



## Features

- High stability cryogen-free operation from 4.5 K to 350 K
- Optional temperature range from 50 K to 475 K
- Control stability to 10 mK
- Sample exchange cycle time of <3.5 h
- Low vibration design: <1  $\mu\text{m}$  at sample stage (X, Y, and Z axes)
- Measurements from DC to 67 GHz
- Sample holders optimized for low noise, high frequency, or high impedance measurements
- Accommodates up to 51 mm (2 in) diameter wafers
- Configurable with up to six thermally anchored 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
- Options and accessories for customization to specific research needs

## Model CRTTP6-4K Probe Station

### Introduction

The Model CRTTP6-4K is a cryogen-free closed cycle refrigerator-based micro-manipulated probe station used for non-destructive testing of devices on full and partial wafers up to 51 mm (2 in) in diameter. It is ideally suited for the dynamic requirements of nanotechnology and advanced semiconductor research, including nanoscale electronics, quantum wires, and quantum dots. The probe station is available with up to six probe arms and a variety of probe configurations for electrical and electro-optical measurements. A wide selection of options and accessories make it easy to configure the Model CRTTP6-4K probe station to meet your specific research needs.

Based on a Sumitomo 4 K base temperature CCR, the CRTTP6-4K provides efficient temperature operation and control over a temperature range of 4.5 K to 350 K without the operating expense of liquid cryogenics. An optional interchangeable high temperature sample holder provides a temperature range of 50 K to 475 K. Each cryogenic stage is equipped with a sensor and heater to provide fast thermal response and rapid warm up for sample exchange. Actively cooled shielding intercepts blackbody radiation before it reaches the sample, ensuring small thermal gradients.

Careful design consideration was taken to provide a low vibration, user-friendly tool. Integrated vibration isolation and damping prevents mechanical vibration from affecting measurement performance. Sample stage vibration is limited to less than 1  $\mu\text{m}$  (X, Y, and Z axes) through the full-scale temperature range.

The CRTTP6-4K is user configured with up to six ultra-stable micro-manipulated probe arms, each providing precise 3-axis probe position control to land the probe tip accurately on device features. Each probe can also be rotated  $\pm 5^\circ$  about its axis (planarized) to ensure multi-tip probes are properly aligned with the sample. DC measurements can be optimized for low-noise, high-impedance (low leakage), or high-thermal contact to the device under test (DUT). RF measurements include configurations up to 67 GHz. Optical sources can be introduced through viewport windows or optional fiber optic probe arm modification. Proprietary probe arms in a variety of sizes and materials minimize thermal mass and optimize electrical contact to the DUT. In addition, probe tips are thermally linked to the sample stage to minimize heat transfer to the DUT.

### Headquarters and Sales

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All specifications subject to change. Rev 11/30/2007

## Applications

- Electrical and electro-optical measurements over a wide temperature range
- DC, RF and microwave
- Parametric testing
- Shielded/guarded/low noise characterization
- High Z
- Non-destructive, full wafer testing
- Multi-port S-parameter

## Materials

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

## Specifications

### Temperature\*

Operating temperature range—overall	Base 4.5 K; control range 5 K to 475 K**		
	2 arms	4 arms	6 arms
ZN50 DC/RF probe with low RF cryogenic coax cable	4.5 K; 5 K to 475 K**	5.25 K; 5.75 K to 475 K**	6 K; 6.5 K to 475 K**
ZN50 DC/RF probe with high RF semirigid coax cable	4.5 K; 5 K to 400 K**	5.25 K; 5.75 K to 400 K**	6 K; 6.5 K to 400 K**
GSG microwave probe with semirigid coax cable	4.5 K; 5 K to 350 K	5.25 K; 5.75 K to 350 K	6 K; 6.5 K to 350 K
<b>Cool down time</b>			
Room temperature to within 5 K of base	1.5 h		
Room temperature to base	2 h		
<b>Warm up time</b>			
From base to room temperature	1 h		
<b>Control stability</b>			
< 10 K	50 mK		
11 K to 250 K	10 mK		
251 K to 350 K	20 mK		
351 K to 475 K**	50 mK		
<b>Temperature control (heaters)</b>			
Sample stage	100 W		
Cold head	100 W		
Radiation shield	100 W		
CCR Riser	200 W (2 parallel heaters, 100 W each)		
Probe arm	Measurement only		

\* Typical temperature performance at 60 Hz, 208 VAC, 25° C cooling water

\*\* Selectable equipment; high temperature coaxial sample holder limits low end temperature to 50 K (base), 55 K (control)

### CCR Vibration

Overall (X, Y, and Z axes)	<1 μm peak to peak at sample stage
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### Pump Down Time

Before CCR start-up (10 <sup>-3</sup> torr)	20 min
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### Vacuum

Volume	8.7 L (530 in <sup>3</sup> )
Room temperature	10 <sup>-4</sup> torr
At base temperature	10 <sup>-5</sup> torr

### Probe Tip Temperature Drift

	77 K to 300 K	Base temp to 300 K
X axis	TBD	TBD
Y axis	<5 μm	<5 μm
Z axis	TBD	TBD

### Probe Arms

Travel	
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 (included with microwave probes)	±5°

### Sample Space

Sample area	Up to 51 mm (2 in)
Sample thickness	Up to 12 mm (thicker samples may reduce probable area)
Working height of sample	89 cm (35 in) from floor
Distance to radiation shield	4.2 cm (1.65 in) from sample holder to bottom of viewport
Distance from vacuum chamber	7.2 cm (2.84 in) from sample holder to top of viewport

### CCR Compressor Requirements

Compressor	CSW-71C	CSW-71D	
Ambient temperature	5 °C to 28 °C; 28 °C to 35 °C with reduced capacity	5 °C to 28 °C; 28 °C to 35 °C with reduced capacity	
Line voltage	208 VAC ±10%	380/400/415 VAC	460/480 VAC
Frequency	50/60 Hz	50 Hz	60 Hz
Phase	3-phase, delta	3-phase, delta	
Power	8.3 kW max	8.5 kW max	
<b>Cooling water</b>			
Temperature	4 °C to 28 °C		
Flow rate	7 L/min at 28 °C to 4 L/min at 4 °C		
Inlet pressure	0.20 MPa (29 psig) to 0.69 MPa (100 psig)		
Pressure drop	0.05 MPa (7 psig) at 4 L/min to 0.32 MPa (46 psig) at 10 L/min		
Gas line length	6 m (19.7 ft) standard		
Approvals	CE, UL		

### Frequency Range

<b>ZN50 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 viewports—located on top lids</b>	Ø54 mm (2.1 in) outer window and Ø51 mm (2 in) inner window
Outer, clear fused quartz	99% IR transmittance
Inner	IR absorbing with narrow band visible light transmittance

<b>Optical resolution—monoscope</b>	
7:1 zoom	5 µm
12.5:1 zoom	4 µm*
16:1 zoom	3 µm*

\*Selectable equipment

### Sample Holder (Chuck)

<b>Maximum sample size—overall</b>	Up to Ø51 mm (2 in)*
SH-1.25-G, Grounded chuck	Up to Ø31.8 mm (1.25 in) and 350 K
SH-1.25-I, Isolated chuck	Up to Ø31.8 mm (1.25 in) and 350 K*
SH-1.25-C, Coaxial chuck	Up to Ø31.8 mm (1.25 in) and 350 K*
SH-1.25-T, Triaxial chuck	Up to Ø31.8 mm (1.25 in) and 350 K*
SH-2.00-G, Grounded chuck	Up to Ø51 mm (2 in) and 350 K*
SH-2.00-C, Coaxial chuck	Up to Ø51 mm (2 in) and 350 K*
SH-2.00-C-HT, Coaxial chuck, high temperature	Up to Ø51 mm (2 in) and 475 K**
SH-2.00-T, Triaxial chuck	Up to Ø51 mm (2 in) and 350 K*

\* Selectable equipment

\*\* Selectable equipment; high temperature coaxial sample holder limits low end temperature to 50 K (base); 55 K (control); requires option PS-HTA-CRTP6 (purchased separately)

## Standard Equipment

<b>Closed cycle refrigerator — SHI RDK-408D2</b>	4.5 K (base); 5 K to 475 K (control)
<b>Sample stage temperature sensor</b>	Lake Shore Model DT-670-SD-1.4H calibrated silicon diode
<b>Cold head stage temperature sensor</b>	Lake Shore Model DT-670C-CU silicon diode
<b>Riser temperature sensor</b>	Lake Shore Model DT-670C-CU silicon diode
<b>Sample stage heater</b>	100 W
<b>Cold head stage heater</b>	100 W
<b>Riser heater</b>	200 W (2 parallel heaters, 100 W each)
<b>Cooled radiation shield and cooled IR-absorbing window above the sample</b>	
<b>Diameter</b>	13 cm (5 in)
<b>Radiation shield temperature sensor</b>	Lake Shore Model DT-670C-CU silicon diode
<b>Material</b>	Aluminum
<b>Radiation shield heater</b>	100 W
<b>Removable top lid with viewport</b>	Ø51 mm (2 in) window; Ø50 mm (1.97 in) viewing area
<b>Sample access</b>	13 cm (5 in)
<b>Typical temperature</b>	30 K to 35 K throughout the full-scale temperature range
<b>Temperature controllers</b>	Two Lake Shore Model 340s, one 3462 2-channel input card, and one Model 142 power supply (independent regulation of sample stage, cold head stage, riser, radiation shield, and probe arm temperature monitoring)
<b>Electroless nickel plated aluminum vacuum chamber</b>	
<b>Diameter</b>	20.3 cm (8 in)
<b>Seals</b>	O-ring (370 Buna-N)
<b>Removable top lid with clear fused quartz viewport</b>	Ø63.5 mm (2.5 in) window
<b>Viewable area</b>	Ø54 mm (2.1 in)
<b>Probe ports</b>	Up to 6 surround the sample thermal radiation shield
<b>Pump port</b>	KF-40 with valve (pump sold separately)
<b>Gauge port</b>	KF-25 (gauge not included)
<b>Gas port</b>	0.25 in NPT with valve (inert gas only)
<b>Over pressure safety</b>	2 kPa (0.3 psi) pressure relief valve
<b>Machined aluminum base plate (table)</b>	63.0 cm × 50.8 cm (25 in × 20 in)
<b>Support stand</b>	Low vibration, welded steel stand with integrated passive vibration isolation and dampening—minimizes system vibration displacement at all frequencies
<b>Up to six 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 DT-670 series silicon diode temperature sensor installed and wired to a 6-pin feedthrough
<b>Grounded sample holder</b>	SH-1.25-G, accommodates up to a Ø31.8 mm (1.25 in) sample with a Ø25.4 mm (1 in) probe area to land all probes
<b>Optics</b>	
<b>Zoom 70 monoscope</b>	7:1 zoom with 5 µm resolution
<b>Color CCD camera</b>	S-video or composite output format
<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>Instrument console</b>	
<b>Basic tools, spares, and cleaning kit</b>	

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

### ZN50 DC/RF PROBES

- Ideal for: DC biasing, low/high frequency measurements, low noise shielded, and low-leakage guarded measurement
- ZN50 probe base incorporates a pair of copper braids that connect to the sample stage to dynamically cool/heat the probe to the sample temperature
- SMA connector mounted directly to a replaceable alumina ceramic blade with a 50  $\Omega$  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)	Description
ZN50-26U	50 $\Omega$ stripline probe body mount (each probe body mount requires a ceramic blade—selectable below)

Part number (ceramic blade)	Tip material	Maximum frequency (GHz)	Tip radius ( $\mu\text{m}$ )
ZN50R-03-W	Tungsten	1 (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)	3
ZN50R-10-W			10
ZN50R-25-W			25
ZN50R-03-P7	Paliney 7		3
ZN50R-10-P7			10
ZN50R-25-P7			25
ZN50R-03-BeCu	BeCu		3
ZN50R-10-BeCu			10
ZN50R-25-BeCu			25
ZN50R-100-BeCu			100
ZN50R-200-BeCu		200	

### ZN50 DC/RF CABLES

Part number	Cable type	Connector type	Feedthrough type	Measurement configuration	Maximum frequency	Maximum temperature
Z50-CU-SS-3650-G	Ultra-miniature cryogenic coax	SMA	BNC	Shielded	50 MHz	475 K**
Z50-CU-SS-3650-T	Ultra-miniature cryogenic coax	SMA	2-lug triax	Low leakage	50 MHz	475 K**
K-085-K-09	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  
 \*\* Selectable equipment; high temperature coaxial sample holder limits low end temperature to 50 K (base); 55 K (control)

### 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
- Include a copper braid assembly to cool the probe to near sample temperature
- Limited to 350 K
- Separate theta planarization module with  $\pm 5^\circ$  rotation mechanism is provided

Part number	Connector type	Maximum frequency (GHz)	Pitch ( $\mu\text{m}$ )
GSG-050-40A-26U-D	K	40	50
GSG-100-40A-26U-D			100
GSG-150-40A-26U-D			150
GSG-200-40A-26U-D			200
GSG-250-40A-26U-D			250
GSG-050-50A-26U-D	2.4 mm	50	50
GSG-100-50A-26U-D			100
GSG-150-50A-26U-D			150
GSG-200-50A-26U-D			200
GSG-250-50A-26U-D			250
GSG-050-67A-26U-D	1.85 mm	67	50
GSG-100-67A-26U-D			100
GSG-150-67A-26U-D			150
GSG-200-67A-26U-D			200
GSG-250-67A-26U-D			250

### 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-09	Stainless semirigid microwave coax	Loss-less compression seal	350 K	K	40 GHz
2.4-085-2.4-09				2.4 mm	50 GHz
1.8-085-1.85-09				1.85 mm	67 GHz

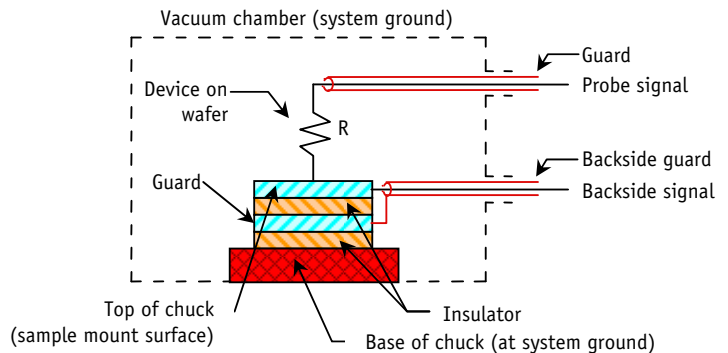
### SAMPLE HOLDERS (CHUCKS)

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 voltage	Maximum temperature	Change in temperature at 4.2 K
SH-1.25-G	Grounded	No	Ø31.8 mm (1.25 in)	NA	350 K	0 K
SH-1.25-I	Isolated			NA	350 K <sup>†</sup>	1.5 K
SH-1.25-C	Coaxial	Yes*		70 V	350 K <sup>†</sup>	2 K
SH-1.25-T	Triaxial	Yes**	Ø51 mm (2 in)	NA	350 K <sup>†</sup>	0.5 K
SH-2.00-G	Grounded	No			350 K <sup>†</sup>	1.5 K
SH-2.00-C	Coaxial	Yes*		70 V	475 K <sup>††</sup>	
SH-2.00-C-HT	Coaxial	Yes*		350 K <sup>†</sup>	2 K	
SH-2.00-T	Triaxial	Yes**		350 K <sup>†</sup>		

\* 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

<sup>†</sup> Selectable equipment

<sup>††</sup> Selectable equipment; high temperature coaxial sample holder limits low end temperature to 50 K (base), 55 K (control); requires option PS-HTA-CRTP6 (purchased separately)

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

### 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-HTA-CRTP6	High temperature option kit used in combination with high temperature sample holders for temperature operation from 50 K (base), 55 K (control) to 475 K. Includes integrated thermal standoff, calibrated PT-100 temperature sensor, heater, electronics, wiring, and cabling. The high temperature sample assembly is interchangeable; standard sample holders can be used when the high temperature sample holder is removed.
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-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)



## Equipment Options, continued

Part Number	Description
PA-SEN	Probe arm modification with silicon diode temperature sensor installed and wired to a 6-pin feedthrough
PA-CRTP6	Probe arm and base for CRTP6-4K
MMS-CRTP6	Micro-manipulated stage for CRTP6-4K
CS-5	Calibration substrate for GSG probes. Pad size: 50 $\mu\text{m}^2$ ; calibration type: SOLT (short-open-load-through), LRL (line-reflective-line), LRM (line-reflective-match); pitch range: 75 to 250 $\mu\text{m}$
CS-15	Calibration substrate for GSG probes. Pad size: 25 $\mu\text{m}^2$ ; calibration type: SOLT (short-open-load-through), LRL (line-reflective-line), LRM (line-reflective-match); pitch range: 40 to 150 $\mu\text{m}$

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 LLTP6**

- 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 EMTP4**

- 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 HVTP6**

- High vacuum to  $10^{-7}$  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

#### **Model CRTP6-4K — Now Available**

- Low vibration, cryogen-free closed cycle refrigerator
- Up to six micro-manipulated probe stages
- Temperature range capabilities from 4.5 K to 475 K
- Up to 51 mm (2 in) diameter wafer capabilities