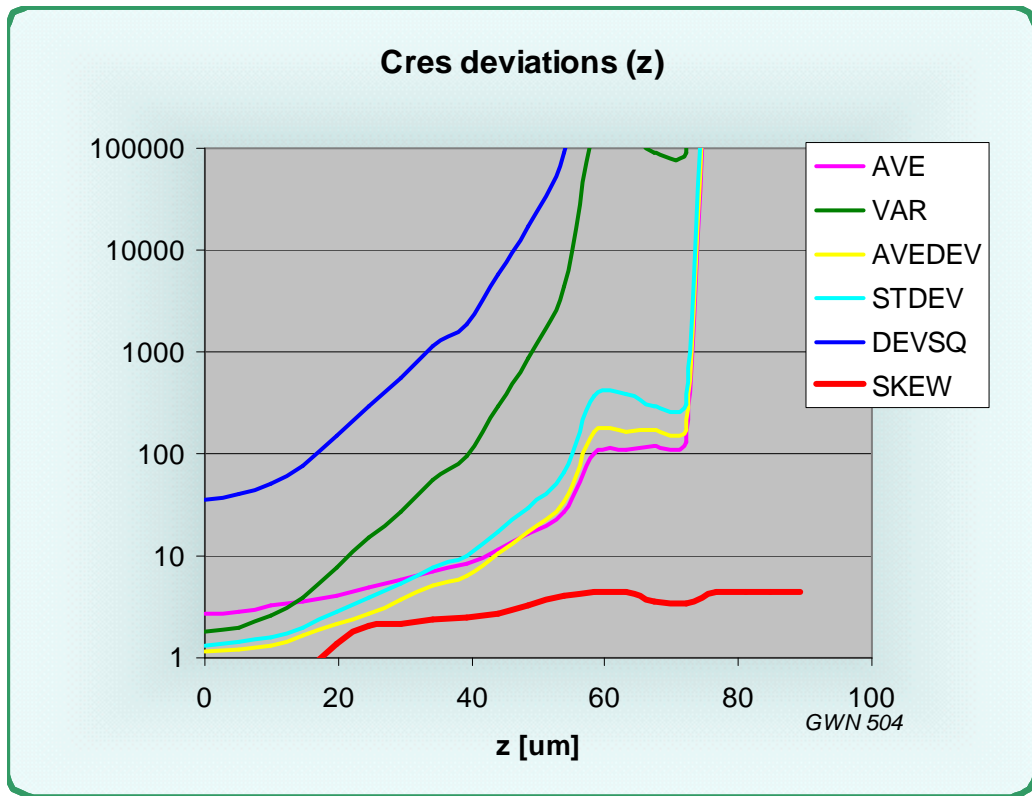


Figure 9 Statistics as a function of displacement

For this to be interpreted properly it must be understood that the socket in an actual application will be operated in a constant force mode, i.e. full insertion at a rated and prescribed force. In this instance, it may therefore be expected that displacement is always less than 20 μm . The corresponding graph for this is shown below:

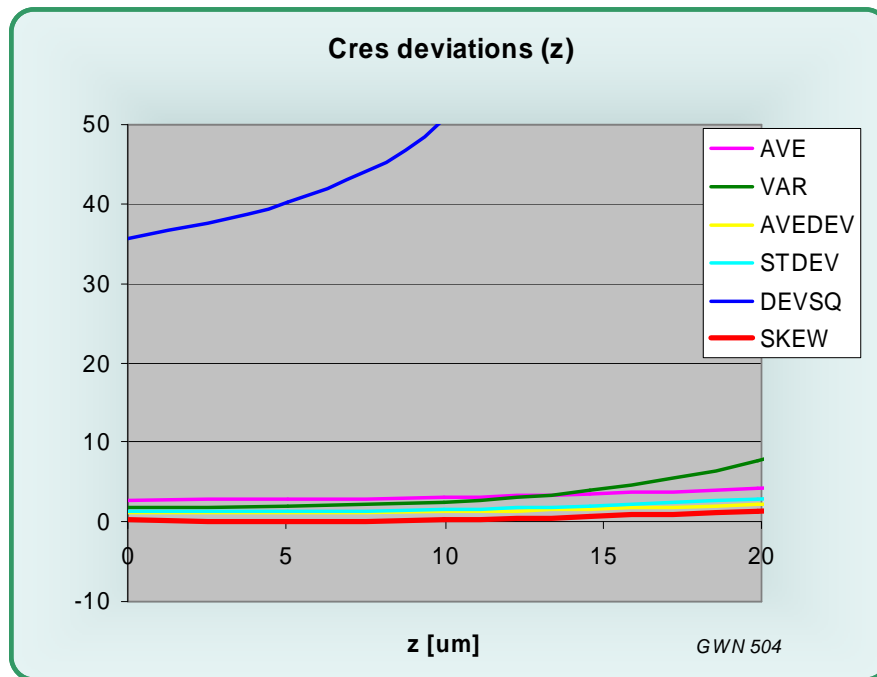


Figure 10 Statistics as a function of displacement (20 um max)

The dataset used for the statistical function is the recorded resistance at a particular displacement for the cycles from 1-20. Data are then displayed for each displacement from minimum to maximum. The following definitions are used (from MS Excel):

AVE is the average (arithmetic mean) of the arguments. VAR estimates the variance based on a sample. AVEDEV is the average of the absolute deviations of data points from their mean. It is a measure of the variability in a data set. STDEV is the standard deviation based on a sample. The standard deviation is a measure of how widely values are dispersed from the average value (the mean). DEVSQ is the sum of squares of deviations of data points from their sample mean. SKEW is the skewness of a distribution. Skewness characterizes the degree of asymmetry of a distribution around its mean. Positive skewness indicates a distribution with an asymmetric tail extending toward more positive values. Negative skewness indicates a distribution with an asymmetric tail extending toward more negative values.

Current – Voltage relation

When measuring the current – voltage relationship for the CSP socket one obtains the following responses (the color coding is identical to the previous graph):

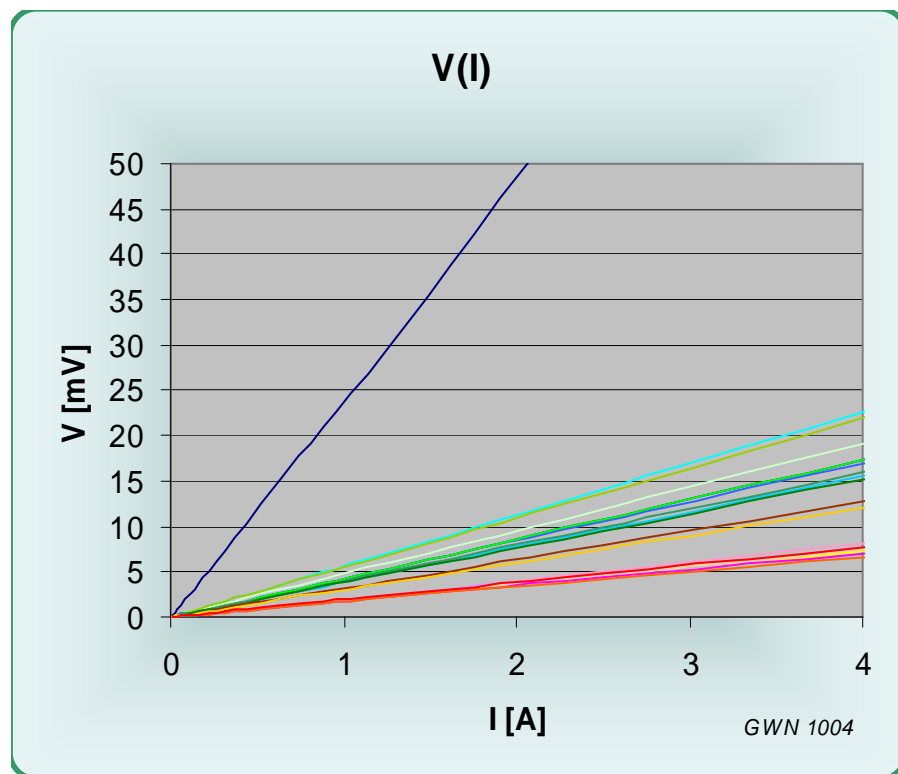


Figure 11 Voltage and resistance as a function of drive current

There are no anomalies in this response. Damage to the contact under maximum rated drive current is not observed. After the first cycle resistance and thus voltage decreases.

From the above graph it is possible to extract the resistance value at the corresponding drive current:

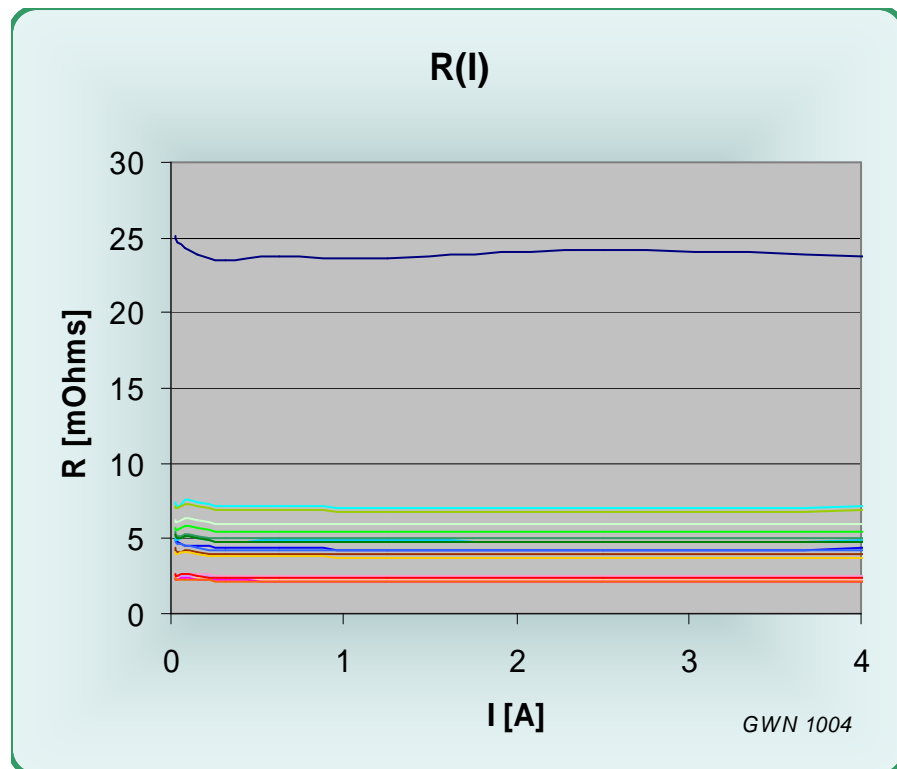


Figure 12 Resistance as a function of drive current

There are no significant changes of resistance with drive level.

When plotting the resistance of the contact at full rated current as a function of cycle time, the following graph is obtained:

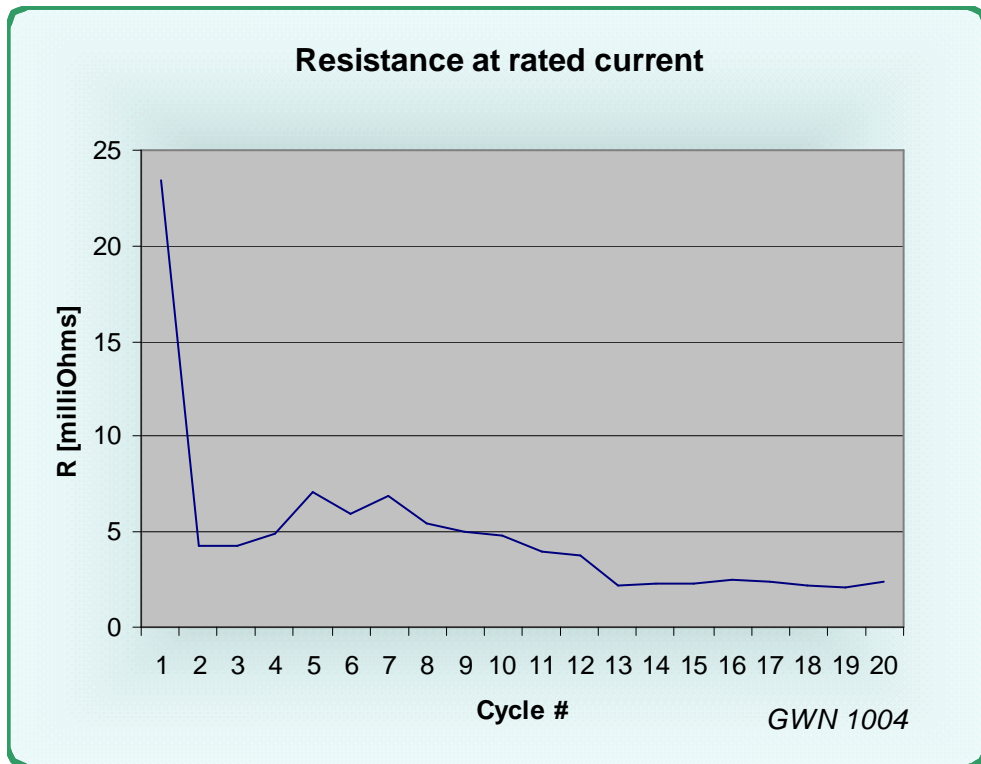


Figure 13 Resistance as a function of cycle # @ max. drive current

This graph shows no abnormal values. With increasing cycle number the overall resistance decreases and shows no irregularities. When comparing this to corresponding resistance measurement values, it must be noted that the cycle numbers are not identical. In other words, these data are obtained after the socket has been tested in the resistance measurement sequence above. Hence, there will be no perfect correlation between these measurements and those obtained in the resistance measurement series.

Statistical evaluation shows the following averages etc. as a function of drive current:

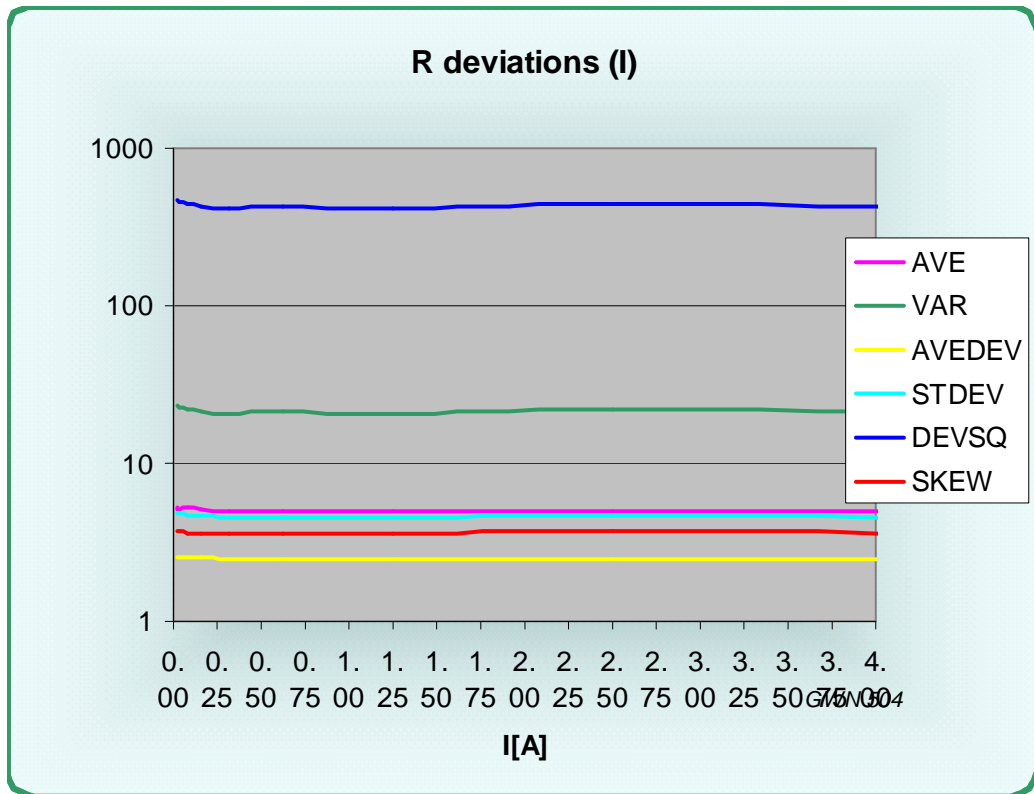


Figure 14 Deviations as a function of drive current

Definitions for the functions are given above. No abnormal values are present.

Leakage current

To find any changes in the insulating performance socket materials and to identify any adverse contributions from debris accumulation, the leakage current was measured as a function of excitation voltage between the probe and all other test pins (ground):

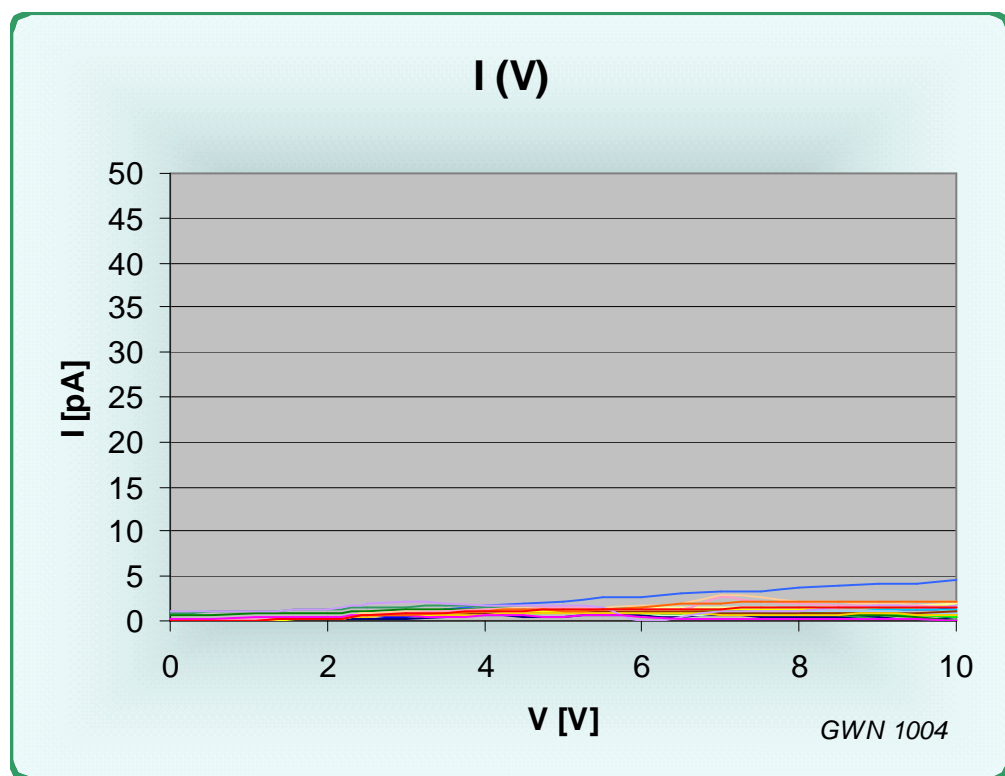


Figure 15 Leakage current as a function of drive voltage

Leakage is very low and is near the system limits of a few pA.

Also of interest is the evolution of leakage with the number of test cycles. As such, the current observed at the 10 V excitation level is shown as a function of the test cycle number:

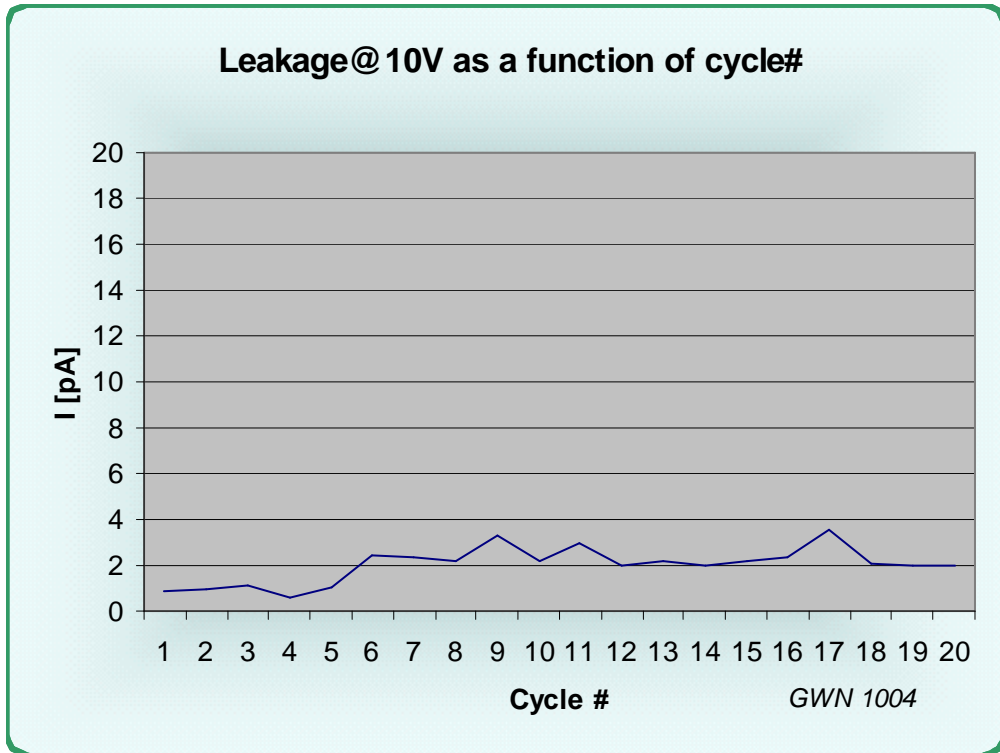


Figure 16 Leakage current @10V as a function of cycle #

All values are within the system uncertainty. After the first four cycles an enhanced measurement technique was used. Values in the first four cycles are saddled with a greater system uncertainty, and hence may show larger leakage than actually present.

When computing the corresponding resistance very large values result:

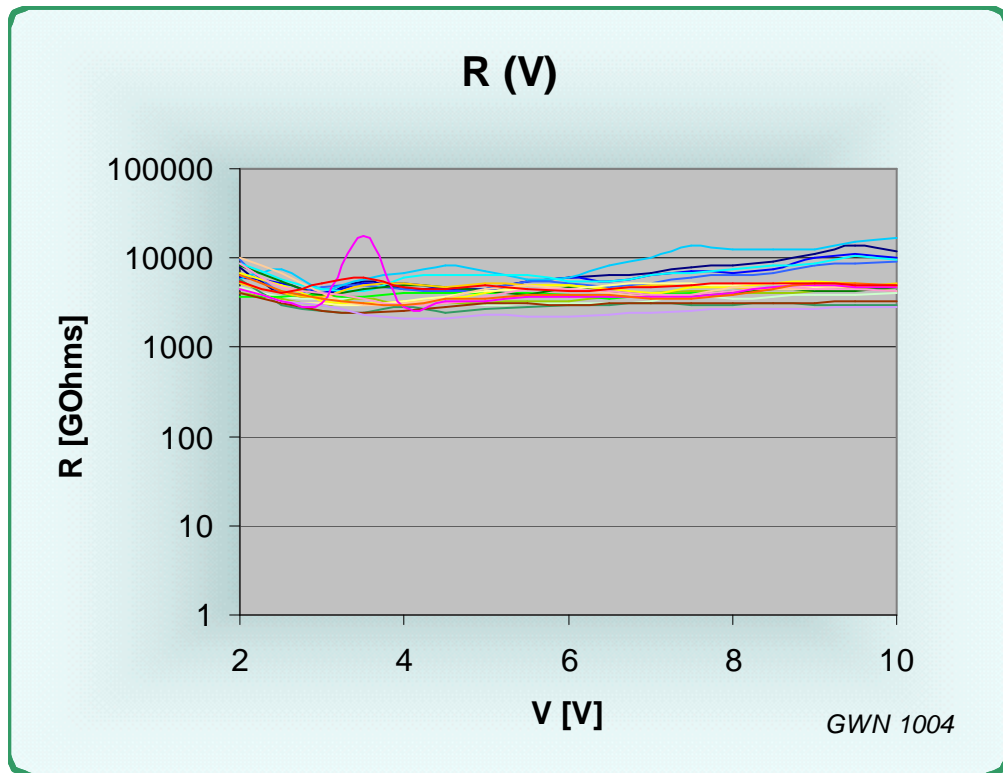


Figure 17 Leakage resistance as a function of drive voltage

Total resistance values are very high and do not give any cause for concern. Values vary, but of course all of them are at the very limit of the system capabilities.

Thus, it is somewhat difficult to consider deviations in an appropriate manner:

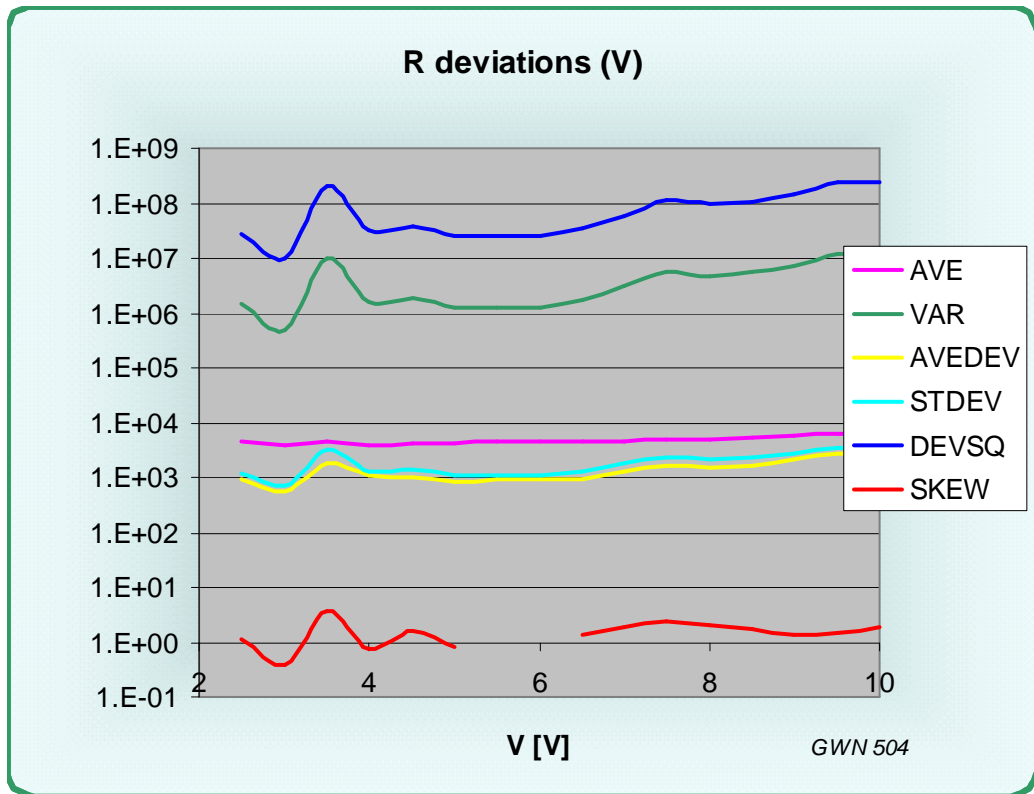


Figure 18 Leakage resistance variations as a function of voltage

Resistance variations will, of course be very large and it is thus perhaps better to consider leakage current statistics as shown below:

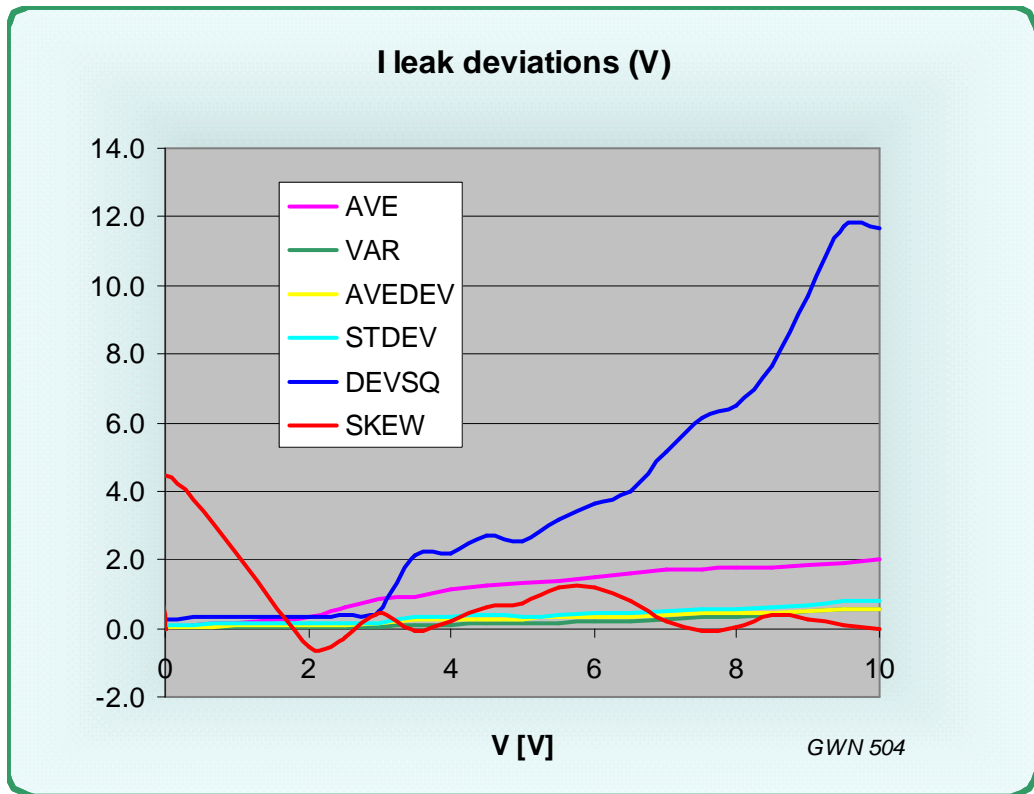


Figure 19 Leakage current variations as a function of voltage

There are no anomalies in this response and no excess current is evident.

Wear patterns

During the cycling, small amounts of debris from the surrogate devices collected in the socket. The picture below shows a view of the socket after the last stage (1M cycles total):

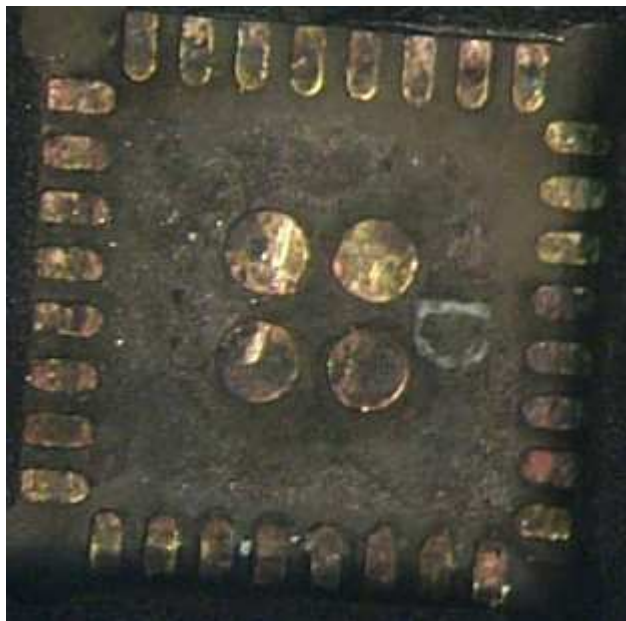


Figure 20 Socket appearance after the last stage of cycling

The contacts showed little wear.

Also of interest were possible wear patterns caused by the contacts in the Au covered base plate.

The image below shows an area of the baseplate after the full complement of 1M cycles. It should be noted that not only have the sockets been cycled to 1 million actuations, but also were mounted and demounted a large number of times on this plate.



Figure 21 Base plate shows no significant signs of wear due to socket

Only a shadow of a wear pattern is discernible, indicating that no undue abrasive forces or movement is transmitted to the PCB side of the socket from the DUT side during device insertion. Wear patterns in the surrogate device, of course, are also not very pronounced. This is not relevant to the socket assessment, however, since here surrogate devices were subjected to very large numbers of repeat insertions, a condition which does not reflect the operating environment found in the actual application.