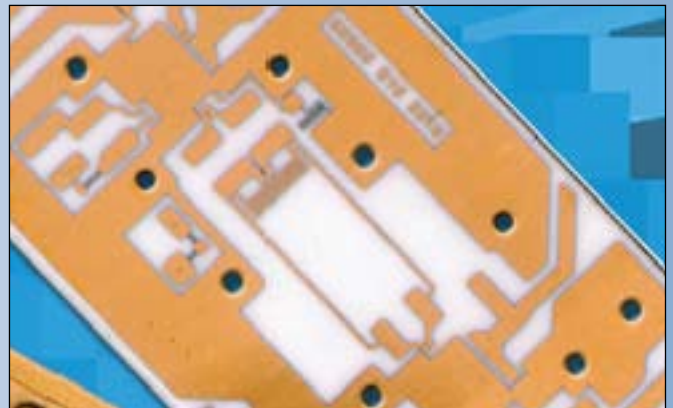
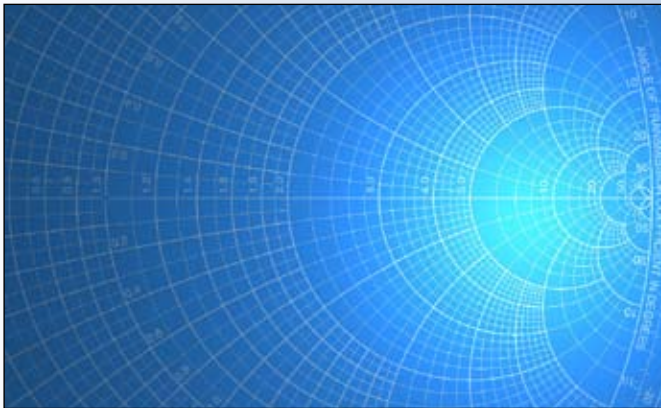


THIN FILM MICROWAVE CIRCUITS - Application Note



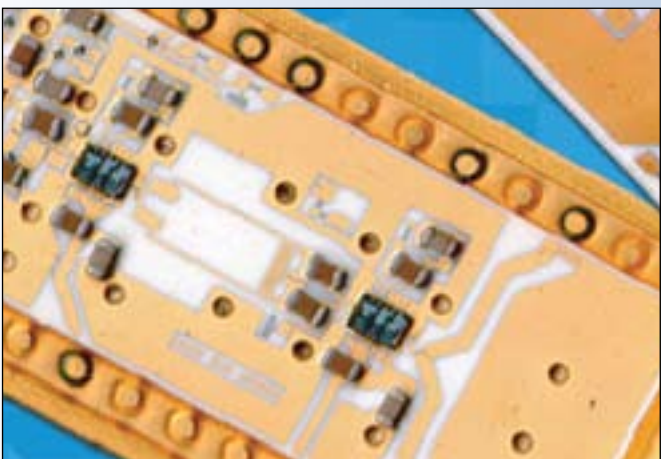
Innovative solutions for demanding applications

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 MICROWAVE CIRCUITS - Application Note

TT electronics, An overview

Corporate Profile

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

Based in Corpus Christi, Texas, International Resistive Company Advanced Film Division (IRC-AFD) a subsidiary of TT electronics is a state of the art manufacturer of a variety of passive products utilizing a wide array of both thin and thick film technologies for resistive, capacitive, temperature sensing, current sensing, 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.

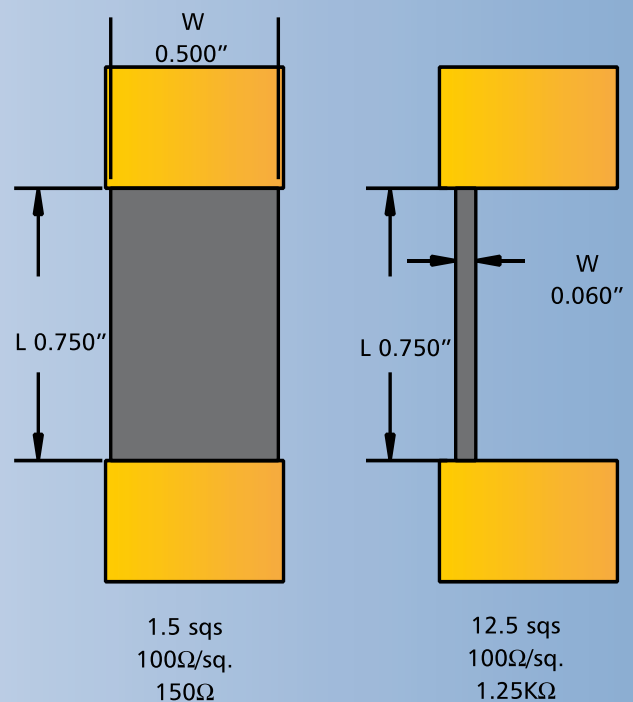
Design Notes

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 MICROWAVE 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 $\pm 0.01\%$. 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

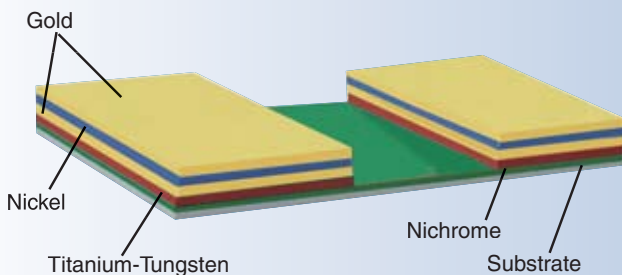
TT electronics thin film microwave circuits find applications in automotive, medical, industrial, aerospace, and telecommunications markets. From collision detection radar systems in automobiles to deep tissue heating for medical applications, TT electronics Thin Film technology provides high frequency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

Typical Metallization Systems

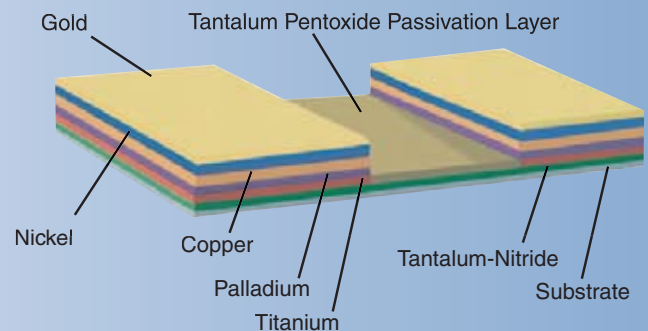
Advantages

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

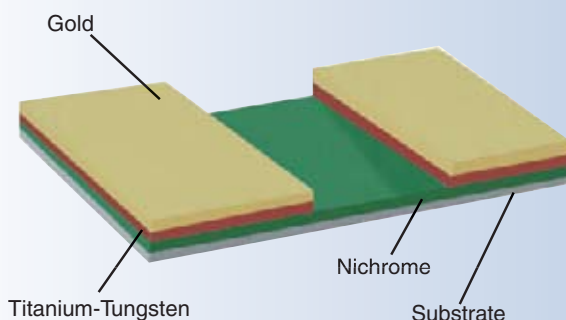
Typical Solderable NiCr Metallization System



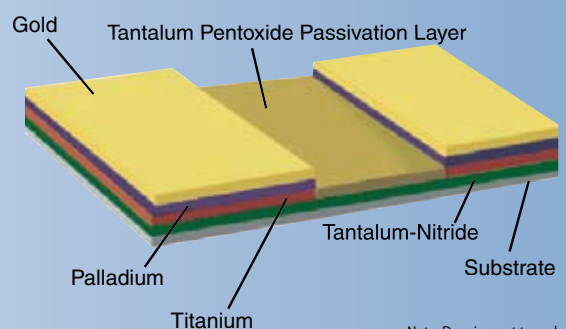
Typical Solderable TaNFilm® Metallization System



Typical Wire Bondable NiCr Metallization System



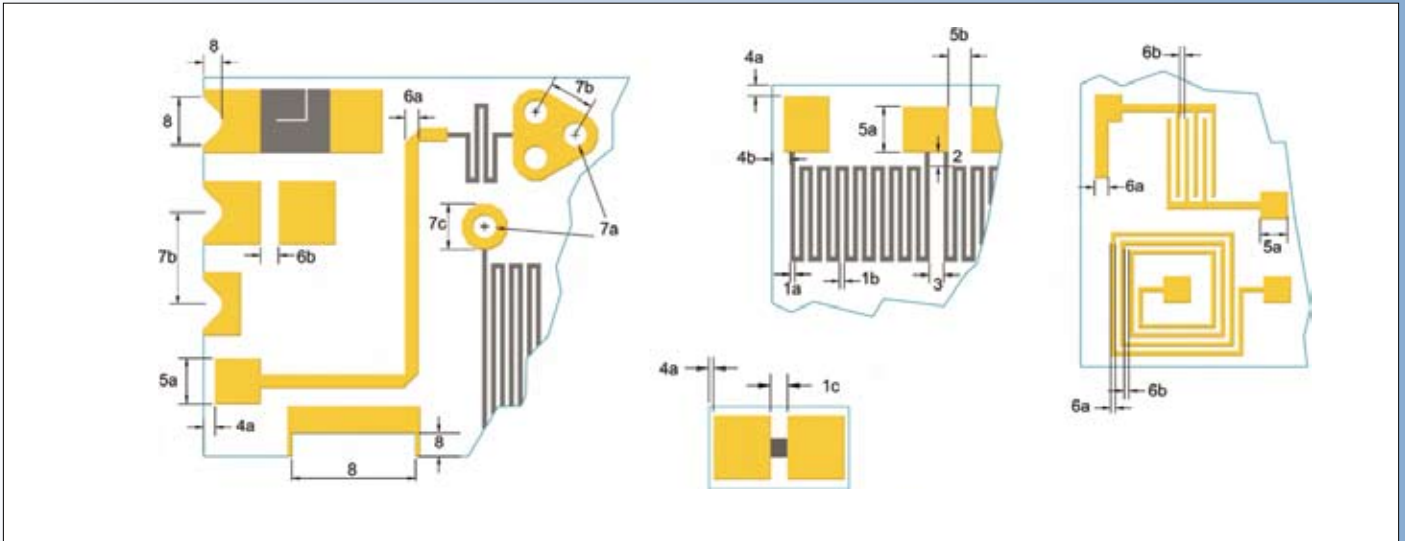
Typical Wire Bondable TaNFilm® Metallization System



Note: Drawing not to scale

THIN FILM MICROWAVE 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/in².

THIN FILM MICROWAVE 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 MICROWAVE 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

			Characteristic	Standard Substrate	Polished Substrate
Facility			Resistor Tolerances		
Total Area	100,000 sq. feet		Absolute	To ±0.01%	To ±0.01%
Class 100 Clean Room	2,600 sq. feet		Ratio	To ±0.005%	To ±0.005%
Class 1000 Clean Room	2,700 sq. feet		Temperature Coefficient		
Metallization			TCR Absolute (ppm/°C)	To ±10	To ±10
Thin Film	Tantalum Nitride	Titanium	TCR Tracking (ppm/°C)	To ±1	To ±1
	Platinum	Aluminum			
	Palladium	Chromaxx™			
	Nickel				
Electroplated	Gold, Copper, Nickel,	Sn/Pb, Sn (matte)	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
Note: Consult factory for double-sided metallization, substrate vias and through hole plating.			Dissipation Factor		
Key Technologies			1 MHz	0.0001	0.0001
In-Line continuous sputtering capability			10 GHz	0.0002	0.0002
TCR control to ±10ppm/°C State-of-the-art computer controlled laser trimmers (Untrimmed resistors available)			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/m²K)	26.6	26.6

TT electronics: leading in fixed resistor technology.

www.ttelectronics.com

www.bitechnologies.com

www.irctt.com

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TT electronics companies

General Note

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