Advanced Technical Ceramics Company

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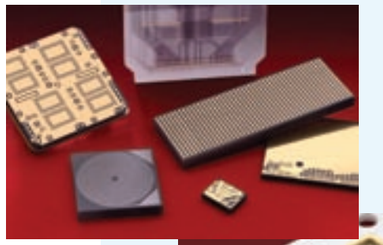
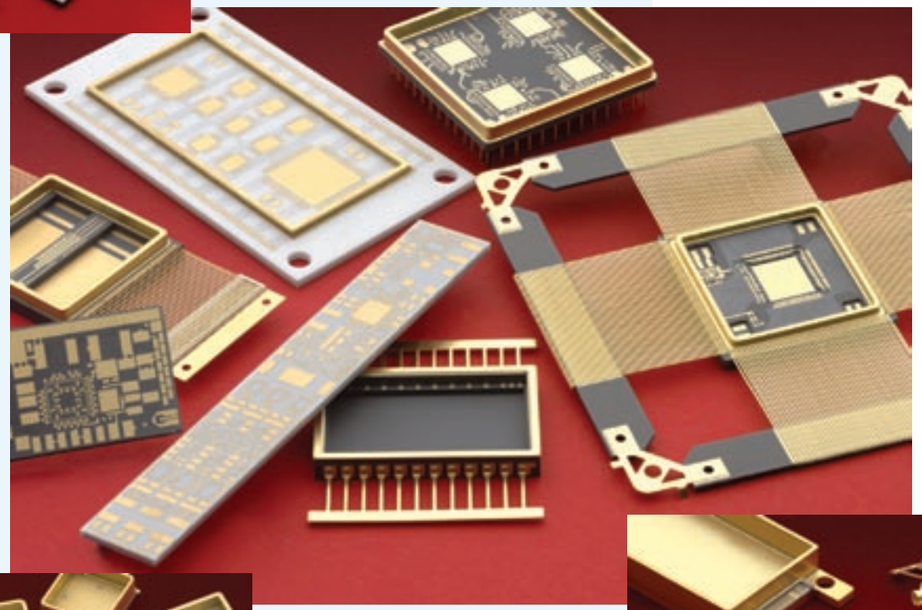
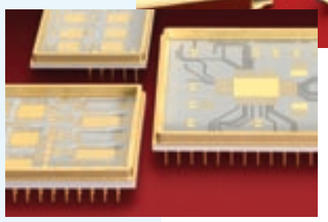
ISO 9001:2000 Certified

AdTech Ceramics



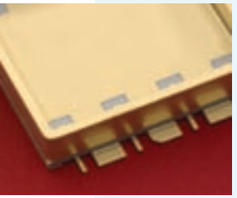


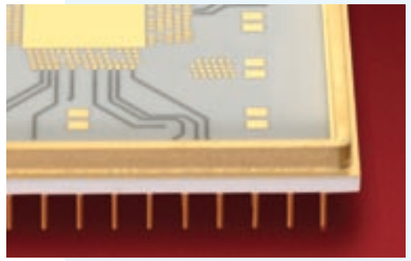


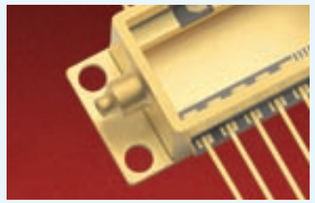
Design Guide

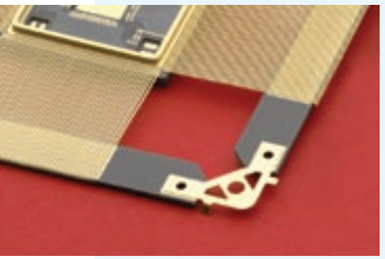
Ceramic Packages

Product Capabilities









Products available include:

- **Custom Advanced Packages**
- **Multichip Modules, Substrates and Packages**
- **Microwave Packages**
- **High Frequency Feed Throughs**
- **Power Dissipation Packages**
- **Optical Packages**
- **High Lead Count Packages**
- **Custom Pin Grid Arrays**
- **Sensor Packages**
- **Crystal/Oscillator/ SAW Packages**
- **Pad Array Carriers (Ball Grid Arrays)**
- **Ceramic/Metal Packages**
- **Chemical Milling**

Note: These general guidelines should be used for typical designs. If exceptions or special requirements are needed they should be reviewed with AdTech Ceramics.

Company Overview

Advanced Technical Ceramics Company (AdTech Ceramics) is a new company located in Chattanooga, Tennessee.

Founded with a proven employee base and manufacturing capability for multilayer co-fired electronic packages

Processes revolve around 30 plus years of experience in material science, engineering, design, tooling and manufacturing of multilayer ceramics

Materials include Alumina (HTCC), Aluminum Nitride, BeO and LTCC

Chemical Milling services available (step lids, leads, seal rings) in Kovar, Alloy 42, Spring Steel and Stainless Steel

Market emphasis targets engineering solutions for high reliability applications

Business model focuses on long term stability and growth

Manufacturing capabilities include prototype to high volume production

US owned, US based, ITAR Compliant

MIL-1-45208

ISO 9001:2000 Certified

AdTech Ceramics continues to drive process, facility and equipment improvements and advancements, and actively seeks new opportunities in advanced material technology.

Process Overview

AdTech Ceramics

Electronic packages produced with the co-fire multilayer ceramic process have four distinct processing stages:

Materials Preparation

Green Processing

Sintering

Post-fire Processing

Materials Preparation

Ceramic materials are prepared by milling precise amounts of raw materials into a homogeneous slurry. This mixture is principally ceramic powders of controlled particle sizes with fluxes and small amounts of organic binders and solvents. This slurry is poured onto a carrier and then passed under a blade to produce a uniform strip of specific thickness. When dried, this strip becomes a ceramic-filled "tape" which is easily handled in rolls or sheets for unfired processing.

Metal powders of exact compositions and particle sizes are prepared as "pastes" for subsequent screen printing on the green ceramic tape, or in some cases, on the fired ceramic. Likewise, ceramic powders can be prepared as pastes to be used as screen printed dielectric layers.

Green Processing

Except for very large or complex products, individual products are arranged in arrays for multiple processing. Via holes, edge castellations and cavities are then punched in the tape. Because of the abrasive nature of ceramics, special tooling must be used for these operations. Green processing of ceramic is very sensitive to particulates and is done in a Class 10,000 Clean Room.

Via holes are filled with a refractory metal paste, or bore coated, to become the vertical electrical interconnections between the layers. Conductive circuit patterns are printed onto the ceramic tape with refractory metal pastes using precision screen printing.

The layers are then stacked and laminated together. At this point the array may be scored to allow post fire operations in the array, or individual products may be cut or punched out of the array prior to sintering.

Sintering (Firing)

The ceramic-refractory metal composite structure is sintered, or "co-fired," at temperatures as high as 1600°C in a carefully controlled atmosphere. During the firing process most ceramics shrink approximately 20% in the X, Y and Z dimension. Hot pressed AIN is physically constrained in the X and Y dimensions so that all shrinkage occurs in the Z dimension.

Post Fire Processing

Ceramic packages are typically supplied with Gold over Nickel plating on the metallized areas, and can have metal components attached by brazing.

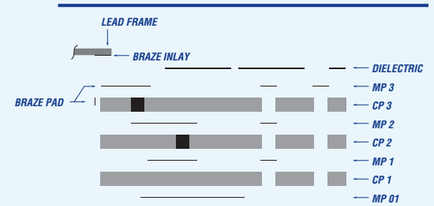
Nickel is plated on all exposed metal surfaces to allow brazing and to provide solderability. Metal leads, pins, seal rings and heat sinks are attached by brazing with silver or a silver-copper eutectic alloy to form a strong hermetic joint.

Final plating may be either electroless or electrolytic gold. Electrolytic plating requires that all exposed circuits be temporarily electrically connected through a lead frame, internal tie bar, or a combination of the two.

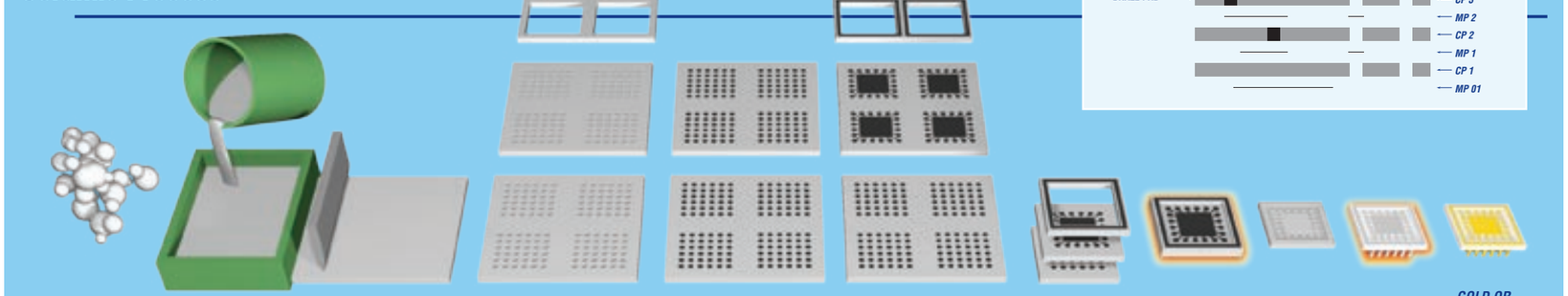
A combination of electrolytic and electroless plating can be used if designs require. (Note: in this case metal components must be electrolytic.)

Post fire metallizations can be used for applications requiring special flatness or precision tolerances. Ceramic grinding, lapping and ultrasonic machining are available for applications requiring features not achievable as-fired.

Co-fire Numbering System



Co-fire Multilayer Ceramic Process



AdTech Ceramics

Multilayer ceramic electronic packages can be produced with a wide choice of materials, each designed to meet specific application needs. The choices include:

- Ceramics
- Metallizations
- Brazed Components
- Platings

Ceramic Materials

AdTech offers a choice of ceramic materials:

- Alumina (HTCC)
- Aluminum Nitride (AlN)
- Low Temp Co-fired Ceramic (LTCC)
- Beryllium Oxide (BeO)

Additionally, custom materials can be developed to meet special needs.

Alumina (92% Al_2O_3) – HTCC

Alumina is the most popular ceramic material for multilayer packages. Because it has been used for many years its performance is well characterized, and it has a proven track record. Alumina offers high strength, good thermal conductivity, hermeticity, excellent electrical properties and the lowest cost high density interconnect. HTCC is available in both white and black.

Aluminum Nitride (AlN)

Due to its high thermal conductivity and excellent Thermal Coefficient of Expansion match to Silicon, Aluminum Nitride is the ceramic material of choice for high heat dissipation and/or large chip applications. AdTech Aluminum Nitride is produced using hot press technology.

It is ideal for applications requiring very high thermal conductivity (160 W/mK). The patented hot press process allows precision tolerances (±0.15%).

Aluminum Nitride's primary application is for MCMs requiring multiple internal metal patterns (30+ layers possible) with vias only terminating on the top and bottom surfaces. The external metal patterns are applied to a precision surface finish, flat to within .001"/inch, using thin film processing.

Typical Ceramic Properties

Material		92% Alumina (Al_2O_3)	Aluminum Nitride (AlN)
Color		Black or White	Translucent Gray
Density	g/cc (#/cu. in.)	3.62 (0.131)	3.26 (0.118)
Hardness	kg/mm^2	1207 (Knoop)	1200 (Knoop)
Flexural Strength	MPa (psi x 10^3)	443 (64)	280 (4)
Youngs Modulus	GPa (psi x 10^6)	275 (40)	340 (49)
Shear Modulus	GPa (psi x 10^6)	112 (16)	140 (20)
Surface Finish	µm (µ")	<1.14 (<45)	<0.76 (<30)
Thermal Expansion (25-300°C)	10^{-6}/°C (10^{-6}/°F)	6.57 (3.64)	4.00 (2.2)
Thermal Expansion (25-500°C)	10^{-6}/°C (10^{-6}/°F)	7.16 (3.98)	4.50 (2.5)
Thermal Conductivity (25°C)	W/mK (BTU-in/ft^2-h-°F)	20.3 (141)	160 (1174)
Dielectric Strength	kv/mm (volts/mil)	11.6 (295)	13.0 (330)
Volume resistivity	ohm-cm^2/cm	>10^{14}	>10^{14}
Dielectric Constant (1MHz)		9.2	8.6*
Dielectric Constant (10 GHz)		9.2*	8.2
Dielectric Constant (30 GHz)		9.2	–
Dissipation Factor (1 MHz)		0.0003*	0.0001
Loss Factor (10 GHz)		0.003*	0.0010
Loss Factor (30 GHz)		0.004	–

*Extrapolated Calculation

Typical Component Properties

Material	Molybdenum	(15-85) Copper Tungsten	Alloy 42	Kovar	Copper	BeO	Tungsten
Thermal Conductivity @25° (W/mK)	138	170	10.5	16.7	398	200-250	173
Thermal Coefficient of Expansion @25°C-100°C (x 10^{-6}/°C)	5.1	7.1	5.0	5.9	16.8	6.9	4.5
Electrical Resistance @25°C (x 10^{-6} ohm-cm)	5.2	6.1	72	49	1.7	n/a	5.5
Specific Gravity (g/cc)	10.2	16.8	8.1	8.4	8.9	2.9	19.3

Metallization

Metallizations are largely dictated by the ceramic base material. Alumina and Aluminum Nitride require refractory metals such as Tungsten (W) and Molybdenum (Mo) for high temperature sintering in protective atmospheres.

Metallization Resistance (Typical)

Ceramic	Alumina	Aluminum Nitride
Metallization	Tungsten	Tungsten or Tungsten-Moly
Buried	.012 ohm/sq (Standard)	.015-.020 ohm/sq
	.008 ohm /sq (High Conductivity)	–
Surface	.005 ohm/sq (Gold Plated)	.005 ohm/sq (Gold Plated)
Vias	.003 ohm (0.25mm (.010") DIA x 0.25mm (.010") length)	–

Brazed Components

Kovar and Alloy 42 are the most popular metals for brazed components due to their good thermal coefficient of expansion match to ceramics and relatively low cost. However, other materials such as Molybdenum and Copper Tungsten, can be successfully brazed to metallized ceramic for heat sink applications.

Plating

AdTech offers electrolytic and electroless Nickel in thicknesses typically from 50µ" to 300µ" and electrolytic and electroless Gold in thicknesses typically from 30µ" to 100µ". Thicknesses outside these ranges are also possible. A combination of both plating types can be used if required.

Plating Specifications

Finish	Process	Specification
Gold	Electroless	Meets MIL-G-45204 or AMS2422
	Electrolytic	MIL-G-45204 or AMS2422
Nickel	Electroless	AMS2404 or AMS2433
	Electrolytic	SAE AMS-QQ-N-290

Structural & Interconnect Design Guidelines

AdTech Ceramics

Design considerations for multilayer ceramic packages can be grouped into these categories:

- Structural Parameters
- Interconnect Layout
- Special Features

Structural Parameters

Each ceramic material has specific design and tolerance limitations due to their physical properties and processing technologies. These include size, number of layers, and flatness.

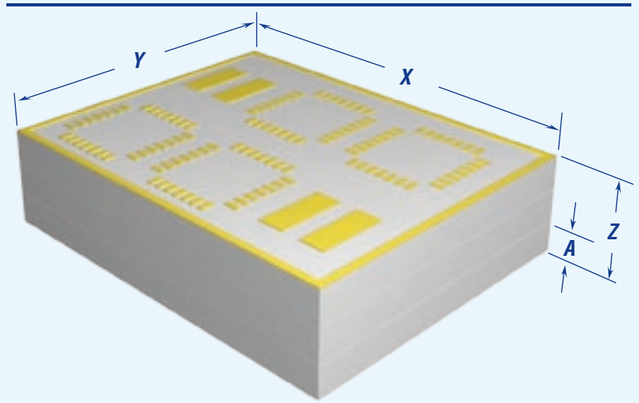
Vertical Interconnects

The basic interconnect between layers is the metal-filled via. Also used are bore coated (metallized side wall) vias, metallized edge castellations and flat edge metallization. Generally, via diameters should be at least the thickness of the ceramic layer and via pitch 2.5 times the layer thickness. Vias may require a cover pad to be printed with the metal interconnect pattern to assure optimal electrical connection between layers.

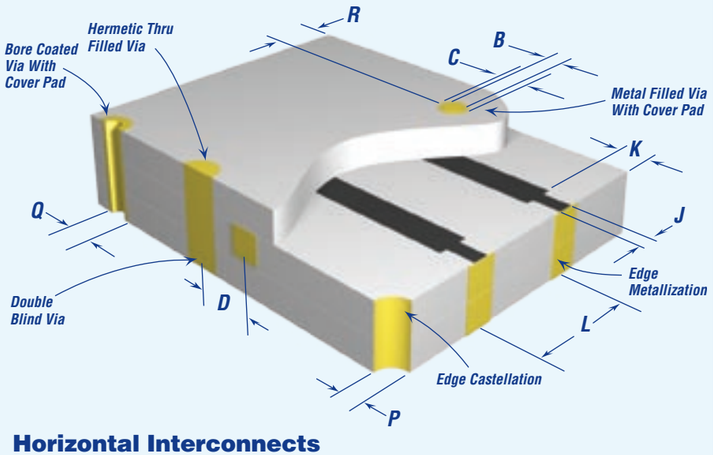
Horizontal Interconnects

Circuit layout is usually a compromise between maximizing conductor trace width to minimize resistance, and maximizing the space between conductors, and other metal features such as vias, in order to minimize yield losses. It is desirable to pull back buried metal features from the ceramic edge, and neck down conductors that terminate with edge metallization. Internal ground planes should be limited to a maximum of 75% metal coverage.

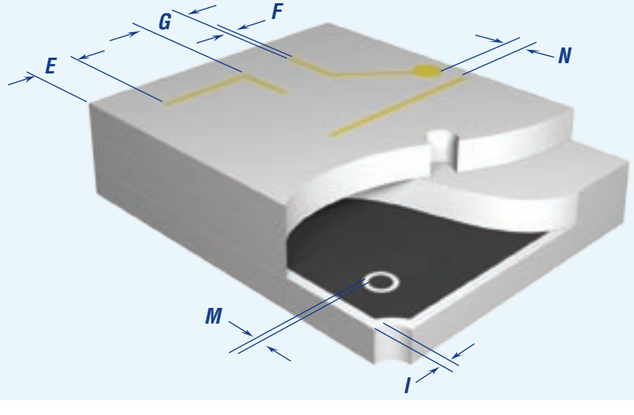
Structural Parameters



Vertical Interconnects



Horizontal Interconnects



Structural Parameters

Feature		Description	Alumina	Aluminum Nitride
Length/Width	(X/Y)	Standard Tolerances	±1% NLT ±0.13mm ±(.005")	±.005"
		Special Tolerances	±.5%	(Sawed) ± 0.05mm (.002")
Layer Thickness	(A)	Standard	0.18mm (.007") to 0.64mm (.025")	0.13mm (.005")
		Special	0.13mm (.005") to 0.76mm (.030")	0.09mm (.0035") to 0.38mm (.015")
		Standard Tolerances	±10%	±10%
		Special Tolerances	±5%	n/a
Package Thickness	(Z)	Range	0.25mm (.010") - 8.89mm (.350")	3.4mm (0.135")max
		Standard Tolerances	±10%	±0.08mm (.003")
		Special Tolerances	±5%	±0.03mm (.001")
Flatness		Standard	0.08mm/mm (.003"/inch)	0.03mm/mm (.001")/inch
		Special (Machined)	0.03mm/mm (.001"/inch)	n/a
Surface Finish		As Fired	<1.14µm (45µ")	n/a
		Lapped	<0.51µm (20µ")	<0.64µm(25µ")
		Polished	n/a	<0.13µm(5µ")

Vertical Interconnects

Feature		Description	Alumina	Aluminum Nitride
Filled Via	(B)	Diameter Range	0.10mm (.004") - 0.51mm (.020")	0.13mm (.005") - 0.51mm (.020")
	(C)	Cover Pad dia (Internal)	Via dia + 0.05mm (.002")	Via DIA+0.05mm (.002")
	(C)	Cover Pad dia (External)	Via dia + 0.13mm (.005")	Via DIA+0.38mm (.015")*
	(D)	Via-to-Via Centerline	0.30mm (.012") Min.	0.38mm (.015") Min.
	(R)	Via-to-Edge (Standard)	w = t + v (web = thickness + via diameter)	0.25mm (.010")
		Via-to-Edge (Sawed Edge)	0.20mm (.008") Internal Via	0.20mm (.008") Internal Via
		Via-to-Edge (Sawed Edge)	0.00 Split Via (see page 10)	n/a
Bore Coated Via	(Q)	Diameter Range	0.30mm (.012") - 0.64mm (.025")	n/a
		Cover Pad Diameter	Hole dia + 0.25mm (.010")	n/a
	(P)	Castellation Radius (Typical)	0.20mm (.008")	n/a
Edge Metallization	(L)	Centerline	0.64mm (.025")Min.	n/a
	(J)	Circuit Neckdown (Range)	0.13mm (.005") to Width of Edge Metal	n/a
	(K)	Pullback From Edge	0.51mm (.020") (TYP) 0.25mm (.010") Min.	n/a

Horizontal Interconnects

Feature		Description	Alumina	Aluminum Nitride (AlN)
Internal Metal Circuit	(F)	Typical Width	0.15mm (.006") - 0.25mm (.010")	0.15mm (.006") - 0.25mm (.010")
		Custom Width	0.10mm (.004")	0.10mm (.004")
	(G)	Typical Space	0.15mm (.006") - 0.25mm (.010")	0.15mm (.006") - 0.25mm (.010")
		Custom Space	0.13mm (.005")	0.13mm (.005")
		Maximum Coverage	85%	75%
		Recommended Grid	Equal lines and spaces	Equal lines and spaces
	(I)	Typical Space from Edge	0.76mm (.030")	0.254mm (.010")
		Custom Space from Edge (Sawed)	0.13mm (.005")	0.20mm (.008")
Surface Metal Circuit	(F)	Typical Width	0.20mm (.008")	0.20mm (.008")*
		Custom Width	0.10mm (.004")	0.10mm (.004")*
	(G)	Typical Space	0.20mm (.008")	0.20mm (.008")*
		Custom Space	0.13mm (.005")	0.10mm (.004")*
		Maximum Coverage	100%	100%
	(E)	Typical Space from Edge	0.25mm (.010")	0.254mm (.010")*
		Custom Space from Edge	0.00mm (.000")	0.18mm (.007")*
Relation to Vias	(M)	Isolation Ring Around Cover Pad	0.38mm (.015")	0.20mm (.008")*
		Custom Isolation Ring	0.25mm (.010")	0.10mm (.004")*
	(N)	Circuit to Cover Pad	0.25mm (.010")	0.20mm (.008")*
		Custom Space (External)	0.15mm (.006")	0.10mm (.004")*
		Custom Space (Internal)	0.20mm (.008")	0.20mm (.008")*

*Thin Film Process

AdTech Ceramics

Special consideration should be given to the design of the following features:

- Cavities
- Wire Bond Pads
- Metal Components
- Special Enhancements or Finishes

Cavities

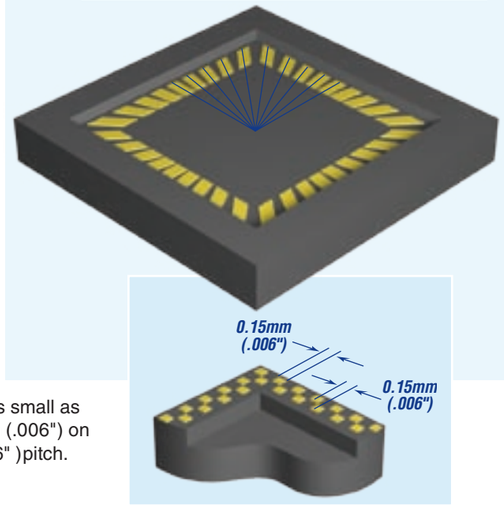
Cavities are punched into the ceramic in its green state. Metallization should generally be pulled back from the edges of cavities. When cavity floors are metallized, the metallization should extend beyond the cavity wall to assure complete coverage.

Wire Bond Pad Design

By designing wire bond pads in a radial pattern (from the center of the cavity) it is possible to compensate for variations in the co-fired shrinkage.

For very high density applications wire bond pads can be staggered in a double row around the die, achieving pads as small as 0.15mm (.006") x 0.15mm (.006") on an effective 0.15mm (.006")pitch.

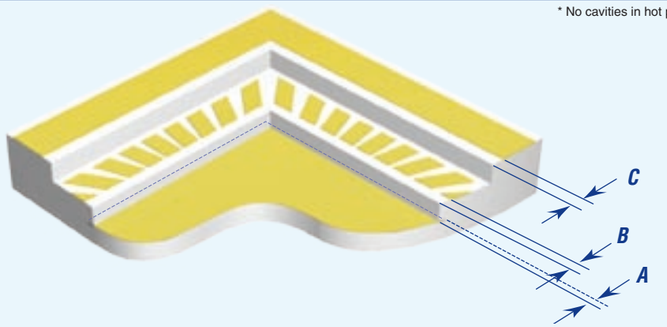
Wire Bond Pad Design



Cavity Design

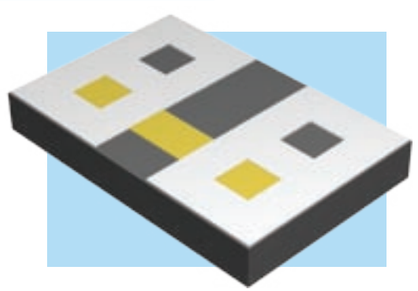
Feature		Description	Alumina	Aluminum Nitride*
Die Attach Pad	(A)	Typical Extension	0.51mm (.020")	N/A
		Minimum Extension	0.25mm (.010")	N/A
Circuit Pattern	(B)	Typical Pull Back	0.13mm (.005")	N/A
		Minimum Pull Back	0.08mm (.003")	N/A
Metallized Seal Ring	(C)	Typical Pull Back	0.25mm (.010")	N/A
		Minimum Pull Back	0.13mm (.005")	N/A

* No cavities in hot press technology



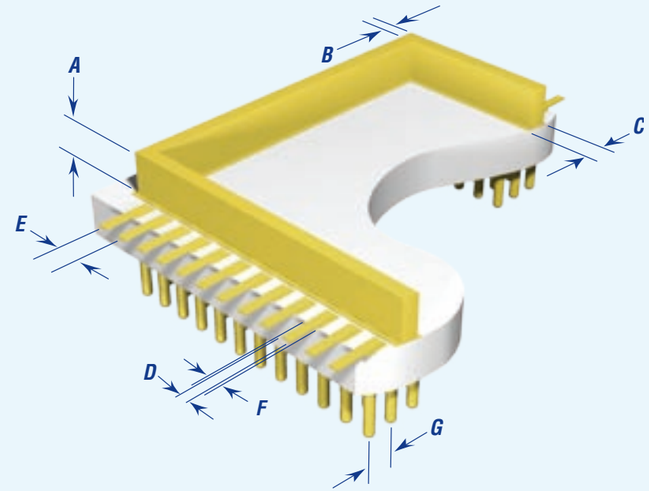
Screened Dielectrics

Screen printed dielectrics are frequently used to reduce overall ceramic thickness, cover exposed circuitry, or form solder or braze dams. The composition of the screened dielectric is the same as that of the base ceramic and is generally applied in the green state for sintering during the co-fire process.



Metal Component

Feature		Description	Specification
Seal Ring Height	(A)	Typical	1.02mm (.040")
		Range	0.25mm (.010") - 5.08mm (.200")
Seal Ring Width	(B)	Typical	1.02mm (.040")
		Range	0.25mm (.010") (Minimum)
Metallized Seal Ring Width	(C)	Typical	Seal Ring Width + 0.51mm (.020")
Lead Frame Width	(D)		0.20mm (.008") (Minimum)
Lead Frame Pitch	(E)		≥ 0.51mm (.020")
Metallized Lead Frame Pad	(F)		D + 0.25mm (.010") (0.13mm (.005") minimum space between pads)
Metal Pin Pitch	(G)	Standard	2,54mm (.100")
		Custom	1,27mm (.050")



Metal Components

Metal components such as seal rings, heat sinks and lead frames may be attached to metallized patterns on the ceramic by high temperature brazing. Leads may be necked down or formed in the braze pad area.

Attachment of metal components to aluminum nitride packages is considered custom and developmental due to TCE mismatch between brazed metal alloys and the AlN.

HTCC Thermal Enhancements

The thermal performance of co-fired alumina packages may be improved by adding thermal vias, or replacing the ceramic base with a brazed heat-sink such as Molybdenum (Mo), Copper Tungsten (Cu-W), Copper Molybdenum (Cu-Mo) or Beryllium Oxide (BeO).

Mechanical Enhancements

The mechanical characteristics of a package may be enhanced through a number of procedures. Lapping, a precision grinding process, can be used to improve flatness or surface finish. Diamond sawing, grinding and ultrasonic machining are available to achieve special features or tighter tolerances. Laser disconnect can be used to allow for all electrolytic plating.

AlN and BeO Solutions

Multi-layer AlN and metallized BeO substrates are also used for elegant thermal solutions for high power applications. BeO ceramics can be metallized and integrated into HTCC package designs, while AlN offers the multi layer circuit integration benefits of HTCC along with the thermal performance of BeO.

Design Capabilities

AdTech maintains in-house design capabilities, as well as excellent relationships with outside design service firms for overflow and special design needs. Additionally, AdTech's design staff can interface with and accept customer design data in a number of formats. Capabilities include but are not limited to:

- Engineering Software
  - AutoCAD
  - Solid Works
  - CAM 350
- Customer Interface - CAD Data Types
  - AutoCAD.DXF or .DWG
  - Gerber Plot Data (RS274, RS274X)
  - MDA Plot Data
  - Barco PDF

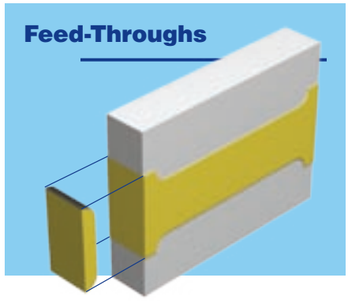
AdTech Ceramics can accept customer files via internet e-mail at design@AdTechCeramics.com or FTP upload.

Special Capabilities

AdTech prides itself on being the innovation leader in the ceramic package business. Co-fired ceramic technology was invented in our Chattanooga facility over 35 years ago, and numerous patents have been issued over the years. Today, the company remains the leading US-owned non-captive supplier of ceramic electronic packages, and continues to lead the industry in innovative uses and designs.

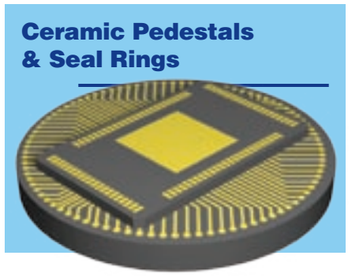
Feed-Throughs

AdTech's patented "split-via" concept provides an exceptionally reliable method of edge metallization without concern for processing damage at the point where metallization wraps around the edges.



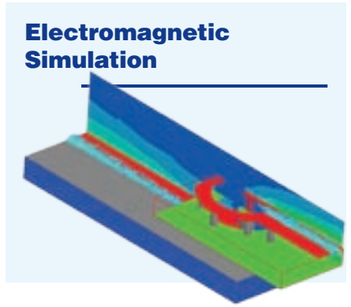
Self-Aligning Pedestals & Seal Rings

A ceramic pedestal may be used in the package design to allow for self-jigging of metal or ceramic lids, or as an isolated ceramic Seal Ring. Circuitry can be added to a pedestal that connects to package base.

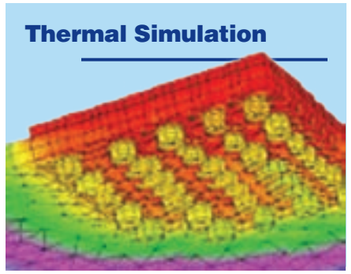


Microwave Design Assistance

AdTech Ceramics produces HTCC and AlN packages for microwave applications in the X through K band frequency ranges. It has a design process that uses state of the art 3D Finite Element Method (FEM) simulators and proprietary numerical



simulators. This process can yield market-differentiating performance while maintaining cost effective solutions. The alternative is to resort to the old cycle of fab, test and redesign. The AdTech solution, on the other hand, offers world class performance with cost competitive ceramic packaging solutions.

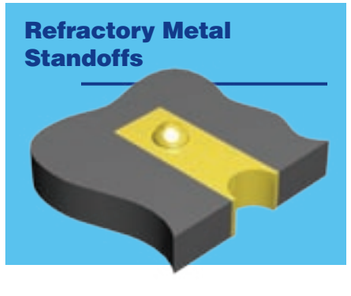


Thermal Modeling

AdTech Ceramics is able to analyze and improve the thermal performance of the ceramic package. It does so by using its unique combination of proprietary thermal analysis tools, commercially available thermal analysis software and highly qualified engineering staff. This capability improves performance and reduces cycle time.

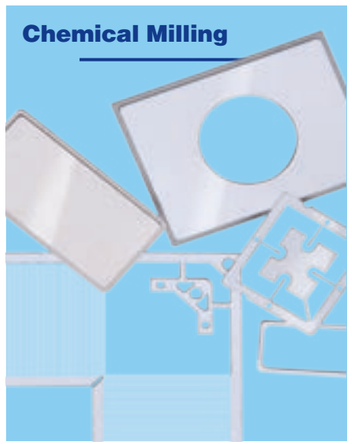
Refractory Metal Standoffs

For the ultimate in standoffs, AdTech can co-fire refractory metal "bumps" on BGAs or substrates that will retain their shape through multiple solder reflow operations.



Chemical Milling

In addition to ceramic products, AdTech makes and supplies high quality chemically milled products in Kovar, Alloy 42, Stainless and Spring Steel. Products include step lids, lead frames, seal rings and other custom applications. Products can be supplied as etched, or with Ni/Au plating for seam welding applications.



Mission Statement and Quality Policy

AdTech Ceramics

Mission Statement

Advanced Technical Ceramics Company strives for continuous improvement in quality and service to meet our customers' requirements for high-performance ceramic packaging products.

AdTech Ceramics' growth is driven by sound business ethics, customer satisfaction and the continuous development of new applications requiring advanced technical ceramic solutions.

Quality Policy

AdTech Ceramics is dedicated to achieving superior levels of customer satisfaction through teamwork and continuous improvement. We will provide quality to our customers, both internal and external, and will deliver products and services which will meet or exceed customer expectations in accordance with our Quality Management System.