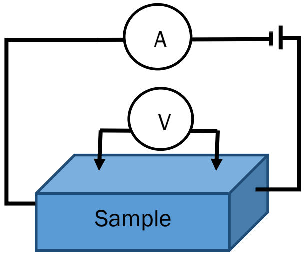
Four Probe Resistivity Measurement Unit

Four probe resistivity measuring technique is standard technique for measuring resistivity of the conducting sample. Our setup can measured the resistivity from room temperature to 200°C. SMU: Keithley 2450 with Everbeing SR-4.

$$R = \frac{V}{I} = \rho\frac{L}{A}$$

$$\rho = R\frac{A}{L}\ [\Omega.cm]$$



Where:

R = Resistance (Ω)

A = Cross section area (cm²)

L = Length (cm)

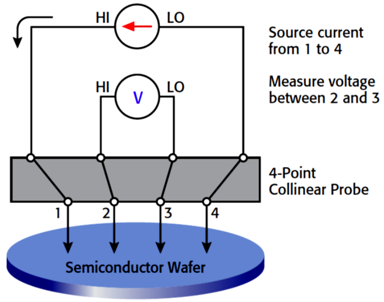
I = Current (A)

V = Voltage (V)

ρ = Resistivity (Ω-cm)

Co-linear four probe resistivity measurement:

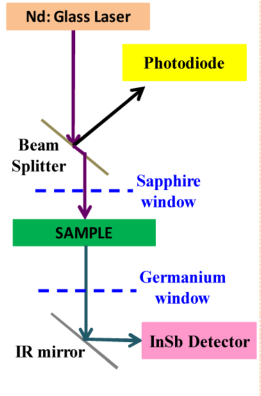
The four-point collinear probe technique involves bringing four equally spaced probes in contact with a material of unknown resistance.



Co-linear Four-point probe resistivity test

Laser Flash System Technical Capabilities & Ray Diagram

Thermal properties analyzer	
High Temperature Furnace Model	FL-5000
Room Temperature Model	EM-200
Temperature Range for FL-5000	Room temperature to 2100°C
Temperature Range for EM-200	Room temperature to 200°C (in air)
Sample shape	Circular Disc & Square
Sample Dimensions	Ø 12.7 mm & square sample length 8 mm thickness 1 to 6mm thick
Coursel Capacity for FL-5000	Six Samples
Coursel Capacity for EM-200	Two Samples
Atmosphere for FL-5000	Innert gas / Vacuum (10 E-5 mbar)
Pulse source:	Nd: Glass laser
Pulse energy	35 J/pulse
Detector	InSb, solid state detector



Laser Beam Ray Diagram

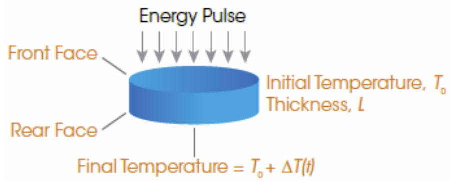
$$\alpha = \frac{0.139L^2}{t_{1/2}}$$

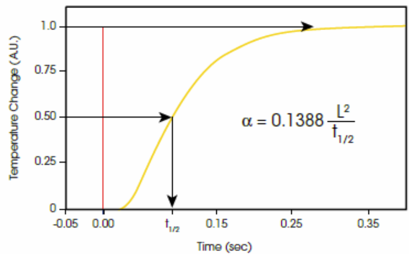
Where,
α= Thermal diffusivity,
L= thickness,
t1/2 = time taken in reaching 50% of the maximum observed temperature on rare face

$$C_{P\,specimen} = \frac{(mC_p\Delta T)_{ref}}{(m\Delta T)_{specimen}}$$

Where,
m= mass, Cp=specific heat,
ΔT =change in temperature,
ref = reference specimen

$$K = \alpha * \rho * Cp$$





Principle and working method of equipment is as per ASTM E1461. A small, thin, disc specimen mounted horizontally or vertically is subjected to a high-intensity short duration thermal pulse. The energy of the pulse is absorbed on the front surface of a specimen and the resulting rear face temperature rise is measured. Thermal diffusivity values are calculated from the specimen thickness and the time required for the rear face temperature rise to reach 50% percentages of its maximum value. System also measures the specific heat capacity of a material by comparative method.

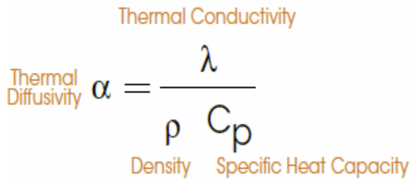
System consists of remote-controlled Class I Nd: glass laser with maximum power 35 joules. Ultrahigh tungsten furnace works under Vacuum (up to 10-6 torr) or argon atmosphere with operating temperature range RT to 2100C. It consist room temperature add-on module with temperature range RT to 200C and LN2 cooled InSb detector for rear surface temperature measurement.

A combined leaflet for (Laser Flash System + Electrical Resistivity Measurement + Magnetron Sputtering System + Microscope + Density Measurement)

Laser Flash System

The thermal diffusivity (a) is ***the speed of heat propagation by conduction during changes of temperature with time***. It is capable of measuring both thermal diffusivity and specific heat capacity of a material and calculate the thermal conductivity.

Laser Flash system has capable for measurement of thermal conductivity from room temperature to 2100°C.



Assembled Laser Flash System

RT module EM-200

Tungsten furnace

Nd:Glass laser

Contact us

High Temperature and Technologies Division

Institute for Plasma Research

Bhat, Gandhinagar 382 428
Ph. 079 2396 2073/2107/4420
Fax. 079 2396 2277
Email id: technology@ipr.res.in
https://www.ipr.res.in/httd/index.html

Contd..four probe resistivity measurement

The probes, mounted into a probe head, are gently placed in the center of the wafer as shown in the resistivity test circuit. The two outer probes, 1 and 4, are used for sourcing current. The two inner probes, 2 and 3, are used for measuring the resulting voltage drop across the surface of the sample. The bulk resistivity (rho) can be calculated by the equation:

$$\rho = \frac{\pi}{ln2}\frac{V}{I}tk = 4.532\frac{V}{I}tk$$

where:

r = the volume resistivity (W-cm)

V = the voltage measured between probes 2 and 3 (voltage)

I = the magnitude of the source current (amps)

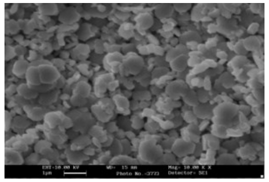
t = the sample thickness (cm)

k = a correction factor based on the ratio of the probe to wafer diameter and on the ratio of wafer thickness to probe

Magnetron Sputtering Unit

Magnetron Sputtering Unit (BC-300) system can be operated at *maximum RF power of 300W and substrate can be heated up to 1000 ^{o}C*. Vacuum chamber of the system can be evacuated to achieve coatings under high vacuum condition of the order of 1.0E-6 mbar. Various metal targets like Ti, Cu, Cr, Al, W as well as non-metal targets like Graphite can be used for sputter coating. Graphite coatings are specifically useful for achieving uniform high emissivity on surface of samples used for measurement of thermal diffusivity & specific heat using Laser flash unit EM-200 & FL-5000.

The system is equipped with vacuum pumping system, gas purging system, PLC controller with HMI touched control panel, substrate holder with heater, substrate rotating function and water chiller for continuous cooling of the vacuum chamber & Magnetron system.



SEM image, Coated sample, loading samples

Density Measurement Kit

The Archimedean principle is applied for determining the specific gravity of a solid with this measuring device. A solid immersed in a liquid is subjected to the force of buoyancy. The value of this force is the same as that of the weight of the liquid displaced by the volume of the solid.

$$\rho = \frac{W(a) \cdot \rho(fl)}{W(a) - W(fl)} \qquad \rho(fl) = \frac{G}{V}$$

Where:

ρ = specific gravity of the solid

ρ (fl) = density of the liquid

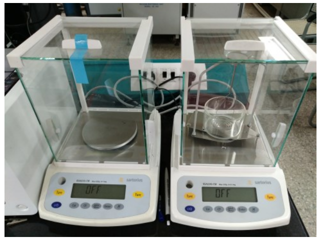
W (a) = weight of the solid in air

W (fl)= weight of the solid in liquid

G = buoyancy of the immersed solid

V = volume of the solid

With a hydrostatic balance which enables us to weigh a solid in air as well as in water, it is possible to (i) determine the **specific gravity of a solid** if the density of the liquid causing buoyancy is known. (ii) determine the **density of a liquid** if the volume of the immersed solid is known.



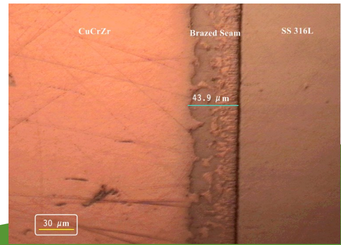
Density measurement kit

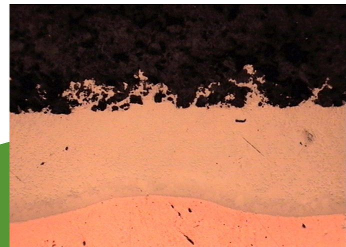
Microscope

Metallurgical Microscope -Image analysis software-CCD colour camera. (Model: SDM 210, Make: Seiwa Japan)

The microscope is generally used for optical microstructure analysis of specimen.

Magnification: 50x ~ 1500x.





Optical image of SS/CuCrZr brazed joint sample and graphite-Ti-OFHC copper/CuCrZr brazed sample