



RESISTIVITY MEASURING SYSTEMS

Resistance & Resistivity





The Resistivity Measuring Systems of Nittoseiko Analytech have been designed to ensure easy RCF calculation and thus resistivity is measured in a simple test procedure. The Systems are specialised in measuring the resistance, the surface resistivity ($\Omega/\square$) and volume resistivity ($\Omega\cdot\text{cm}$) of various substances and materials of all shapes and sizes in the high- and low-resistance measuring range.

The Powder Resistivity Measuring System contains a high precision pressure gauge for the measurement of conductive powders.

NH Instruments the exclusive representative of Nittoseiko Analytech in German speaking territories (DACH) and the Benelux Union and offer technical advice and support.

Nittoseiko Analytech

RESISTANCE AND RESISTIVITY

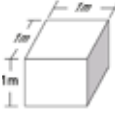
As science and technology advance, demand has increased for simple, quick and precise classification of material properties in diverse fields such as research and development, production engineering and quality control.

According to the conventional method, resistance (Ω) was used for this purpose. However, resistance does vary depending on the type, shape and size of the material and also the measuring point. Therefore, the approved measuring method uses resistivity ($\Omega\cdot\text{cm}$) which expresses absolute and real material values.

Resistivity is simply calculated by multiplying the measured resistance (Ω) with a Resistivity Correction Factor (RCF). The resistivity measuring systems of Nittoseike Analytech have been designed to ensure easy RCF calculation and thus resistivity is measured in a simple test procedure.

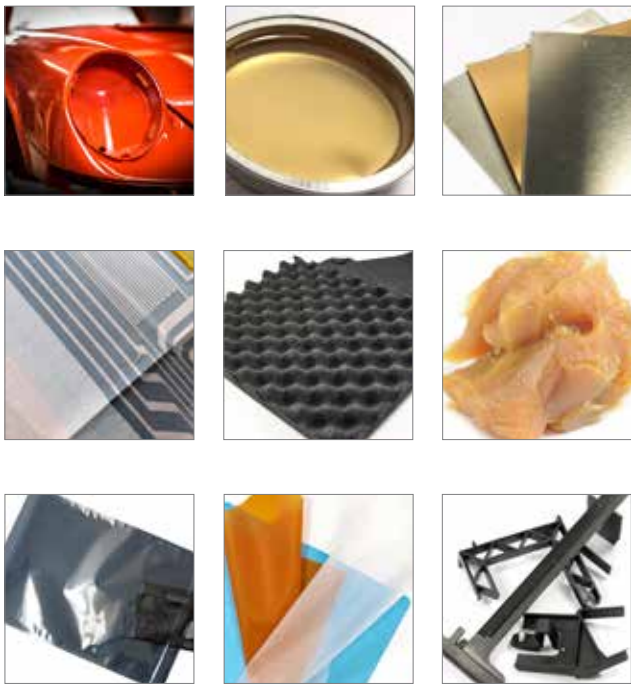
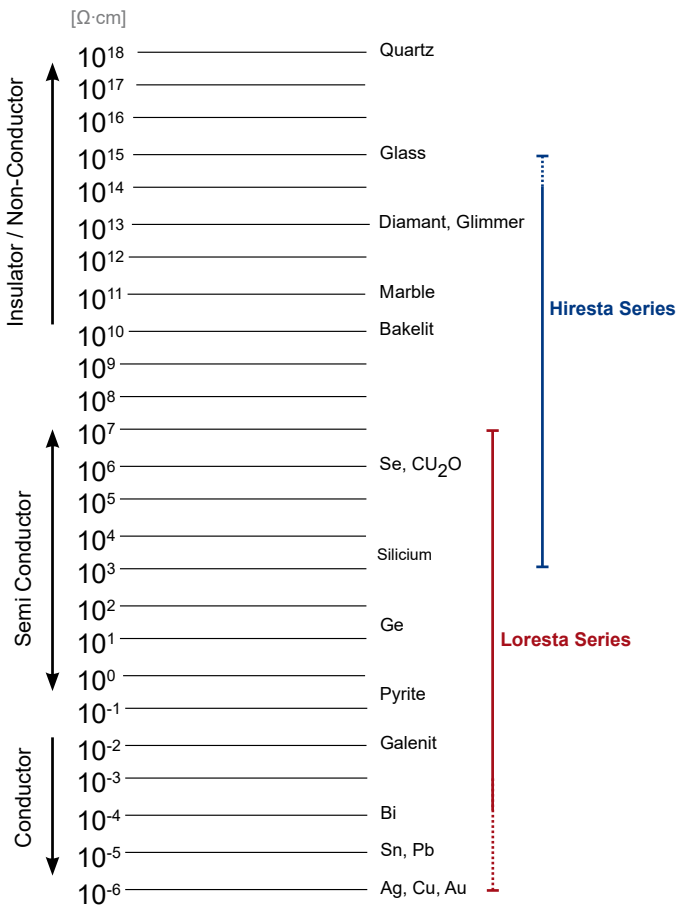
Resistivity is an absolute value

A short test proves this:

Material	Au (Gold)		
Dimensions			
Resistance [Ω]	$2.4 \cdot 10^{-8}$	$2.4 \cdot 10^{-6}$	$2.4 \cdot 10^{-2}$
Resistivity [$\Omega\cdot\text{cm}$]	$2.4 \cdot 10^{-6}$	$2.4 \cdot 10^{-6}$	$2.4 \cdot 10^{-6}$

The results show obvious differences in resistance values, although the same test material has been used. Therefore, resistivity is the best reliable index for material evaluation.

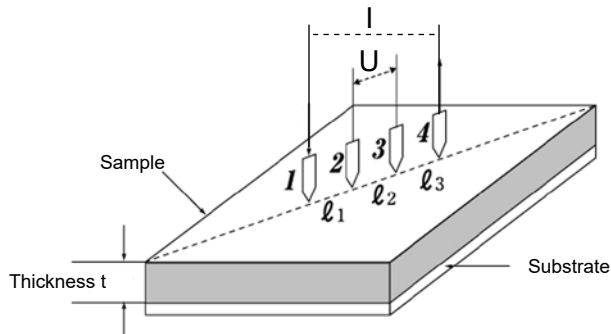
Each material has a unique resistivity value.



Resistance (R)

Ohm's law states that the current (I) through a conductor between two points is proportional to the potential difference (V) across the two points and inversely proportional to the resistance (R) between them.

$$\text{Resistance } R [\Omega] = \frac{U [\text{V}]}{I [\text{A}]}$$



Volume Resistivity (ρ_v)

Volume Resistivity (ρ_v) expresses the resistance per unit volume of a sample and is also called specific resistance. It is the term mostly used for material classification ($\Omega \cdot \text{cm}$). Each material has a unique characteristic value for volume resistivity.

$$\text{Volume Resistivity } \rho_v [\Omega \cdot \text{cm}] = R [\Omega] \cdot \text{RCF} \cdot t [\text{cm}]$$

Surface Resistivity (ρ_s)

Surface Resistivity (ρ_s) is the resistance per unit surface of a sample and is also called sheet resistance. In order to distinguish this from resistance, it is written $\Omega/\square$ or $\Omega/\text{sq.}$. Since surface resistivity varies with the sample thickness, it is often used to evaluate paint and thin films.

$$\text{Surface Resistivity } \rho_s [\Omega/\text{sq.}] = R [\Omega] \cdot \text{RCF} = \rho_v \cdot \frac{1}{t}$$

t : Materialdicke

Conductivity (σ)

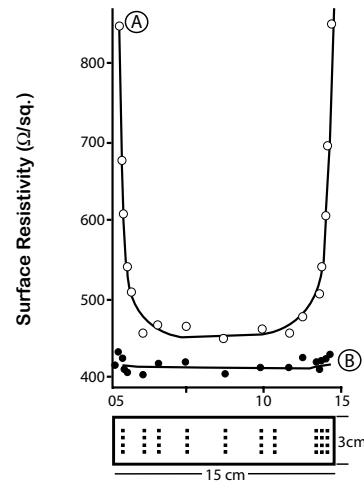
Conductivity (σ) is inversely related to volume resistivity. It is also called specific conductivity. The unit is S/cm.

$$\text{Conductivity } \sigma [\text{S/cm}] = \frac{1}{\rho_v}$$

Factors

Influence of Measuring Position, Sample Size and Thickness on Resistivity

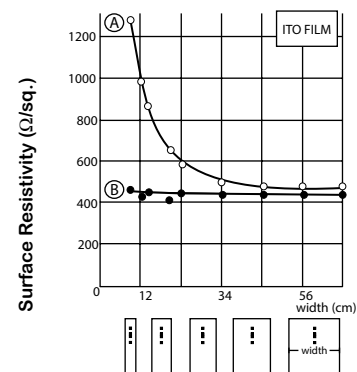
Measuring Position



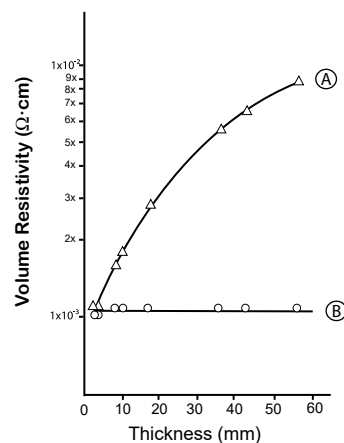
(A) shows graph with constant RCF (4.532)

(B) shows graph with variable RCF

Sample Size



Sample Thickness



Sample: isotropic graphite, Size: 7cm x 7cm
Measured with 4-pin probe at center of the sample

2- AND 4-TERMINAL METHOD

The multimeter, equipped with 2 terminals, is a cheap and simple instrument for measuring voltage, current and resistance. However, the conventional 2-terminal method is not suitable for material evaluation. The 4-terminal probe of the MCCAT Measuring Systems eliminates lead-wire connector and contact resistance. More precise measuring of resistance is achieved.

In the case of the 4-pin probe method, 4 needle-type electrodes are placed linearly on a sample, a certain current flows between 2 external pin probes (1 and 4), and a potential difference formed between 2 inner pin probes (2 and 3) is measured to determine the resistance.

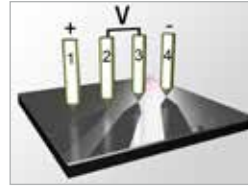
Then, multiplying the measured resistance (R in the unit of Ω) with the sample thickness (t) and the Resistivity Correction Factor (RCF) derives the volume resistivity. In this way, the 4-pin probe method and 4-terminal method have a common measurement system, but the electrode sections in contact with the sample is different. Only the placement of a probe on a sample is required for measurement in this 4-pin probe method, but electrode formation over the sample is not required unlike the 4-terminal method and thus the procedure is remarkably more efficient.



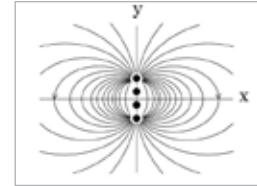
Multimeter with 2 Pins



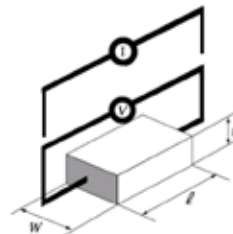
4-Pin Probe



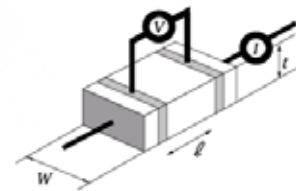
Placement on the measurement object



Electric Field Strength (4-Pin Probe)



2-Pol-Method



4-Pol-Method

RESISTIVITY CORRECTION FACTOR (RCF) - 4-PIN PROBE

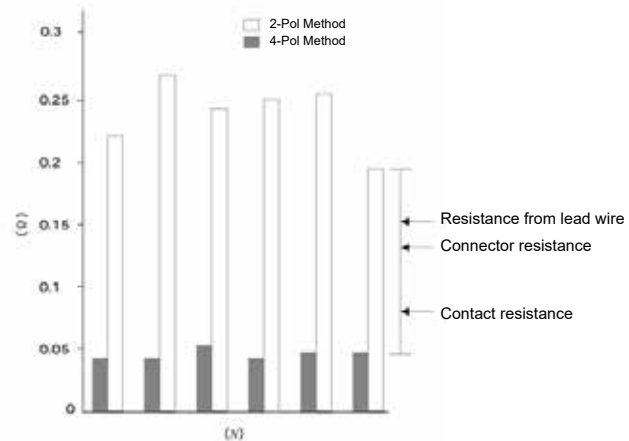
The Resistivity Correction Factor (RCF) is changed with the sample shapes and sizes as well as measuring positions. In the 4-pin probe method, since the sample size or measuring position are not fixed, the electric energy distributed in the sample is changed with the sample size and the measuring positions. If the sample size is small or the measuring position is near the sample edge, the peak of the electric field becomes higher to yield a high resistance. This is caused by the electric energy being contained in the sample. The Resistivity Correction Factor is used to obtain correct values for the volume or surface resistivity by forecasting such difference in the peak of the electric energy. The electric potential $\Phi(r)$ in an optional point in a sample and is calculated by solving a Poisson's equation under a specific condition.

Poisson'sche Equation

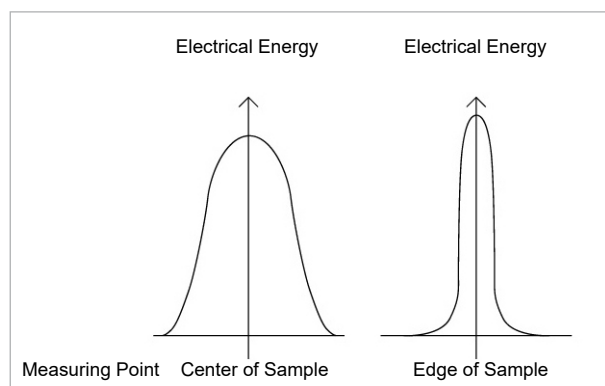
$$\nabla^2 \Phi(r) = 2 \rho_v / \epsilon \quad [\delta(r-rD) - \delta(r-rA)]$$

The Loresta-GX has a built-in software for calculating this factor and is able to derive the factor by simple input of the sample shapes (rectangular or disk) and size as well as the measuring position. The Loresta-AX uses a fixed RCF which allows a sufficient precise measuring.

The 4-pin probe method was included to the JIS K7194 (Japanese Industrial Standard) in 1994.



Comparison 2- and 4-Pol Method



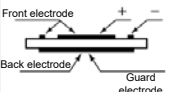
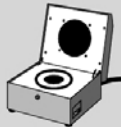
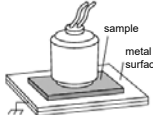
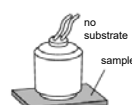
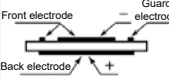
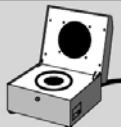
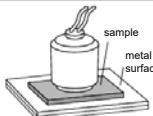
Verteilung der elektrischen Energie in einem Messobjekt

MEASURING METHOD FOR HIGH RESISTIVITY

When measuring high-resistivity material (standard value $R_x > 20M\Omega$), small current can not be applied stably. Therefore, the constant-voltage process of applying constant voltage and measuring leak current is used. The material condition of the surface is different from the one of the inside. It's necessary for material control that indicating condition by each index. The surface resistivity is results of surface condition and the volume resistivity is one of inside condition. They're defined according to JIS K 6911 or ASTM D257 standard.

The Measurement Systems of the Hiresta Series works with ring electrode probes. The probes have a concentric ring electrode.

Due to the small size of flowing current, a higher measuring voltage up to 1000V is needed. Low currents can be falsified very easy by external influences and leak currents, so a special guard technic is used. For that technic a third connection between measuring equipment and measuring object is required. This additional connection has ground potential and ensures a common reference potential for shielding, without falsify the current measurement. The outer electrode works as the guard electrode and the current passed through the exterior of the detection electrode (the inner electrode) flows to the ground. Hiresta-UX can display the RCF by selecting the surface and volume directions and a probe type.

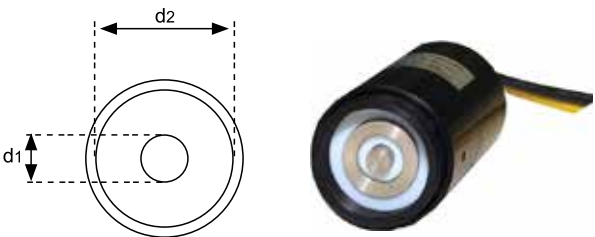
Item	ASTM-Method (ASTM D257)	Hiresta UX Method		
		JBox X Type	Method 1	Method 2
Surface resistivity				
Volume resistivity				



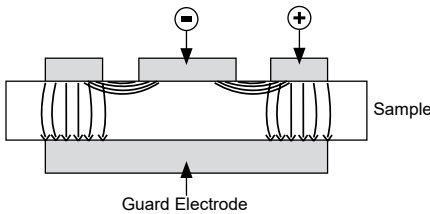
RESISTIVITY CORRECTION FACTOR (RCF) - RING ELECTRODE

The correction factors RCF (S) and RCF (V) of the ring electrode probe are determined by the electrode diameters. Correction factors of probes is registered previously in Hiresta-UX. Therefore the value can be called up automatically by selecting a probe type.

Probe	d2 (cm)	d1 (cm)	RCF _s	RCF _v
UR-SS	0.6	0.3	9.065	0.071
URS	1.1	0.59	10.09	0.273
UR	3.0	1.6	10.00	2.011
UR-100	5.32	5.0	100	19.63
UA	--	--	1.050	--
U-Type JBox	7.0	5.0	18.85	19.63

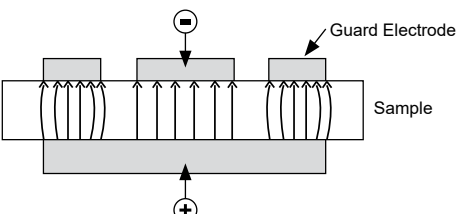


Measurement of Surface Resistivity



Surface Resistivity
 $\rho_s [\Omega/\text{sq.}] = R [\Omega] \cdot \text{RCF}_s$

Measurement of Volume Resistivity



Volume Resistivity
 $\rho_v [\Omega \cdot \text{cm}] = R [\Omega] \cdot \text{RCF}_v \cdot \frac{1}{t}$ t: sample thickness

HIGH RESISTIVITY
HIRESTA-UX

USE

R&D, Production Engineering, Quality Control
Related to ASTM D257 / ISO 2951 / JIS K 6911

APPLICATIONS

- antistatic materials
- Flooring materials
- Paper, packaging materials
- Paints, pastes, paints
- Fibers, clothes, fabrics
- Adhesives, greases
- Glass, concrete, ceramics
- Plastics, film materials, foils
- etc.

FEATURES

The Hiresta UX is specialised in measuring the resistance, the surface and volume resistivity of various substances and materials of all shapes and sizes in the high-resistance measuring range.

- 29 steps of applied voltage with Auto Sweep Function enables measuring voltage dependence of resistance value
- With the new Built-in Switch Box, volume resistivity can be measured just by connecting a „Resitable UFL“ (optional) to Hiresta UX
- Up to 2000 measurement results can be exported to USB memory stick
- The probe is designed to read fast and accurately with one touch

SPECIFICATIONS

Measuring method	Constant-voltage apply / Leak-current					
Range Switching	Automatic, Manual					
Display	7.5" TFT LC-Touch Display, 640 x 480 pixel					
Power Supply	AC 85-264V / 47-63Hz / 92VA					
Comparator	Maximum and Minimum values can be set manually					
Data Output	USB					
Dimensions	330mm x 270mm x 113mm (W x D x H) / Lid opened: 330mm x 270mm x 215mm (W x D x H)					
Weight	2,4 kg					
Standard Accessories	URS Probe RMH214, Probe Checker RMH327 (500 MΩ), Portection gloves					
Maesurement Range and Trueness	1 ~ 10V	10 ³ ~ 10 ⁹ [Ω]: ±2%	10 ¹⁰ [Ω]: ±3%			
	20 ~ 400V	10 ⁶ ~ 10 ¹⁰ [Ω]: ±2%	10 ¹¹ [Ω]: ±3%			
	500 ~ 900V	10 ⁷ ~ 10 ¹⁰ [Ω]: ±2%	10 ¹¹ [Ω]: ±3%	10 ¹² [Ω]: ±4%		
	1000V	10 ⁸ ~ 10 ¹⁰ [Ω]: ±2%	10 ¹¹ [Ω]: ±3%	10 ¹² [Ω]: ±4%	10 ¹³ [Ω]: ±5%	10 ¹⁴ [Ω]: ±12%

ACCESSORIES



RMJ360 - Fixer
for URS-Probe
(RMH214)

Probe	UR-SS	URS	UR	UR-100	UA
Application	smallest samples	standard	larger surfaces	Measurment Range 10 ¹⁵ Ω/sq.	thin samples
d2 (cm)	0.6	1.1	3.0	5.32	20mm pin distance
d1 (cm)	0.3	0.59	1.6	5.0	Ø2mm
Order No.	RMH215	RMH214	RMH212	RMH216	RMH211
Probe Checker	RMH328	RMH327	RMH326	RMH321	RMH325



Resitable UFL (RMJ354)
für Hiresta & Loresta

LOW RESISTIVITY LORESTA-GX

USE

R&D, Production Engineering, Quality Control
Related to ASTM D 991 / ISO 2878 / ISO 1853 /
JIS K 7194 / JIS R 1637

APPLICATION

- Paints, pastes, paints, printing ink
- Plastics, rubber
- metallic thin films, metallised films
- amorphous silicon / silicon wafer
- antistatic materials
- EMC shielding materials
- ITO glass, coated glass
- passivated metals
- magnesium alloys
- Coated sheet metal, steel, aluminum
- etc.

FRATURES

LORESTA-GX has a expanded measuring range of $10^{-4} \sim 10^7 \Omega$. The probe enables one-touch direct reading of $[\Omega]$, $[\Omega/\text{sq.}]$, and $[\Omega \cdot \text{cm}]$. It has a special silicon mode for silicon wafer measurement and one-touch automatic measurement by new functions like Auto-Hold and Timer Mode. The accurate low resistivity meter based on 4 Terminal 4 Pin method. It ensures a high accuracy by MCP probes' spring contact method which keeps pin pitch, pressure and contact area on samples constant.

SPECIFICATIONS

Measuring Method	4-pin probe, constant-current method
Measuring mode	Auto-Function: Auto-Hold / Timer Mode - Special Silicon measuring mode
Display	7.5" TFT LC-Touch Display, 640 x 480 Pixel
Power Supply	AC 85-264V / 47-63Hz / 40VA
Interface of data output	USB
Dimensions	320mm x 285mm x 110mm (B x T x H) / bei geöffneter Abdeckung: Höhe 220mm
Weight	2,4 kg
Standard accessories	ASP probe RMH110 (4-pin probe, inter-pin distance 5mm, pin-head radius 0.37mm) Probe checker RMH304 (1.0 Ω)

		Power Supply							
		1A	100mA	10mA	1mA	100 μ A	10 μ A	1 μ A	0.1 μ A
Range	10^{-4}	$\pm(2.0\% + 30\text{dgt})$							
	10^{-3}	$\pm(2.0\% + 20\text{dgt})$	$\pm(2.0\% + 20\text{dgt})$						
	10^{-2}	$\pm(1.0\% + 5\text{dgt})$	$\pm(1.0\% + 5\text{dgt})$	$\pm(2.0\% + 20\text{dgt})$					
	10^{-1}	$\pm(1.0\% + 3\text{dgt})$	$\pm(1.0\% + 3\text{dgt})$	$\pm(1.0\% + 5\text{dgt})$	$\pm(2.0\% + 20\text{dgt})$				
	10^0		$\pm(0.5\% + 3\text{dgt})$	$\pm(0.5\% + 3\text{dgt})$	$\pm(1.0\% + 5\text{dgt})$	$\pm(2.0\% + 20\text{dgt})$			
	10^1			$\pm(0.5\% + 3\text{dgt})$	$\pm(0.5\% + 3\text{dgt})$	$\pm(1.0\% + 5\text{dgt})$	$\pm(2.0\% + 20\text{dgt})$		
	10^2				$\pm(0.5\% + 3\text{dgt})$	$\pm(0.5\% + 3\text{dgt})$	$\pm(1.0\% + 5\text{dgt})$	$\pm(2.0\% + 20\text{dgt})$	
	10^3					$\pm(0.5\% + 3\text{dgt})$	$\pm(0.5\% + 3\text{dgt})$	$\pm(1.0\% + 5\text{dgt})$	$\pm(2.0\% + 20\text{dgt})$
	10^4						$\pm(0.5\% + 3\text{dgt})$	$\pm(0.5\% + 3\text{dgt})$	$\pm(1.0\% + 5\text{dgt})$
	10^5							$\pm(0.5\% + 3\text{dgt})$	$\pm(1.0\% + 3\text{dgt})$
	10^6								$\pm(1.0\% + 3\text{dgt})$
	10^7								$\pm(2.0\% + 5\text{dgt})$



LOW RESISTIVITY
LORESTA-AX

USE

R&D, Production Engineering, Quality Control

APPLICATION

- Paints, pastes, paints, printing ink
 - Plastics, rubber
 - metallic thin films, metallised films
 - amorphous silicon / silicon wafer
 - Coated sheet metal, steel, aluminun
- EMC shielding materials
 - ITO glass, coated glass
 - passivated metals
 - magnesium alloys
 - antistatic materials
 - etc.

FEATURES

Loresta AX is a simplified resistivity meter and uses a manually adjustable RCF. When measuring various shapes and measuring points of samples, it is recommended to use the high-grade type of resistivity meter Model Loresta GX. The Loresta-AX has a wide measuring range from 10mΩ to 10MΩ. The 4-pin probe ensures quick and precise resistivity measurements. A LC Dispaly is for easy reading of data. Data saved can be transmitted via USB-memorystick. The probe enables one-touch direct reading of [Ω], [Ω/sq.] and [Ω·cm].

SPECIFICATIONS

Measuring method	4-pin probe, constant-current method								
Measurement range [Ω]	10 ⁻²	10 ⁻¹	10 ⁰	10 ¹	10 ²	10 ³	10 ⁴	10 ⁵	10 ⁶
Supplied voltage	100mA		10mA		1mA		100μA	10μA	1μA
Measuring accuracy	± 1.0% ± 20dgt.	± 1.0% ± 5dgt.	± 0.5% ± 5dgt.	± 0.5% ± 3dgt.					± 2.0% ± 5dgt.
Display	LCD								
Power supply	AC 90-264V / 47-63Hz / Nickel-Hydrogen Battery								
Data output	USB-Memorystick								
Dimensions	85mm x 228mm x 65mm (W x D x H)								
Weight	420 g								
Standard accessories	ASP Probe, Probe checker (1.0Ω)								

ACCESSORIES LORESTA-SERIE

dgt. = digits



Probe	ASP	ESP	LSP	TFP	QPP	PSP	BSP	NSCP
Application	Standard	non-uniform samples	soft surfaces	thin films, glass substrate	small samples, thin films	small samples, thin films	large samples	hard surfaces
Inter-pin distance	5 mm	5 mm	5 mm	1.0 mm	1.5 mm	1.5 mm	2.2 mm	1.0 mm
Pin-head radius	0.37 mm	Pin Ø2 mm	Pin Ø2 mm	0.15 mm	0.26 mm	0.26 mm	0.37 mm	0.04 mm
Spring pressure	210 g/pin	240 g/pin	130 g/pin	50 g/pin	70 g/pin	70 g/pin	210 g/pin	250 g/pin
Order No.	RMH110	RMH114	RMH116	RMJ217	RMH115	RMH112	RMH111	RMJ202
Probe	RMH304	RMH304	RMH304	RMH312	RMH313	RMH311		RMH312



POWDER RESISTIVITY MEASURING SYSTEM PD-600

USE

Research & Development, Quality Control, etc.

APPLICATIONS

Powder materials of carbon products:

Materials used for rechargeable battery electrodes, condensers and resistance material and insulating electronics / cokes / graphite / carbon black / carbon fiber / nano carbon, etc.

Metal powder:

Materials used for battery electrodes, thin film materials such as copper powder or ITO powder, for circuit board materials, for example conductive paste and electro conductive paint.

Others:

Printer toner, magnetic material such as ferrite, food material, pharmaceutical related and automobile parts

SPECIFICATIONS

Measuring method	Constant-current / -voltage methods
Measuring Units	Low resistance (10^{-4} - $10^7 \Omega$) Loresta-GX High resistance (10^3 - $10^{14} \Omega$) Hiresta-UX
Power supply	AC 90 - 240V / 50 - 60Hz
Max. Load	0,01kN - 20kN (~60Mpa)
Hydraulic unit	automatic
Probe unit	20mm (Ø) x 40mm (L)
Probe types	4-Pin Electrode (inner-pin distance 3mm) Ring Electrode (Ø 20mm)
Necessary accessories	Window PC with Excel
Dimensions (W x D x H in cm)	
Main Unit	43 x 23 x 49 (42kg)
Hydraulic Pump	57 x 37 x 32 (29kg)

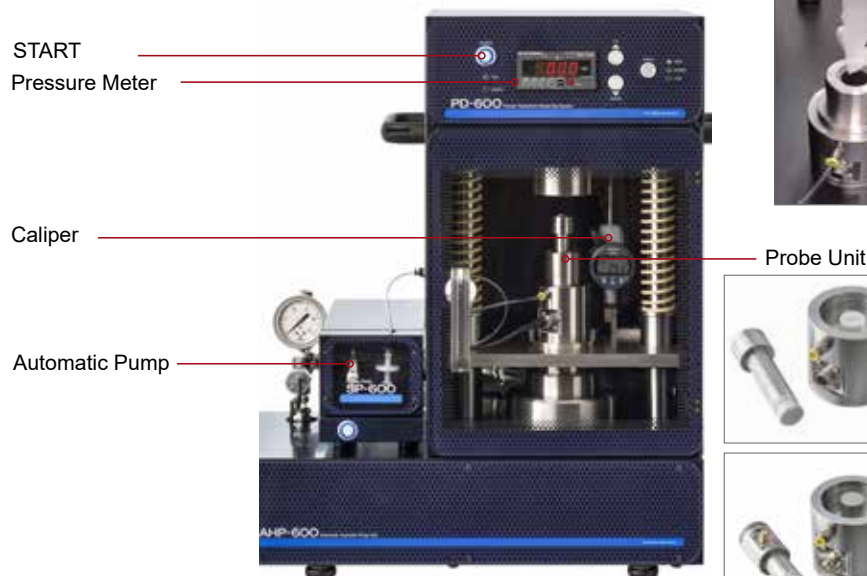


FEATURES

The Powder Measuring System MCP-PD600 contains a high precision pressure gauge for the measurement of conductive powders for maximum pressure of 20kN and is quickly attached to either the Loresta-GX or Hiresta-UX unit.

- Fully automatic, just input the load value and press START
- Newly developed cylinder pump allows measuring from low load (0.01kN)
- 4-pin probe for precise measurement of low range resistivity / Ring probe for high range resistivity
- Improved powder filling performance with a new vacuum-pump.

DETAILS

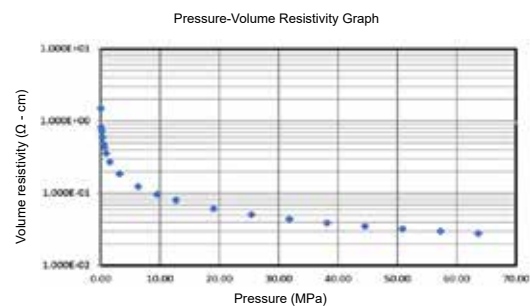


PROBES

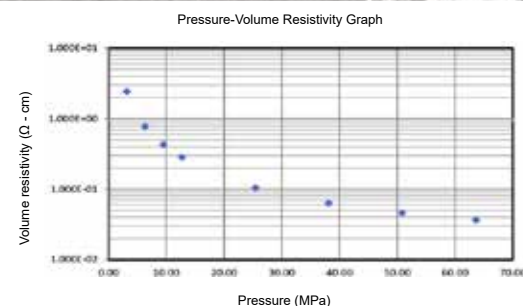


TEST REPORT (EXAMPLE)

Sample CARBON BLACK									
No.	Load (kN)	Pressure (MPa)	Thickness (mm)	RCF	Resistance (Ω)	Resistivity (Ω -cm)	Conductivity (S/cm)	Density (g/cm³)	
1	0.01	0.03	11.60	1.460	OK	8.804E-01	1.491E+00	6.706E-01	1.388E-01
2	0.03	0.10	10.94	1.539	OK	4.869E-01	8.199E-01	1.220E+00	1.472E-01
3	0.05	0.16	10.40	1.610	OK	4.378E-01	7.332E-01	1.364E+00	1.548E-01
4	0.10	0.32	9.58	1.730	OK	3.639E-01	6.032E-01	1.658E+00	1.681E-01
5	0.15	0.48	9.03	1.819	OK	2.969E-01	4.878E-01	2.050E+00	1.783E-01
6	0.20	0.64	8.72	1.874	OK	2.663E-01	4.354E-01	2.297E+00	1.846E-01
7	0.29	0.92	8.21	1.972	OK	2.206E-01	3.569E-01	2.802E+00	1.963E-01
8	0.49	1.56	7.50	2.121	OK	1.713E-01	2.724E-01	3.671E+00	2.148E-01
9	1.00	3.18	6.47	2.372	OK	1.213E-01	1.863E-01	5.368E+00	2.448E-01



Sample IRON POWDER									
No.	Load (kN)	Pressure (MPa)	Thickness (mm)	RCF	Resistance (Ω)	Resistivity (Ω -cm)	Conductivity (S/cm)	Density (g/cm³)	
1	0.09	3.15	4.19	3.096	OK	1.875E+00	2.433E+00	4.110E-01	3.039E+00
2	1.99	6.33	4.02	3.155	OK	6.127E-01	7.777E-01	1.286E+00	3.166E+00
3	2.99	9.52	3.90	3.200	OK	3.442E-01	4.291E-01	2.330E+00	3.269E+00
4	3.99	12.70	3.78	3.241	OK	2.309E-01	2.827E-01	3.537E+00	3.371E+00
5	7.99	25.43	3.46	3.349	OK	8.970E-02	1.039E-01	9.624E+00	3.682E+00
6	11.97	38.10	3.23	3.424	OK	5.725E-02	6.330E-02	1.580E+00	3.994E+00
7	15.97	50.83	3.05	3.479	OK	4.331E-02	4.594E-02	2.177E+00	4.177E+00
8	19.99	65.63	2.91	3.520	OK	3.560E-02	3.647E-02	2.742E+00	4.376E+00





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