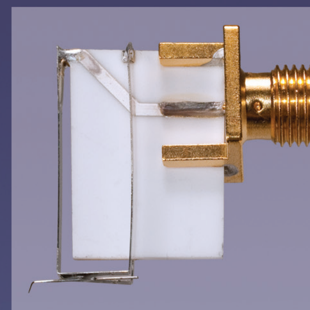
New Model ZN50R-CVT Probes

NOW TAKE CONTINUOUSLY VARIABLE TEMPERATURE MEASUREMENTS IN YOUR LAKE SHORE CRYOGENIC PROBE STATION

Developed in collaboration with TOYO Corporation of Japan, Lake Shore Model ZN50R-CVT DC/RF probes take cryogenic, micro-manipulated probing to the next level. Unlike traditional cryogenic probing methods, these new patent pending probes allow you to measure through full scale temperature sweeps without the inconvenient and time consuming need to lift and re-land your probes each time you adjust temperature. Unique to Lake Shore cryogenic probe stations, the probes automatically compensate for the material temperature expansion and contraction common to all cryogenic probe stations, significantly improving throughput, efficiency, and measurement reliability. When combined with Lake Shore's industry leading, fully integrated cryogenic temperature sensors and instruments, the probes allow you to perform unattended variable temperature measurements—spend less time supervising your measurements and more time conducting research. Model ZN50R-CVT probes also enhance the overall functionality of your Lake Shore probe station by making many of your measurement applications easier and more convenient to perform, as well as supporting new measurement applications



The Problem is Thermal Expansion and Contraction

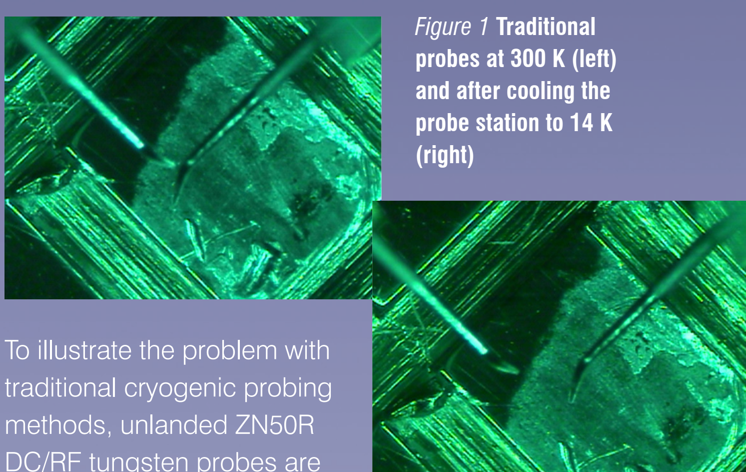


Figure 1 **Traditional probes at 300 K (left) and after cooling the probe station to 14 K (right)**

To illustrate the problem with traditional cryogenic probing methods, unlanded ZN50R DC/RF tungsten probes are observed as a probe station vacuum chamber is cooled from 300 K to 14 K.

The probes are seen to move approximately 300 μm along the arm axis. This directionality indicates that the probe movement is caused by thermal expansion and contraction of the arms.

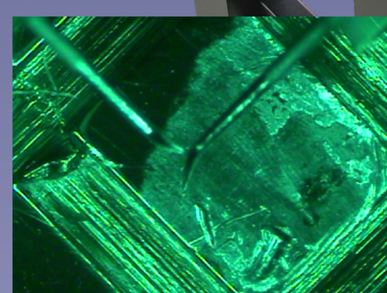
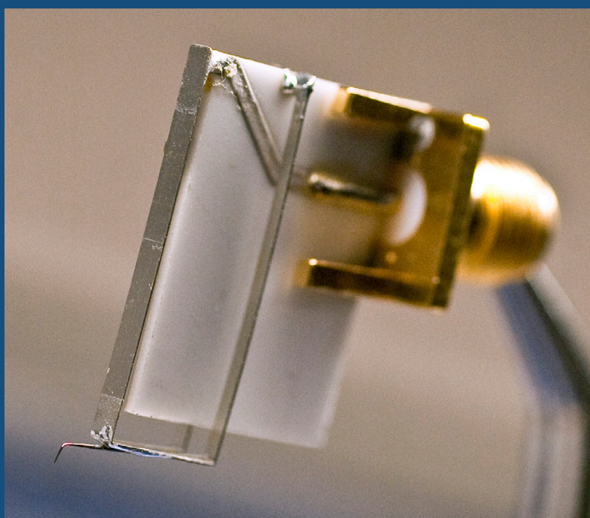


Figure 2 **Probe position when the temperature is returned to 300 K**

When warmed back to 300 K, the probes return to the original position, showing that the expansion and contraction cycle is reversed over large temperature excursions, and that the material expansion and contraction is in the linear region. This movement prevents automated variable temperature measurements from being made, as probes have to be lifted and relanded for each temperature transition.

Solution: Drift Absorbing Probes

One potential solution is to design low thermal expansion probe arms from quartz, or some other low expansion glass. Not only is this solution complex, expensive and cumbersome to integrate in the field, but the arms would be inherently fragile and require great care in handling. Perhaps more importantly, quartz has a low thermal conductivity, leading to large thermal gradients above the sample and more thermal loading on the sample.



The Lake Shore solution is a patent pending ZN50R-CVT DC/RF probe design that absorbs probe arm movement caused by thermal expansion and contraction. The result is a stable probe tip position throughout your full scale temperature sweep.

Model ZN50R-CVT probes are easy and inexpensive to integrate without significant hardware changes to your probe station. They're also backward compatible, meaning they can be added to expand the convenience and functionality of any Lake Shore cryogenic probe station in the field without having to purchase expensive upgrades or retrofit kits. Probe tip materials including Beryllium Copper (BeCu) and Tungsten (W) are available in tip radii of 10 μm and 25 μm to meet your specific measurement needs. The soft, compliant BeCu tips are commonly used to make low resistance contacts to conductive surfaces, including gold pads. W is very stiff, hard, and sharp, which is best for probing fine details or scratching through hard oxide layers to make electrical contact with underlying layers.

ZN50R-CVT Probes in Action

To prove the performance capability of the Model ZN50R-CVT probes, 25 μm W tips were landed on 550 μm × 650 μm gold pads, at 4.2 K inside the vacuum chamber of a Lake Shore cryogenic probe station. The probe station vacuum chamber was then warmed to 275 K at increments of 5 K/min. Figure 3 illustrates the probe position at both 4.2 K and 275 K.

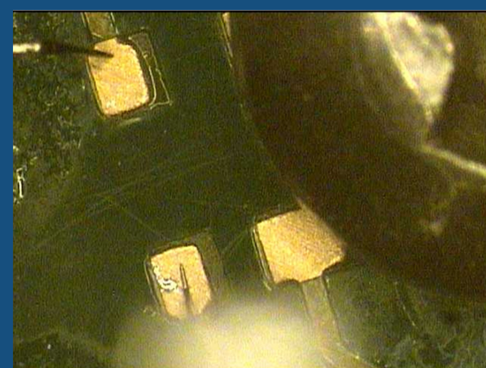


Figure 3 **Top: ZN50R-CVT probes at 4.2 K; Bottom: the same probes at 275 K**

The probes were lifted from the gold pads at 300 K. Figure 4 illustrates a slight indentation from the probe tip, but no scratching of any significant length. Using the standard Lake Shore Zoom 70 probe station microscope with a resolution of 4 μm, it was observed that the overall tip movement was less than 5 μm.

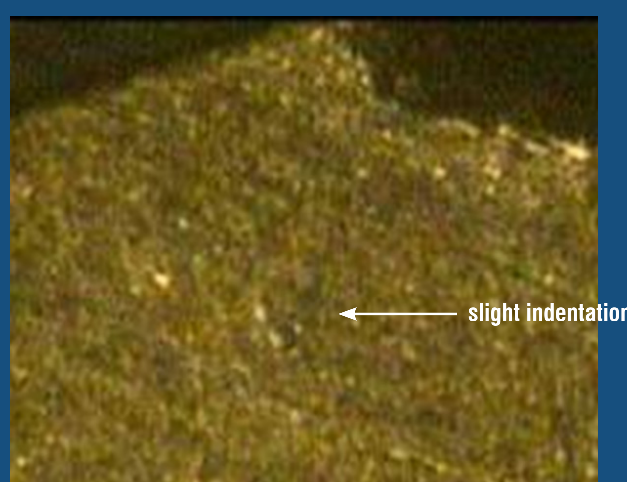


Figure 4 **Pad after probe was lifted, showing no scratch on the gold**

Enhanced Measurement Functionality

The new Model ZN50R-CVT probes allow you to take continuously variable temperature probe station measurements without the inconvenience of lifting and repositioning your probes each time you change temperature. Simply program the temperature zones in your temperature controller and walk away. In addition to improved workflow efficiency and throughout, measurement uncertainty is greatly reduced and the overall functionality of your probe station is enhanced. Measurements including Hall effect, gated Hall, gated current/voltage (IV), anomalous Hall effect (AHE), Kerr effect, magnetoresistance (MR), deep level transient spectroscopy (DLTS), capacitance/voltage (CV), photoluminescence and seebeck effect are much easier and more convenient to perform.

Figures 5 and 6 demonstrate the real-world measurement performance of the continuously variable temperature ZN50R probes. Resistivity versus temperature was measured and Hall mobility versus temperature was derived, comparing the ZN50R-CVT probes to the standard ZN50R probes. As a reference point, data were also recorded using the Lake Shore Model 9709A 9 T superconducting magnet-based Hall effect measurement system (HMS) with leads soldered to sample contact pads. The same indium arsenide (InAs) sample was used for both the probe station and HMS measurements. Measurements using the Model ZN50R-CVT-25-W and ZN50R-25-W probes were taken on a Lake Shore Model CPX-VF 2.5 T vertical field superconducting magnet based probe station. The ZN50R probes were lifted during temperature changes and re-landed once the temperature settled. The ZN50R-CVT probes were landed at 20 K and left on the sample through the full scale temperature range of 20 K to 300 K. For both experiments, temperature was ramped in point-by-point mode, whereby the setpoint was changed, temperature allowed to settle and measurements were taken. Figure 7 and Figure 8 demonstrate the percent deviation of the ZN50R-CVT probes relative to the Lake Shore Model 9709A HMS and standard ZN50R probes.

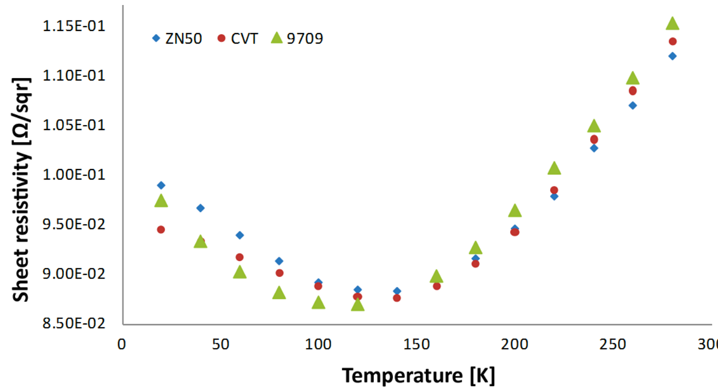


Figure 5 **Measurement of InAs Resistivity vs. Temperature**

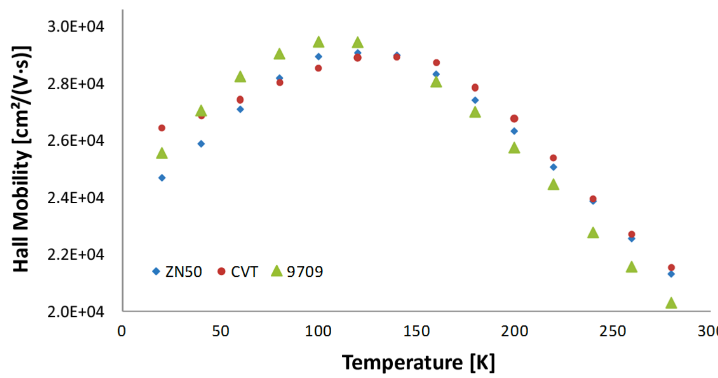


Figure 6 **Measurement of InAs Hall Mobility vs. Temperature**

When landed properly and used with proper contact pads, the Lake Shore ZN50R-CVT probes virtually eliminate the inconvenience of material expansion and contraction issues due to temperature changes, expanding the functionality of your Lake Shore probe station.

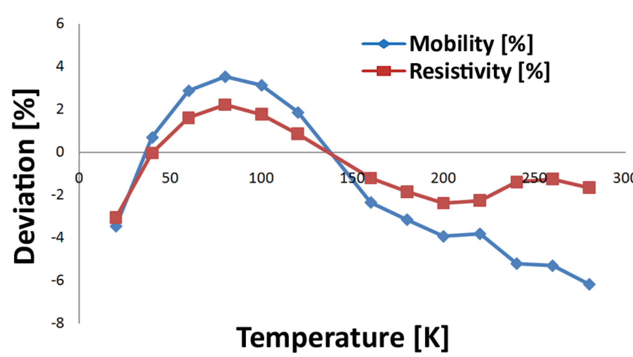


Figure 7 **ZN50R-CVT relative to Model 9709A HMS**

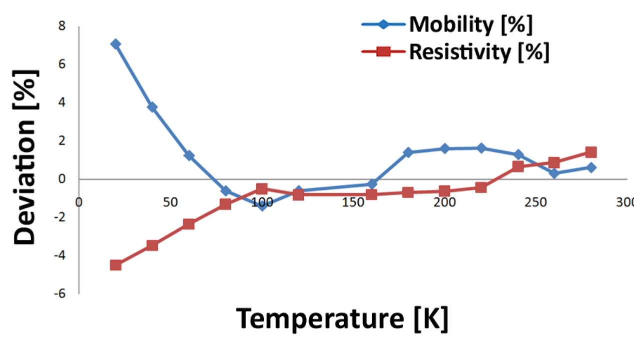


Figure 8 **ZN50R-CVT relative to ZN50R**

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Model ZN50R-CVT Specifications

Temperature range

Operating temperature range—overall	1.5 K to 475 K*

**Range may be limited by probe station model*

DC/RF Probe Frequency Range

Tungsten with cryogenic coaxial cable	0 to 50 MHz
Tungsten with semirigid coaxial cable	0 to 1 GHz*†
BeCu with cryogenic coaxial cable	0 to 50 MHz
BeCu with semirigid coaxial cable	0 to 1 GHz†

†S21 > -10 dB up to 1 GHz, except for a (-40 dB) spike between 400 MHz and 800 MHz depending on probe model and placement; S11 < -3 dB up to 1 GHz

Sample resistance range	0 – 100 GΩ (in a properly guarded system)
Insulation resistance	>30 GΩ (signal to ground in an unguarded system)
Connector	SMA coaxial connector (compatible with ZN50)

Probe tip compliance

Tip motion will be <5 µm in the x, y and z directions for the x-direction arm travel distances listed

Tip material	Radius	Landing surface*	Warming travel (+x direction)	Cooling travel (-x direction)
BeCu	10	Soft	0.3 mm	0.5 mm
BeCu	25	Soft	0.5 mm	0.8 mm
W	10	Soft	0.7 mm	1 mm
W	25	Soft	1 mm	1.5 mm
W	10	Hard	0.4 mm	0.4 mm
W	25	Hard	0.8 mm	1 mm

**Tips must be landed as specified below*

Probe landing requirement

10 µm radius tips	0.15 mm to 0.25 mm (15–25 tick marks on micrometer) of additional lowering Z movement after contact with sample
25 µm radius tips	0.30 mm to 0.50 mm (30–50 tick marks on micrometer) of additional lowering Z movement after contact with sample

**Tips can land in single point in all models except for the EMPX-HF, where opposing tips can land in single point but adjacent probe tips require 305 µm (0.012 in) between landing points*

Established in 1968, Lake Shore Cryotronics, Inc. is an international leader in developing innovative measurement and control solutions. Founded by Dr. John M. Swartz, a former professor of electrical engineering at the Ohio State University, and his brother David, Lake Shore produces equipment for the measurement of cryogenic temperatures, magnetic fields, and the characterization of the physical properties of materials in temperature and magnetic environments.

Ordering Information

Part number	Description
ZN50R-CVT-10-W	10 µm radius, tungsten, up to 1 GHz*
ZN50R-CVT-25-W	25 µm radius, tungsten, up to 1 GHz*
ZN50R-CVT-10-BECU	10 µm radius, beryllium copper, up to 1 GHz*
ZN50R-CVT-25-BECU	25 µm radius, beryllium copper, up to 1 GHz*

**Maximum frequency is 50 MHz with ZN50C-G or ZN50C-T cable. Maximum frequency is 1GHz with MWC-XX-00K cable.*

All specifications are subject to change without notice 102609