Innovative Technologies

Conductive and Resistive Inks

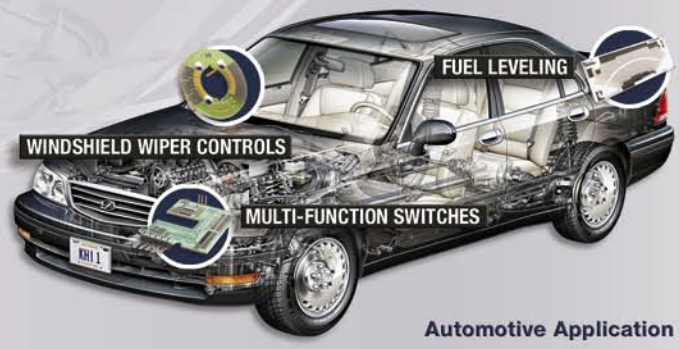
Methode Development Company (MDC) is an industry leader in the design and development of conductive and resistive inks. We offer a wide range of solutions using our custom ink technology that provides customers with significant cost and space savings over alternative technologies. Our products are developed to meet requirements for size, substrate material, resistance values, and tolerances as determined by our customers' specific applications.

MDC inks can be specifically formulated to meet all of the following requirements:

- ✓Conductors
- ✓EMC Shielding
- ✓Jumpers
- ✓Sensors
- ✓Magnetics
- ✓Overprinting
- ✓Resistors

Methode Development Company's expertise with inks and the printing of inks allows us to provide high-quality circuit technology solutions to our customers. These solutions include high wear flexible circuits, polymer thick film, and cermet hybrids. All inks can be sprayed or screen printed to meet our customer's demanding requirements. The following pages offer a small sampling of off-the-shelf standard inks MDC has available. For standard and application specific conductive and resistive ink solutions, visit our website at www.methodedevelopment.com, or call MDC at 708-867-6777 to speak with our experts.

1210 Silver Conductive Blind, Buried and Through Hole Via Plugging Ink



Automotive Application

METHODE ELECTRONICS, INC.

Technology Leadership...Global Manufacturing...Enabling Solutions

Polymer Thick Film Silver Conductor #6105

Product Description
6105 Silver Conductor is a flexible, low electrical resistance, screen printable composition.

Processing Substrates
Polyester, paper, polyimide, other plastics, FR4

Screen Mesh and Type
200 to 325 mesh stainless steel, 230 to 305 mesh polyester, 1/2 mil emulsion

Squeegee
70 durometer

Typical Cure Cycle
30 minutes at 130°C in a box oven or IR equivalent. Resistance can be lowered at higher cure temperatures.

Typical Cured Print Thickness
8 to 10 microns

Shelf Life
Shelf life in unopened jars is six months when stored at room temperature. Some settling of the ink may occur during storage, so thorough stirring before use is recommended.

Typical Properties
Viscosity: 20K to 40K CPS, HBT #3 spindle, 10 RPM

Percent Solids: 76 to 82

Coverage: 100 to 200 sq cm/gm depending on screen

Sheet Resistivity: Less than 3 milliohms per square per mil on higher temp substrates; Less than 5 milliohms per square per mil on lower temp substrates

Adhesion: Passes cross hatch tape test (3M Scotch Tape #810)

Clean Up: Isopropyl Alcohol or Acetone

Polymer Thick Film Silver Conductor #1828

Product Description
Polymer conductor #1828 has high conductivity and good print characteristics. It is intended for use on higher temperature substrates such as polyimide, polysulphone and ceramic. The cured print is flexible and can therefore be used on polyimide film.

Typical Applications
This polymer is typically used for circuit traces on high temperature rigid or flexible substrates.

Processing Details
Viscosity: 120,000 CPS (Brookfield LVT #5 spindle, 1.5 RPM)

Recommended Screen: 200 mesh stainless steel, .25 mil emulsion

Drying: 15 minutes at 140°C

Curing: 20 minutes at 200°C

Clean-up Solvent: MDC #942; also may use common aromatics and ketones

Thinner: MDC #356 coverage: 10 in^2 per gram with 200 mesh stainless steel screen

Substrates: High temperature molding plastics and high temperature flexible films

Performance Details
Sheet Resistivity: 50-60 milliohms per square, 1 mil thickness

Adhesion: Excellent – no peeling as tested per cross hatch test IPC D-320, paragraph 2.4.28

Print Resolution: 10 mil lines and spaces on typical thick film printers

Polymer Thick Film Silver Conductor #1212

Description
Polymer conductor #1212 is used where a printed conductive trace will be used with a sliding contact. This material exhibits both excellent conductivity and an extremely long wearing surface, even under high contact pressure.

Typical Applications
This polymer is typically used for on-off slide switches, position sensing switches and variable resistor terminations.

Processing Details

Viscosity: 500,000 CPS (Brookfield LVT #5 spindle, 1.5 RPM)

Recommended Screen: 200 mesh stainless steel, 1.4 mil emulsion

Drying: 5 minutes at 160ºC

Curing: 30 minutes at 160ºC

Clean-Up Solvent: MDC #942; also may use common aromatics and ketone solvents

Thinners: MDC #382

Coverage: 10 in^2 per gram

Substrates: FR2, FR3 and FR4 PCB substrates

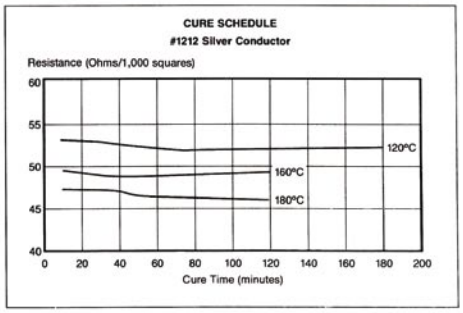
Performance Details
Sheet Resistivity: 35-40 milliohms per square, 1 mil thickness

Adhesion: Passes IPC D-320, 2.4.28

Wear Resistance: 150 grams pressure; 50,000 cycles; 50 grams pressure: in excess of 250,000 cycles

Note: This test was performed on custom built rotary test equipment capable of adjustable pressure on a .050 radius and half-hard bronze single contact. Each cycle consists of a 90º rotation and return motion.

Print Resolution: 10 mil lines and spaces on typical thick film printers



Resistance measurements at thickness as printed by recommended screens.

Polymer Thick Film Silver Conductor #1950

Description
Polymer conductor #1950 is a highly conductive silver paste specially designed for printed jumper connections between copper foil traces. It is silk screenable to a smooth finish and smoothness can be enhanced with a slight addition of thinner. It also serves as an all purpose conductor adhering to glass as well as to all typical circuit board substrates.

Typical Applications
This polymer is typically used for circuit board jumper prints and printed circuitry requiring good conductivity.

Processing Details
Viscosity: Approximately 450,000 CPS (Brookfield LVT #5 spindle, 1.5 RPM)

Recommended Screen: 200-325 mesh stainless steel, .0016 wire; 156-280 mesh polyester

Drying: 20 minutes at 160-180ºC

Curing: 45 minutes at 160ºC, up to 90 minutes for hardest cure

Clean-Up Solvent: MDC #942; also may use common aromatics and ketones

Thinner: Propylene glycol ether acetate

Coverage: 10 in^2 per gram with 200 mesh stainless steel screen

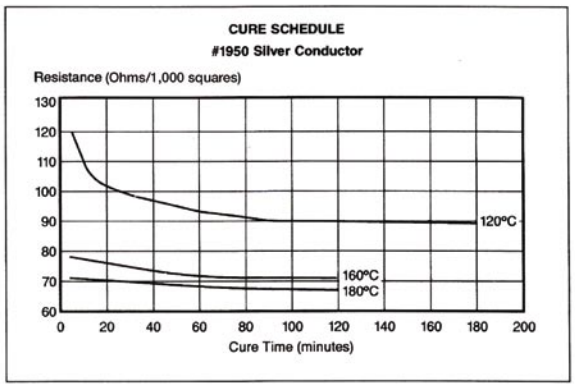
Substrates: FR2, FR3 and FR4, most molded plastics, soda lime glass, hard glass and ceramic.

Performance Details

Sheet Resistivity: 50-60 milliohms per square, 1 mil thickness, 160ºC cure

Adhesion: Excellent – no peeling as tested per cross hatch test IPC D-320, paragraph 2.4.28

Print Resolution: 10 mil lines and spaces on typical thick film printers



Resistance measurements at thickness as printed by recommended screens.

Polymer Thick Film Silver Conductor #6130

Description

The #6130 Series of highly conductive silver filled polymers were developed for printing circuitry on treated and untreated polyester film. It is available in three different drying rates:

#6130S – Slow Drying
#6130M – Medium Drying
#6130F – Fast Drying

Typical Applications

The most common application of the #6130 Series conductor is membrane switches printed on polyester film. The slow and medium versions are used for hand printing and with common silk screen printing machines. The fast version can also be hand printed if the operator is careful not to let the screen stand idle. Its intended application is on high speed printing presses such as a Klem Press.

Processing Details

Viscosity: Brookfield LVT, 24ºC, #6130S, 80,000 CPS, #6130M, 17,000 CPS, #6130F, 16,000 CPS

Recommended Screen: 200-325 mesh stainless steel, 0.5 mil emulsion; 156 polyester, 0.5 mil emulsion, 70 durometer squeegee.

Drying: 10 minutes at 80ºC

Curing: Convection Oven

INK#	Cure Time	Cure Temperature
6130S	45 Min.	95ºC
6130M	35 Min.	95ºC
6130F	20 Min.	95ºC

Note: #6130F on a high speed press with a forced hot air curtain, and a heated support plate can be cured in seconds allowing normal high speed operation of the equipment.

Clean-Up Solvent: M-Pyrol, cyclohexanone (see also recommended thinners).

Thinners:

INK#	THINNER
6130S	Butyrolactone
6130M	Butyrolactone
6130F	Propylene Glycol Ether Acetate

Coverage: 10 in^2 (6,450 mm^2) per gram with 200 mesh stainless steel screen

Substrates: Treated and untreated polyester film. Also, #6130 can be used on flexible polyimide and polycarbonate films.

Performance Details

Sheet Resistance:

INK#	PRINT THICKNESS (CURED)	SHEET RESISTANCE
6130S	1/2 mil	60 milliohms/sq.
6130M	1/2 mil	50 milliohms/sq.
6130F	1/2 mil	40 milliohms/sq.

Adhesion: Excellent, no peeling or lifting as tested per crosshatch test IPC D-320 paragraph 2.4.8

Resolution: Ten mil lines and spaces on typical thick film printers

Resistivity: After flex test (% retained)

0-180º, one fold with crease – 98%

0-360º, first and second fold with crease – 92%

Test performed on 1,000 square serpentine pattern on 30 mil polyester film

Pencil Hardness: 2H

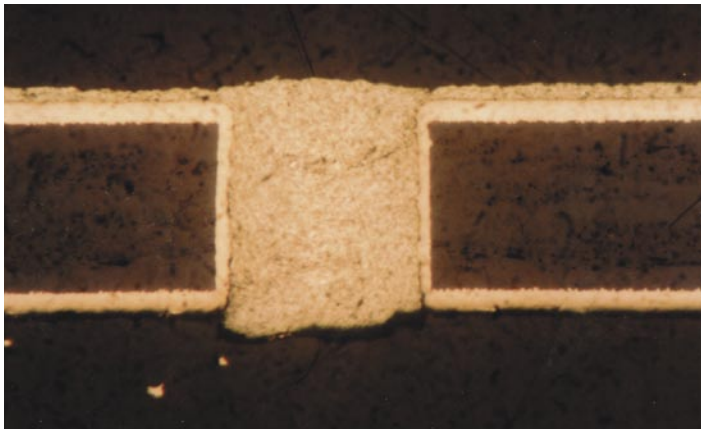
Operation Temperature: 70ºC maximum

Humidity Effects: 200 Hrs., 65ºC, 95% RH, less than 5% change in resistance

Notations

Silver printed circuitry can tarnish after prolonged exposure to atmospheric conditions. Although tarnish seldom affects electrical performance, the circuit can be protected using #6175 flexible carbon overprint.

Silver Conductor Via Plugging Material #1210



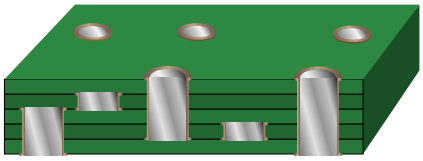
Product Description

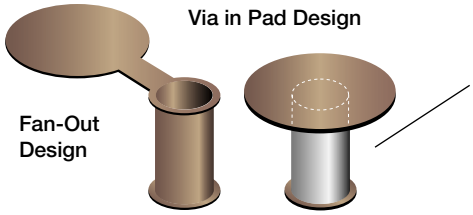
1210 Silver Conductive Via Plugging Material provides low cost blind and buried vias with or without through-hole plating, where the core boards are fully planar and thus more reliable. This is a 100% solids system with no shrinkage on curing that provides a high-density via plug. PCB's can now be designed to recapture much of the real estate that is currently lost to plated through-holes and land patterns. In order to utilize this material, a cost effective and simple application process can be implemented. Another benefit is a 30% reduction in the total number of production processes required to manufacture sequentially built-up boards.

Features

- Significant reduction in the amount of processing steps required to manufacture sequentially built-up boards by eliminating many of the expensive plating and lamination steps.
- 100% solids system with virtually no shrinkage on curing.
- Compatible with conventional copper plating techniques.
- Excellent thermal and electrical conductivity.
- Provides a flush surface to reduce the amount of copper plating required in sequential build-up.

1210 Silver Conductive Blind, Buried and Through-Hole Via Plugging Ink





Ink Properties

Glass Transition (Tg): 120ºC

Coefficient of Temperature Expansion (CTE): 40 ppm/ºC from -50º to +120º

Thermal Conductivity: 2W/M/ºK

Volume Resistivity: Less than 1μΩ-m at 25ºC

Sheet Resistivity: < 100 milli Ω/❑/25μ

Shelf Life: 30 days at room temperature or 3 months at -10ºC

Adhesion, Tape Test: No material transfer

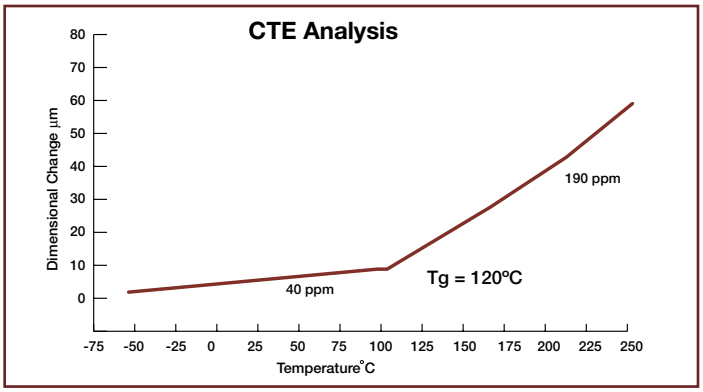
Plateability: Compatible with conventional copper plating techniques

Change in Physical and Electrical Properties After Temperature Cycling: Passes. No electrical failures

Viscosity: 3,000,000 CPS at 0.3 RPM with a Brookfield model LVT with a number LV5 spindle at 25ºC

Specific Gravity: 4 grams/cc

Thermal Gravametric Analysis (TGA): 0.2% loss typical



Processing

- Ordinary stencil printing equipment can be used to apply the 1210 Conductive Material into the via holes.
- Recommended stencil: 4 to 5 mils thick stainless steel. The hole opening in the stencil needs to be 4 to 6 mils larger than the hole diameter in the circuit board.
- An 80 to 90 durometer (hard) squeegee is recommended. This will minimize the tendency of the squeegee to scoop out the material from the via hole in the printing operation.
- Use a squeegee speed of about 2 inches per second. Two of these passes of the squeegee will be needed for each 0.010" of board thickness.
- Via aspect ratios of up to 6:1 (hole depth: hole diameter) have been successfully filled. Printing in both directions is recommended, if possible.
- Recommended curing is 45 minutes at 155ºC.
- Clean up solvents are acetone, alcohol, toluene or mixtures.

Goldstone® 3100 Carbon Based Polymer Overprint Ink

Product Description

GOLDSTONE #3100 is an excellent low cost alternative to gold plating. It provides the copper pads and tabs with protection from oxidation which causes possible failures. The printed oxide free pads and tabs provide reliable contacts. Our screen printable polymer eliminates the extensive and costly gold plating process, thereby shortening the total cycle time with fewer production steps. Instead of contending with environmental plating regulations, Goldstone offers an alternative that provides exceptional performance.

Goldstone provides excellent and consistent printability, with fine lines achievable down to 0.010" wide. Saw tooth edges, bleeding and irregular print definitions are effectively eliminated. The hard surface provides excellent wear resistance for up to five million cycles. Goldstone can be used as a protective coating over silver polymer thick film inks to reduce the chance of silver migration and sulfur attack.

Features

- Material savings of 35 - 40% over gold plating.
- Shortens total cycle time by reducing the 15 steps required for gold plating down to 5 for printing Goldstone.
- Highly conductive 1 to 3 Ohms contact resistance. Size, shape, contact finish and pressure will determine final resistance values.
- Extremely wear resistant, can withstand up to 5 million cycles.
- Convection oven curable at 145°C for 45 minutes or infrared with suitable profiles in less than 12 minutes.

Ink Properties

Viscosity:	50,000 to 100,000 CPS spindle #5 at 0.6 RPM, Brookfield Viscometer Model #LVT.
Shelf Life:	Six months from date of shipment.
Sheet Resistance:	40-60 Ohms/sq @ 1 mil.
Rheology:	Thixotropic ink for screen printing applications. Some settling may occur, so ink should be stirred thoroughly before use.
Storage:	Ambient temperature with container securely closed. If ink is refrigerated, allow it to rise to room temperature before use.
Adhesion:	No peeling resulting from crosshatch per IPC D-320, paragraph 2.4.28.
Humidity:	Test results of MIL-STD-202F, Method 106E, showed a stable polymer system with cycling of humidity and temperature. A slight increase in resistance occurred, as would be expected, and minimal variation was shown through repetitious cycling.
Soldering:	Not affected by soldering. Conductivity and adhesion remain unchanged after exposure to solder operations, even when strong active fluxes are used in the process.

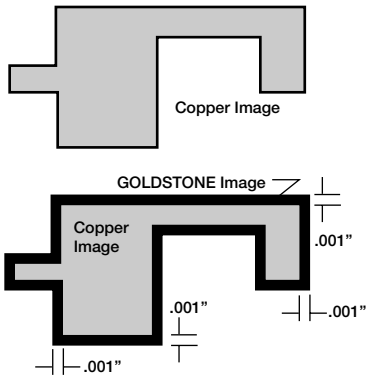
Goldstone can be specifically formulated to meet your specific application needs in the areas of electroluminescent lamps, membrane switches, flexible circuitry, pads for zebra strips and LCD fabrication.

Processing

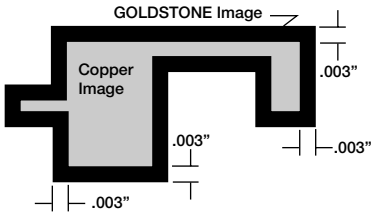
- Stir ink in the jar before it is used, checking for homogeneity. If the ink still looks thick after stirring, add 1% to 2% thinner to the ink. Recommended thinners are Butyl Carbitol, Butyl Carbitol Acetate or Isophorone.
- It is critical that the copper pads and tabs be chemically micro etched or brush scrubbed clean. Make sure all the moisture is out of the board. This can be done by drying at 200°C for two minutes. The PC boards should be printed within 24 hours after drying or the copper surface will start to oxidize.
- Semiautomatic or manual screen printing equipment can be used.
- A 200 mesh stainless steel screen with a 0.5 mil back emulsion is recommended. 110 to 180 mesh polyester screens can be used.
- Be generous with the amount of ink poured on the screen. Make sure it extends over one inch on both sides of the print pattern for the copper key pads. Flood screen first, then print. Always flood first then do the printing.
- Use a 70 durometer squeegee material, keeping the squeegee at a 45° angle when printing. Apply even pressure to the squeegee and keep it parallel to the screen. The print speed should be 3" to 5" per second.
- When using a frame 15" x 15" or larger, your snap off distance should be 0.045" to 0.055".
- Wet thickness of the ink should be .0010" to .0012" when printed with the recommended screen. The cured thickness is about 0.0008".
- Do not allow the ink to remain for more than 10 minutes in the screen without using it. The ink may be pooled at the bottom or top of the screen for up to 15 minutes. Make sure to clean the screen out when exceeding this time.
- Periodically clean both top and bottom of the screen with a lint free cloth and a ketone or aromatic solvent.
- During initial usage, the solvents tend to evaporate. To replace the evaporated solvent use 1% to 2% of one of the following solvents: Butyl Carbitol, Butyl Carbitol Acetate or Isophorone. These will thin the Goldstone to the recommended viscosity.
- Do not allow the jar of ink to remain open with the lid off.
- Do not expose the ink to elevated temperatures which will cause the ink to prematurely harden.
- Cure the ink at 145ºC for 45 minutes in a convection or hot air circulating box oven and then cool at room temperature.
- When printing is complete for the day, clean the screen with ketone or aromatic solvent.

Artwork

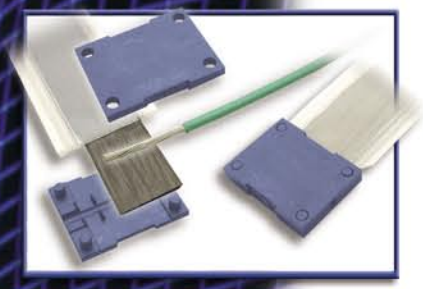
The artwork for making the Goldstone screens must exceed the image of the copper keypad by .001" in each direction to allow the ink to encapsulate the copper pad.



In addition, further expansion of the Goldstone artwork is required to compensate for the ability of the process to maintain registration. For example, if the board making process can hold ±.002" registration from board to board, the Goldstone artwork expansion required to ensure complete encapsulating of all traces on all boards would be .001" + .002", or .003" in each direction, as shown below.



The print pattern for the copper keypads needs to be at least 3" to 4" away from the top, bottom and sides of the aluminum frame.



Sonicrimp, Carbon Fiber Heaters, shrinkMate™ EMC Heat Shrink Tubing, and Conductive Specialty Inks

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Methode Electronics, Inc. (NASDAQ: METH) is a global manufacturer of component and subsystem devices with manufacturing, design and testing facilities in the United States, Malta, Mexico, United Kingdom, Germany, Czech Republic, China and Singapore. We design, manufacture and market devices employing electrical, electronic, wireless, sensing and optical technologies to control and convey signals through sensors, interconnections and controls. Our business is managed on a segment basis, with those segments being Automotive, Interconnect, Power Distribution and Other. Our components are in the primary end markets of the following industries: automobile, information processing and networking equipment, voice and data communication systems, consumer electronics, appliances, aerospace vehicles and industrial equipment. Further information can be found at Methode's website www.methode.com.

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