



THICK-FILM COATING
DESIGN GUIDE

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CoorsTek manufactures critical components and complete assemblies for semiconductor, automotive, electronics, medical, telecommunications, military, and other industrial applications. Using advanced technical ceramics and high-performance plastics, our solutions enable customers' products to overcome technological barriers and improve performance, especially in demanding or severe service environments.

CoorsTek has a highly qualified staff to assist with material selection and product design. Please contact us today at 303-277-4802 for more information.

For general information about CoorsTek, please visit our website at www.coorstek.com.

I. Introduction

CoorsTek employs a variety of coating techniques for a wide range of substrate configurations. Our printing and etching technologies are capable of achieving line width and spacing fineness to 0.001" (0.0254 mm) with tolerances to ± 0.0001 " (0.00254 mm). Extensive manufacturing capability enables CoorsTek to supply complete circuits, multi-layer hybrids, and assemblies for many applications.

II. Conductors

Gold and gold alloys along with silver and silver alloys are used extensively for optimum conductance, solderability, and wire bonding. Critical solderable applications require fritted or alloyed compositions to ensure solder leach resistance. Molybdenum Manganese or Tungsten coatings ensure excellent interface bonding of conductor to substrate when brazing or plating is desired.

Property	Seed Layers		Plated Conductors			Thick-Film Conductors	
	MoMn	Tungsten	Nickel ⁴	Gold ⁵	Tin ⁵	Gold/Gold Alloys	Silver/Silver Alloys
Typical Fired Thickness μ " (mm)	400 – 1200 (10 – 30)	400 – 1200 (10 – 30)	80 – 180 (2 – 4.5)	40 (1) min. Flash: 15 (0.4) min.	80 – 180 (2 – 4.5)	Wire bond: ≤ 500 (12.5) Solder: 300 – 700 (7.5 – 17.5) Etch: 150 – 200 (3.75 – 5)	Wire bond: ≤ 500 (12.5) Solder: 300 – 700 (7.5 – 17.5) Etch: 150 – 200 (3.75 – 5)
Minimum Trace Widths; Spaces (mm)	0.005" \pm 0.002" (0.13 \pm 0.05)	0.005" \pm 0.002" (0.13 \pm 0.05)	–	–	–	Std: 0.005" \pm 0.002" (0.13 \pm 0.05) Ultra fine line: 0.001" \pm 0.0001" (0.03 \pm 0.003)	Std: 0.005" \pm 0.002" (0.13 \pm 0.05) Ultra fine line: 0.001" \pm 0.0001" (0.03 \pm 0.003)
Cost* (Relative to Manufacturing Costs)	1	1	4	5	4	5	3
Leach Resist. Solderable Materials (Good, Fair, Poor)	–	–	Good	Good	Good	Pure Gold: Poor Gold Alloys: Good	Pure Silver: Poor Silver Alloys: Fair – Good
Aluminum Wire Bonding Rating*	–	–	1 – 2	3	2	4	4
Gold Wire Bond Rating*	–	–	1	4 – 5	1	5	1
Resistivity, 20° C millohm (mohm/sq) ^{††}	–	5 – 6	8 – 9	2 – 3	11 – 12	Pure Gold: 2 – 3 Gold Platinum: 60 – 100 [†]	Pure Silver: 1 – 2 Silver Palladium: 10 – 50 Silver Platinum: 4 – 5
Solderability*	–	–	4	5	3	Pure Gold: 1 Gold Alloys: 4 – 5	Pure Silver: 5 Silver Alloys: 2 – 4

* Scale of 1-5, 1 = lowest or worst, 5 = highest or best

[†] Variances will be design specific

^{††} Resistivities can be obtained in the ranges shown.

Notes: 1. Other thick-film conductors and plated materials are possible. Contact a CoorsTek representative for information or call 303-277-4615.

2. A dash (–) indicates unavailability of information or a situation generally not applicable.

3. Figures in the above table are for reference, and are not intended to be absolute.

4. Electrolytic or Electroless Plating Method (see "Plated Conductors" above)

5. Electrolytic Plating Method (see "Plated Conductors" above)

III. Resistors, Capacitors, and Thermistors

CoorsTek has the capability of applying resistors, capacitors, and thermistors. Laser trimming can be performed for resistance tolerances $\leq 10\%$. Contact CoorsTek for materials and design criteria.

IV. Dielectrics

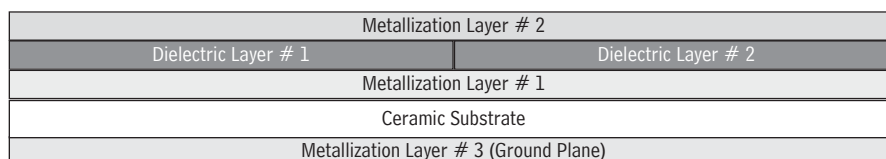
Thick-film dielectrics are insulators between conductive layers in multi-layer applications, as well as protective coatings for resistors and capacitors. Dielectric coatings can be used for corrosive and other severe environmental conditions.

	Dielectric Constant	Dissipation Factor	Breakdown Voltage (V/mil)	Fired Thickness	Insulation Resistance (ohms)
Standard	9 ± 3	< 0.5%	> 400	0.0015" – 0.002" (0.04mm – 0.05mm)	> 10 ¹¹ @ 100V
Low - K	~	< 0.1% 0.4% @ 20GHz	> 400	0.001" – 0.002" (0.03mm – 0.05mm)	> 10 ¹¹ @ 100V

(Above figures are for reference, and not intended to be absolute.)

V. Thick-Film Multi-Layers

CoorsTek has the capability to layer conductors and dielectrics for multi-layer applications. The same metals used in thick-film coating can be used in multi-layer packages, such as gold/gold alloys, and silver/silver alloys. The diagram below represents an edge view of how applications may look with layered conductors and dielectrics on the ceramic substrate.



VI. High-Definition Photo Etching

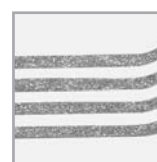
Used primarily for high-frequency and high-speed applications, CoorsTek has ultra-fine photo etching which achieves extremely high-resolution lines and spaces. Specially formulated gold and silver pastes with high-conductivity and high-backlit density make up the base conductor layer used for etching.



25 micron (0.001")
220x Magnification



32.5 micron (0.0013")
200x Magnification



50 micron (0.002")
200x Magnification

VII. Vias – Feature Sizes

Vias typically serve as conducting “through-holes” within the ceramic substrate or dielectric layers. CoorsTek has extensive lasering capability for drilling a variety of precise sizes and configurations to meet customer specifications.

	Minimum	Standard
Substrate Via Size (diameter)	0.008" (0.2mm)	0.010" – 0.020" (0.2mm – 0.5mm)

- Notes:**
1. Spacings between edges of vias must be ≥ substrate thickness.
 2. Via diameter capability is dependent on substrate thickness. Minimum via diameter must increase as board thickness increases.
 3. For special applications exceeding these standards, contact your CoorsTek representative or call 303-277-4615.

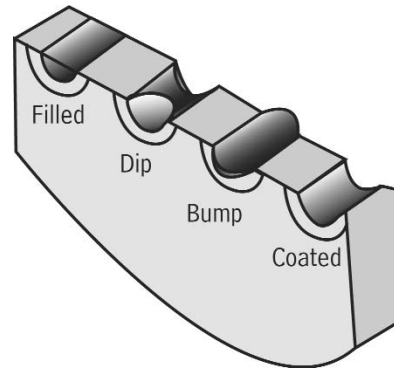
VIII. Via Fill / Bore Coat

Via fills and plugs are generally done using gold/gold alloys, or silver/silver alloys. Via filling commonly will result in a "dip" or "bump" relative to the surface of the substrate, which may or may not influence performance. CoorsTek can provide a planar flush condition of the fill to substrate surface.

Bore coating is typically a via connection between front and back screened patterns, and is not intended to fill or plug the via. Thick-film conductors are generally used for coating vias.

Typical Via Filled or Bore Coated Materials:

- Silver
- Platinum Silver
- Palladium Silver
- Gold
- Gold alloys



IX. Substrates

In addition to coatings, CoorsTek is a leading producer of ceramic substrates providing superior thermal and dielectric properties. Typical substrates are flat plates of 90% or greater aluminum oxide in thicknesses of 0.010" - 0.050" (0.254 mm - 1.27 mm). Sizes typically range from 1" to 4.5" (25.4 mm - 114.3 mm) squares. Other compositions, shapes, sizes, and thicknesses are available. Contact a CoorsTek representative for additional information or call 303-277-4615.

Table IV – Substrate Materials Properties

Characteristic	Units	Alumina				Zirconia	Titanates			Others	
		AD-94	AD-96	AD-995	AD-996	YTZP	TD-20	TD-36	TD-82	Fused Quartz	AlN
Dielectric Constant (25° C)	@ 1 MHz	8.9	9.5	9.7	9.9	29	19.5 ± 1*	36.5 ± 1.5*	81.5 ± 3*	3.75 @ 20° C	8.0 – 9.0
Dielectric Strength (0.025" thick)	V/mil	550	600	580	600	9.0 ac-kv/mm (6.25mm)	–	–	–	–	673
Coefficient of Thermal Expansion (25-1000° C)	x10 ⁻⁶ /°C	7.9	8.0	8.3	8.3	10.3	8.6 [†]	6.5 [†]	9.0 [†]	5.5 X 10 ⁻⁷ /°C (20 – 320° C)	5.7
Thermal Conductivity (20° C)	W/m °K	18	26	34	35	2.2	4.2	2.1	2.1	(K ≈ 1.5)	170
Dissipation Factor (25° C)	@ 1 MHz	0.0001	0.0001	0.0001	0.0001	0.001	–	–	–	< 0.0001 @ 20° C	0.0001

* 20° C at 4GHz

† Temperature range 20 - 200° C

Note: Not all substrate materials are compatible with all coatings. Contact a CoorsTek representative for additional information. (Figures in the above table are for reference, and not intended to be absolute.)

IX. Substrates (cont'd)

0.010"	(0.254mm)
0.015"	(0.381mm)
0.020"	(0.508mm)
0.025"	(0.635mm)
0.030"	(0.762mm)
0.035"	(0.889mm)
0.040"	(1.016mm)
0.050"	(1.27mm)
0.060"	(1.524mm)
0.080"	(2.032mm)
0.100"	(2.54mm)
0.120"	(3.048mm)

Standard substrate thickness tolerances are $\pm 10\%$. Tighter tolerances can be provided for special applications.

1" x 1"	(25.4mm x 25.4mm)
2" x 2"	(50.8mm x 50.8mm)
3" x 3"	(76.2mm x 76.2mm)
3.5" x 3.5"	(88.9mm x 88.9mm)
4.5" x 4.5"	(114.3mm x 114.3mm)
4.5" x 6.5"	(114.3mm x 165.1mm)
5" x 7"	(127mm x 177.8mm)
5.5" x 6.5"	(139.7mm x 165.1mm)
6" x 6"	(152.4mm x 152.4mm)

Reference CoorsTek Thick and Thin-Film Design Guides for sizes.

X. Spin Coating

This is a method of completely coating small parts with refractory metallization. The Molybdenum Manganese or Tungsten serves as seed layering when metallic plating such as nickel is required. Isolations can be created by grinding after the metallization process. Coating tends to be thinner at sharp edges, and thus thickness control can be difficult to maintain.

	Minimum	Average	Maximum
Typical Coating Thickness	Trace: $\leq 50 \mu\text{m}$ ($\leq 1.3 \mu\text{m}$)	$600 \mu\text{m} - 800 \mu\text{m}$ ($15 \mu\text{m} - 20 \mu\text{m}$)	$1200 \mu\text{m}$ ($30 \mu\text{m}$)



Example of spin coating (coated completely)

XI. Radial Coating

This method is used primarily for O.D. stripe coating of cylindrical shapes. Coatings are generally seed layer metallization, thick-film conductors, and/or a dielectric glaze.

Feature	Minimum	Maximum
O.D.	0.090" (2.3mm)	0.400" (10.2mm)
I.D.	0.060" (1.5mm)	0.300" (7.6mm)
Length	0.100" (2.5mm)	1" (25.4mm)
Band width	$0.010" \pm 0.005"$ ($0.25\text{mm} \pm 0.13\text{mm}$)	$1" \pm 0.005"$ ($25.4\text{mm} \pm 0.13\text{mm}$)



Examples of radial coating

XII. Special Coating Techniques

Complex shapes or products involving prototype development may require precision coating techniques. Experienced personnel working in a laboratory environment can perform coatings by hand, brush, or needle dispensing.

XIII. Brazing and Solder Assemblies

CoorsTek is capable of producing brazed and/or soldered assemblies. Brazing involves a bonding process of metal to ceramic for structural purposes. The metal of choice is usually Kovar, a nickel/iron/cobalt alloy. This is primarily because the Coefficient of Thermal Expansion (CTE) closely matches that of the alumina substrate. The brazing process is usually done at temperatures exceeding 700° C. Typical braze materials used are silver/copper, pure silver, copper, and gold.

Solder coatings are also available from CoorsTek. These are generally applied by printing on fired coatings of Molybdenum Manganese or thick-film conductors. Solder coatings are typically alloys of tin, lead, silver, indium.

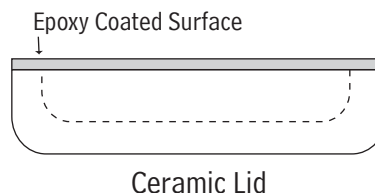
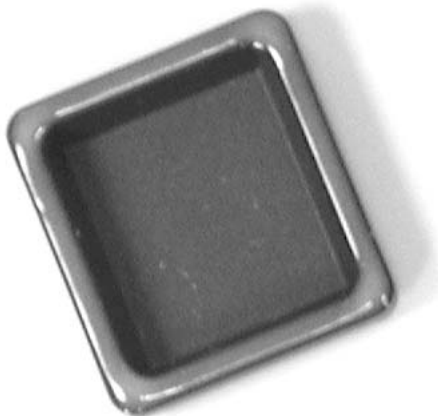


Examples of brazing and solder assemblies



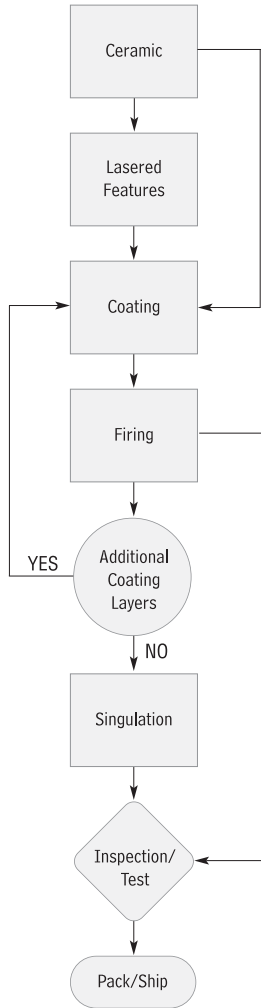
XIV. Epoxy Coatings

CoorsTek offers B-stage epoxy sealing capability for lids, caps, covers, and frames. Epoxy seals provide high strength, moisture resistance, and are a less expensive alternative to brazing or soldering where applicable. For detailed information, reference CoorsTek publication "Epoxy Seal Lids for Electronic Packages", or contact a technical representative at 303-277-4615.

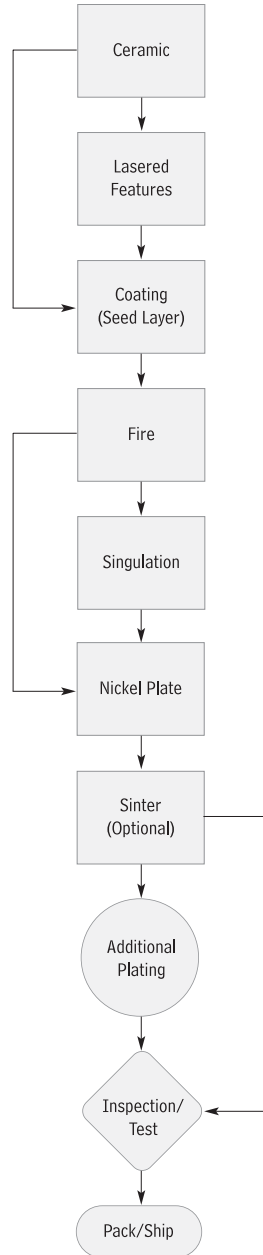


Example of a lid with epoxy coating on open face

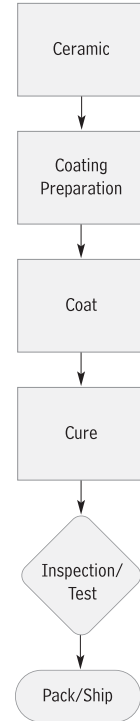
XV. Basic Coating Process Flows



Screen Printing



Plating



Epoxying



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European Union (EU) Directive on Restriction of Hazardous Substances (RoHS): The EU Directive on RoHS specifies that an electronic product or component may not contain a listed substance except as specifically provided in the directive. CoorsTek bare ceramic substrates meet the requirements of the Directive.

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