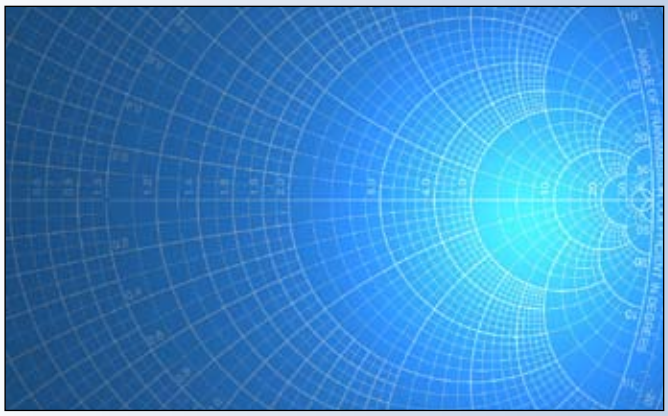
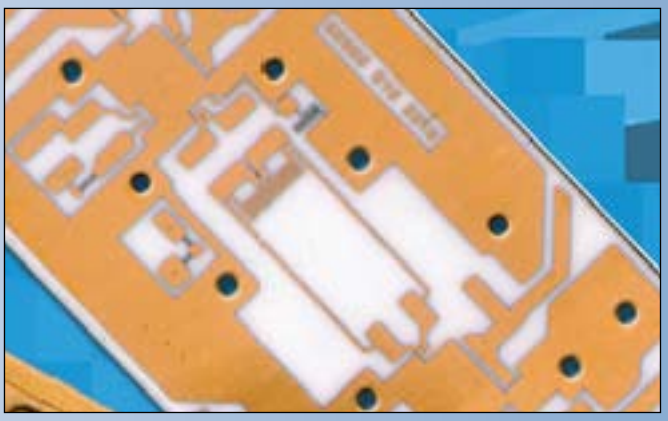
THIN FILM CIRCUITS - Application Note



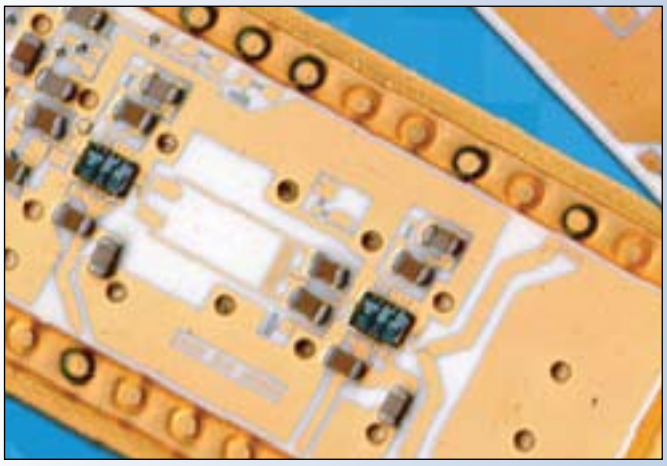


Innovative solutions for demanding applications

With more than 30 years of experience in Thin Film deposition and lithography, TT electronics is acknowledged as the world leader in custom thin film circuits and hybrid substrates. The unique characteristics of TT electronics' self-passivating Tantalum Nitride film ensure accuracy and long-term stability even in harsh environments.

TT electronics' continuous sputtering process and proprietary vacuum anneal process along with state-of-the-art laser trim equipment provide the consistent high stability performance characteristics for which TaNFilm® products are known. Critical process operations are performed within a Class 100 clean room resulting in exceptional line definition and repetitive circuit patterns from unit to unit and lot to lot.

A broad range of available materials and process capabilities combined with a strong applications engineering group unite to make TT electronics the first choice in the most demanding thin film circuit designs.



Versatile manufacturing and special requirements are our business. A combination of quality materials, tight tolerance and ratio matching allows TT electronics to offer high quality thin film resistors built to fit your most exacting high frequency specifications.

THIN FILM CIRCUITS - Application Note

TT electronics, An overview

TT electronics plc is one of the largest suppliers of electronic components worldwide, providing products to OEMs, major distributors and electronic manufacturing services. The wide range of products include fixed and variable resistors, networks, capacitors and assemblies, magnetic components and materials. Manufacture is worldwide including UK, continental Europe, North America, Mexico, Barbados, Malaysia, India, and China.

Markets served include Industrial/Instrumentation, Automotive, Telecommunication, Computing, Defense/Avionics and Medical. TT electronics has a proven track record over many years through its subsidiaries and continues to expand both internally and by acquisition to add to the depth and range of its products and technologies.

Our main emphasis is supplying solutions to customer's needs. This enables them to be more competitive by using application engineering techniques to design components or assemblies tailored to individual requirements.

Company Profile

Our tantalum nitride thin film plant, located at Corpus Christi, Texas, USA manufactures a variety of passive products utilizing thin film technology for resistive, capacitive, integrated passive and circuit substrate products. The 100,000 square-foot plant houses class 100 and 1000 clean rooms, modern processing equipment, large volume thin film deposition and a new semiconductor fab for producing the company's TaNSil® and TaNCap® tantalum nitride on silicon products. Automated world-class equipment keeps TT electronics a cost-effective supplier of state-of-the-art products for today's demanding passive electronic applications.

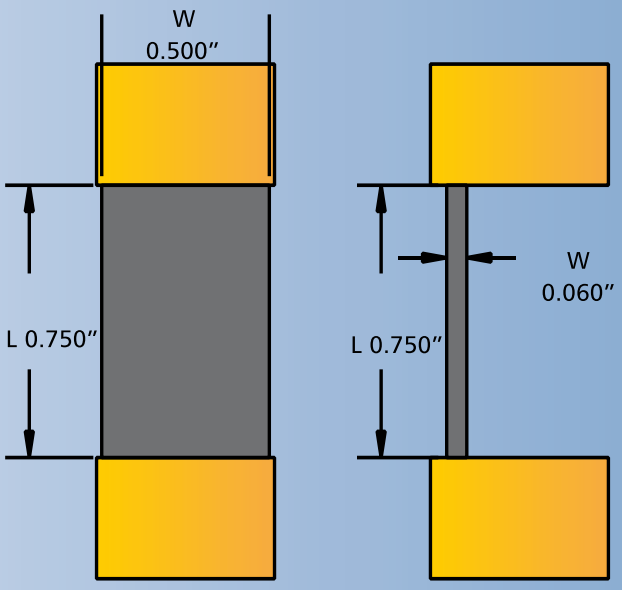
Design Notes

Note A Resistor design: Resistor geometries are measured in "squares"; a dimensionless ratio of length over width. A rectangular resistor that is 0.750" long and 0.500" wide is 1.5 squares. If using 100Ω/sq sheet resistance material, this resistor would be 150Ω. Using 100Ω/sq sheet resistance material, a 100KΩ resistor would need to have 1000 squares. A 90° corner counts as 0.5587 squares.

Note B Laser trim probing: Each resistor to be tested or trimmed needs a pad of sufficient size to be probed. Single-probe pad size minimum of 0.004" x 0.004" is good only for resistor values greater than 100Ω or tolerances greater than 0.2%.

Note C Overall substrate dimension tolerances ±0.002".

Note D Preferred data formats: AutoCAD® ".DWG" or ".DXF", Gerber, or GDSII.



THIN FILM CIRCUITS - Application Note

Design Notes

High performance by design
High frequency substrate design is simple when utilizing TT electronics' broad range of thin film processes and materials. Well-defined capabilities and materials allow microwave circuit designers to create high performance circuits to meet the most stringent design requirements.

TaNFilm®: stability, quality and performance
High conductivity thin film and plated materials, such as aluminum, copper and gold, help to minimize impedance changes at high frequencies due to skin effect while providing highly patternable and repeatable lumped or distributed circuit elements on stable, ceramic substrates. TT electronics' highly acclaimed TaNFilm® resistive elements provide stability over time and temperature, even in moist environments, and are laser trimmed to tolerances as tight as ±0.01%. Ceramic substrates provide a rigid, stable platform with consistent dielectric constant from circuit to circuit and lot to lot. A variety of inorganic and organic overcoat materials are available from 0.2 microns thickness to 10 microns thickness with dielectric strengths up to 200 volts per micron.

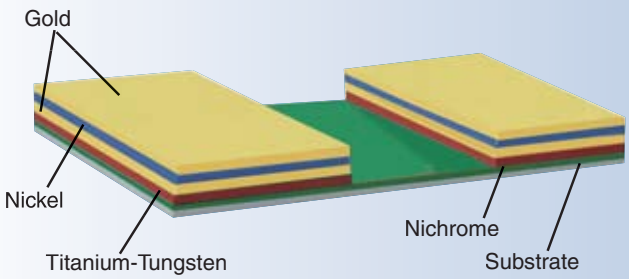
Solutions for every industry
TT electronics thin film microwave circuits find applications in automotive, medical, industrial, aerospace, and telecommunications markets. From collision detection radar systems in automobiles to deep tissue heating for medical applications, TT electronics Thin Film technology provides high frequency thin film solutions for a broad spectrum of industries and applications.

Typical Metallization Systems

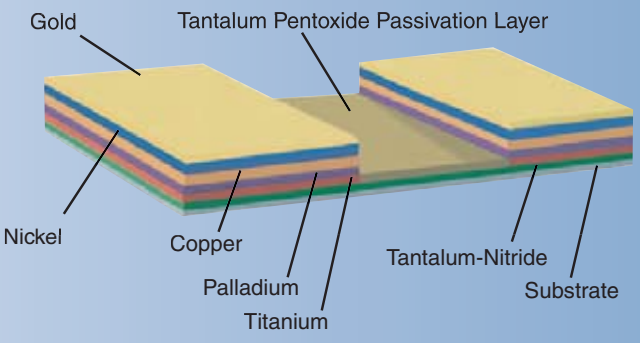
Advantages

- **Thin film technology**
- **Built to customer requirements**
- **Tight tolerance and ratio matching**
- **Solderable and wire bondable conductor available**

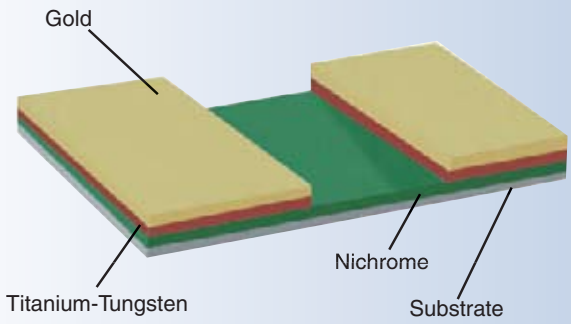
Typical Solderable NiCr Metallization System



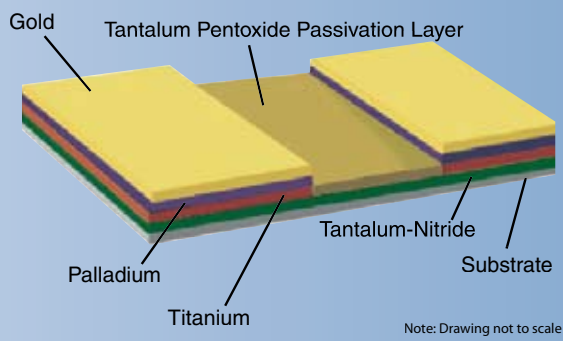
Typical Solderable TaNFilm® Metallization System



Typical Wire Bondable NiCr Metallization System



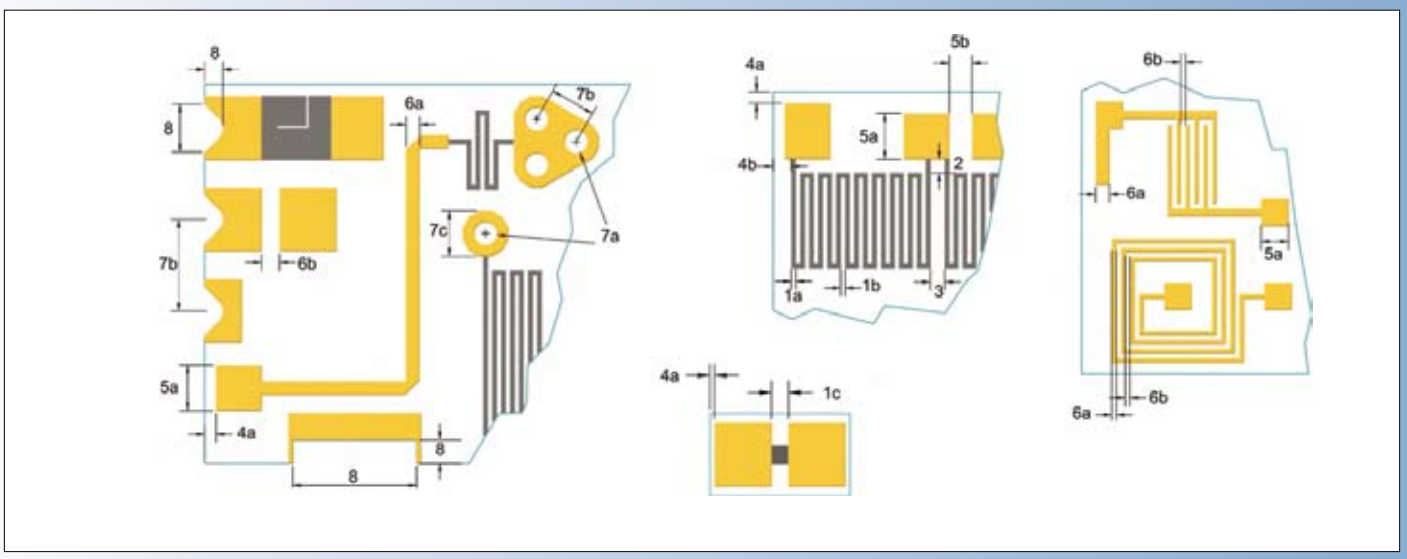
Typical Wire Bondable TaNFilm® Metallization System



Note: Drawing not to scale

THIN FILM CIRCUITS - Application Note

Thin Film Design Guidelines



Thin Film Design Feature Sizes

ID	Description	Typical	Minimum
1a	Resistor line width*	25µ ± 2µ	12µ ± 2µ
1b	Resistor line spacing	25µ ± 2µ	12µ ± 2µ
1c	Block resistor size*	250µ X 250µ ± 10µ	100µ X 100µ ± 10µ
2	Resistor to conductor spacing	125µ ± 25µ	100µ ± 25µ
3	Spacing between different resistors	125µ ± 10µ	100µ± 10µ
4a	Conductor to substrate edge	150µ ± 25µ	50µ ± 25µ
4b	Resistor to substrate edge	200µ ± 25µ	100µ ± 25µ
5a	Pad Size (see Note B on previous page)	250µ X 250µ ± 25µ (for 2 probes)	100µ X 100µ ± 25µ (single probe)
5b	Spacing between pads	250µ ± 25µ	125µ ± 25µ
6a	Conductor line width	100µ ± 5%	25µ ± 10%
6b	Conductor spacing	100µ ± 5%	25µ ± 10%
7a	Via hole diameter	375µ + 75µ / -25µ	250µ + 75 / -25µ
7b	Via hole pitch	(2.5 X hole dia) ± 50µ	(2.5 X hole dia) ± 25µ
7c	Via hole cover pad	(via hole dia + 500µ) ± 50µ	(Via hole dia + 250µ) + 50µ
8	Edge vias or wraparounds (castellations)	Entire vertical or horizontal edge or any rectangular feature intruding on an edge	525µ wide with 200µ intrusion ±50µ

*Resistors are limited by a maximum Power Density of 1000 W/in^2.

THIN FILM CIRCUITS - Application Note

Production Capabilities

Overcoat Materials

Material	Photo Patternable	Thickness	Dielectric Strength
Polyimide	Yes	1µ to 10µ	200v/µ
Epoxy	No	25µ	20v/µ
SiO_2(plasma)	Yes	0.2µ to 1µ	500v/µ

Plated Materials

Material	Thickness	Sheet Resistance	TCR	Typical Use
Gold	1µ to 4µ	0.010Ω/sq. to 0.020Ω/sq	+4000ppm/°C	Conductor
Copper	1µ to 10µ	0.002Ω/sq. to 0.020Ω/sq	+6000ppm/°C	Conductor
Nickel	1µ to 5µ	0.020Ω/sq. to 0.10Ω/sq	+5000ppm/°C	Conductor
Solder	5µ to 20µ	N/A		Termination Conductor
Tin (matte)	5µ to 20µ			Termination Conductor

Thin Film Materials

Material	Sheet Resistance	TCR	TCR Tracking	Patterned Tolerance	Trimmed Tolerance	Trimmed Ratio Tolerance	Typical Use
Titanium	5Ω/sq. to 25Ω/sq	NA		±10%	NA		Adhesion Layer
Palladium	0.5Ω/sq. to 5Ω/sq			±10%			Adhesion Layer
Titanium-Tungsten	8Ω/sq			±10%			Adhesion Layer
Gold	0.08Ω/sq	NA		±10%	NA		Conductor
Aluminum	0.02Ω/sq. to 0.1Ω/sq			±10%			Conductor
Tantalum Nitride	5Ω/sq. to 100Ω/sq	To ±10ppm/°C	To ±1ppm/°C	±10%	To ±0.01%	To ±0.005%	Resistor
Nichrome	10Ω/sq to 200 Ω/sq	To ±10ppm/°C	To ±1ppm/°C	±10%	To ±0.01%	To ±0.005%	Resistor
Chromaxx™	To 4kΩ/sq	To ±50ppm/°C	To ±5ppm/°C	±10%	To ±0.1%	To ±0.1%	Resistor
Platinum	0.05Ω/sq to 1Ω/sq	+3750ppm/°C +3850ppm/°C	N/A	±10%	To ±0.5%	N/A	Temperature Sensor

THIN FILM CIRCUITS - Application Note

Typical Applications

Industrial
- Test and measurement systems
- Power switches
- Frequency converters
- Power dividers
- Low noise amplifiers
- Passive signal buffers

Medical
- Microwave deep tissue heating
- Balun
- Antennas

Radar
- Up/down converters
- Receivers
- Transmitters
- Antennas
- Detector log video amplifiers
- Frequency activity detectors
- Instantaneous frequency
- Measurement receivers
- Switched multiplexers
- Frequency memory loop
- Switched filters
- Digital radio frequency memory

Automotive
- Collision detection

Aerospace Defense
- Microwave sub-system assemblies

Communications
- Direct line of sight communications base stations
- Bluetooth
- IEEE 802.11
- WLANs
- WMANs

Production Capabilities

Facility

Total Area	100,000 sq. feet
Class 100 Clean Room	2,600 sq. feet
Class 1000 Clean Room	2,700 sq. feet

Metallization

Thin Film	Tantalum Nitride Platinum Palladium Nickel	Titanium Aluminum Chromaxx™
Electroplated	Gold, Copper, Nickel,	Sn/Pb, Sn (matte)

Note: Consult factory for double-sided metallization, substrate vias and through hole plating.

Key Technologies

In-Line continuous sputtering capability
TCR control to ±10ppm/°C State-of-the-art computer controlled laser trimmers (Untrimmed resistors available)

Characteristic	Standard Substrate	Polished Substrate
Resistor Tolerances		
Absolute	To ±0.01%	To ±0.01%
Ratio	To ±0.005%	To ±0.005%
Temperature Coefficient		
TCR Absolute (ppm/°C)	To ±10	To ±10
TCR Tracking (ppm/°C)	To ±1	To ±1
Substrate		
Material	99.6% Alumina	99.6% Alumina
Thickness (mil)	10, 15, 20, 25	10, 15, 25
Dimensions (in)	Up to 3.74 x 4.5	1.0 to 4.5
Surface finish (µin)	3	1
Dissipation Factor		
1 MHz	0.0001	0.0001
10 GHz	0.0002	0.0002
Dielectric strength (V/mil)	575	575
Dielectric constant	9.9 ±0.1	9.9 ±0.1
Volume resistivity (Ω-cm)	>1014	>1014
Thermal conductivity @ 100°C (W/m°K)	26.6	26.6

TT electronics: leading in fixed resistor technology.

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TT electronics companies