Resistance Measurements of Small-Scale and Microscopic Material Samples and Components Using the TEGAM Model 1740 Microohmeter

Introduction

This application note describes a measurement system developed by TEGAM and a customer to make high-accuracy, four-wire milliohm measurements of small-scale or microscopic components and material samples utilizing the TEGAM 1740 microohmeter and a specialized test setup.

Figure 1

Figure 1 – The TEGAM Model 1740 Microohmeter employs a four-wire Kelvin lead configuration to achieve a basic accuracy of 0.02% with 1 μΩ resolution. The TEGAM 1740 is fully programmable via its RS-232 and GPIB interfaces (model 1740/GPIB) and is PLC compatible.

Application Summary

Resistance measurements, and other related measurements such as resistivity and conductance, at very small scales present numerous challenges for manufacturers and researchers. Where high accuracy measurements are required, problems compound.
Since the quality of the resistance measurement necessarily depends upon positive physical contact with the material or component under test, the first challenge is securely positioning the test material. Using a sophisticated combination of micropositioners and stages, we were able to positively secure the material under test while still allowing sufficient space to maneuver and position measuring probes.

Once the material under test is positioned, the next hurdle is making the measurement itself. Typically, high-accuracy milliohm measurements require a high excitation current in order to develop sufficient voltage for measurement. But when working at the microscopic level, continuously-applied high currents can cause component or probe degradation leading to inaccurate measurements, or worse, damaged equipment.

TEGAM has been working to overcome these challenges for over 15 years. With its line of microohmeters, TEGAM has developed a novel approach to high-accuracy, high-speed, milliohm measurements that can be employed to solve these problems. Coupled with a trinocular microscope and specialized staging setup, we were able to accomplish these measurements to a high degree of certainty.

Stage, Microscope, and Measurement Probes

To address the staging challenges of small-scale measurements, we utilized the Jmicro Technology LMS-2709 Microprobing Station. The LMS-2709 implements a vacuum clamping stage that acts as a stable and secure foundation for the material under test without inhibiting probe access to the measurement surface. Further, the stage allows for precision positioning of the test material using a combination of dials to move the stage in the X, Y, and Z axes.

Figure 2

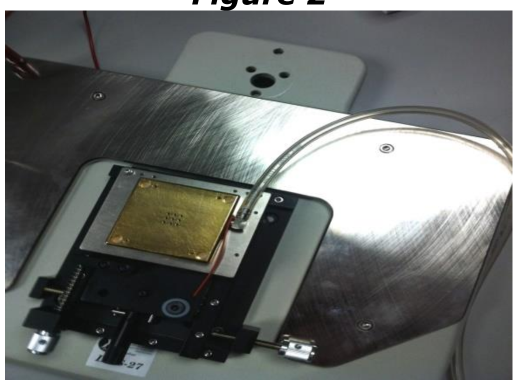

Figure 2 - LMS-2709 Vacuum Clamping Stage with ferromagnetic plate.

Surrounding the vacuum stage is a ferromagnetic plate. Magnetically attached to this plate are two 3-axis micropositioners which hold and position the measurement probes. Similar to the stage adjustments, these micropositioners use a combination of dials for very precise adjustment of the probe position through all three axes. Using ferromagnetic materials to secure the micropositioners creates a very secure foundation for the probes while still being easy to reposition, even with one hand, when needed.

The stage and micropositioners sit beneath a trinocular microscope mounted to a gliding arm boom stand. With the aid of the microscope, the operator can easily arrange the component or material to be tested and position the measurement probes in virtually any configuration necessary to achieve optimal measurement results.

The advantage of the trinocular head is that it allows the attachment of a digital camera to the microscope, duplicating the presentation as seen through the eyepiece. In this case, a 2.1 megapixel USB2.0 Digital Color CCD Camera is used. The camera and accompanying software can be used to display the objective view on a local or remote monitor, and if desired, record the measurement process.

For measurements in the milliohm range, minimizing the effects of lead resistance that can distort readings and degrade measurement accuracy is imperative. Here, we used a zadjustable Kelvin probe set which has a tip spacing of just 15 thousandths of an inch. This allows for true four-wire measurements of very small material samples or components.

Figure 3

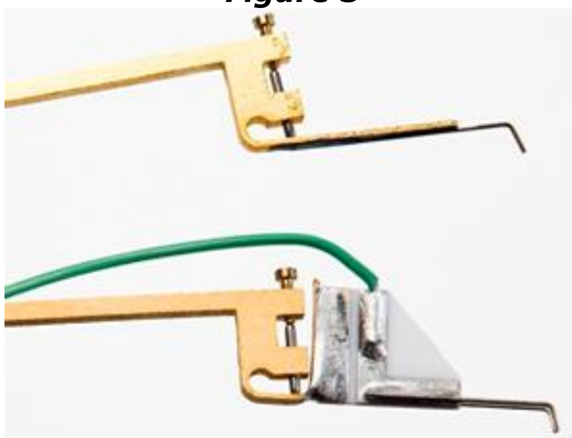

Figure 3 - Kelvin probes, with available tip spacings of 2 mils to 60 mils.

TEGAM 1740 Microohmeter

At the heart of the system is the TEGAM 1740 Microohmeter. Our microohmeter is uniquely suited for this application for several reasons. First, it implements a switched DC excitation current source applied to the material under test. This bipolar measurement current allows the TEGAM 1740 to cancel out thermal offset voltages common in all low resistance measurements.

Second, highly sensitive voltage measuring circuitry also reduces the need for higher current levels required by other less precise instruments. This means measurements can be made that would damage the material under test in the past.
Third, the unit self-corrects for ambient and internal temperature drift by virtue of a precise internal voltage reference. The TEGAM 1740 recurrently measures this voltage reference and applies correction coefficients when necessary.

These innovations allow for precise milliohm measurements to a basic accuracy of 0.02% at very high speeds. Further, the TEGAM 1740 is fully programmable via its RS-232 and GPIB interfaces, providing the opportunity for easy integration into existing or new software systems.

Together, the 1740 and a microprober station create a high-accuracy, user-friendly measurement system for making low-resistance measurements on very small components or material specimens. The micropositioners and vacuum clamping stage make it easy to achieve repeatable and reproducible measurements, and the TEGAM 1740 provides the high accuracy required in research and engineering applications.