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CONDUCTIVE PASTES

Materials for high-tech revolution

Innovative, Technological Advancements

Innovative materials for completion of advanced technology -
Changsung's conductive paste spreads its application
from alternative energy field
to high efficiency energy industry.

Chang Sung Corporation CSC

CONDUCTIVE PASTES

Conductive pastes are well distributed compounds of metal powders or inorganic powders in organic fluid vehicle systems.
The mixture of conductive fillers, organic vehicles (solutions of polymers in solvents), glass frits, ceramic powders and several kinds of additives by printing, spraying or dipping and then by drying or heating process, it has conductive property.

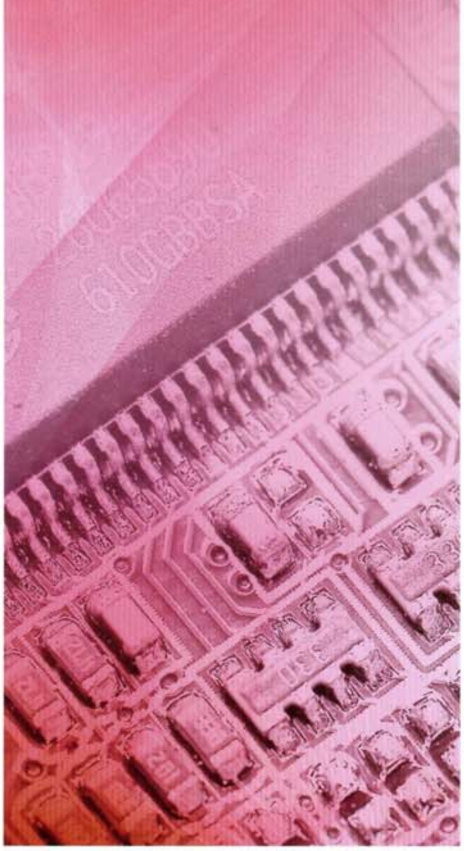
▼ Types of Conductive Pastes

CURING TYPE CONDUCTIVE PASTES

- Membrane Touch Switch
- PCB Through-Hole
- Flexible Printed Circuit Boards
- Touch Screen Electrode
- RFID Tag Antenna
- Insulation Coating

FIRING TYPE CONDUCTIVE PASTES

- Chip Varistor
- Chip Inductor
- MLCC
- Silicon Solar Cell
- Dye-Sensitized Solar Cell
- Piezo / Microwave Products



LOW TEMPERATURE SINTERING PASTES

- Low Temperature Sintering Pastes

▼ MANUFACTURING PROCESS

THE CONDUCTIVE PASTE IS COMPLETED BY CHANG SUNG WITH LEADING-EDGE TECHNOLOGY.

1_Metal Powder

For special characteristics of various metal powders, particle size, distribution and morphology are controlled by advanced powder manufacturing processes.

2_Premixing

Inorganic powders including metal powders were wetted homogeneously through premixing before dispersing process.

3_Dispersion

The aggregations of metal powder were separated into the individual particles and they were completely wetted and stabilized by organic vehicle through dispersing process.

4_Inspection

Final products were inspected based on customer's specification.

CURING TYPE CONDUCTIVE PASTES

PASTES FOR MEMBRANE TOUCH SWITCH

Product No.	Filler	Curing Conditions	Resistance (mΩ/□/mil)	Viscosity (Pa·s)	Comments
Paron-910 Series	Ag	130°C/30~60min	15~50	15	Low resistivity
Paron-961		140°C/30~60min	20	15	Halogen free, Low resistivity
Paron-960			15	20	Halogen free, Excellent flexibility
Paron-950 Series		80°C/30~60min	15~30	25	Low temperature curing
Paron-931		130°C/30~60min	50	20	Low cost
Paron-930	Ag+C		40	15	Carbon blended, Low cost
Paron-920	C		40,000	20	Excellent flexibility

▸ Applications
- Membrane touch switch
- Flexible circuit
- Heating element

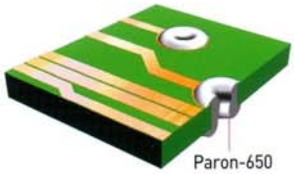
▸ Main Features
- High conductivity
- Excellent flexibility
- Fine line resolution

PASTES FOR PCB THROUGH-HOLE

Product No.	Filler	Curing Conditions	Resistance (mΩ/□/mil)	Viscosity (Pa·s)	Comments
Paron-621	Ag	50°C, 70°C,150°C /each 30min	200	6	High reliability, Low resistivity
Paron-650	(Ag/Cu)			6	Low cost
Paron-630	C	150°C/30min	2 X 10^5	15	Low resistivity

▸ Applications
- Double side PCBs

▸ Main Features
- High conductivity
- Excellent adhesion to Cu plate and phenolic board
- No defects like pinholes and cracks



PASTES FOR FLEXIBLE PRINTED CIRCUIT BOARDS

Product No.	Filler	Curing Conditions	Resistance (mΩ/□/mil)	Viscosity (Pa·s)	Comments
Paron-610	Ag	150°C/30min	200	25	Low cost
Paron-611				25	High reliability, Low resistivity
Paron-612	Resin		-	25	Excellent flexibility

▸ Applications
- Shielding for flexible PCBs
- Conductive circuit for flexible PCBs

▸ Main Features
- Excellent adhesion to PI film
- Excellent flexibility

PASTES FOR TOUCH SCREEN ELECTRODE

Product No.	Filler	Curing Conditions	Resistance (mΩ/□/mil)	Viscosity (Pa·s)	Fine line width(μm)	Comments
Paron-810	Ag	130°C/30min	30	25	100	Resistive type touch screen
Paron-810A			30	25	100	
Paron-810E	Ag+Ni		60	20	200	
Paron-811	Ag		30	80	50	Capacitive type touch screen
Paron-811A			30	70	70	

▶ Applications
- Resistive type touch screen
- Capacitive type touch screen

▶ Main Features
- High conductivity and low contact resistance
- Excellent adhesion to ITO electrodes and PET film
- Fine line resolution

PASTES FOR RFID TAG ANTENNA

Product No.	Filler	Curing Conditions	Resistance (mΩ/□/mil)	Viscosity (Pa·s)	Comments
Paron-320	Ag	130°C/20min	10	25	Low resistivity
Paron-321			20	25	High resolution
Paron-322	Ag/Cu		50	25	Low cost

▶ Applications
- 13.56MHz & 900MHz
- RFID Tag Antenna

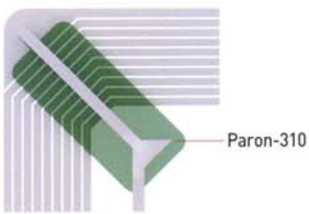
▶ Main Features
- High conductivity
- Excellent adhesion to PET and PI film
- Fine line resolution

PASTE FOR INSULATION COATING

Product No.	Filler	Curing Conditions	Insulation Resistivity (mΩ/□/mil)	Viscosity (Pa·s)	Comments
Paron-310	Resin	300 ~ 600 mJ/cm²	10^{10}	15	Green color
Paron-310T		500 ~ 1,000 mJ/cm²		15	Colorless & Transparency

▶ Applications
- Insulation Coating
- Spacers

▶ Main Features
- Excellent insulation resistance
- Excellent adhesion to treated or untreated PET film
- Excellent flexibility



FIRING TYPE CONDUCTIVE PASTES

PASTES FOR CHIP VARISTOR

Product No.	Filler	Firing Conditions	Viscosity (Pa·s)	Comments
Paron-V10	Pd	1,100 ~ 1,300°C	50	High reliability
Paron-V23	Ag/Pd=7:3	950 ~ 1,150°C	30	Electrical property control
Paron-V22	Ag/Pd=8:2	900 ~ 1,050°C	35	Electrical property control, Low cost
Paron-V27C	Ag	600 ~ 800°C	45	Excellent solderability

▶ Applications
- Internal and terminal electrodes of Chip Varistor

▶ Main Features
- Internal electrode
  - High reliability
  - Excellent electric properties
  - Cp controlled with the same metal contents
- Terminal electrode
  - Excellent solderability
  - Strong adhesion strength

PASTES FOR CHIP INDUCTOR

Product No.	Filler	Silver Content(%)	Firing Conditions	Viscosity (Pa·s)	Comments
Paron-L61	Ag	85~90	850 ~ 900°C	200	Excellent conductivity
Paron-L69		86~88	850 ~ 900°C		Excellent line resolution
Paron-L65		55~65	600 ~ 800°C	50	Excellent solderability

▶ Applications
- Internal and terminal electrodes
  - Multilayer inductor
  - Chip bead
  - Power inductor
  - Common mode filter

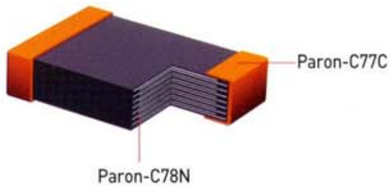
▶ Main Features
- Internal electrode
  - High reliability
  - Fine line resolution after printing and firing
  - Excellent surface roughness
- Terminal electrode
  - Excellent solderability
  - Strong adhesion strength to ceramic

PASTES FOR MLCC

Product No.	Filler	Firing Conditions	Viscosity (Pa·s)	Comments
Paron-C78N	Ni	1,200 ~ 1,300°C	18	High degree of dispersion Thin and uniform thickness
Paron-C77C	Cu	800~850°C	35	Good thermal match to ceramic

▶ Applications
- Internal and Terminal electrodes of MLCC
- Inert and reducing atmosphere

▶ Main Features
- Internal electrode
  - High degree of dispersion
  - Thin and uniform thickness
  - Low shrinkage
- Terminal electrode
  - Good adhesion
  - Good thermal match to ceramic



FIRING TYPE CONDUCTIVE PASTES

PASTES FOR SILICON SOLAR CELL

Product No.	Filler	Silver Content(%)	Firing Conditions	Viscosity (Pa·s)	Comments
Paron-S81	Ag	80 ~ 86	700 ~ 800℃/2~5sec (Actual peak temperature)	250	Pb & Cd free - Suitable for SiNx Low contact resistance
Paron-S82	Al	70 ~ 82		50	Excellent adhesion to the Si-wafer Smooth surface roughness

▶ Applications
- Front electrodes for Si solar cell
- Back surface electrode for Si solar cell

▶ Main Features
- High reliability
- Excellent electric properties
- Excellent adhesion to the Si-wafer

PASTES FOR DYE-SENSITIZED SOLAR CELL (DSSC)

Product No.	Filler	Silver Content (%)	Firing Conditions	Viscosity (Pa·s)	Comments
Paron-S83	Ag	83 ~ 86	450 ~ 500℃/30min	150	Excellent adhesion to the substrate Low contact & Line resistance
Paron-S84	Glass	65 ~ 75	500℃/30min	100	Excellent durability in electrolyte Excellent adhesion

▶ Applications
- DSSC
  - Conductive electrode for glass substrate
  - Electrode Protection

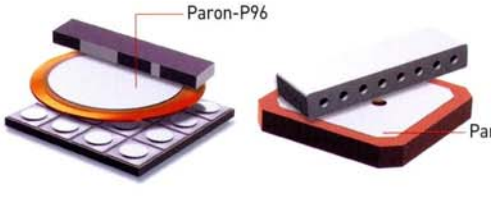
▶ Main Features
- Ag Paste
  - Low contact resistance
  - Good adhesion
- Glass Paste
  - Excellent durability
  - Excellent adhesion

PASTES FOR PIEZO/MICROWAVE PRODUCTS

Product No.	Filler	Silver Content (%)	Firing Conditions	Viscosity (Pa·s)	Comments
Paron-P96	Ag	60	750 ~ 850℃	100	Controlled shrinkage
Paron-W38		80	800 ~ 890℃	200	High Q-factor
Paron-W38A		80	830 ~ 880℃	200	High solder resistance
Paron-W38E		50	800 ~ 890℃	100	High Q-factor, Low cost

▶ Applications
- GPS Patch Antenna
- Dielectric Chip Antenna
- Piezo-Electric Product

▶ Main Features
- Piezo Product
  - Excellent solderability
  - Strong adhesion to piezo ceramics
- Microwave Product
  - High solder resistance
  - Excellent adhesion strength



LOW TEMPERATURE SINTERING PASTES

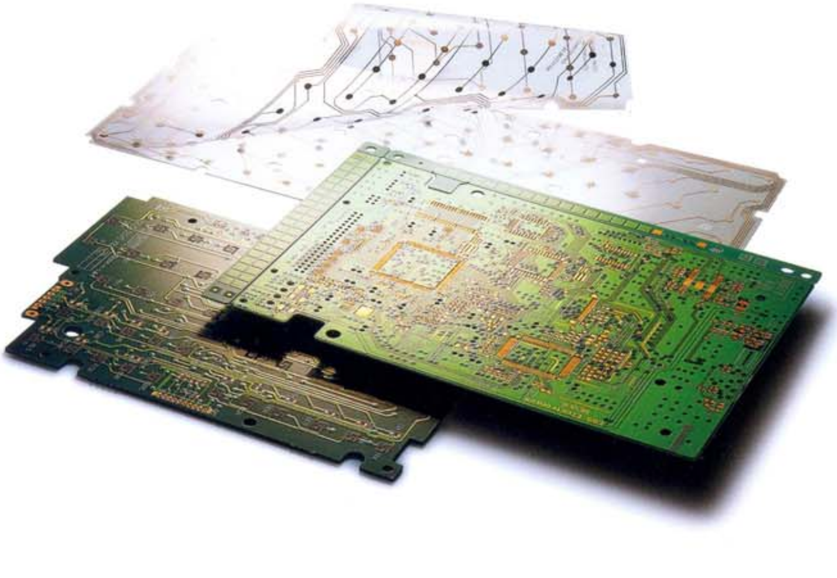
Product No.	Filler	Sintering Conditions	Specification	Comments
Paron-350	Ag	150°C/20min	Sheet Resistivity 2mΩ/□/mil	Excellent Conductivity Screen printing, R2R printing
Paron-351	Ag	170°C/20min	Thermal Conductiviy > 80 W/m·K	High Thermal conductivity Good adhesion on substrate
Paron-352	Ag	170°C/20min	Super height > 100um Sheet Resistivity 8mΩ/□/mil	High conductivity after sintered Screen printing
Paron-353	Ag (Ag/Cu)	170°C/20min	Sheet Resistivity 12mΩ/□/mil	Good hole plugging Excellent chemical stability Low cost compared with silver
Paron-360	Cu	250°C/20min	Sheet Resistivity 4mΩ/□/mil	Good conductivity Screen printing, R2R printing

▶ Applications

- FPCB(Flexible Printed Circuit Board)
- RFID Tags
- Solar cells
- Electromagnetic shielding patterns
- Touch sensors
- LED Die Attach Adhesive
- B2it Bump
- PCB Hole Plugging

▶ Main Features

- Low temperature sintering
- Excellent conductivity



CONDUCTIVE PASTES APPLICATIONS

More Thinner, Lighter, and Economical
CSC conductive paste adds infinite power
to the leading edge technology.

CSC's R&D CENTER

The R&D center continues to be the core competency in supporting Changsung to be a global leading company in the conductive paste industry and to develop the product for brighter future.

MATERIALS TO COMPLETE A VARIETY

EQUIPMENTS

- Scanning Electron Microscope
- Laser Particle Size Analyzer
- Surface Area Analyzer(BET)
- Atomic Absorption Spectrometer
- Optical Emission Spectrometer
- Optical Microscope
- Stereo Microscope
- Thermal Analysis Equipment (TG/DTA)
- Differential Scanning Calorimeter
- Vibrating Sample Magnetometer
- Universal Testing Machine
- Color and Color Difference Meter
- Electrolysis Analyzer
- Sonic Sifter
- Oxygen / Nitrogen Analyzer
- Hardness Testers
- Electric Furnaces
- Zeta Potential Meter
- B-H Analyzer
- Gloss Meter
- FT-IR
- Dilatometer
- Solar simulator
- Color 3D laser scanning microscope

GUIDE TO SCREEN PRINTING PROCESS

1. Screen

The frame must be flat enough to ensure that it is parallel to the substrate surface. The mesh materials should be flexible to conform to surface variation of the component being printed and resilient to return to its original shape after passage of the squeegee. The screen tension should be sufficient enough to stretch the mesh to cause the screen to peel away from the substrate after printing.

2. Squeegee

The squeegee material should be resistant to the solvents, vehicles and screen cleaner. Polyurethane is the most popular. The width of the squeegee must be large enough to depress the mesh evenly across the printed area of the screen. The distance from each end to the frame will depand on the type of mesh, its tension, the screen gap, the hardness of squeegee and the size of printing pattern. Wear is slow process and deterioration of print quality is not easily observed, so the squeegee should be checked before every use.

3. Process variables

1) Squeegee Pressure

Pressure uniformity along the length of the substrate is ensured by having the squeegee pressures are 0.2~0.5Kg/cm of squeegee length. For good thickness uniformity it is helpful to increase the squeegee pressure. On very uneven surfaces, pressure must be increased and the use of a more flexible mesh would be advantageous.

2) Squeegee speed

A range of 50~300mm/sec covers most requirements. For high viscosity, thin thickness and good repeatability, slow speed is required.

3) Attack angle

Print thickness decreases as the squeegee becomes more perpendicular to the screen surface. High squeegee pressure, high paste viscosity, high squeegee speed and the use of stainless steel mesh will decrease more the attack angle.

Poor fill and good clearance | Good fill and clearance | Good fill and poor clearance | "60 degree"squeegee but 45 degrees at tip

4) Screen gap

The stripping action can be controlled by adjustment of the screen gap. The screen gap required will vary with screen tension, image area, ink viscosity, squeegee speed, ect. A good starting figure can be obtained by multiplying the width of the screen by 0.004 for stainless steel, 0.006 for polyester, 0.010 for nylon.

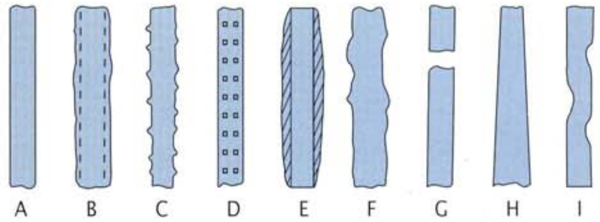
5) Down stop

The squeegee may be prevented mechanically from descending below a set height, corresponding with a position slightly below the component surface. The drop of the squeegee is approximately 0.1mm below the top of the component by using a down stop.

4. Characteristics of a print

There are three important characteristics of a print during printing process. Its shape, position and thickness must be controlled exactly to get a best quality print.

1) Shape



	Defect	Cause
A	Ideal	
B	Line widening	Too Low yield point Too low viscosity
C	Scalloping of edges	Too high viscosity Too high squeegee pressure
D	Marked screen pattern	Too high yielding point
E	Bleed out on edges	Improper wetting Too coarse filler
F	Smearing	Too much surfactant
G	Broken line	Too sharp step on substrate
H	Uneven thickness	Poor screen alignment
I	Lines not full width	Too large screen gap

2) Position

Three point location(Three fixed stop) gives unique position and vacuum is provided to hold the component down in the fixture. the component should be surrounded by asqueegee support to pressing the screen against the edge of component. The component must protrude slightly (0.1~0.2mm) above the surround.

3) Thickness

The parameters effecting print thickness.

	Variable	**High**	**Low**
Printer	Squeegee pressure	thin	thick
	Squeegee speed	thick	thin
	Squeegee angle	thin	thick
	Squeegee hardness	thin	thick
	Screen gap	thick	thin
	Down stop	thick	thin
Process	Theoretical paste volume	thick	thin
	Emulsion thickness	thick	thin
	Paste viscosity	thick	thin
Others	Temperature	thin	thick
	Squeegee wear	thick	thin
	Screen tension	thick	thin

PHYSICAL PROPERTIES OF CONDUCTIVE PASTES

Viscosity

Viscosity is the most widely used parameter to access a paste's flow behavior. It is the internal resistance exerted by a fluid to the relative motion of its parts and is expressed in units of pascal seconds(Pa · sec). It is defined as shear stress divided by shear rate, where shear stress is the force in pascals applied to a viscous fluid to cause its movement, and shear rate, in reciprocal seconds, is the rate of travel of two parallel plates separated by a fluid, divided by the distance between the plates(cm/sec·cm^{-1}=sec^{-1}).
It can be expressed as follows;

$$\eta = \text{Viscosity} = \frac{\text{Shear stress(Pa)}}{\text{Shear rate}(sec^{-1})} = \frac{F}{S}$$

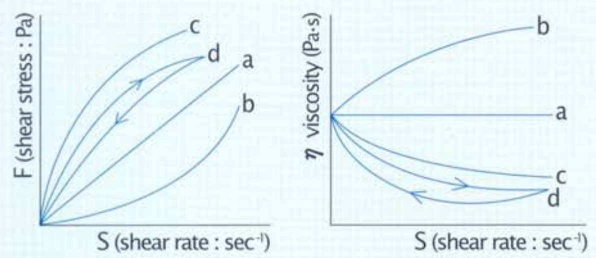
(1Pa • s = 10poise = 1000cps)

* Viscometer
- Brookfield HBDV-II+
- RION VT-04
- Malcom : PCU-205

** Standard : JIS K 7117

Thixotropic Index (TI)

The flow behavior of conductive paste, which is the mixture of inorganic filler and organic vehicle, is thixotropic flow. In the figure below, various kinds of flow behavior are illustrated.



a : Newtonian flow
b : Dilatant flow
c : Pseudoplastic flow
d : Thixotropic flow

A thixotropic flow undergoes a decrease in viscosity with time, while it is subjected to constant shearing.

When subjected to various rates of shear, the "up" and "down" curves of thixotropic flow do not coincide. This "hysteresis loop" is caused by the decrease in fluid viscosity with increasing time of shearing.
Thixotropic index is a measure of thixotropic property of the non-Newtonian fluid. A common method for characterizing and quantifying TI is to figure the ratio of the fluid viscosity as measured at two different speeds(with the same spindle). These measurements are usually made at speeds that differ by a factor of 10(for example, 10 and 100 rpm). TI can be expressed as below;

$$TI = \frac{\eta_1}{\eta_2} = \frac{\text{Viscosity at low rpm}}{\text{Viscosity at high rpm}}$$

TI of the paste must be optimized because the rheological behavior of the paste has a profound effect on the quality of screen printing.

* Viscometer : Brookfield HBDV- II +
** Standard : ASTM D 2196-86

Resistivity

The resistivity of the conductive film is usually expressed as sheet resistivity, which is the resistance of the unit area at a given thickness. Resistivity(R) is calculated from the following equation.

$$R = \frac{\rho_s}{T} \cdot \frac{L}{W} \text{(ohm)}$$

T : thickness (mm)
W : width (mm)
L : length (mm)
ρ_s : resistivity coefficient

Sheet resistivity(R's) is obtained by dividing R with L/W.
The standard resistivity(Rs) is defined as the resistivity of a standard film thickness. The standard resistivity of 15μm film thickness is shown below ;

$$Rs = R's \times \frac{Tm}{15}$$

Tm : measured thickness (μm)

* mΩmeter : HIOKI 3540
** Surface Resistance Tester : CMT-1000N