



## Features

- 5.5 kOe (0.55 T) horizontal (in-plane) field electromagnet
- 360° sample stage rotation option
- High stability operation from 5 K to 475 K
- Active cryogenic control of the cold head and radiation shield
- Measurements from DC to 67 GHz
- Accommodates up to 25 mm (1 in) diameter wafers
- Configurable with up to four micro-manipulated probe arms
- Probe arms with 3-axis adjustments and  $\pm 5^\circ$  theta planarization
- Cables, shields, and guards minimize electrical noise and thermal radiation losses
- High resolution optical system
- Non-magnetic vibration isolation table
- Options and accessories for customization to specific research needs

## Model EMTP4 Probe Station

### Introduction

The Model EMTP4 is a versatile cryogenic electromagnet-based micro-manipulated probe station used for non-destructive testing of devices on full and partial wafers up to 25 mm (1 in) in diameter. The EMTP4 is a platform for measurement of magneto-transport, electrical, electro-optical, parametric, high Z, DC, RF, and microwave properties of materials and test devices. Nanoscale electronics, quantum wires and dots, semiconductors, superconductors, and spintronic devices are typical materials measured in an EMTP4. A wide selection of probes, cables, sample holders, and options makes it possible to configure the EMTP4 to meet your specific measurement applications.

Mounted on a vibration isolation table, the EMTP4 is equipped with a 5.5 kOe (0.55 T) horizontal (in-plane) field electromagnet. The EMTP4 operates over a temperature range of 5 K to 475 K. The probe station provides efficient temperature operation and control with a continuous refrigeration system using either helium or nitrogen. Field dependent measurements at ambient temperature are possible without the use of cryogens. Liquid helium is only required for cooling the device under test (DUT) to below 80 K. Vapor-cooled shielding optimizes efficiency and intercepts blackbody radiation before it reaches the sample. A 100 W cartridge heater on the cold head minimizes temperature gradients across the sample and, along with independent control of radiation shield heaters, provides the probe station with fast thermal response.

The EMTP4 is user configured with up to four ultra-stable micro-manipulated stages, each providing precise 3-axis control of the probe position to accurately land the probe tip on device features. The 360° sample stage rotation option allows you to measure angular-dependent and anisotropic magneto-transport properties of the DUT. Proprietary probe tips in a variety of sizes and materials minimize thermal mass and optimize electrical contacts to the DUT. Probe tips are thermally linked to the cold head to minimize heat transfer to the DUT.

For increased versatility, EMTP4 options include 360° sample stage rotation, a LN<sub>2</sub> Dewar kit, higher magnification monoscopes, vacuum turbo pumping system, pump-line vibration isolator, recirculating chillers, and fiber optic probe arm modification.

### Headquarters and Sales

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All specifications subject to change. Rev 9/18/2007

## Applications

- Angular-dependent and anisotropic magneto-transport measurements
- Electrical and electro-optical measurements over a wide temperature range
- RF and microwave
- Parametric testing
- Shielded/guarded/low noise characterization
- High Z
- Non-destructive, full wafer testing

## Specifications

### Magnetic Field

<b>Maximum field</b>	5.5 kOe (0.55 T)*
<b>Field uniformity (at 70 A)</b>	
1 cm diameter wafer	0.6%
1.27 cm diameter wafer	1.1%
2 cm diameter wafer	2%
2.54 cm diameter wafer	2.6%
<b>Field control stability</b>	<50 mG RMS**

\*Hall probe is calibrated to read field at the center of the magnet gap

\*\*With settle band of 100 mG

### Temperature

<b>Operating temperature range—overall*</b>	5 K to 475 K**	
ZI50 DC/RF probe with low RF cryogenic coax cable	5 K to 475 K**	
ZI50 DC/RF probe with high RF semirigid coax cable	5 K to 400 K**	
GSG microwave probe with semirigid coax cable	5 K to 400 K**	
<b>Temperature control (heaters)</b>		
Cold head	100 W	
Two radiation shields	100 W each	
Probe arm	Measurement only	
<b>Temperature control stability</b>		
With LHe	5 K to 50 K	<5 mK RMS
	50 K and higher	<50 mK RMS
With LN <sub>2</sub>	80 K and higher	<100 mK RMS

\*Limited from 10 K to 400 K when configured with the PS=EMTTP4-360 360° sample stage rotation option

\*\* Selectable equipment

## Materials

- Nanoscale electronics (carbon nanotube transistors, single electron transistors, molecular electronics, nanowires, etc.)
- Quantum wires and dots, quantum tunneling
- Single electron tunneling (Coulomb blockade)
- Superconductors
- Spintronic devices
- Basic semiconductor devices including organics, LEDs, and dilute magnetic semiconductors

### Probe Arm Adjustments

<b>Travel</b>	
X axis	51 mm (2 in)
Y axis	25 mm (1 in)
Z axis	18 mm (0.7 in)
<b>Translation resolution</b>	
X axis	20 μm
Y and Z axes	10 μm
Theta planarization*	±5°
<b>Sample stage (sample holder) Rotation**</b>	
	360°

\*Included with microwave probes

\*\*Optional — recommended when taking measurements using microwave probes

## Frequency Range

<b>ZI50 DC/RF probe frequency range</b>	
Tungsten with cryogenic coax cable	0 to 50 MHz*
Tungsten with semirigid coax cable	0 to 1 GHz* <sup>†</sup>
Paliney 7 with cryogenic coax cable	0 to 50 MHz*
Paliney 7 with semirigid coax cable	0 to 1 GHz* <sup>†</sup>
BeCu with cryogenic coax cable	0 to 50 MHz*
BeCu with semirigid coax cable	0 to 1 GHz* <sup>†</sup>
<b>GSG microwave probe frequency range</b>	
Low frequency with K connector	0 to 40 GHz*
Mid frequency with 2.4 mm connector	0 to 50 GHz*
High Frequency with 1.8 mm connector	0 to 67 GHz*

\*Selectable equipment

<sup>†</sup> 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

## Optical

<b>Optical viewport—located on top lids</b>	Ø54 mm (2.1 in) outer window and Ø51 mm (2 in) inner window
<b>Outer, clear fused quartz</b>	99% IR transmittance
<b>Inner</b>	IR absorbing with narrow band visible light transmittance
<b>Optical resolution—monoscope</b>	
<b>7:1 zoom</b>	5 µm
<b>12.5:1 zoom</b>	4 µm*
<b>16:1 zoom</b>	3 µm*

\*Selectable equipment

## Sample Holder (Chuck)

<b>Maximum sample size—overall</b>	Up to Ø25 mm (1 in)
<b>SH-1.00-G, grounded chuck</b>	Up to Ø25 mm (1 in) and 475 K
<b>SH-1.00-I, isolated chuck</b>	Up to Ø25 mm (1 in) and 400 K*
<b>SH-1.00-C, coaxial chuck**</b>	Up to Ø25 mm (1 in) and 400 K*
<b>SH-1.00-T, triaxial chuck**</b>	Up to Ø25 mm (1 in) and 400 K*

\*Selectable equipment

\*\*Not available in combination with the 360° sample stage rotation feature

## Standard Equipment

<b>Electromagnet</b>	5.5 kOe (0.55 T), horizontal field
<b>Water flow rate</b>	7.6 L/min (2 gal/min)
<b>Electromagnet power supply</b>	Lake Shore Model 642
<b>Output type</b>	Bipolar, linear, 4-quadrant, DC current source
<b>Current</b>	±70 A
<b>Voltage</b>	±35 V
<b>Water flow rate</b>	5.7 L/min (1.5 gal/min)
<b>Gaussmeter and Hall probe</b>	Lake Shore Model 475 with probe (control and monitor field)
<b>Open cycle sample stage refrigerator</b>	5 K to 475 K
<b>Cold head stage temperature sensor</b>	Lake Shore Model TG-120-SD-4H calibrated GaAlAs diode
<b>Cold head stage heater</b>	100 W
<b>Cooled radiation shield and cooled IR-absorbing window above the sample</b>	
<b>Two radiation shield temperature sensors</b>	Lake Shore Model DT-670C-CU silicon diode
<b>Two radiation shield heaters</b>	100 W and 100 W
<b>Removable top lid with viewport</b>	Ø51 mm (2 in) window
<b>Temperature controllers</b>	One Lake Shore Model 340, one Model 332S, and one Model 142 200 W (2-channels, 100 W each) power supply (independent regulation of cold head stage, radiation shield, and probe arm temperature monitoring)
<b>Vacuum chamber</b>	
<b>Outside Dimensions</b>	34 cm x 20.3 cm (13.4 in x 8 in)
<b>Removable top lid with clear fused quartz viewport</b>	Ø54 mm (2.1 in) window
<b>Probe ports</b>	4 equally spaced surround the sample thermal radiation shield
<b>Machined aluminum base plate</b>	71.1 cm x 70 cm (28 in x 24 in)
<b>PS-TMC vibration isolation system</b>	Includes pneumatically driven gimbal piston isolator, actuators, and supports; self leveling with a resonant frequency below 2 Hz; requires 80 psi nitrogen or air
<b>Isolator natural frequency</b>	Vertical 0.8 Hz, horizontal 1.0 Hz
<b>Isolator efficiency at 5 Hz</b>	Vertical 80 to 97%, horizontal 60 to 90%
<b>Isolator efficiency at 10 Hz</b>	Vertical 90 to 99%, horizontal 70 to 95%
<b>Four XYZ precision micro-manipulated probing stages</b>	
<b>Probe arms, thermal radiation shields, stainless steel welded bellows, and feedthrough ports</b>	
<b>Thermally linked probe mounts</b>	Probe mounts and radiation shield are thermally anchored to the cold head; one probe mount includes a platinum temperature sensor installed and wired to a 6-pin feedthrough
<b>Grounded sample holder</b>	SH-1.00-G, accommodates up to a Ø25 mm (1 in) sample with a Ø25 mm (1 in) probe area
<b>Optics</b>	
<b>Zoom 70 monoscope</b>	7:1 zoom with 5 µm resolution
<b>Color CCD camera</b>	
<b>Swing arm</b>	Optics can be manipulated to view any part of the sample or wafer, and can be retracted and swung away to allow access to the top of the vacuum chamber for sample exchange
<b>Video monitor</b>	High resolution, 17-inch
<b>Sample illumination</b>	Coaxial via fiber optic or ring light from an adjustable light source and power supply (must specify sample illumination at time of order) <b>NOTE: Coaxial illumination is recommended for highly reflective materials</b>
<b>High efficiency helium transfer line with foot valve for precise flow regulation</b>	
<b>Instrument console</b>	
<b>Basic tools, spares, and cleaning kit</b>	

## Probes, Probe Tips, and Cables — Required User Configurable Equipment

### ZI50 DC/RF PROBES

- Ideal for: DC biasing, low/high frequency measurements, low noise shielded, and low-leakage guarded measurement
- ZI50 probe base is linked to the sample stage to dynamically cool/heat the probe to the sample temperature
- SMA connector mounted directly to an alumina ceramic blade with a 50 Ω stripline routed to the probe contact

We understand that today's researcher requires flexibility. Our wide selection of probes, cables, sample holders, and options make it possible to configure a probe station to meet your specific measurement applications.

Part number (probe body and ceramic blade)	Tip material	Maximum frequency (GHz)	Tip radius (µm)
ZI50-03-W	Tungsten	1*	3
ZI50-10-W			10
ZI50-25-W			25
ZI50-03-P7	Paliney 7		3
ZI50-10-P7			10
ZI50-25-P7			25
ZI50-03-BeCu	BeCu		3
ZI50-10-BeCu			10
ZI50-25-BeCu			25
ZI50-100-BeCu			100
ZI50-200-BeCu			200

\*Maximum frequency 50 MHz with Z50-CU-SS-3650-G or Z50-CU-SS-3650-T cable; maximum frequency 1 GHz with K-085-K cable

### ZI50 DC/RF CABLES

Part number	Cable type	Connector type	Feedthrough type	Measurement configuration	Maximum frequency	Maximum temperature
Z50-CU-SS-3650-G-12	Ultra-miniature cryogenic coax	SMA	BNC	Shielded	50 MHz	475 K
Z50-CU-SS-3650-T-12	Ultra-miniature cryogenic coax	SMA	2-lug triax	Low leakage	50 MHz	475 K
K-085-K-12	Stainless semirigid microwave coax	K	Loss-less compression seal	High frequency	1 GHz*	400 K

\* 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

**GSG MICROWAVE PROBES\***

- Coplanar waveguide probe with ground-signal-ground (GSG) contact geometry
- User-specified pitch (spacing)
- Optimized low thermal conductivity coax leading to low thermal conductivity tips
- Cooled to near-sample temperature
- Limited to 400 K
- Separate theta planarization module with  $\pm 5^\circ$  rotation mechanism is also provided

Part number	Connector type	Maximum frequency (GHz)	Pitch ( $\mu\text{m}$ )
GSG-050-40A-DNM	K	40	50
GSG-100-40A-DNM			100
GSG-150-40A-DNM			150
GSG-200-40A-DNM			200
GSG-250-40A-DNM			250
GSG-050-50A-DNM	2.4 mm	50	50
GSG-100-50A-DNM			100
GSG-150-50A-DNM			150
GSG-200-50A-DNM			200
GSG-250-50A-DNM			250
GSG-050-67A-DNM	1.8 mm	67	50
GSG-100-67A-DNM			100
GSG-150-67A-DNM			150
GSG-200-67A-DNM			200
GSG-250-67A-DNM			250

\*PS-EMTTP4-360 360° sample stage rotation option recommended when taking measurements using microwave probes

**GSG MICROWAVE CABLES**

- Loss-less compression seal
- Semirigid with stainless steel outer jacket, silver plated BeCu inner conductor, and Teflon® dielectric

Part number	Cable type	Feedthrough type	Maximum temperature	Connector type	Maximum frequency
K-085-K-12	Stainless semirigid microwave coax	Loss-less compression seal	400 K	K	40 GHz
2.4-085-2.4-12				2.4 mm	50 GHz
1.8-085-1.85-12				1.8 mm	67 GHz

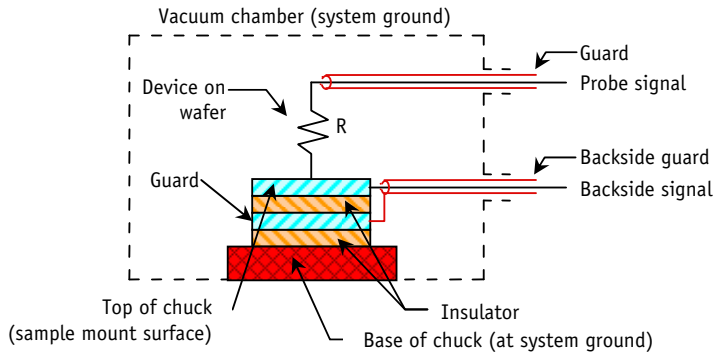
### SAMPLE HOLDERS (CHUCKS)

Typical sample holder configuration characterized by:

- Leakage resistance between
  - Top surface and guard
  - Guard and ground
- Capacitance between
  - Top surface and guard
  - Guard and ground

### Types of sample holders

- Grounded sample holder—sample mount surface at system ground
- Isolated sample holder—backside contact not needed; sample mount surface is electrically non-conductive and isolated from ground
- Coaxial sample holder—backside contact can be made; sample mount surface is isolated from ground
- Triaxial sample holder—guarded backside contact can be made; sample mount surface has guarded isolation from ground



Part number	Measurement configuration	Separate feedthrough required	Maximum sample (diameter)	Maximum temperature
SH-1.00-G	Grounded	No	Ø25 mm (1 in)	475 K
SH-1.00-I	Isolated			400 K
SH-1.00-C***	Coaxial	Yes*		400 K
SH-1.00-T***	Triaxial	Yes**		

\*Coaxial sample holders require one FT-BNC or FT-TRIAX feedthrough as listed below

\*\*Triaxial sample holders require one FT-TRIAX feedthrough as listed below

\*\*\*Cannot be used in combination with the 360° sample stage rotation option

Part number	Description
FT-BNC	Coaxial feedthrough and coax cable, installed and wired
FT-TRIAX	Triaxial feedthrough and coax cable, installed and wired

### Site Requirements

**Power** — Standard single-phase (20 A maximum) power is required for instrumentation and optional pumps. The magnet power supply and optional recirculation chiller require 3-phase (21 A maximum) power.

**Water** — Electromagnet requires one supply and one return line for cooling with 7.6 L/min at a pressure drop of 30 psi. Magnet power supply requires 5.7 L/min at a pressure drop of 1.5 psi. Water temperature should be 15 °C to 25 °C.

### Equipment Options

Part Number	Description
PS-FOA	Fiber optic probe arm modification. Transmit or receive light or IR/UV radiation. Fiber optic terminated with SMA connector or compression feedthrough. (Fiber optic wire not included. Fiber optic and probe cannot be used simultaneously.)
PS-Z12.5	12.5:1 zoom monoscope upgrade for 4 µm resolution NOTE: upgrade is not field-installable
PS-Z16	16:1 zoom monoscope upgrade for 3 µm resolution NOTE: upgrade is not field-installable
PS-EMTTP4-360	360° sample stage rotation NOTE: limits overall temperature range to 10 K to 400 K; ΔT between the sample and the cold head stage temperature sensor is <math>\pm 2</math> K over the full temperature range; recommended when taking measurements using microwave probes
PS-DPC	Automatic Dewar (gas) pressure controller, regulates Dewar liquid flow

## Equipment Options, continued

Part Number	Description
PS-V81TP	Turbo pumping system—includes Varian V-81 Turbo Pump cart with DS 102 backing pump, vacuum gauging for high vacuum and fore line, controller, and adaptors (specify 110 V/60 Hz or 220 V/50 Hz)
PS-V81DP	Turbo pumping system—includes Varian V-81 Turbo Pump cart with oil free backing pump, vacuum gauging for high vacuum and fore line, controller, and adaptors (specify 110 V/60 Hz or 220 V/50 Hz)
PS-LN2	Nitrogen Dewar with stainless fittings, gauges, and adaptors; allows LN <sub>2</sub> use with the LHe transfer line
PS-OAC	Oil-less air compressor for PS-TMC (only available in 110 V)
PS-PLVI-25	Pump-line vibration isolator—includes NW-25 fittings, 1 m stainless steel bellows, clamps, and rings (placed between pump cart and system); requires one bag of cement
PA-SEN	Probe arm modification with platinum temperature sensor installed and wired to a 6-pin feedthrough
CS-5	Calibration substrate for GSG probes. Pad size: 50 μm <sup>2</sup> ; calibration type: SOLT (short-open-load-through), LRL (line-reflective-line), LRM (line-reflective-match); pitch range: 75 to 250 μm
CS-15	Calibration substrate for GSG probes. Pad size: 25 μm <sup>2</sup> ; calibration type: SOLT (short-open-load-through), LRL (line-reflective-line), LRM (line-reflective-match); pitch range: 40 to 150 μm
RC-EM4-200230-60-CE	Recirculating chiller; PD-2, 200 to 230 V, 60 Hz, 12 A, 2.2 kW, 12.9 lpm, 50 psi
RC-EM4-200-50-CE	Recirculating chiller; PD-2, 200 V, 50 Hz, 12 A, 2.2 kW, 11.4 lpm, 40 psi
RC-EM4-230-50-CE	Recirculating chiller; PD-2, 220 to 240 V, 50 Hz, 10 A, 2.2 kW, 11.4 lpm, 40 psi

Lake Shore Cryotronics is a leading supplier of cryogenic, superconducting magnet-based, electromagnet-based, high vacuum, and load-lock probe stations. We offer a full line of standard probe stations to meet your research requirements.

### Our standard line of probe stations includes:

#### Model TTP4

- Up to four micro-manipulated probe stages
- Temperature range capabilities from 3.2 K to 475 K
- Up to 51 mm (2 in) diameter wafer capabilities

#### Model TTP4-1.5K

- Up to four micro-manipulated probe stages
- Standard temperature range from 1.5 K to 475 K
- Up to 25 mm (1 in) diameter wafer capabilities

#### Model TTP6

- Up to six micro-manipulated probe stages
- Temperature range capabilities from 3.2 K to 475 K
- Up to 51 mm (2 in) diameter wafer capabilities

#### Model FWP6

- Up to six micro-manipulated probe stages
- Standard temperature range from 4.5 K to 475 K
- Up to 10.2 cm (4 in) diameter wafer capabilities

#### Model LLTTP6

- Load-lock — for fast sample exchange at any temperature
- Up to six micro-manipulated probe stages
- Standard temperature range from 10 K to 400 K
- Up to 51 mm (2 in) diameter wafer capabilities; up to 12.7 mm (0.5 in) with load-lock assembly

#### Model HFTTP4

- 1 T horizontal field split pair superconducting magnet
- Up to four micro-manipulated probe stages
- Temperature range capabilities from 2 K to 400 K with field on or off
- Up to 25 mm (1 in) diameter wafer capabilities

#### Model VFTTP4

- 2.5 T vertical field solenoid superconducting magnet
- Up to four micro-manipulated probe stages
- Temperature range capabilities from 2 K to 400 K with field on or off
- Up to 51 mm (2 in) diameter wafer capabilities

#### Model EMTTP4

- 0.55 T horizontal (in-plane field) electromagnet
- Up to four micro-manipulated probe stages
- Standard temperature range from 5 K to 475 K
- Up to 25.4 mm (1 in) diameter wafer capabilities

#### Model HVTTP6

- High vacuum to 10<sup>-7</sup> torr
- Up to six micro-manipulated probe stages
- Temperature range capabilities from 2 K to 475 K
- Up to 51 mm (2 in) diameter wafer capabilities