

RESISTIVITY MEASURING SYSTEMS

Resistance & Resistivity



Nittoseiko Analytech



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 (Ω/\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.

RESISTANCE AND RESISTIVITY

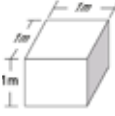


As science and technology advance, demand has increased for simple, quick and precise classification of material properties in diverse fields such as research and development, production engineering and quality control.

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 Mitsubishi Chemical Analytech (MCCAT) have been designed to ensure easy RCF calculation and thus resistivity is measured in a simple test procedure.

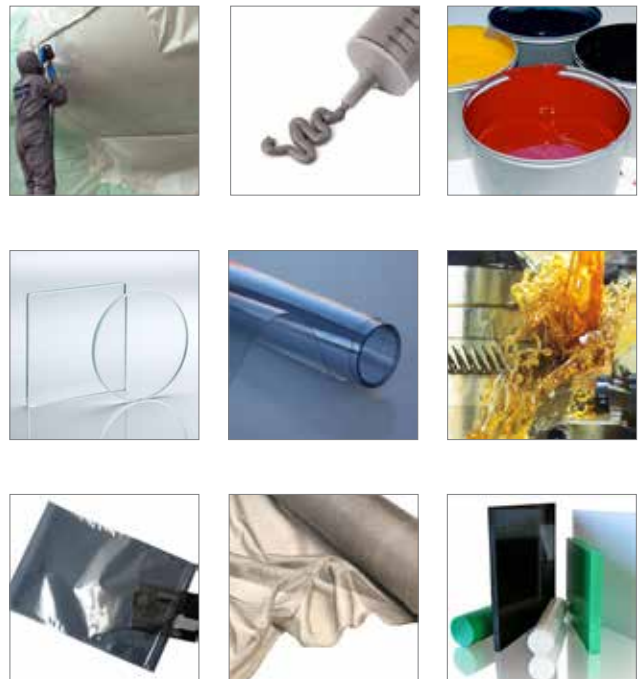
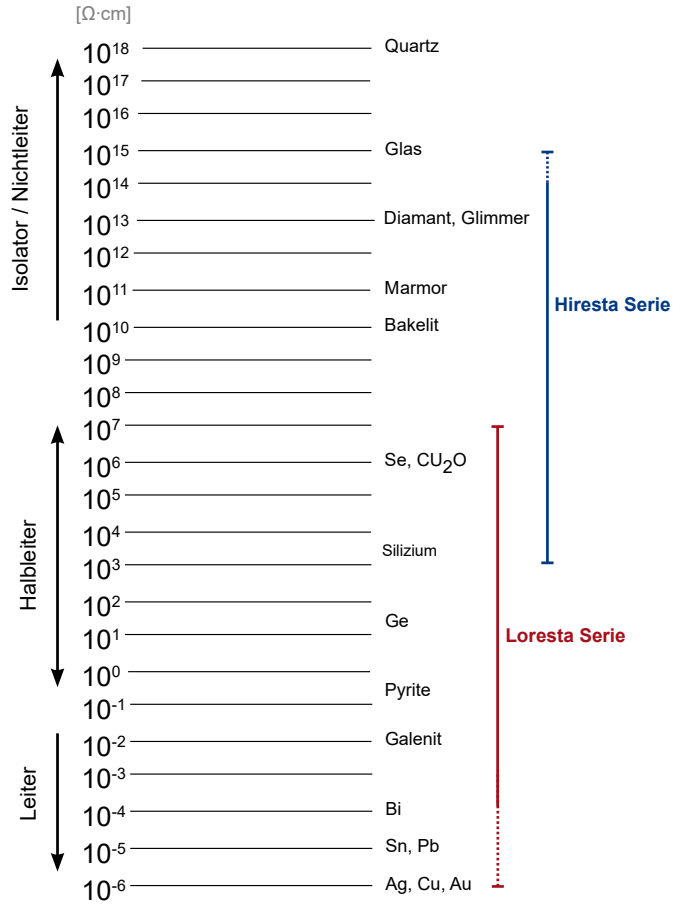
Resistivity is an absolute value

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.

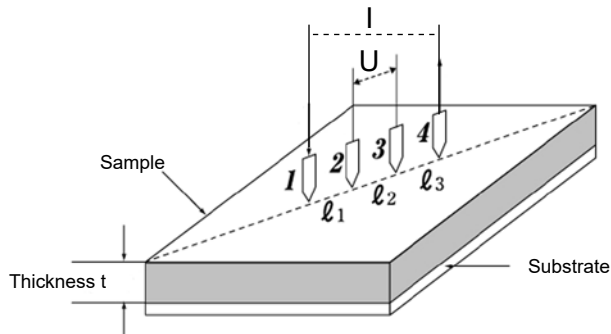
Each material has a unique resistivity value.



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 Ω/\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)

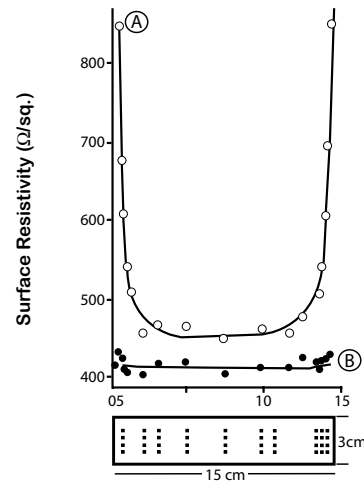
Conductivity (σ) is inversely related to volume resistivity. It is also called specific conductivity. The unit is S/cm.

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

Factors

Influence of Measuring Position, Sample Size and Thickness on Resistivity

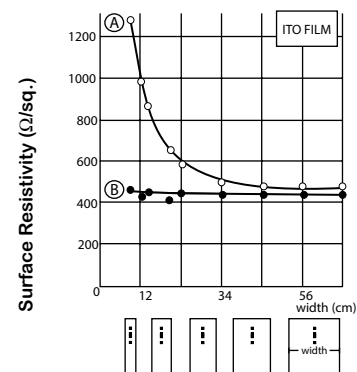
Measuring Position



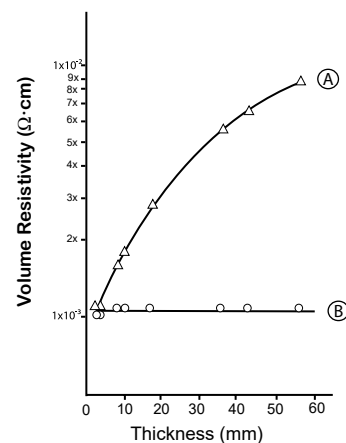
(A) shows graph with constant RCF (4.532)

(B) shows graph with variable RCF

Sample Size



Sample Thickness



Sample: isotropic graphite, Size: 7 cm x 7 cm
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.

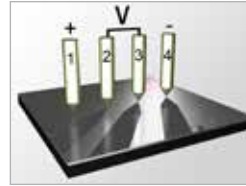
Then, multiplying the measured resistance (R in the unit of Ω) with the sample thickness (t) and the Resistivity Correction Factor (RCF) derives the volume resistivity. In this way, the 4-pin probe method and 4-terminal method have a common measurement system, but the electrode sections in contact with 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.



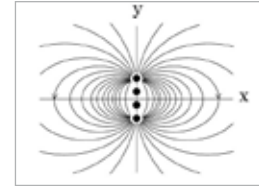
Multimeter with 2 Pins



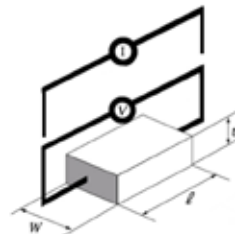
4-Pin Probe



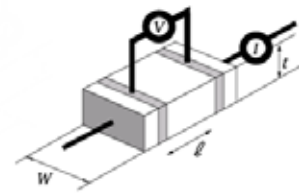
Placement on the measurement object



Electric Field Strength (4-Pin Probe)



2-Pol-Method



4-Pol-Method

RESISTIVITY CORRECTION FACTOR (RCF) - 4-PIN PROBE

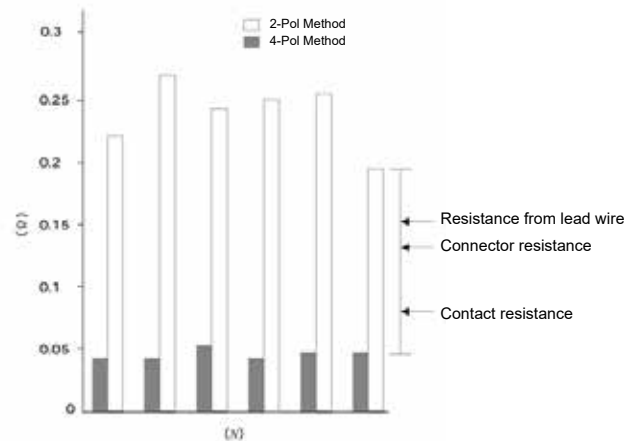
The Resistivity Correction Factor (RCF) is changed with the sample shapes and sizes as well as measuring positions. In the 4-pin probe method, since the sample size or measuring position are not fixed, the electric energy distributed in the sample is changed with the sample size and the measuring positions. 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

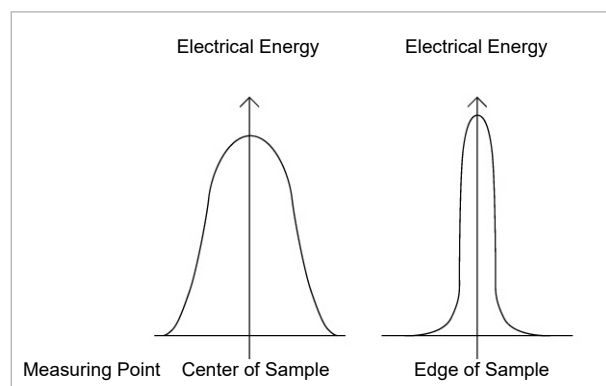
$$\Delta \Phi(r) = 2 \rho_v \int [\delta(r-rD) - \delta(r-rA)]$$

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 on JIS K 6911-2006 or ASTM 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 D 257)	MCC-Method (Mitsubishi Chemical Method)		
		U type JBox	Method 1	Method 2
Surface resistivity				
Volume resistivity				---

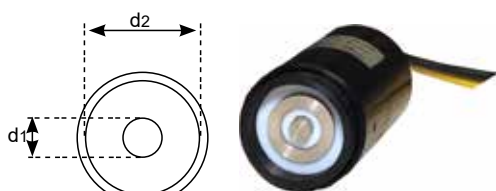


Box for JIS K 6911-1995

RESISTIVITY CORRECTION FACTOR (RCF) - RING ELECTRODE

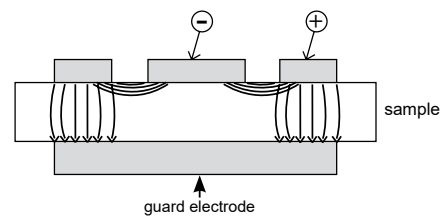
The correction factors RCF (S) and RCF (V) of the ring electrode probe are determined by the electrode diameters. Correction factors of probes is registered previously in Hiresta-UX. Therefore the value can be called up automatically by selecting a probe type.

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
J-Box	7.0	5.0	18.85	19.63
UA	--	--	1.050	--



Ring electrode probe

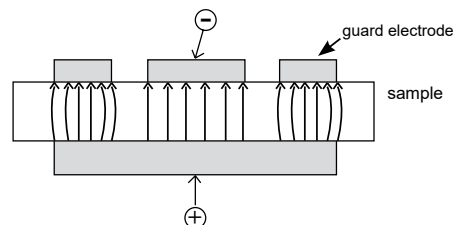
Measurement of Surface Resistivity



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

HIRESTA-UX MCP-HT800

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 „Resistable 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), Protection gloves				
Measurement 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
 Probe Fixer for
 URS-Probe
 (RMH214)

Probe	UR-SS	URS	UR	UR-100	UA
Application	smallest samples	standard	larger surfaces	Measurement Range 10 ¹⁵ Ω/sq.	thin samples
d2 (cm)	0.6	1.1	3.0	5.32	20 mm 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



Resistable UFL (RMJ354)
 for Hiresta & Loresta

LOW RESISTIVITY

LORESTA-GX MCP-T-700



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} ~ 10^7 Ω . The probe enables one-touch direct reading of [Ω], [Ω /sq.], and [Ω -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 MCP-T-370

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, aluminum
- 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 fixed 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 Display 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-probe	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

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



FEATURES

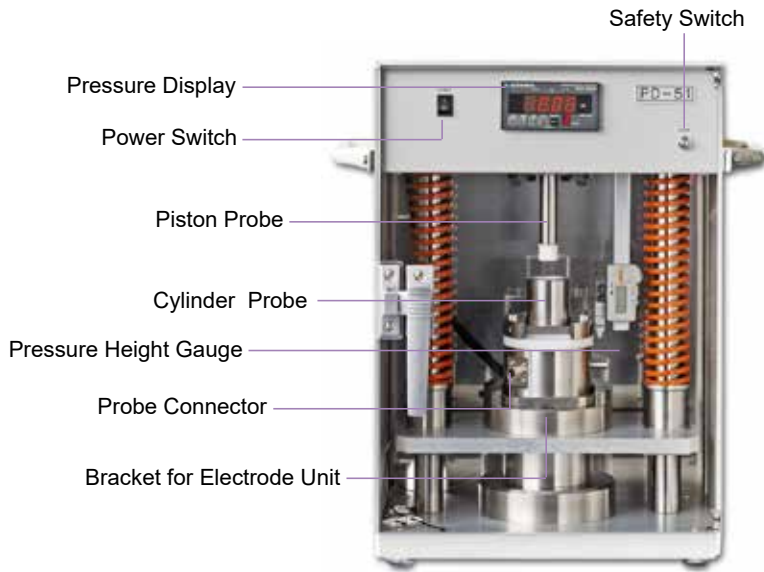
The Powder Measuring System MCP-PD51 contains a high precision pressure gauge for the measurement of conductive powders for maximum pressure of 20kN and is quickly attached to either the Loresta-GX or Hiresta-UX unit.

- Easy sample change and cleaning
- 4-pin probe for precise measurement of low range resistivity
- Ring probe for high range resistivity
- Powder is pressed in a cylindrical shape for measuring

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 to the power unit	20kN (ca. 60MPa)
Hydraulic unit	Oil pressure (manual operation)
Probe unit	20mm (Ø) x 50mm (L)
Probe types	4-pin electrode (inner-pin distance 3mm) Ring electrode (Ø 20mm)
Dimensions	430mm x 230mm x 490mm (W x D x H)
Weight	Main unit 56kg, Hydraulic unit 22kg
Necessary accessories	Window PC with Excel

DETAILS



PROBES



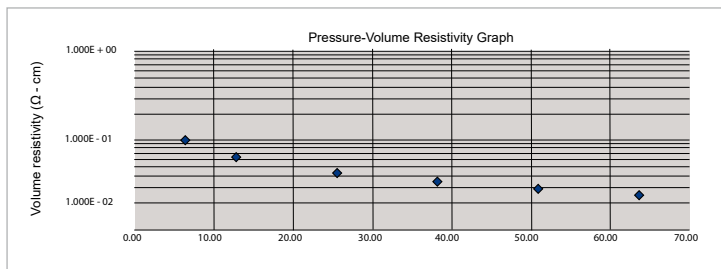
For Low Resistivity Measurement
(Electrode for 4 Terminal Method)
MCP-PD511



For High Resistivity Measurement
(Ring Electrode)
MCP-PD522

TEST REPORT (EXAMPLE)

Sample			CARBON BLACK						
No.	Load (kN)	Pressure (MPa)	Thickness (mm)	RCF	Resistance (Ω)		Volume resistivity (Ω -cm)	Conductivity (S/cm)	Density (g/cc)
1	2.00	6.37	4.95	2.833	OK	7.078E-02	9.926E-02	1.007E+01	6.431E-01
2	4.00	12.73	4.15	3.110	OK	5.132E-02	6.624E-02	1.510E+01	7.670E-01
3	8.00	25.46	3.46	3.349	OK	3.788E-02	4.389E-02	2.278E+01	9.200E-01
4	12.00	38.20	3.10	3.463	OK	3.206E-02	3.442E-02	2.906E+01	1.027E+00
5	16.00	50.93	2.86	3.533	OK	2.860E-02	2.890E-02	3.460E+01	1.113E+00
6	20.00	63.66	2.64	3.590	OK	2.570E-02	2.436E-02	4.106E+01	1.206E+00



NOTICE



In our division NH Instruments we distribute the Resistivity Measuring System from Nittoseiko Analytech and offer the appropriate technical advice and support.

Nittoseiko Analytech from Japan has been developing and manufacturing measuring instruments for chemical analysis technology for more than 40 years. The product range includes u.a. Measuring instruments for determining surface conductivity, volume resistivity and conductivity of pulverized materials. The measuring instruments are mainly used in the field of industrial quality assurance.

Service

- Presentation and demonstration at our laboratory at N&H in Willich, Germany or on site
- Individual and low-cost solutions provided on-site
- Installation of systems and machinery with On-Site Training
- Maintenance and Service contracts (optional)

Sample Measurement



We also offer the analysis of your materials as a service in our laboratory. After the measurement, you will receive a detailed measurement protocol. Please contact us for an individual offer.

Contact



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