Aries

QFP microstrip socket

Cycling Test

DC Measurement Results

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Objective

The objective of these measurements is to determine the DC performance of an Aries QFP microstrip 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. 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 socket to four successive mechanical actuations and data acquisitions. After this sequence, the socket is subjected to cycling with surrogate devices in a mechanical cycler that is adjusted and adapted to the socket 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 socket to any prior surrogate device insertion. A sequence of 4 successive tests was performed with a mechanical actuation of the socket 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 For this actuation, the shorting plunger (see setup) was withdrawn until it cleared the contacts completely.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 cycles 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 socket was performed at the requested intervals.

For leakage testing the socket is 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 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.

A table with the test number vs. the number of surrogate device insertions is shown below:

Test #	*# of DUT insertions*
1	0
2	0
3	0
4	0
5	8192
6	8192
7	8192
8	8192
9	65536
10	65536
11	65536
12	65536
13	262144
14	262144
15	262144
16	262144
17	1048576
18	1048576
19	1048576
20	1048576

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 socket, typically the second from the top. The same contact will be used for all dc measurements, shown here in white.

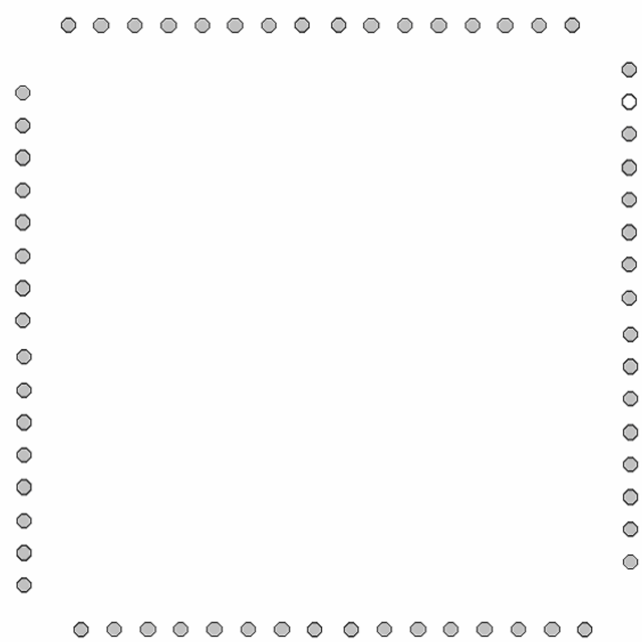

Figure 1 QFP socket test arrangement

The 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.

Sketches of the setups used during load cycling and testing are shown in the figures below:

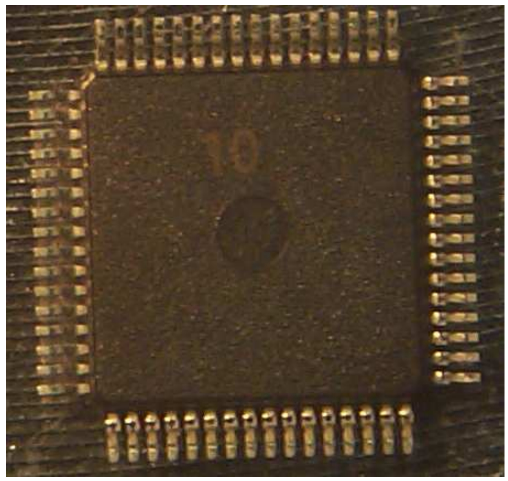

Figure 2 Surrogate IC

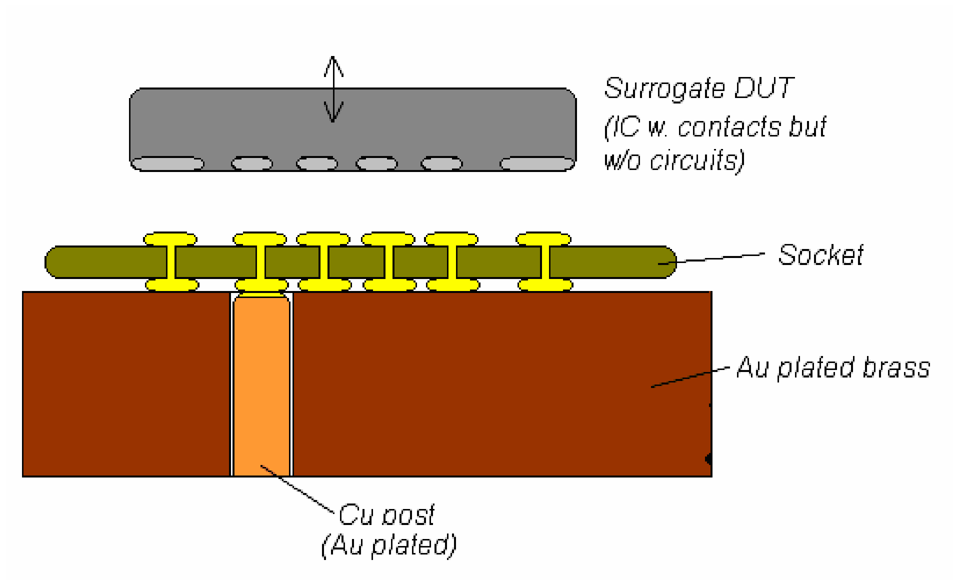

Figure 3 Cycling setup for socket testing

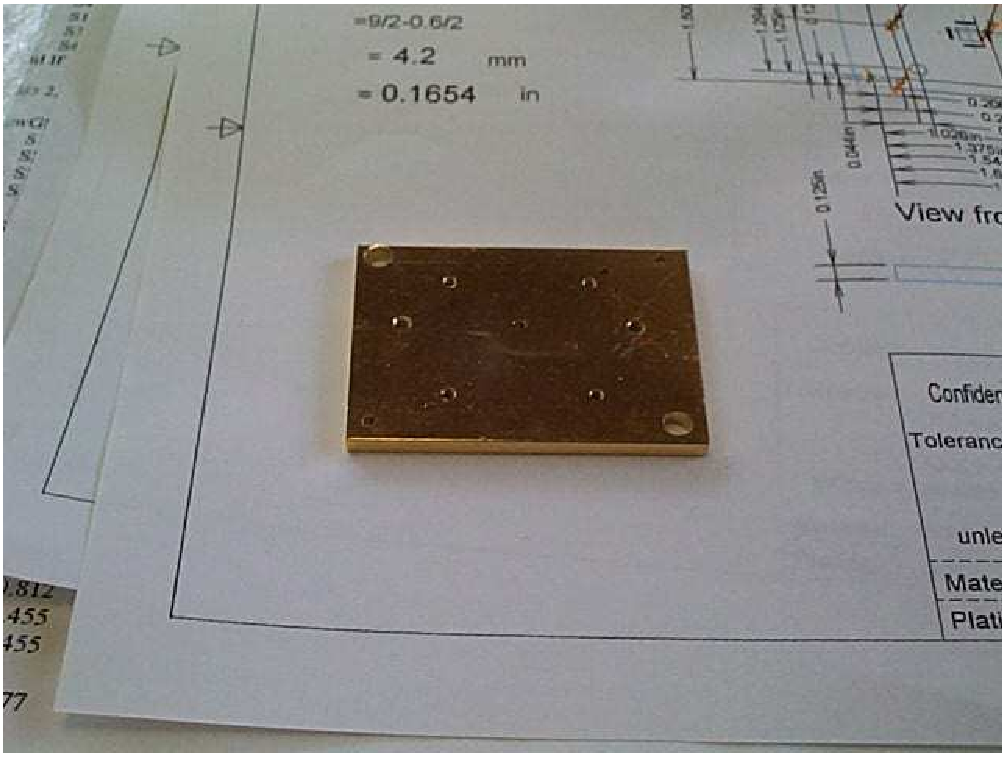

Figure 4 QFP socket mounting plate example

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).

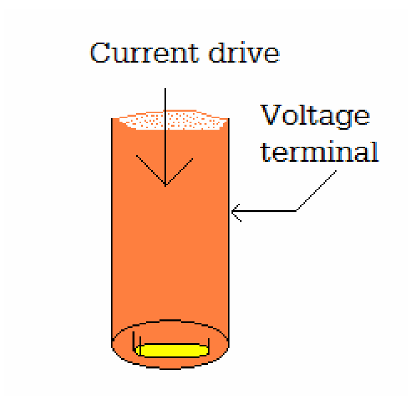

Figure 5 Current drive probe

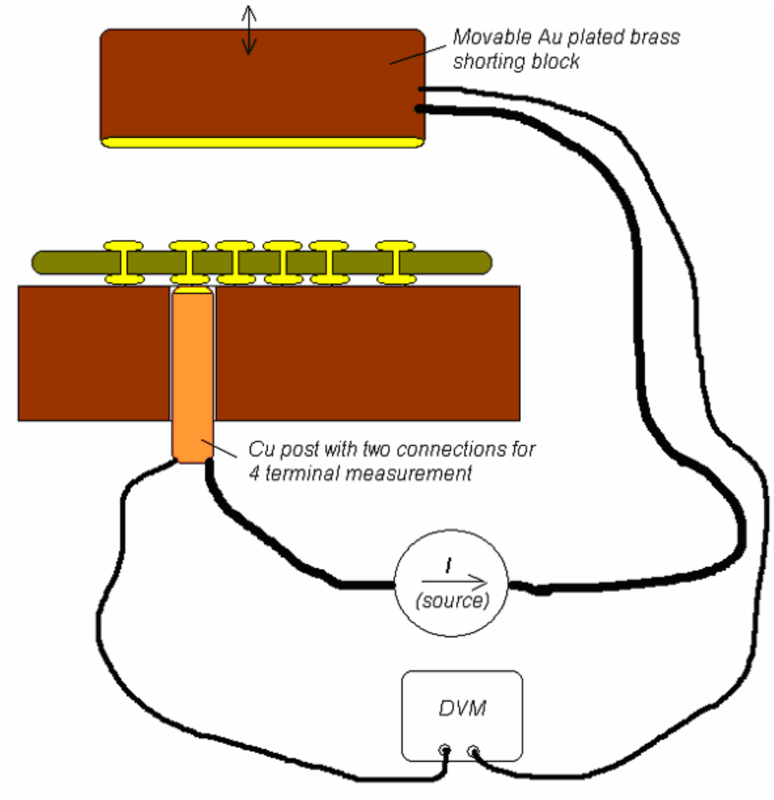

Figure 6 Test setup for 4 terminal (Kelvin) measurements

The socket with its plate is mounted in a test stand with XYZ adjustment capability (Fig. 7).

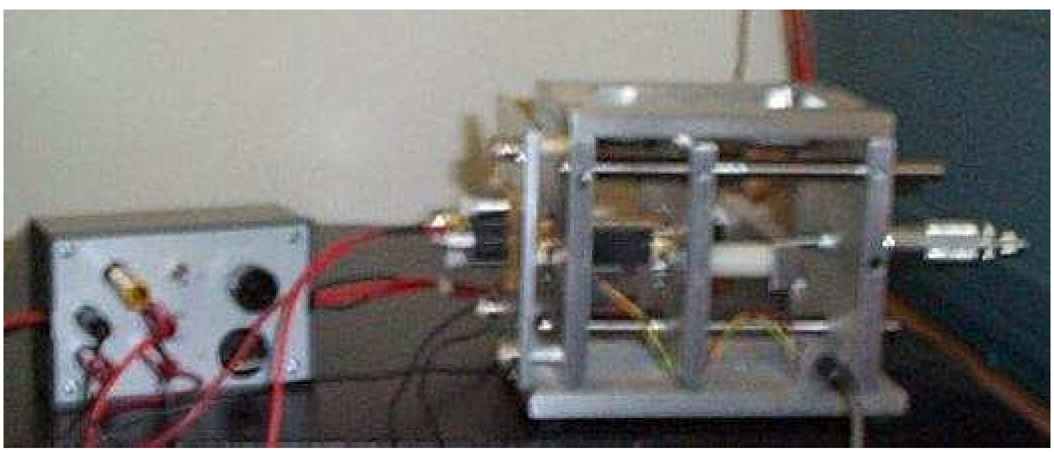

Figure 7 Test stand

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 socket is then 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 cycler with parallel plates moving by a small amount or a solenoid based cycler were used. Displacement was typically established such that the surrogate test devices bottom 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 8 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:

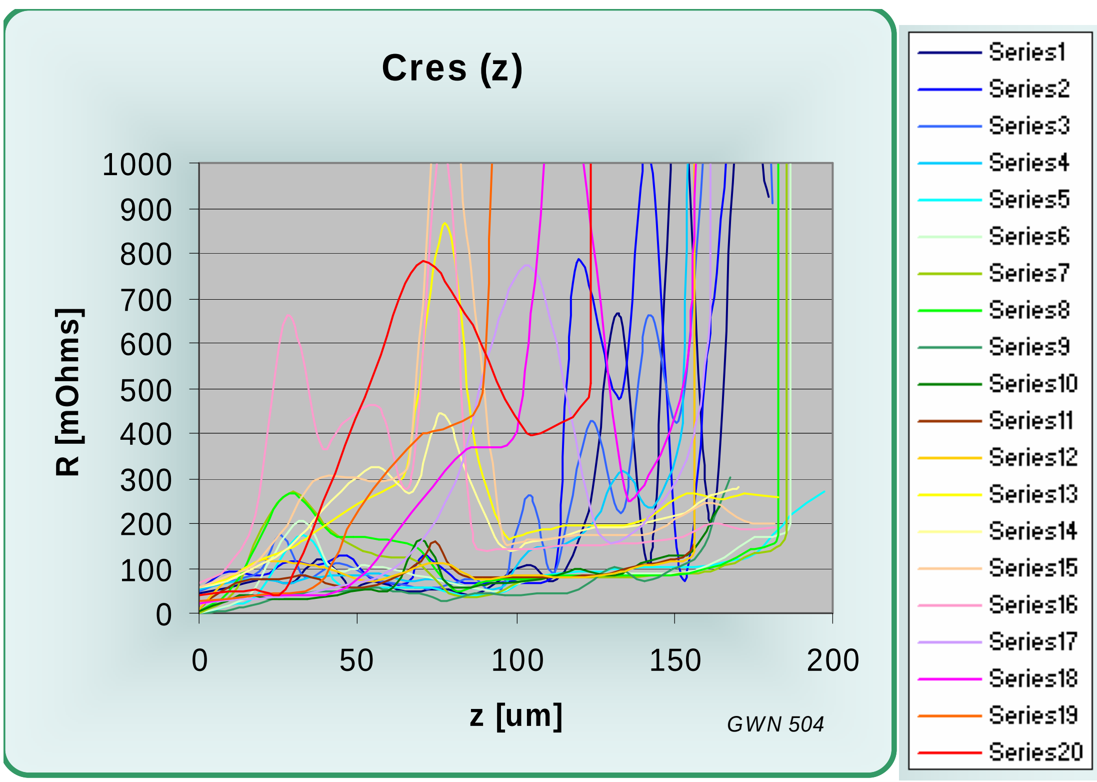

Figure 9 Contact resistance as a function of displacement

For this graph, the value z=0 represents the maximum compression in operation, i.e. with the DUT fully inserted. The results are corrected with the functional dependence of resistance as a function of displacement as obtained via regression during the cycle

0 test. A setup malfunction was detected during the initial portion of this test. An inadequate contact had been present between the socket and the 4-point test probe. This is evident in the large resistance excursions for tests 1-4 (blue curves). This was corrected after the first round of cycling. However, the initial measurements could, of course, not be recreated, since the socket had already undergone a number of DUT insertions. It may be assumed here, that the initial results in reality were better than those obtained for test numbers 5 and up. As cycle numbers increase (=> series#), so does the overall resistance. It should be kept in mind here, that the resistance indicated includes contact resistance to the probe (=loadboard), the DUT, and the contact itself. For complex contact assemblies, this may be a significant contribution to the overall value.

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:

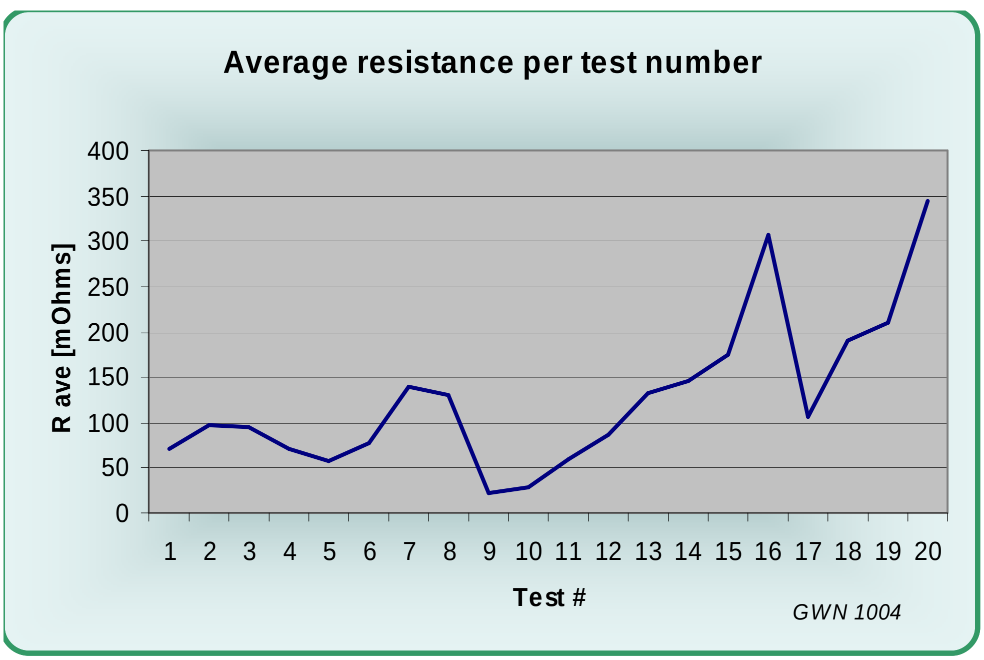

Figure 10 Contact resistance as a function of test number

There is some resistance increase with increasing cycle numbers. It should be kept in mind, that the socket under test undergoes a number of matings/dematings with the test plates and probes. This may affect the backside contact of the socket and therefore the results shown.

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.

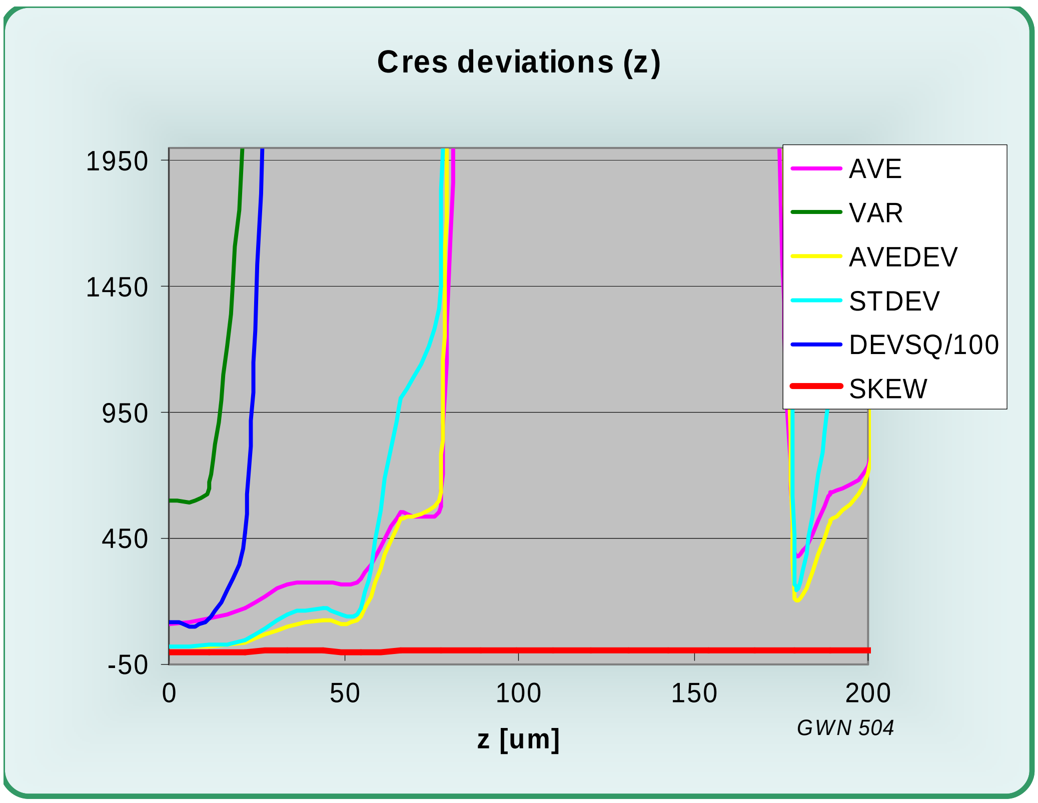

Figure 11 Statistics as a function of displacement

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 QFP microstrip socket, the following responses were obtained (the color coding is identical to the previous graph):

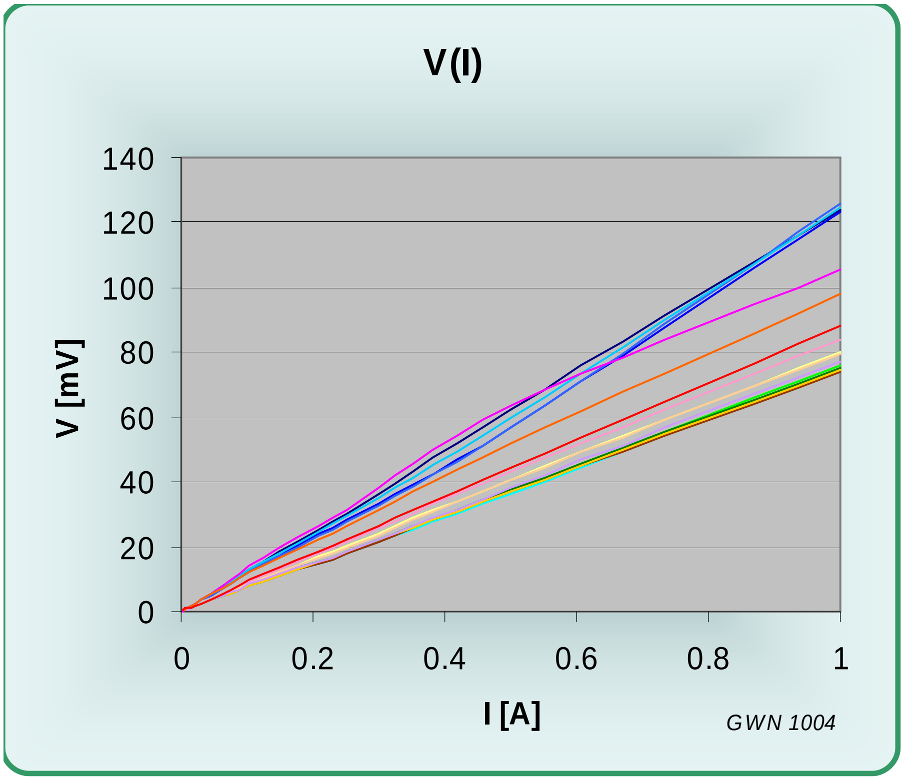

Figure 12 Voltage and resistance as a function of drive current

There are no anomalies in this response. At one million cycles, resistance has increased. Damage to the contact under maximum rated drive current is not observed.

From the above graph it is possible to extract the resistance value at the corresponding drive current. Because of the absence of the strip under the socket and the resulting drive from the contact end, the current level was limited to 1A instead of the rated 4A to prevent damage. Values here are NOT corrected for the absence of a strip under the socket and therefore show a higher value than in the Cres measurement above. In reality the resistance level will be lower than shown in the following graphs. Therefore, this measurement is to be taken only as an indication of repeatability, NOT absolute resistance.

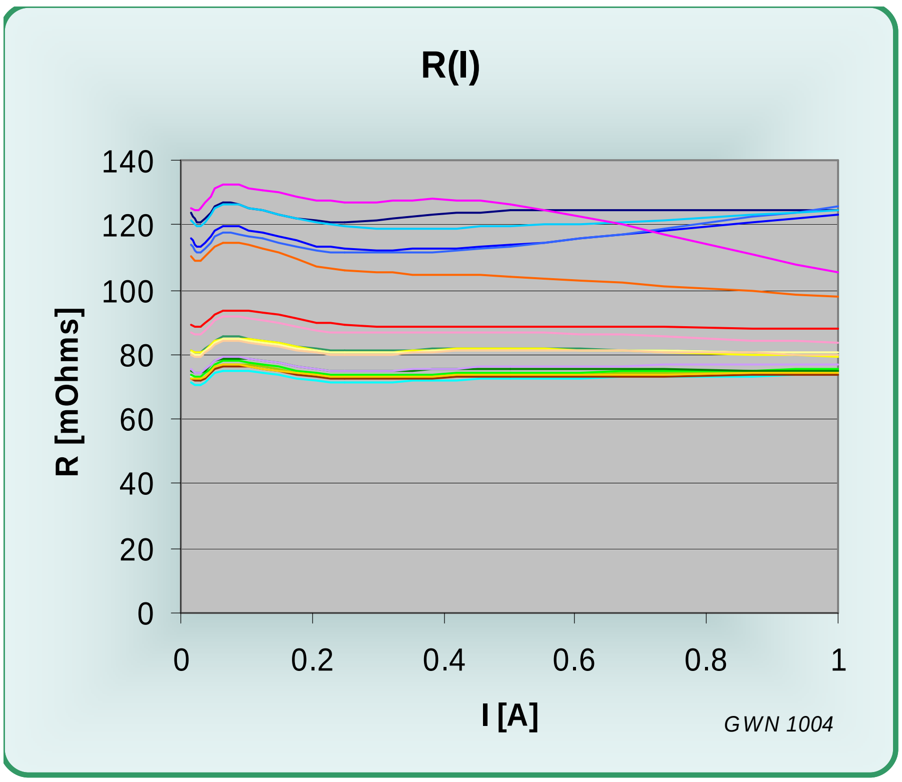

Figure 13 Resistance as a function of drive current

There are no significant changes of resistance with drive level. At current values below 20 mA the accuracy of the 10A current source is not sufficient to warrant extraction of resistance data.

When plotting the resistance of the contact at 1A current as a function of cycle time, the following graph is obtained:

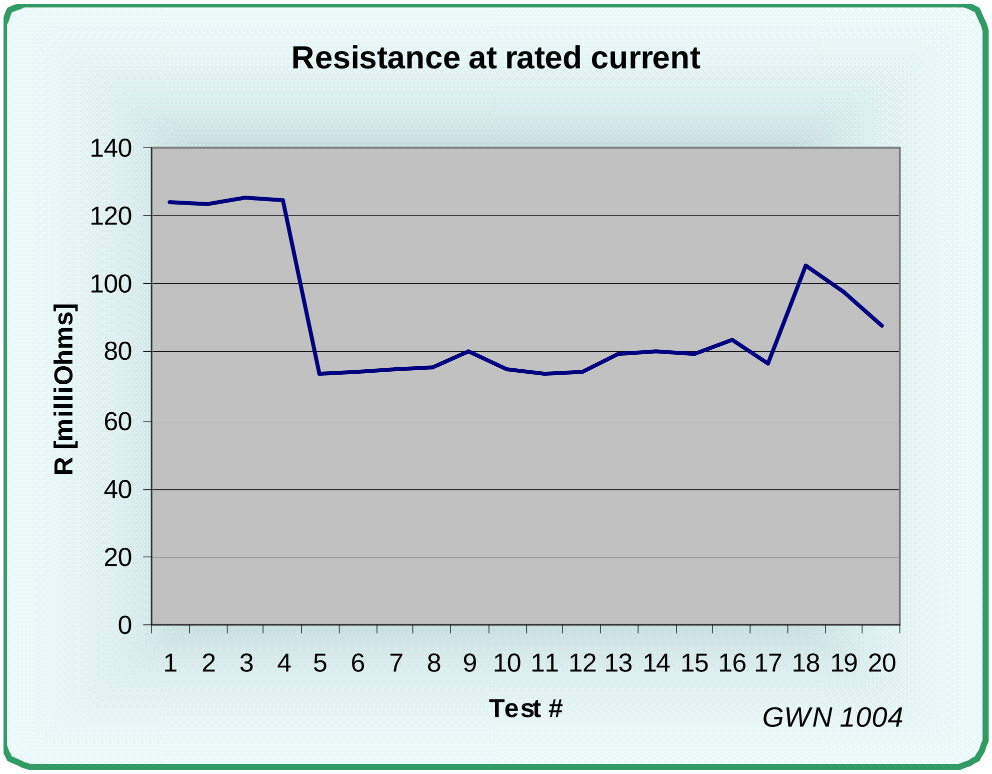

Figure 14 Resistance as a function of cycle # @ max. drive current

Again, this test was conducted WITHOUT a strip underneath the socket, so inreality resistance values will be significantly lower (see Cres results above). This graph shows no abnormal values. The drop after test #4 is due to the above mentioned setup malfunction. With increasing cycle number the overall resistance increases slightly, but shows no irregularities. When comparing this to corresponding resistance values, it must be noted that the test 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:

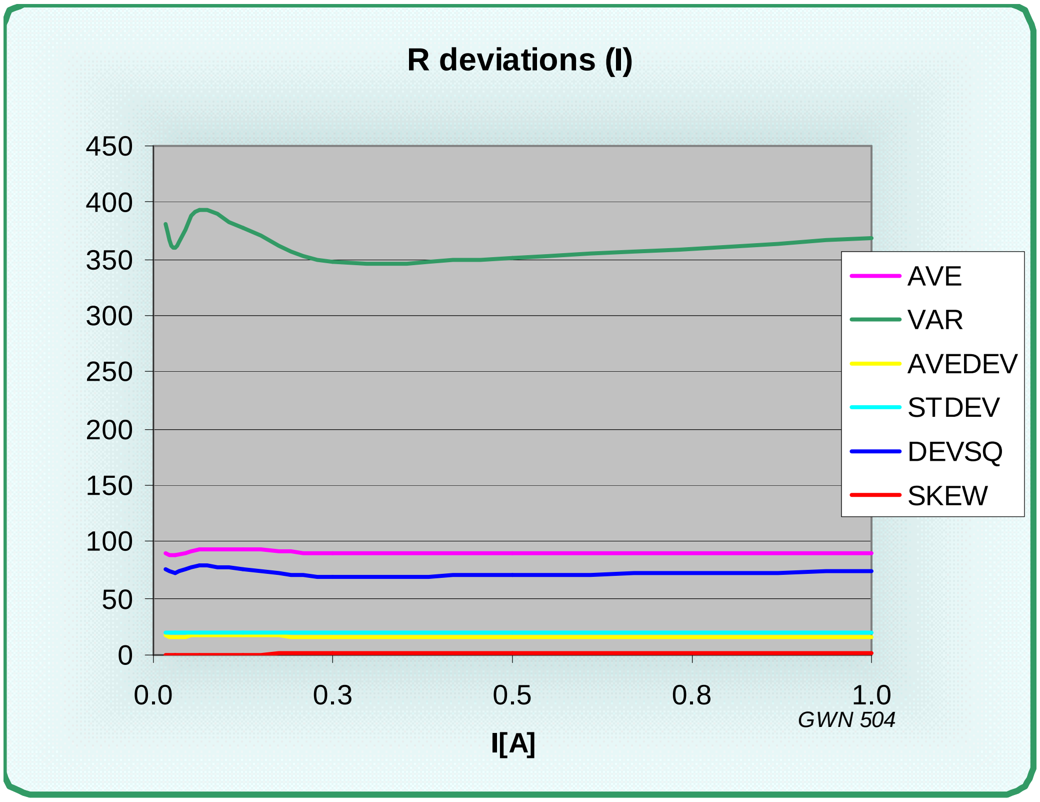

Figure 15 Deviations as a function of drive current

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):

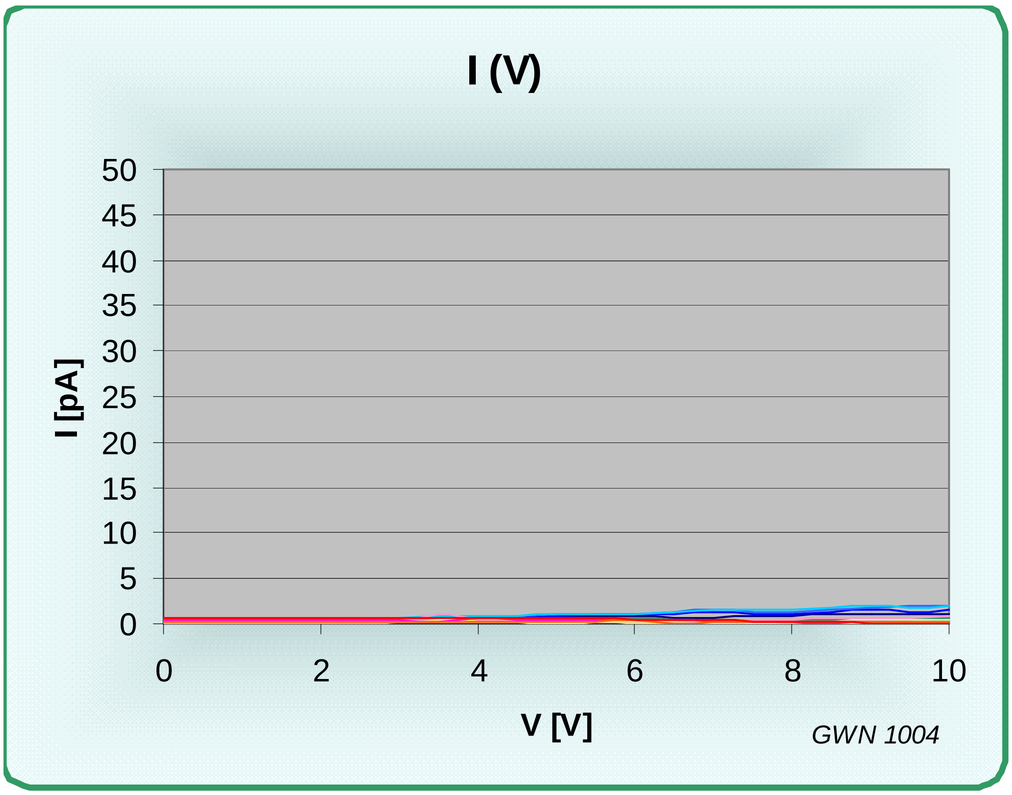

Figure 16 Leakage current as a function of drive voltage

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:

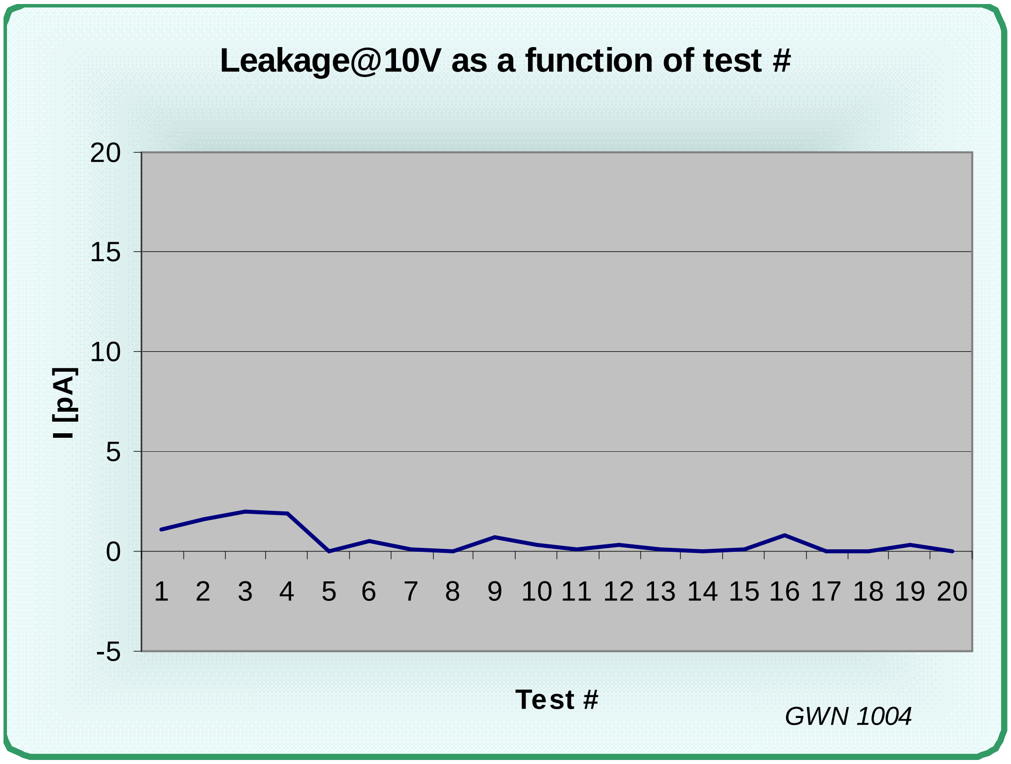

Figure 17 Leakage current @10V as a function of cycle #

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:

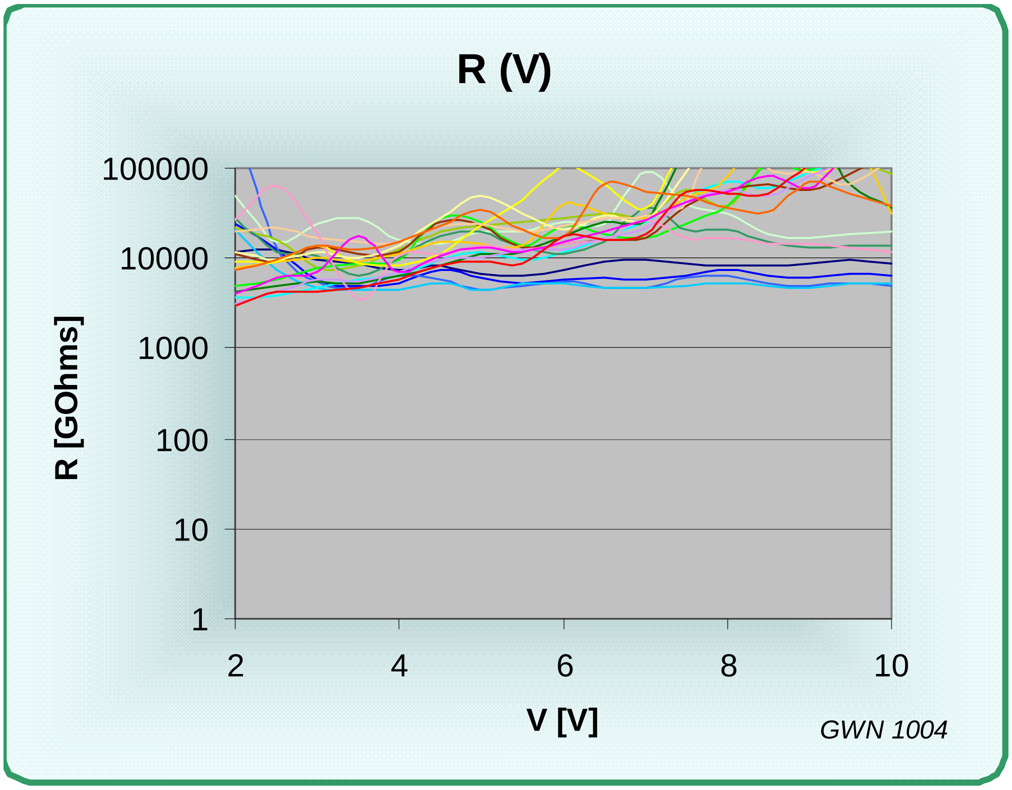

Figure 18 Leakage resistance as a function of drive voltage

Total resistance values are very high and do not give any cause for concern. Values vary greatly, 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:

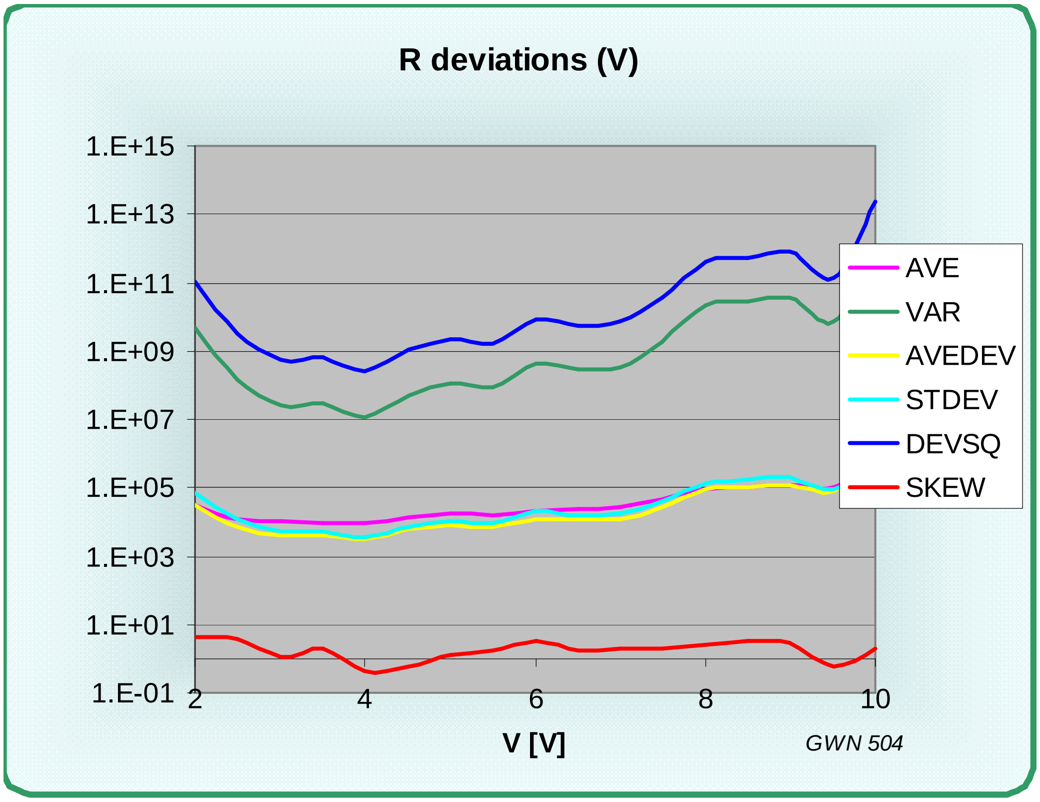

Figure 19 Leakage resistance variations as a function of voltage

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

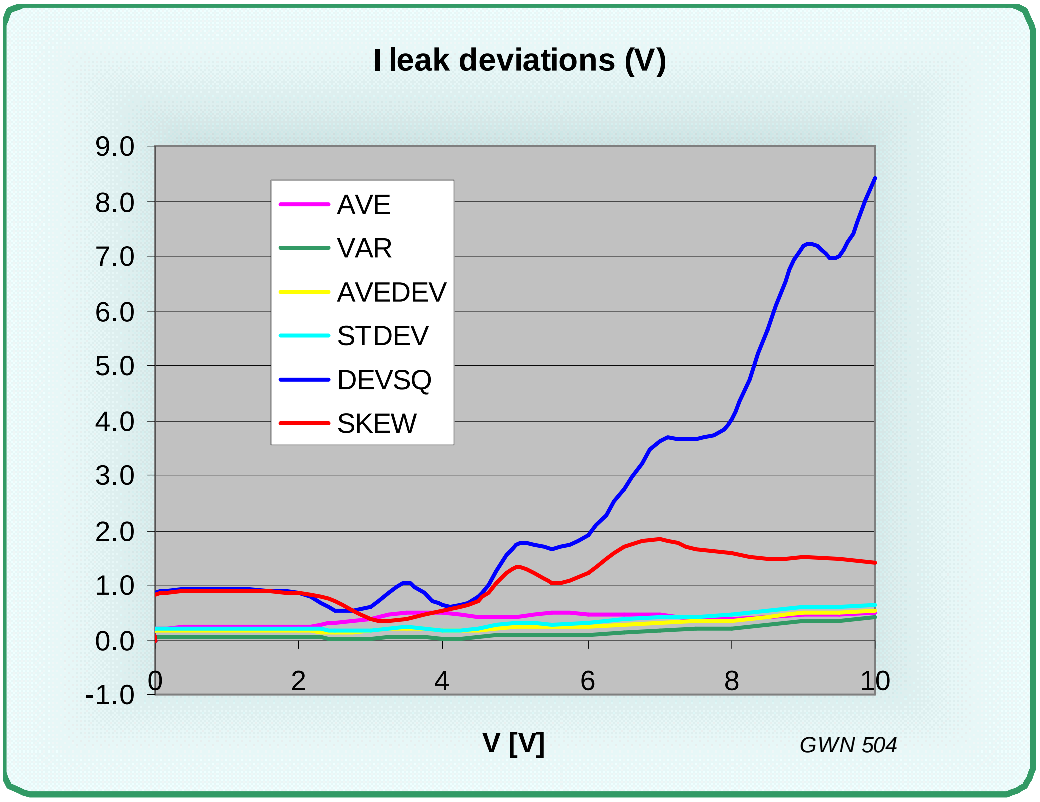

Figure 20 Leakage current variations as a function of voltage

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

Wear patterns

During the cycling, small amounts of metal from the surrogate devices collected in the socket. Hence, sockets were periodically cleaned with a light brush to remove the larger loose particles. The picture below shows a view of the socket after the last stage (1M cycles total) and before cleaning:

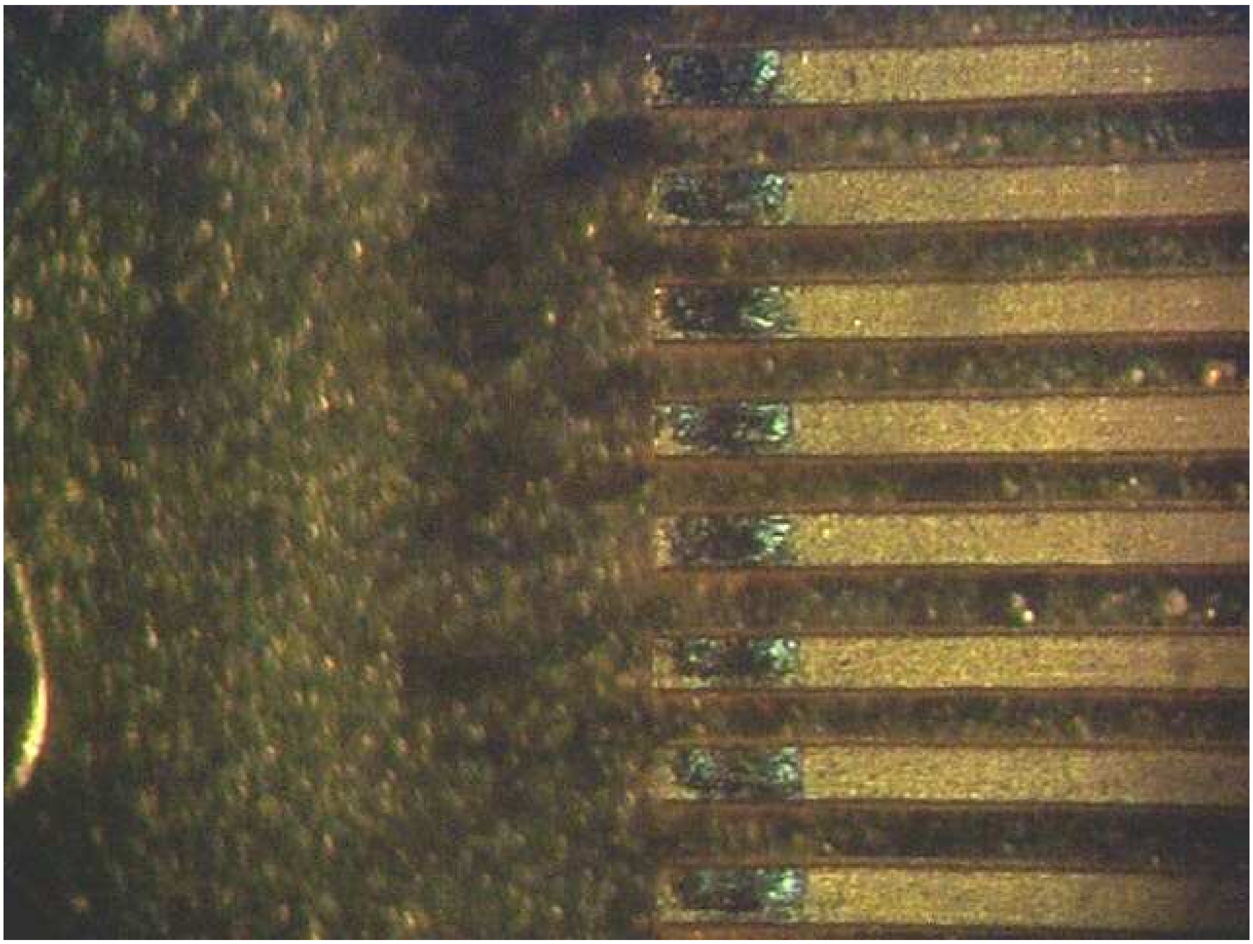

Figure 21 Contact tip appearance after the last stage of cycling (before cleaning)

The contact tips showed little wear despite the fact that the high number of cycles with the same surrogate device led to exposure of the underlying materials in the DUT.

Also of interest were possible wear patterns caused by the contacts in the Au covered base plate. An image shows the area of that plate after the full complement of 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 22 Base plate shows slight signs of wear

A slightly visible wear pattern is discernible, likely caused by the socket strip contact pressing down on the plate during device insertion (left half of picture). Also noticeable are slight indentations at the rear end of the socket, where protrusions press into the base plate (right half of picture). Wear patterns in the surrogate device, of course, are very noticeable. This is not relevant to the socket assessment, however, since here surrogate devices were subjected to very large numbers of repeat insertions, a condition that does not reflect the operating environment found in the actual application.