COATES CARBON INKS FOR PCB APPLICATIONS

This article describes two applications for carbon inks used in PCB production and gives details of Coates inks, which meet the requirements for these applications.

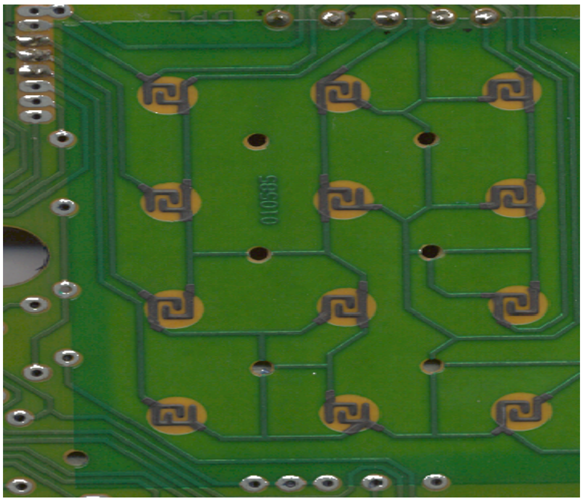
PCB APPLICATIONS

REPLACEMENT FOR GOLD PLATING

Traditionally, nickel/gold plating has been applied over copper tracks used for keyboard contacts or edge fingers(1). This provides a conductive, corrosion resistant, environmentally stable coating. Replacement of gold plating by carbon ink offers the following additional advantages(2):

- **Cost** – Replacing gold with carbon reduces Materials costs and replacing the electrolytic bath with a simple screen-printing process reduces process costs.
- **Robustness** - Tests have shown that a typical carbon ink is hard enough to withstand >1 million pushbutton operations (keypad) or 100 insertion operations with a 75g force (edge connector) without showing wear or increased resistance.
- **Resistance** – The above advantages are gained without a significant increase in loop resistance of the closed circuit using the graphite pill. The thin print of carbon ink (typically 15μm) has a low resistance, less than the resistance across the graphite pill. Figure 1 is an example of carbon ink over a copper keypad.

FIGURE 1 - MOBILE PHONE CIRCUIT



Carbon inks must have good viscosity stability for warmer climates and require good printing properties to give even coverage over the copper pads. The cured ink must be hard and must withstand subsequent processing steps such as solvent cleaning and soldering without loss of adhesion and conductivity. Peelable solder mask is often used to protect keypads and edge connectors during solder against flux contamination and solder pick-up; the carbon ink must resist these materials.

CROSSOVERS

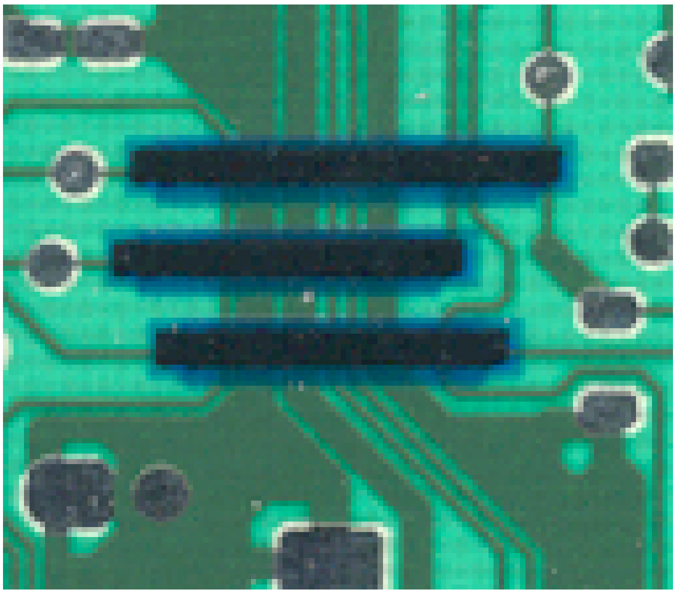
The trend towards more complex and smaller circuits has created a challenge for the single-sided producer who needs to produce more complex boards. The answer is to add a second layer of circuitry that can cross over each other on the single-sided board[(2)]. This second layer of conductive tracks can be printed over the first layer of copper tracks using carbon ink, with contacts to the underlying copper pads at each end. An insulating layer of dielectric ink separates the copper and conductive ink layers. Two prints of dielectric ink may be required to eliminate rejects due to shorts between the conductor layers arising from small pinholes, and also to give a smooth surface on which to print the carbon ink. During the cure of the dielectric layer, the copper pads will oxidise so will require cleaning to ensure low contact resistance and good adhesion of the carbon ink. Finally, a further dielectric layer can be printed over the carbon to ensure optimum environmental stability. This added dielectric layer can be seen in Figure 2, which is an example taken from a part of a single-sided board.

Crossovers have the following advantages:

- **Cost** – Materials and process costs for carbon ink and screen printing are much lower than the alternative of drilling and through-hole plating needed to produce produce double-sided or multilayer boards.
- **Proven method** - Boards for telephones, toys, television remote controls, computer keyboards, etc have been produced by this method.

Carbon inks must have good adhesion to copper and dielectric and be unaffected by the subsequent processing steps described above for the replacement of gold plating.

FIGURE 2 – CROSSOVER TRACKS



COATES CARBON INKS

PRODUCTS

The Coates XZ302-1 series carbon inks are single pack inks, which meet the above requirements. They are supplied at three viscosities:

1. XZ302-1HV has the highest viscosity.

2. XZ302-1MV has 40% lower viscosity than HV.

3. XZ302-1LV has 80% lower viscosity than MV.

XZ302-1HV and MV give a hard resistant film, which can be applied to a variety of substrates. They have good compatibility with peelable soldermasks such as Coates XZ93-S. They meet typical loop resistance specifications, e.g. <100 Ω/☐, for push button operated circuits when activated with a graphite loaded pill. They are expected to withstand >1 million operations; to verify this, customers are advised to carry out their own investigations. XZ302-1LV is a thinner for XZ302-1MV.

For details refer to APPENDIX 2 (product and pack codes) and APPENDIX 3 (ink properties).

CLEANING OF COPPER

To ensure good electrical continuity and adhesion between XZ302-1 and copper, the surface should be free of all contaminants. The presence of dust, oxide, organic coatings and residues, intermetallic layers will have a detrimental effect.

INK ADJUSTMENT

XZ302-1HV is supplied as a single part ink and should be used from the can without thinning. If viscosity is too thick, XZ302-1MV is the recommended alternative.

XZ302-1MV can be used from the can without thinning. If a lower viscosity is required then blend with XZ302-1 LV at the recommended proportions on the graph in Appendix 4. The inks must be mixed thoroughly before printing.

PRINTING AND DRYING

Coates Conductive Inks XZ302-1 HV and MV are suitable for use on hand, semi-automatic or fully automatic screen printing machines. Resistance is governed to a large extent by print thickness. This is governed by a number of factors including mesh count, stencil thickness, squeegee hardness and print speed.

Monofilament meshes of 49 - 77T/cm. (125 - 200T/inch) are recommended. Finer meshes give thinner prints and higher actual (as printed) resistance values. The smaller mesh hole area is unable to allow as much ink through. APPENDIX 1 shows typical surface resistance values obtained with different polyester screens with 23µm emulsions. For optimum results a polyurethane squeegee of 65° Shore hardness was used. Prints were dried at 150^{o}C (302^{o}F) for 60 minutes in a fan convection oven. Under curing may adversely affect electrical resistance, solvent rub resistance, and adhesion.

REFERENCES

1. Wagner, P.,"Polymer Thick Film for Corrosion Protection", *Connection Technology*, August (1986).
2. Fearns, D. J., "Applications of Polymer Thick Film Inks in Surface Mount Technology", *Circuit World*, Vol.14, No.3, (1988).
3. Keeler, R., "Polymer Thick Film Multilayers Poised for Takeoff", *Electronic Packaging & Production*, August (1987).

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APPENDIX 1

SCREEN MESHES

XZ302-1 SERIES	HV			MV		
Mesh Count (TPC / TPI)	49/125	62/160	77/195	49/125	62/160	77/195
Sheet resistance as printed (Ω/)	12.5	15	20.5	13.2	14	18.8
Dried film thickness (µm)	18	16	11	17	15	12
Normalized sheet resistance (Ω/ @15µm)	15	16	15	15	14	15

Differences in viscosity were not large enough to effect printing thickness. Resistances normalised to a standard dried film thickness (d.f.t) of 15µm were comparable.

APPENDIX 2

PRODUCT AND PACK CODES

PRODUCT CODE	DESCRIPTION	PACK SIZE	PACK CODE
XZ302-1 HV	Conductive Carbon Ink	1 kg.	CHSN8032
XZ302-1 MV	Conductive Carbon Ink	1 kg	CHSN8033
XZ302-1 LV	Conductive Carbon Ink	1 kg	CHSN8034
XZ46	Screen Cleaner	5 Ltr.	CDSN4008
11-00	Universal Screenwash	5 Ltr.	CDSN4000

APPENDIX 3

CARBON INKS - TYPICAL PROPERTIES

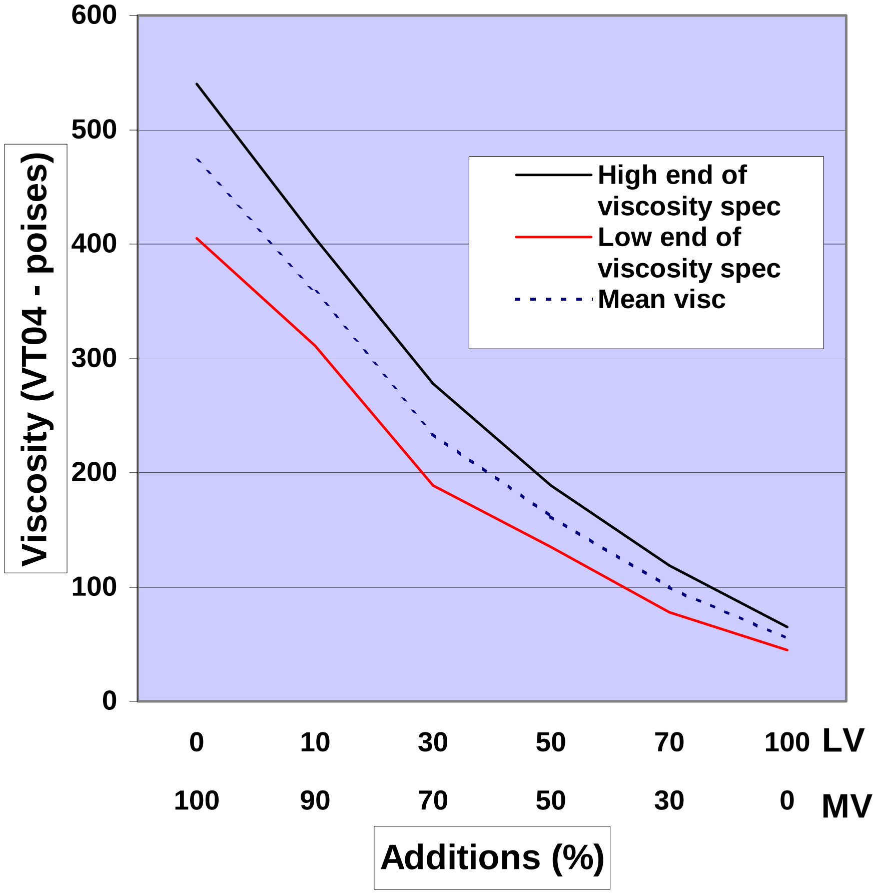
XZ302 – 1 SERIES	HV	MV	LV
LIQUID PROPERTIES			
Pigment	Carbon		
Medium	Thermoset Resin		
Viscosity[(1)] @25°C Haake VT02 & VT04 (Poise) Haake VT550 (Pas)	700 – 1000 55 – 65	400 –600 30 – 40	40 – 60 4 – 8
Viscosity Stability; 30 days@40°C (% Change in viscosity))	<6	<6	<6
Shelf Life @10 – 25°C sealed container (months)	12	12	12
Screen Life; drying time on screen (Minutes @25°C; 15µm d.f.t.)	>210	>210	NA
Solids (%)	64	61	52
S.G. (gm/cm^3)	1.15	1.15	1.35
Coverage (m²/kg @ 15µm d.f.t)	~38	~ 38	NA
CURED PROPERTIES (150°C 60 mins)			
Sheet Resistance (Ω/ @15µm. d.f.t)	≤18	≤18	<30
Resistivity (mΩ cm.)	<27	≤27	<50
Resistance to soldering; 5 secs solder dip – nil Peelable (% change in resistance)	≤13	≤13	NA
Resistance to soldering; 5 secs solder dip – with Peelable XZ93-S (% change in resistance)	≤6	≤6	NA
Flexibility; change in resistance;100 folds on 3mm mandrel (% change in resistance)	<15	<15	NA
Chemical Resistance (double rubs with $MeCl_2$)	>200	>200	>200
Pencil Hardness	3H	3H	3H
X Hatch Adhesion (1=nil, 10=complete removal)	1	1	1

1. Viscosity will vary according to conditions; temperature, viscometer, sample size.

This information is provided for guidance only and does not form a specification.

APPENDIX 4

VISCOSITY ADJUSTMENT OF XZ302-1 MV (Using XZ302-1 LV Thinner)



Please note that Coates Conductive Ink XZ302-1 HV & MV tend to 'set' with time, but the viscosity will rapidly return to normal when stirred and during printing.