DuPont Conductive Silver Compositions for General Purpose Air-Dry Applications

Technical Data Sheet

Product Description

The compositions described in this bulletin are suspensions of specially prepared silver powders combined with a variety of organic binder systems. They are air-dry or low temperature-curing formulations for application on substrates which will not generally tolerate high-temperature firing. They are formulated to produce electrically conductive paths on paper, plastic, rubber, cloth, wood, etc., and may be applied by dip, spray, brush, stylus, syringe or screen print.

These highly conductive air dry/thermoset (epoxy) compositions exhibit versatility and are useful over a broad range of applications. Suggested uses are:

- Printed Electronics
- Tantalum Capacitors
- Static Shielding
- Electrical Games and Toys
- Microwave Applications
- PC Board Repair
- Electroplating Base

The compositions described in this bulletin are divided into three groups based on similarities in composition, cure, properties
and end uses.

Choice of an air dry or thermosetting conductive silver composition for a given use is dependent upon the method of application preferred and the required properties in the end product. Trade-offs in final film properties are sometimes necessary.

Drying rate is a function of the solvent system in a composition and method of application is dictated by viscosity, a function of binder to solvent ratio.

Dry strength, flexibility, adhesion and temperature stability are functions of the binder system. No one binder system exhibits optimum capabilities of all functions. Lower metal contents are generally least expensive if cost is a primary consideration. Higher metal contents develop maximum conductivity and load carrying capabilities, and are more easily soldered.

Application Methods

DuPont conductive silver compositions are formulated for application by screen printing, spraying, dipping, brushing,
banding or stylus. In most cases the compositions are produced to a consistency suitable for use as received and require only stirring to redisperse the solids.

Recommended thinners for individual compositions may be added, with thorough blending, to replace solvent losses or to make slight adjustments for ease of application. Only the recommended thinner should be used. In handling and using
organic solvents, the safety precautions recommended by the solvent supplier should be observed.

Effect of Curing Temperatures

This bulletin discusses two types of compositions: air dry and thermoset (epoxy). In an air-dry system, the metal-binder film is formed when the solvent system is evap-orated or “dried:’ In a thermoset system, there is a drying step where the solvent is removed, followed by a chemical reaction of binder materials in the system to give a higher temperature resistant binder film for the metal. The later chemical reaction is called “curing” and is different than drying.

While some compositions, if given sufficient time, will adequately dry or cure at room temperature, a more effective result is achieved in much less time through low temperature thermal exposure with a moderate time/temperature drying or curing. Optimum properties in air & dry and low-temperature-cure compositions are developed only after the compositions have been properly dried or cured. The drying or curing cycle for most compositions is a function of time versus temperature up to the point of degradation of the organic system. In a system which will dry or cure in from 12 to 16 hours at room temperature (25°C) the same degree of drying or curing can be achieved in less than 2 hours at 60°C and in less than 1 hour at 100°C.

Elevated temperature drying or curing of these compositions can be continuous, box oven or infrared. The heat should be applied from the bottom up to permit internal gases to escape before the top surface is completely dry. “Flash drying,” a momentary exposure to excessively high temperatures, is likely to form a surface skin that traps internal gases, resulting in bubbles in the dried film.

Failure to achieve rated conductivity indicates either that the applied composition is too thin with poor uniformity or that it has been incorrectly dried and/or cured.

Soldering
Some DuPont air dried and thermoset compositions are more commonly used as conductive cements in lead attachment, attachment of discrete components or in simple interconnections. For these applications, solderability is not important and is not generally recommended.

Electroplating/Electroforming
The use of DuPont air dry/thermoset conductive silver compositions as bases for electroplating and electroforming is wide-spread. Ease of application, broad curing ranges, high conductivity and dimensional stability mark DuPont Group I compositions as leaders in the field.

Storage and Shelf Life
Group I and II compositions (air-dry) should be stored at room temperature. Shelf life of material in unopened containers is six months from date of shipment with the exception of 4817N (three month shelf life). Group III materials (thermoset) should be refrigerated at 2”-4°C (35”-40°F). Shelf life of material in unopened containers under these storage conditions is three months from date of shipment. Shelf life can be extended considerably by storage at temperatures of -18°C (0°F) or below. Materials should be allowed to return to room temperature before opening to preclude moisture condensation in the jar, to assure that the proper viscosity has been reached, and to assure consistent results with whatever cure cycle is being used.

Coverage
Coverage of silver compositions depends on metal content and thickness of application. Screen print compositions printed with a 165- or 200-mesh screen will generally result in a cured film 12-20 pm (0.48-0.8 mil) thick. Brush band, dip or spray application will normally result in film thickness of 13 -18 pm (0.5-0.7 mil). Thinner films (increases coverage) can be applied by thinning the compositions with the recommended thinner; however, this will result in a cured film with a higher sheet resistivity. Thicker films can be achieved by brushing or spraying simply by applying more material.

The coverage figures shown in Table III for Group I and III compositions are for typical cured thickness of 12-20 µm (0.48-0.8 mil) as outlined above.

The coverage figures for Group II com-positions are for typical cured thickness of 8-15 µm (0.32-0.6 mil) screen printed with a 325-mesh stainless steel screen.

Group I
Group I conductive silver compositions exhibit a moderately fast drying rate, good adhesion to most substrates and high conductivity. They are used to produce electrically conductive patterns on surfaces of paper, film, plastic, rubber or wood as well as on conventional ceramic substrates. They are widely used in the manufacture of tantalum capacitors to metallize the anode, making it a good electrical contact.

For dip, spray, brush or screen print application, Group I compositions can be cured in 16-20 hours at room temperature (25°C) or may be oven cured in 1 hour or less at 60”-100°C.

4817N, for spray or dip application, is widely used in electroforming, in electroplating, in static shielding, in magnetic tapes and in the manufacture of tantalum capacitors. Its low metal content places 4817N in a moderate price range attractive for many applications.

4922N is a high metal content, high viscosity version of 4817N suitable for brush, stylus or machine banding application where its somewhat higher conductivity is desired. 4922N is widely used in circuit board repair and in the manufacture of tantalum capacitors. 4922N may be thinned with butyl acetate to achieve optimum application properties.

4929N is a paste version of 4922N for screen print or stylus application where it is desired to deposit a circuit or pattern as in electronic circuitry, microwave applications, computer punch cards, ballistic targets, or in toy and game circuitry.

Group II

Group II compositions were designed to be screen printed on flexible films such as Mylar'" polyester. They are used to produce highly conductive and highly flexible patterns on various plastic films for the manufacture of membrane touch switches (MTS) and keyboards. They can be cured at 100°C to 150°C in conventional drying ovens or infrared drying equipment. See Polymer Thick Film Selector Guide for additional products.
See Bio Selector guide for silver/silver chlorides, carbon, silver, platinum and gold electrode materials.

See attached tables for product specifics.

Group III

Group III compositions are single component, epoxy based preparations suitable for use as conductive cements in lead and
discrete component attachment. They exhibit good conductivity, high adhesion and excellent resistance to abrasion. These compositions are divided into two types: anhydride-cured and amine-cured. Anhydride-cured compositions display excellent thermal stability up to 250°C whereas amine-cured products start to degrade appreciably at temperatures above 200°C with attendant loss of properties. Both systems, however, can withstand short excursions to higher temperatures.

See the CB selector guide for a selection of CB products for use in circuit board applications.

While not suggested for direct solder, the compositions may be electroplated to provide a solderable surface.

Optimum cure for Group III compositions will depend on process and equipment parameters as well as the mass, heat capacity and transfer, and sensitivity of the materials involved. Cure schedules listed in Table I are recommended as minimal starting points with compositions 5504N and 5815 after applying and allowing to air-dry until tack free. The drying time can be accelerated by heating to 50°C. Longer cure schedules may be required to optimize properties depending on end-use requirements. For example, in die-attach application, a cure schedule of 2 hours at 200°C has been found to yield stable and reliable die-to-substrate interfaces capable of withstanding a high degree of thermal and physical stress.

The cure schedule show in Table I are also applicable to composition 6838.

Safety and Handling

For Safety and Handling information pertaining to this product, read the Material Safety Data Sheet (MSDS).

Table 1

Temperature °C [°F]	Time hours
200 (392)	0.7
180 (356)	1.5
160 (320)	2.5
Typical physical properties of properly cured Group III composition are shown in Table II	

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Table 2
Typical Physical Properties of Thermosetting Compositions (Cured Film)

Test	Properties	Typical
Sheet Resistivity (mΩ/sq)	≤ 100	12
Bulk Resistivity (Ω/cm)	3×10^{-5}	-
Adhesion Strength (N/cm²) Tensile Lap Shear	≥ 700 ~ 1400	1000
Thermal Conductivity (J/(cm·s·ºC))	0.04	-
Specific Heat (J/(g·ºC))	0.30	-
Coefficient of Thermal Expansion (m/m)/ºC	3×10^{-5}	-
Modulus of Elasticity (tensile) (Pa)	4×10^{10}	-
Poisson's Ratio	0.35	-

Group I Silvers

Test	Screen Print 4929N	Brush/Brand 4922N	Dip/Spray 4817N
Viscosity (Pa.S)[KcP]	52 - 69 (Brookfield HBF, spindle #4, 10 rpm)	38 - 54 (Brookfield HBF, spindle #4, 10 rpm)	0.200 - 0.280 (Brookfield LVT, spindle #2, 60 rpm)
Thinner	DuPont 4987	DuPont 8459	DuPont 8459
Cure	1 hr @ 100C	1 hr @ 100C	1 hr @ 60C
Sheet Resistivity (Ω/sq)†	< 0.05	< 0.05	< 0.1
Coverage (cm2/g) (in²/g) @ 50µm (2 mil) wet film thickness	72 (11)	72 (11)	120 (18.5)
Remarks † 25 µm (1 mil) film thickness	Paste version of DuPont 4922N for screen print or stylus application where it is desired to deposit a pattern for electrical circuits.	High metal content, high viscosity version of 4817N suitable for brush, stylus or machine banding application where its somewhat higher conductivity is desired. 4922N is widely used in circuit board repair.	For spray or dip application.

Group II Silvers

	5000	5021	5025	5028	5029	5064	9169
Viscosity (Pa.S) [KcP]	3.5 - 16	10 - 28	20 - 30	15 - 30	35 - 50	10 - 20	40 - 70
Thinner	DuPont 8260	DuPont 3610	DuPont 8210	DuPont 3610	DuPont 3610	DuPont 8260	DuPont 8210
Cure	8 - 10 min @ 120C	1 - 5 min @ 120C	5 - 6 min @ 120C	8 - 10 min @ 120C	2 - 5 min @ 120C	10 min @ 130ºC	10 min @ 120ºC
Resistivity (mΩ/s/mil) †	8 - 14	13 - 17	12 - 15	7 - 12	12 - 15	≤ 10	≤ 18
Coverage (in^2/g)	29.8 @ .3 mil	22 @ .4 mil	22 @ .4 mil	20 @ .4 mil	18 @ .4 mil	170 @ 0.35 mil	120 @ 1 mil
Remarks	Low silver / high conductivity	Fast cure / high flexibility	Fast curing and higher operating use temperature (MTS) and keyboards	High conductivity	High solids / high conductivity	Highest conductivity of all	Good adhesion to ITO coated substrates

Group III Silvers

	Screen Print 5504N	Brush/Band 6838	Dip/Spray 5815
Viscosity (Pa.S) [KcP]	68 - 92 (Brookfield HBF, spindle #4, 10 rpm)	37 - 50 (Brookfield HBF, spindle #4, 10 rpm)	0.800 - 0.950 (Brookfield LVT, spindle #2, 30 rpm)
Thinner	DuPont 4987	DuPont 4987	DuPont 8459
Cure	(see text)	(see text)	(see text)
Sheet Resistivity (Ω/sq)†	≤ 0.1	< 0.05	≤ 0.1
Coverage (cm^2/g) (in^2/g) @ 50 mm (2mil) wet film thickness	72 (11)	62 (9.5)	100 (15.5)
Remarks	Single component epoxy (anhydride-cure agent)	Single component epoxy (amine-curing agent)	Low viscosity of DuPont 5504N)

† 25 µm (1 mil) film thickness

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