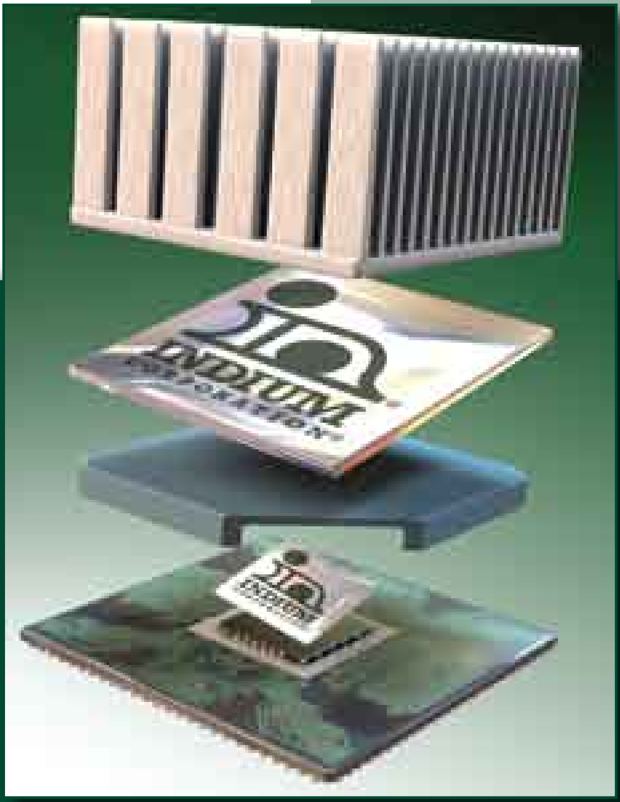
Metal Thermal Interface Materials



- **Liquid Metal**
- **Compressible Metal**
- **Solder**
- **TIM Fluxes**

Products

- Au/Sn Solder
- In/Pb Solders
- Pure Indium
- Informs
- SMA-TIM
- SAC Pb-Free Solders

86W/m·K

INDIUM CORPORATION®

Metal Thermal Interface Materials

Introduction

Metal Thermal Interface Materials
Radically Improve:

- Heat Dissipation Efficiency in Electronic Devices
- Thermal Conductivity for High Power Devices with Power Densities in Excess of 50W/cm^2
- End-of-Life Performance at the Thermal Interface – to Avoid Failures Common with Fluidic Solutions Such as Greases
- Portable Device Battery Performance – by Reducing Thermal Resistance and Cooling Fan Size
- Portable Device Use Profile – by Reducing Heatsink Size and Mass
- Compliance with RoHS While Accommodating Step Soldering Requirements

Indium Corporation Has Solutions for:

- Telecom
- Computing
- Semiconductors
- LEDs
- Photonics

Applications

Some Applications Include:

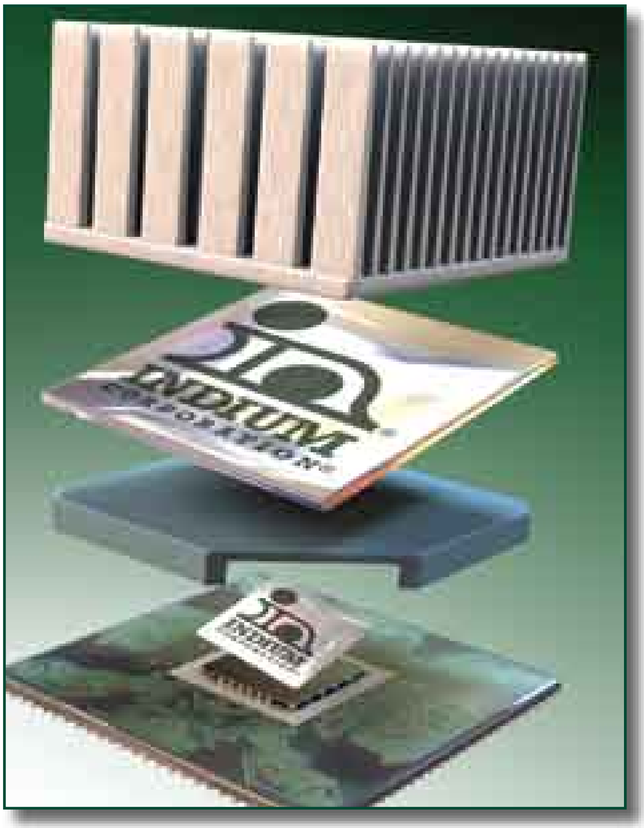
- Semiconductor Integrated Circuits
- Power QFNs
- Power Device to PCB Attach (TO220, etc.)
- Telecom
- Die-Attach (Photonics, MOSFETS, LED etc.)
- Laser Diodes

Products

- Au/Sn Solder
- In/Pb Solders
- Pure Indium
- Informs
- Sn/Pb Solders
- SAC Pb-Free Solders

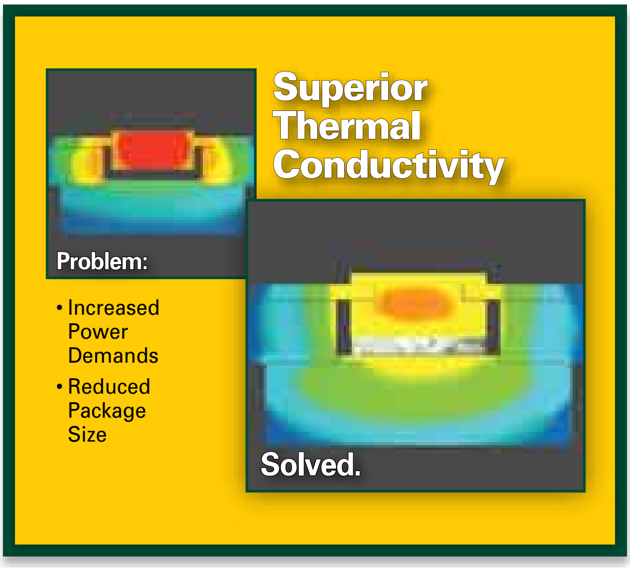
Packaging

- Tape and Reel
- Syringe
- Bottle
- Custom Packaging



Types of Metal TIMs:

- **Liquid**
- **Compressible Metal**
- **Solderable**
- **Low-Melting Alloy**



Liquid

Indalloy® Alloys Liquid at Room Temperature

Introduction

Several very low melting point **Indalloy® alloys** are liquid at room temperature. These gallium-based alloys are finding increased use in various applications as a replacement for toxic mercury, which has a high vapor pressure at room temperature. These alloys have reduced toxicity and lower vapor pressure than mercury.

Excellent Thermal and Electrical Conductivity

Alloy systems that are liquid at room temperature have a high degree of thermal conductivity far superior to ordinary non-metallic liquids. This results in the use of these materials for specific heat conducting and/or dissipation applications. Other advantages of these liquid alloy systems are their inherent high densities and electrical conductivities.

Wetting to Metallic and Non-Metallic Surfaces

These alloys will wet most metallic surfaces once oxides have been sufficiently removed from the substrate surface. However, gallium is very reactive with some metals, even at room temperature. At high temperatures, gallium dissolves most metals, although a number, including Na, K, Au, Mg, Pb, Ni and interestingly Hg, are only slightly soluble at moderate temperatures.[1]

As stated, gallium is corrosive to all metals except tungsten and tantalum which have a high resistance to corrosion. Columbium, titanium and molybdenum have resistance to corrosion but less than tungsten and tantalum.[2]

Gallium and the gallium alloys, like indium, have the ability to wet to many non-metallic surfaces such as glass and quartz. Gently rubbing the gallium alloy into the surface may help induce wetting.

Note: These alloys form a thin dull looking oxide skin that is easily dispersed with mild agitation. The oxide-free surfaces are bright and lustrous.

Applications

Typical applications for these materials include thermostats, switches, barometers, heat transfer systems, and thermal cooling and heating designs.

Uniquely, they can be used to conduct heat and/or electricity between non-metallic and metallic surfaces.

Packaging

Alloys are packaged in polyethylene bottles and shipped in accordance with applicable federal regulations.

Storage/Shelf Life

Unopened bottles have a guaranteed one-year shelf life. It is recommended that, as the alloy is removed from the bottle, the volume be replaced with dry argon. This will minimize the possibility of oxidation at the surface of the alloy. If the alloy has been stored below its melting point and has solidified, it should be re-melted and thoroughly shaken or mixed before use. Care should be taken in reheating the alloy in the original packaging provided. Temperatures should not exceed 65.6°C.

1. Pergamon Texts in Inorganic Chemistry Volume 12, The Chemistry of ALUMINUM, GALLIUM, INDIUM, and THALLIUM by K. Wade & A. J. Banister, University of Durham, Pergamon Press, 1975.
2. Lyon, Richard N., ed. *Liquid Metals Handbook.* 2nd ed. Washington DC: 1952

Indalloy Number	Type	Liquidus	Solidus	Composition	Density lb/in^3	Specific Gravity
46L	Ordinary Alloy	7.6°C	6.5°C	61.0Ga/25.0In/13.0Sn/1.0Zn	0.2348	6.50
51	Eutectic Alloy	10.7°C	10.7°C	62.5Ga/21.5In/16.0Sn	0.2348	6.50
60	Eutectic Alloy	15.7°C	15.7°C	75.5Ga/24.5In	0.2294	6.35
77	Ordinary Alloy	25.0°C	15.7°C	95Ga/5In	0.2220	6.15
14	Pure Metal	29.78°C	29.78°C	100Ga	0.2131	5.904

Metal Thermal Interface Materials

Compressible Metal–SMA-TIM

Introduction

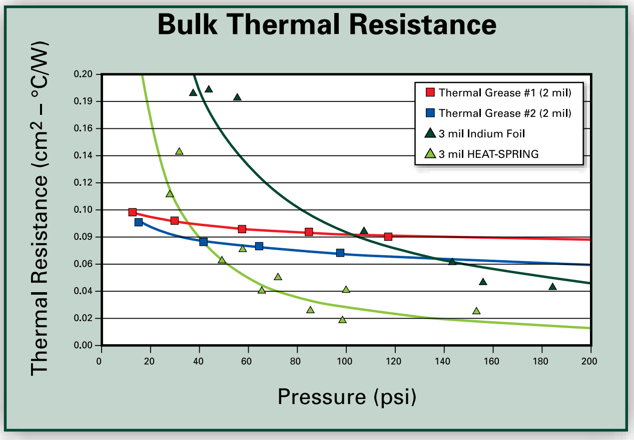
Indium's **Soft Metal Alloy Thermal Interface Materials (SMA-TIM)** exhibit superior thermal conductivity, compressibility and ease of application. SMA-TIM preforms constructed of indium with our heat-spring processing technology are a highly effective choice for high-end cooling devices.

Specifications

Typical Dimensions	25.4mm x 25.4mm x .05-.3mm (1" x 1" x .002"-.012")
Application Pressure	>20psi
Alloy Purity Level	99.99% In
Max. Operational Temp.	140°C
Thermal Conductivity	86W/m•K

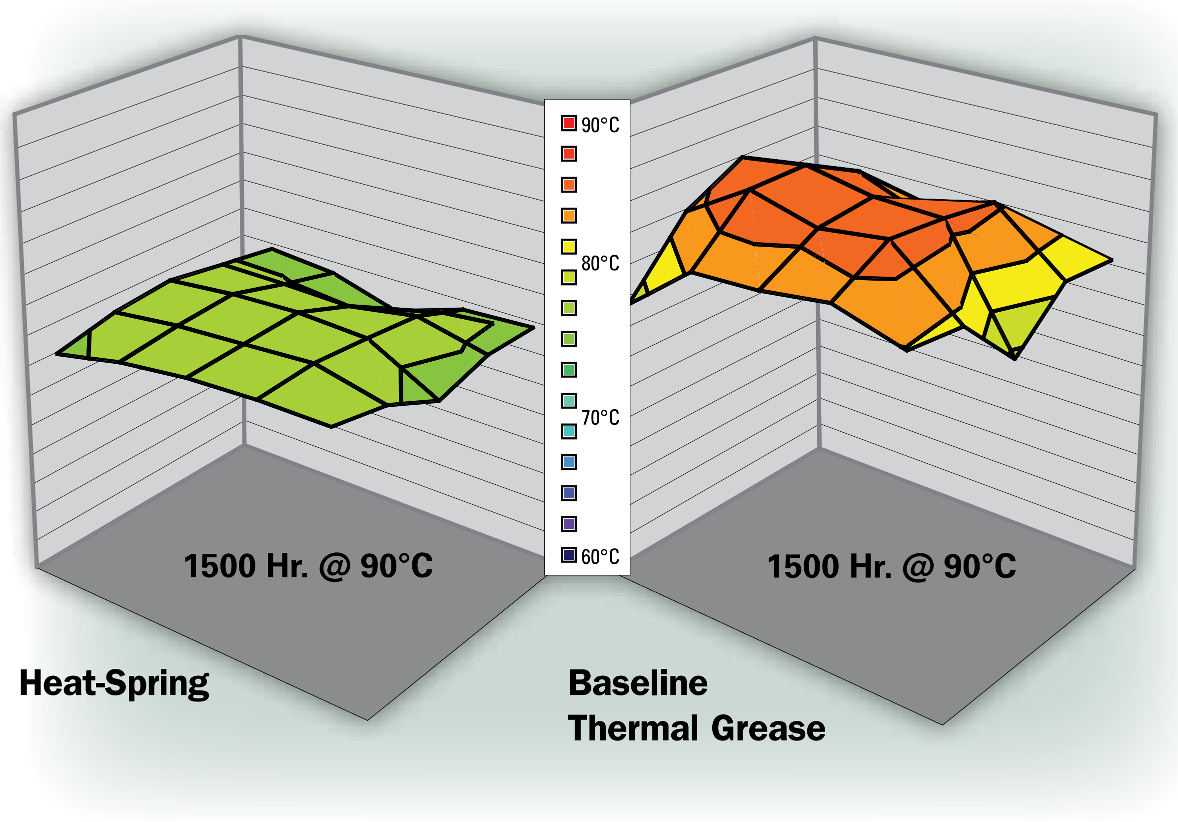
Compressed Interface Application

An SMA-TIM made of indium offers uniform thermal resistance at lower applied stresses in compressed interfaces. The malleability of indium minimizes surface resistance and increases heat flow. Our patent pending heat-spring technology will further reduce the thermal resistance.



Reliability

Indium's high-end thermal interface materials deliver superior performance. As SMA-TIM products are made of metal, they do not experience pump out problems even under power cycling. The heat-spring material, which does not contain silicone, will conform to surface irregularities, thereby reducing thermal resistance through the life of the TIM. Due to its solid state, the SMA-TIM also resists bake out as shown in the diagram below.



Solderable Metal

Introduction

Thermal interface materials are useful for a variety of applications, but solder thermal interface materials (sTIM) are especially suited to high-end device cooling. To improve package reliability, it is especially important to choose the right alloy. Indium, in particular, should be considered as a sTIM because of its high thermal conductivity, compressibility (SMA-TIM), and ease of application.

Specifications

Max. Operational Temp.	125°C
Standard Purity Level	99.99%
Typical Size	25.4mm x 25.4mm x .05-.3mm (1" x 1" x .002"-.012")

Applications

Indium Preforms may be used in a variety of processes.

- **Compressed Between Two Surfaces Without Reflow**
  (SMA-TIM) Soft Metal Alloy-TIM
  The extreme malleability of indium allows it to minimize surface resistance – thereby increasing heat flow. The graph below demonstrates this phenomenon.
- **Soldered Between Two Surfaces**
  (sTIM) Solder-TIM
  Used to further improve thermal resistance, this application may require the use of a flux to reduce oxides on soldering surfaces.
- **Cold-Welding**
  Another process that is used to create a thermal interface involves reflowing indium preforms onto each solderable surface. Then, indium-coated surfaces should be cleaned and pressed together to form a fluxless cold-weld solder joint. (See the Application Note: *Etching Indium to Remove Oxides* for more information about this process.)

Storage and Packaging

SMA-TIM Preforms come in a variety of packaging options, including tape & reel and custom adhesive carriers for direct-attach to heat-sinks. To minimize excessive handling and oxidation due to air exposure, it is recommended to keep TIM preforms in their original container in a cool dry place. Indium SMA-TIMs, when exposed to air, will self-passivate to a level of approximately 10 nanometers and will have a useful life of at least six months. SMA-TIMs can also be stored in an inert atmosphere such as nitrogen.

Properties

Indalloy	#4
Electrical Conductivity ('% of IACS) (1.72microhms-cm)	24
Thermal Conductivity (W/m•K) (@ 85°C)	86
Coefficient of Thermal Expansion (µin/µin per °C) (@20°C)	29
Density (lb/cu. in.)	0.2641
Mass Density (gm/cm^3)	7.31
Tensile Strength (PSI)	273
Shear Strength (PSI)	890
Young's Modulus (PSI X 10x6)	1.57
%Elongation	22 to 41
Brinell Hardness (2mm ball, 4kg load)	0.9
Latent Heat of Fusion (J/g)	28.47
Melting Point (°C)	156.7

Material Safety Data Sheet

The MSDS for this product can be found online at http://www.indium.com/techlibrary/msds.php

Metal Thermal Interface Materials

Solderable

Introduction

Solder Preforms are used in a variety of applications that require precise amounts of solder.

Preforms come in standard shapes such as squares, rectangles, washers and discs. Typical sizes range from .254mm (.010") up to 50.8mm (2"). Smaller and larger sizes, as well as custom shapes, are also available. Dimensions can be held to tight tolerances to assure volume accuracy.

Selecting Alloys

A wide assortment of alloys is available in liquidus temperatures that range from 47°C to 1063°C. Alloys can be indium–contained, gold-contained, lead–free, fusible or standard tin–lead, as well as many others.

1. Alloy selection should be based on strength and other required physical properties, as well as the preferred soldering temperature and the operating temperature of the device being soldered. A general rule is to select an alloy that melts at least 50°C higher than the operational temperature of the part being soldered.
2. Next, consider the materials being soldered and what solder is most compatible with them. For example, tin–based solders will scavenge the gold from gold-plated parts, forming brittle intermetallics, so indium-based solders are generally recommended in these cases.
3. Metals and alloys have different characteristics that can affect the ease with which they can be made into different shapes and thicknesses. It is important to consider the shape of the final preform in the alloy selection process.
4. The operating environment of the completed assembly is also an important consideration for alloy selection. Will it operate in very high or very low temperatures, or be subjected to vibration? If so, you need to select an alloy that will stand up to these conditions.

Our Application Engineers will work with you to determine the best alloy for your application.

Selecting Dimensions

The location of the solder joint and the volume of solder needed will determine the size and shape of the preform. Once the flat dimensions (diameter, length, width) have been determined, the thickness can be adjusted to achieve the desired volume of solder. Generally, for through–hole connections, add 10–20% to the calculated volume for a good fillet. For pad to pad joints, figure about 5% less surface area than the pad.

Each Solder Preform should have a burr tolerance specified. You should stay as close to standard tolerances as possible to avoid adding cost and lead time to your preforms.

Indium Corporation has an extensive library of sizes and shapes from which you can choose, or we can create a set–up specifically for your application. Using an existing preform size can eliminate the additional time associated with creating a new set–up.

Dimensional Specification Recommendations

Width/length or diameter:	**Typical Tolerances**
Up to 2.54mm (0.100")	± 0.051mm (± 0.002")
Over 2.54mm (0.100")	± 0.127mm (± 0.005")
Thickness:	
Up to 0.025mm (0.001")	± 0.005mm (0.0002")
0.025mm (0.001") to 0.050mm (0.002")	± 0.0076mm (0.0003")
> 0.050mm (0.002") to 0.254mm (0.010")	± 0.0127mm (0.0005")
> 0.254mm (0.010") to 0.508mm (0.020")	± 0.0254mm (0.0010")
> 0.508mm (0.020") to 1.27mm (0.050")	± 0.0635mm (0.0025")
> 1.27mm (0.050")	± 5%
Burr Tolerances (Discs, Squares & Rectangles):	
≤ 1.27mm (0.050")	0.050mm (0.002")
> 1.27mm (0.050") to 12.7mm (0.500")	0.076mm (0.003")
> 12.7mm (0.500")	0.127mm (0.005")
Burr Tolerances (Washers & Frames):	
≤ 2.54mm (0.100")	0.076mm (0.003")
When thickness ≥ 2/3 of I.D.	0.127mm (0.005")

Flux-Coated Preforms

Features

- Eliminates the need for manual fluxing
- Eliminates excessive flux residue
- Increases productivity
- Applies flux precisely where it is needed
- Applies a uniform amount every time

Introduction

Flux Coated Preforms eliminate the costly production step of separate fluxing and increase throughput yields. Flux Coatings for Preforms are available in no-clean and rosin-based chemistries with a variety of activity levels to suit your substrate metallizations.

Flux Coatings

Indium Corporation's unique coating process can control the amount of flux to tight tolerances. Flux Coatings are measured and applied by weight percentage. The coatings range from 1-3% and standard tolerances are controlled at +/- .5%. Coatings can be applied to most sizes and shapes of preforms.

Using Flux-Coated Preforms In Soldering

For certain soldering applications, flux coated preforms may offer the greatest number of benefits over other more conventional forms of solder. For applications other than active device manufacture, flux can be incorporated as an integral part of the preform design to meet customer needs for the precise amounts of flux, easy automation, and elimination of costly separate flux applications.

In general, fluxes should be avoided in active device assembly due to the difficulty in removing the flux residue after soldering. If care is taken to ensure the joining surfaces and the preforms are thoroughly clean, and if a reducing atmosphere at 350°C is used, flux coating is usually not necessary.

Flux coated Indalloy soft solder preforms eliminate the necessity of manually applying external liquid fluxes in operations such as vapor phase soldering of back-plane wiring assemblies and capacitor manufacture. Flux coated preforms are manufactured with the exact amount of flux required for the specific application, providing a high degree of consistency from one bond to another. Flux percentages can be specified between 0.5% and 3% by weight with a tolerance of ±0.5%. The most popular percentage being 1.0% by weight.

Indalloy flux types are available in non-activated pure gum rosin (type R), mildly activated rosin (type RMA) and fully activated rosin (type RA). RMA fluxes have a small but highly effective amount of an activator added to increase fluxing action over the R type. RA fluxes contain a small amount of an amine hydrochloride activator that provides superior fluxing action, as compared to R and RMA type fluxes. RA flux finds use in soldering assemblies where a high degree of fluxing action is desired, e.g. soldering to tarnished copper or nickel plate. RSA, an enhanced version, is also available for preform coating. This flux is the strongest of the rosin types. NC-7 and NC-9 fluxes are specially formulated RMA type fluxes that, along with the R type flux, leave nonconductive and non-corrosive residues that can safely be left on an assembly without fear of corrosion. However, for aesthetic or visual inspection purposes, the flux residue can be removed using a bipolar solvent to remove both the rosin portion and the ionizable activator portion of the flux. This is most often accomplished using vapor degreasing equipment.

In summary, the use of Indalloy flux coated preforms can result in the following advantages:

1. All fluxes used to coat preforms, when reflowed using a standard Sn63 profile, pass SIR tests.
2. The precise amount of flux and alloy are delivered to the solder joint.
3. The costly production step of separate fluxing is eliminated.
4. Bonding is faster because the flux is positioned where it is required, next to the surfaces to be joined, unlike the case with flux-filled preforms.
5. Because less flux is used, post solder cleaning is easier.
6. The flux quantity is uniform in thickness and consistent in amount from piece to piece.
7. The dull, flux-coated surface is ideal for IR reflow.
8. Since the flux on flux coated preforms contains no solvent, voiding is typically less than when manually applying liquid flux to uncoated preforms.

Metal Thermal Interface Materials

Suggestions for Solder Preform Design

Solder preforms are manufactured solder shapes that come in standard forms such as squares, rectangles, discs, washers and frames. They can also be manufactured with custom geometries. Preforms provide consistent part-to-part dimensions that result in constant solder volumes, thereby insuring consistency in solder assembly. Because preforms are made with a uniform shape and size, automation of the assembly process can be easily implemented, resulting in faster production and reduced costs.

Tooling design changes can increase costs rapidly, especially when experimenting with multiple shapes and sizes. A “trial and error” approach to determining the best preform geometry for an application that includes solders containing precious metals can also create unnecessary expenditures. It is best to do all the preform design homework before committing to final tooling. This application note will explore some simple ways to arrive at the optimum preform size and shape while reducing costs. The principles below can be used in concert with one another.

1) **Avoid using solder alloys that contain precious metals when determining the optimum preform geometry**
Determining the best geometry can be done using a less expensive alloy. For example, if the application calls for Au/Sn solder, use 90Pb/10Sn or some other lower cost alloy to optimize preform dimensions to determine the required solder volume for the joint. Higher lead containing alloys are preferred since the density of lead is closer to gold than tin. If the application restricts the 2 dimensional shape of the preform, varying the thickness is a good way to arrive at the appropriate volume of solder required.

2) **Cut preforms by hand from solder ribbon or sheet when prototyping**
Changes to tooling design can add cost and impact the overall total cost of preforms. Fabricating small volumes of preforms manually can be an economic method of arriving at the optimum preform shape and size.

   Standard alloys and many specialty solder alloys can be purchased in ribbon or sheet form in widths close to that of one dimension of the preform. Using a sharp cutting instrument, such as an X-Acto knife, cut the experimental shape from the ribbon or sheet.

3) **Begin evaluations using thin solder materials**
If the proper preform thickness is in question, it is best to begin with the thinnest preform possible. If the appropriate volume is not immediately achieved with one preform, they can be stacked. Multiple preforms will flow together and function as one.

   For example, after attempting to use a preform that is .002” thick, it is evident that the volume of solder provided by the preform is insufficient. The amount of solder can be doubled by stacking two preforms, which would equate to having one preform that is .004” thick. The solder volume can be tripled, and even quadrupled until the proper volume is achieved. This allows for the appropriate thickness of a single production preform to be determined.

4) **Use the simplest preform geometry possible**
Engineering charges for intricate designs can cost substantially more than less complex designs. Design the solder locations so that they can be adequately bonded using simple preform geometries such as washers, frames, discs, rectangles, etc.

5) **Determine from the solder supplier the sizes and shapes for which tooling exists**
An important issue in any soldering application is the resultant volume of solder at the joint after reflow. The size and shape of the preform are generally secondary considerations. Often existing tooling that yields slightly different x and y dimensions from the ideal size can be utilized if the thickness of the preform is adjusted accordingly to produce the same solder volume.

   For example, the design of an application calls for a solder preform in the shape of a 1.2” x 1.2” square. The solder supplier does not have tooling for this size but has existing tooling for a 1.0” x 1.0” preform. To avoid additional tooling costs the 1.0” x 1.0” size is selected and the preform thickness increased to yield the same solder volume.

Informs

Reinforced Indium and Solder Alloy Fabrications

Introduction

InFORMS® are patented fabrications in which braided, woven, or random-fiber metal or non-metal substrate materials are sandwiched between layers of pure indium or solder alloy. In the manufacturing process, material from the surface layers passes through the substrate matrix to cold weld where the metals meet within the matrix. The process produces a reinforced indium or solder fabrication with improved strength and handling characteristics.

The layers may also be adhered to the substrate without cold welding at the interface so the substrate can flex to accommodate shear or thermally-induced forces. Another option, would be to adhere an outer indium or alloy layer to only one side of a substrate.

For solder applications, flux may be incorporated within the matrix or applied as a coating.

After the laminating process is complete, parts are cut or punched into discs, washers, rectangles and other shapes to suit specific application requirements. Strip materials can also be provided for custom sizing by the user.

Product Advantages

Informs offer dramatically improved handling when compared to conventional solder alloy or indium sheet, foil, ribbon or large preform materials. InFORMS also offer increased tensile and compressive strength via the substrate materials while retaining the unique attributes of the outer layer metal (e.g. the softness, ductility, and other advantages of indium).

Applications

InFORMS provide engineers with an enhanced material for the development of new, or the improvement of existing, applications. They can be used in cryogenic or vacuum seals, EMI and RFI shielding, ground straps, stand-offs, thermal mismatch devices or backplane assembly washers. While a number of metals may be used, indium should be considered in many applications because of its unique attributes. For example, Indium readily wets glass, quartz, and glazed ceramics. When compared to conventional solders, indium-based solders significantly reduce scavenging and leaching of gold and other precious metals.

Substrates and Outer Layer Metals

InFORMS can be produced from a wide range of metal and non-metal substrates depending on the needs of the application. **InFORMS** have been successfully produced using tin plated copper shielding mesh, stainless steel mesh, and even woven and random-fiber fiberglass cloth. Please contact our Technical Support Engineers if you would like us to work with you to develop samples for experimentation, including special substrate materials, layer thicknesses, or outer layer metallizations.

In applications where the metal meets in the substrate matrix, metals used on outer layers may be dissimilar as long as they are compatible with each other. Where the application does not require cold welding of the outer layers, the layers may also be dissimilar. In either case, compatibility with the substrate material must be considered in applications development. Most compatibility issues are documented in solder technical guides. However, if in question, it’s always a good idea to contact Indium Corporation for advice. When solder alloys are specified, published temperature guidelines are applicable.

Dimensional Specifications

InFORMS are produced in sheet form and can be cut or punched into large unique shapes for applications such as cryogenic or vacuum seals, or into small preforms for tasks such as component assembly. Dimensional tolerances can be held to those normally specified for standard solder preforms, but may vary depending on the part size, thickness, substrate, and outer layer materials. Please contact us if you have special requirements.

Summary

InFORMS add handling capability to soft and ductile indium and solder alloys. They also strengthen and yet retain, the unique attributes of the metals selected for the outer layers. **InFORMS** offer countless opportunities for solving difficult application problems.

Tape and Reel Packaging

Introduction

Solder Preforms are used in a variety of applications that require precise amounts of solder. Dimensions can be held to tight tolerances to assure volume accuracy. Solder preforms are available in a variety of alloys, including indium, gold, tin, lead, and many others.

Solder Preforms come in standard shapes, such as squares, rectangles, washers, and discs. Typical sizes range from 0.010” (.254mm) up to 2” (50.8mm). Smaller and larger sizes, as well as custom shapes, are also available.

Tape and Reel packaging of preforms allows for easier use in high volume and automated manufacturing environments.

Applications

Tape and Reel Preforms offer advantages over loose-packed preforms in many applications. Some common examples are:

- Automation – **Tape and Reel Preforms** allow for easy use with pick and place equipment in SMT lines. They can be precisely placed as fast as your equipment will allow.
- Solder Fortification – There are certain instances in SMT applications where simply printing paste does not provide sufficient solder volume. Rather than resort to step stenciling or dispensing, a placed preform can be more efficient by giving you precise, repeatable solder volume.

Flexibility

Tape and Reel pockets are available in a wide range of sizes to accommodate various preform shapes and sizes.

Shelf Life

The shelf life of solder preforms is dependent on the alloy composition. Pb-free alloys, and alloys with lead content of less than 70%, have a shelf life of 1-year from the date of manufacture (DOM). Alloys with lead content >70% have a shelf life of 6-months from the DOM.

Technical Support

Indium Corporation’s internationally experienced engineers provide in-depth technical assistance to our customers. Thoroughly knowledgeable in all facets of Material Science as it applies to the electronics and semiconductor sectors, Technical Support Engineers provide expert advice in solder properties, alloy compatibility and selection of solder preforms, wire, ribbon and paste. Indium Corporation Technical Support engineers provide Rapid Response to all technical inquiries.

Metal Thermal Interface Materials

Clad Solder Preforms

Benefits

- Maintains standoff
- Bridges gaps
- Adds strength to solder joints

Introduction

Clad Solder Preforms are manufactured shapes that deliver a precise amount of solder while maintaining and/or bridging a particular gap. They consist of a copper layer that is clad on one or both sides with a specified thickness of solder. Dimensions can be held to tight tolerances to assure volume accuracy. Clad solder preforms come in standard shapes and sizes such as squares, rectangles, washers, frames and discs. Typical sizes range from .254mm up to 50.8mm. Smaller and larger sizes, as well as custom shapes, are also available.

Alloys/Materials

Typical alloys include:

- Sn62/Sn63
- 96.5Sn/3.5Ag
- Sn10
- Other alloys are available upon request.

The core material is OFHC Copper:

- Annealed Per ASTM-B152
- F scale
- Tensile Strength 35,000 psi max.
- Other coppers are available upon request.

Packaging

Clad Solder Preforms are packaged in formats similar to standard preforms and take into consideration the size and strength of the preform. Common packing methods include jars, boxes (stack or layer pack) and tape & reel. Most packages can be backfilled with argon upon request.

When possible, we suggest filling each package with the quantity of clad solder preforms that will be consumed in one shift.

Storage and Handling Procedures

Clad Solder Preforms should be kept in their unopened container in a cool dry place until time of use, preferably in a nitrogen dry box. After opening, any unused preforms should be stored in these same conditions.

Safety

Eating, drinking and smoking should be avoided while handling preforms. Hands should be washed immediately following use. If possible, preforms should be handled with protective gloves or finger cots.

Applications

- Heat Sink Attach
- Pin Soldering
- 3D Soldering
- Jumper Bridges
- Connectors

And other soldering applications where the following properties are desired:

- Strength
- Wear Resistance
- Formability
- Electrical Properties
- Thermal Properties

Compatible Products

- **Clad Solder Preforms** can be flux coated with any of our standard preform flux coatings.
- Indium Corporation's liquid fluxes and TACfluxes.

Fluxes

Rosin/Resin Based Liquid Soldering Fluxes

Flux	#5R	#5RMA	#5RA
Rosin/Resin Bas	Heat Stabilized Resin	Heat Stabilized Resin	Heat Stabilized Resin
Soldering Temperature Range	125°C - 350°C	125°C - 350°C	125°C - 350°C
Metallization To Be Soldered	Au, Ag, Pt, Pd, Clean Cu	Au, Ag, Pt, Pd, Clean Cu, Sn, Solder Plate	Ni, Rh, Cd, Brass, Bronze BeCu, Pb, Oxidized Cu
Activation	None Added	Mildly Activated	Fully Activated
Solids Content	47%	46%	44%
Water Resistivity Extract (ohm-cm)	>100,000	>100,000	>50,000
Specific Gravity	.90	.91	.88
Boiling Point	84°C	84°C	84°C
Flash Point	11°C	11°C	11°C
IPN	84072	84032	84039
Thinner	#8300 (Part Number 84041) - all fluxes		

All information is for reference only. Not to be used as incoming product specifications.

Flux Removal

Since the post solder residues of types R and RMA fluxes are considered non-corrosive, non-conductive and non-hydroscopic, flux removal is not usually necessary. If cleaning is desired this is best accomplished with a commercially available flux residue remover.

Best practice is to always remove RA residues in electronics applications.

Standard Packaging

These liquid soldering fluxes are packaged in 2 different size plastic containers:

- 1 U.S. pint (0.473 liter)
- 1 U.S. gallon (3.785 liter)

NC-506 Flux

Features

- Suitable for Pin-Grid Array and standard Ball Grid Array applications
- Excellent solderability to all common surface metallizations
- No-clean residue
- Can be used for printing, dipping, and pin transfer deposition
- Offers high yields in BGA bumping process
- Suitable for both Pb-Free or Sn/Pb applications

Introduction

Ball Attach Flux NC-506 is a low viscosity thixotropic no-clean flux designed for use in ball attachment to substrates (BGA manufacturing). It is especially useful in applications requiring soldering to surface finishes with tenacious oxides, such as nickel. It can also be used wherever a no-clean ball attach flux is needed, and is suitable for a variety of different deposition methods.

Properties

	Value	Test Method
Flux type Classification:	ROL1	J-STD-004 (IPC-TM-650: 2.3.32 and 2.3.33)
Typical Viscosity:	320kcps	Brookfield HB DVII+-CP (5rpm)
SIR (ohms, post cleaning):	Pass (>10^9 after 7 days @ 85°C & 85% RH)	J-STD-004 (IPC-TM-650: 2.6.3.3 IPC-B-24
Typical Acid Value:	103mg KOH/g	Titration
Typical Tack Strength:	250g	J-STD-005 (IPC-TM-650: 2.4.44)
Shelf Life:	6 months (-20°C to +5°C)*	Viscosity change/ microscope examination

All information is for reference only. Not to be used as incoming product specifications.

Fluxes

WS-366 Interconnect Flux

Benefits

- Excellent cleanability, residue can be removed with room temperature water
- Can be used for printing, dipping, and pin transfer deposition
- Offers high yields in BGA bumping process
- Excellent solderability
- Wide process window
- Suitable for Sn/Pb, Pb-Free, and high lead-containing applications
- Designed for Flip-Chip applications

Introduction

WS-366 Interconnect Flux is a high viscosity paste-type flux designed for use in BGA bumping and board level attachment. It can also be used wherever a water-soluble flux with excellent cleanability is desired.

Properties

Flux type Classification:	H1
Color:	Amber to brown
Stencil Life:	>8 hours at room temperature
Shelf Life:	3 months at 0 to +30°C
SIR (ohms, post cleaning):	Pass (>10^9 after 7 days @ 85°C & 85% RH)
Typical Viscosity:	
Brookfield:	425 kcps at 5rpm
Halide Content:	<3% Cl equivalent
Acid Value:	30-50
Tack Strength:	100-400g

All information is for reference only. Not to be used as incoming product specifications.

Fluxless Soldering

Some applications are very sensitive to the use of a flux due to the post reflow residue that may be present. Also, flux may be a problem in a vacuum environment or in an application in which it must be free of corrosive or volatile materials.

If gold is used for the outer metalization on the parts to be joined, acceptable wetting may be possible without the use of a flux. If this is not possible, a reducing atmosphere may be used to remove the oxides and result in sufficient wetting. Below are suggestions and helpful hints for choosing a reducing atmosphere that fits your application.

- Common reducing atmospheres are:
  88% nitrogen, 12% hydrogen
  90% nitrogen, 10% hydrogen
  95% nitrogen, 5% hydrogen
  100% hydrogen
- The higher the reflow temperature the more effective the oxidation removal using a reducing atmosphere. A reflow temperature that is 350°C and above is the best for oxide removal.
- Nitrogen or argon is sometimes used in fluxless soldering because it prevents the formation of oxides during reflow. However, these gases do not remove preexisting oxides on the metalization, only the hydrogen can do that.

Fluxless soldering is also used when joining the two substrates together where flux residue would be detrimental to the operation of the final product. For example, voiding due to flux entrapment can result in poor performance because of reduded electrical or thermal conductivity.

In an application where a reducing atmosphere is not practical, two or more metalizations can be joined using flux in the initial pre-coating of the substrates. After pre-coating is complete, the flux residue can be removed using an appropriate solvent. The cleaned parts can then be assembled without a flux and reflowed a final time to join them. This method is especially effective when fairly large pieces need to be joined and flux entrapment can not be tolerated.

Metal Thermal Interface Materials

Bonding Non-Metallic Materials

Using Indium and High Indium Alloys

Application

A unique property of indium is that it will wet and bond to certain non-metallics such as glass, glazed ceramics, mica, quartz and various metallic oxides.

Metal/Alloy Selection

Indalloy #4 (100% indium) and Indalloy #1E (52In48Sn) exhibit the best wetting quality on non-metallics. Indalloy #3 (90In10Ag) and Indalloy #290(97In3Ag) exhibit slightly lower wettability, but higher strength, due to the hardening effect of the silver present.

Surface Preparation

Before bonding, thoroughly clean the non-metallic substrate with a strong alkaline cleaner. Rinse with distilled water and rinse again with electronics grade organic solvent, such as acetone. In the case of glass, quartz or glazed ceramics, adhesion is enhanced by heating the material to about 350°C, then cooling to about 200°C.

Bonding Procedure

Apply indium to the heated non-metallic using an indium-plated nickel felt applicator. Rub gently until the non-metallic is coated with a thin film of indium.

To bond two non-metallic substrates together, precoat each surface with indium as described above. Bring the two precoated substrates in contact with each other and reflow at 20-30°C over the liquidus temperature of the solder used to precoat.

To bond a non-metallic substrate to a metallic substrate, precoat the non-metallic surface with indium as described above. Precoat the metallic surface with the same indium alloy as used on the non-metallic surface, using an appropriate flux. Completely remove the flux residue. Bring the two precoated surfaces in contact with each other and reflow at 20-30°C over the liquidus temperature of the solder used to precoat.

In most cases, ultrasonic energy, like that generated by an ultrasonic soldering iron or pot, is effective in promoting wetting of the surface. Bond strengths of 400-700 PSI are typical of this technique.

The following list of four alloys are recommended for bonding non-metallic materials. The melting temperatures and some of the properties of the individual alloys are also listed.

Indalloy Number	Liquidus	Solidus	Tensile Strength PSI	Electrical Conductivity % of IACS	Thermal Coefficient of Expansion µ in/in/°C @20°C	Thermal Conductivity W/m•K @85°C	Composition
# 1E	118°C	E	1720	11.7	20	34	52In 48Sn
# 3	237°C	143°C	1650	22.1	15	67	90In 10Ag
# 4	157°C	MP	273	24.0	29	86	100In
# 290	143°C	E	800	23.0	22	73	97In 3Ag

E= Eutectic, MP= Melting Point

Metal Thermal Interface Materials

Designing a sTIM

For Worst Case Bondline Thickness

Contact area in a thermal interface is a key consideration, especially in real-world applications involving surfaces that are not ideal.

Typical flip-chip die surfaces on laminate packages can vary .001”/.4”(1cm), and the same is true with lidded components. Most of this variation occurs because of stresses imparted during the attachment of the die or package. On the heatsink side, manufacturing methods vary – as does surface planarity. The first part of planning the desired thickness of your thermal interface material (TIM) is to determine a stack-up dimension of tolerances. Take into account maximum surface variations at ambient conditions and during operational temperatures (including burn-in) to compensate for the least ideal assembly that is possible from your procedure.

Assembly can also increase the gap between the heat generating component and the lid or heat sink. For instance, on a 1cm die, 1° of misalignment creates a gap of .007” (Refer to Fig.#2). Misalignment needs to be filled with a thermal interface material for proper conduction.

Finally, it is important to make sure there is some TIM between the two interfaced surfaces at the closest point. It may be necessary to add .001” of sTIM thickness to the previously estimated stack-up thickness. Even an ideally flat, aligned interface should have a .001” sTIM bondline.

Suggested Preform Thickness

(1cm x 1cm interface)

Die Curvature(µm)	Lid Curvature (µm)	Misalignment (µm)	Suggested Thickness (µm)
10	10	10	60-90
10	10	30	80-100
10	30	30	90-110
30	10	30	90-110
10	10	50	100-130
10	30	50	110-140
30	10	50	110-140
30	50	80	180-200
50	50	80	200-230

Less roughness, less curvature, smaller area and reduced CTE will enable a thinner bondline.

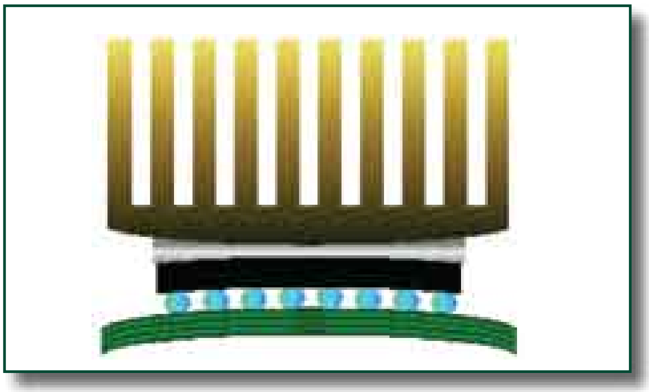


Fig.#1 Heatsink/Board WarpFig.

Fig.#2 Compound Warp/Alignment

Etching Indium to Remove Oxides

The formation of metal oxides on indium is self-passivating. A thickness of 80-100 Angstroms of oxide is all that will form on the surface. Prior to using indium in a sealing or cold welding application, it is recommended that this oxide layer be removed. Here is the recommended procedure for oxide removal:

1. Degrease the indium with an organic solvent, such as acetone, to remove any organic contaminants that may be on the surface.
2. Mildly etch the indium surfaces in a solution of 5-10% hydrochloric acid (by volume) at room temperature for 1 to 5 minutes, depending on oxide thickness, until surface appears bright. This will remove the 80-100 Angstroms of oxide that form on the surface.
3. Thoroughly rinse twice in DI water.
4. Rinse off the water with acetone (preferred) or isopropyl alcohol.
5. Blow-dry with dry nitrogen.

Note: Because this procedure slightly etches the metallic surface, exposing a larger surface area to oxidation, only the indium that is going to be used immediately should be cleaned by this procedure. Return any unused, etched indium to storage under nitrogen or argon.

Indium Cold Welding

Indium has the unique ability to cold weld to itself. If the surfaces have been coated with indium (minimum 0.002”-0.003”), they can be joined by following this procedure:

1. Degrease the indium with an organic solvent, such as acetone, to remove any organic contaminants that may be on the surface.
2. Mildly etch the indium surfaces in a solution of 5-10% hydrochloric acid (by volume) at room temperature for 1 to 5 minutes, depending on oxide thickness, until surface appears bright. This will remove the 80-100 Angstroms of oxide that form on the surface. [Indium is self-passivating and will form an oxide layer that is only 80-100 Angstroms thick. The oxide, once removed, will reform to the 30-40 Angstroms level immediately and to the 80-100 Angstroms level in about 3 days. This oxide layer reduces indium’s ability to cold weld.]
3. Thoroughly rinse twice in DI water.
4. Rinse off the water with acetone (preferred) or isopropyl alcohol.

Indium ribbon being etched in the hydrochloric acid solution for 1 minute to remove oxide layer.

Etched indium ribbon wound back on itself and cold-welded to form a loop.

Pure indium ribbon with normal oxide layer of 80-100 Å (formed at room temperature in ambient conditions).

5. Blow-dry with dry nitrogen.
6. A mild pressure is all that is usually required to join the indium surfaces together.
7. Use caution to properly align the indium before joining, as they will not easily separate without damaging the joint. They will stick like contact cement.

Metal Thermal Interface Materials

Material	Indalloy Number	Thermal Conductivity W/m•K at 300K	Thermal Conductivity W/m•K at 85C	Liquidus (C)	MP/E	Solidus (C)
Diamond		1300-2400				
SiC		611				
Ag		429				
Cu		401				
Au100	200		318	1064	MP	
Au		317				
BeO		250				
Al		240				
AlN		200				
W		180				
Zn		116				
Ni		91				
Fe		84-90				
In100	4	82	86	156.7	MP	
In97 Ag3	290		73	143.3	E	143.3
Sn100	128		73	232	MP	
Pd		72				
Pt		72				
In90Ag10		67				
In90 Ag10	3		67	237		143
Sn		66				
Sn91 Zn9	201		61	199	E	199
Au80 Sn20	182	57	57	280	E	280
Sn77.2 In20 Ag2.8	227		54	187		175
Sn62.5 Pb36.1 Ag1.4	104		50	179	E	179
Sn63 Pb37	106	50.9	50	183	E	183
Sn60 Pb40	109	49.8	49	191		183
Sn62 Pb36 Ag2		49				
Sn50 Pb50	116	46.7	48	212		183
Sn70 Pb18 In12	9		45	167		154
Pb60 Sn40	130		44	238		183
Au88 Ge12	183	44	44	356	E	356
Sn40 Pb60		43.6				
In80 Pb15 Ag5	2		43	154		149
Pb70 Sn30	141	40.5	41	257		183
In70 Pb30	204		38	175		165
Pb80 Sn20	149	37.4	37	280		183
Pb100	170	35	35	327	MP	
In52 Sn48	1E		34	118	E	118
In50 Sn50	1		34	125		118
Sn96.5 Ag3.5	121	33	33	221	E	221
Sn60 Bi40	281-338		30	170		138
In60 Pb40	205		29	181		173
Sn95 Sb5	133	28	28	240		235
Pb88 Sn10 Ag2	228		27	290		267
Au96.76 Si3.24	184		27	363	E	363
Pb90 Ag5 Sn5	155		25	292	MP	
Pb92.86 In4.76 Ag2.38	6		25	300	MP	
Pb90 Sn10	159	35.8	25	302		275
Pb89.5 Sn10.5	242		25	302		275
Pb90 In5 Ag5	12		25	310		290
Pb92.5 In5 Ag2.5	164		25	310		300
Sb		24				
Pb37.5 Sn37.5 In25	5		23	181		134
Pb97.5 Ag1.5 Sn1	165		23	309	E	309
Pb95 Sn5	171	35.2	23	312		308
Pb94.5 Ag5.5	229		23	365		304
In50 Pb50	7	35	22	210		184
Pb95 In5	11		21	313		300
Bi58 Sn42	281		19	138.3	E	138.3
Pb60 In40	206		19	231		197
Pb75 In25	10		18	260		240
Pb81 In19	150		17	275		260
Alloy 42		15.6				
Bi52 Pb30 Sn18	39		13	96	E	96
Boron Nitride filled Silicone		6				
Bi55.5 Pb44.5	255		4	124	E	124
Solver Filled Phase Change		3.0 - 8				
Ag - Filled Die Attach		1.3 - 5				
Molding Compounds		0.6 - 0.7				
BT Epoxy		0.19				
FR-4		0.11				
Air		0.03				

Typical Indium Applications

Indium, the 49th element, was discovered in Germany in 1863. In 1934, Indium Corporation of America was the first to begin commercial development of indium, and is still the leading refiner, fabricator, and marketer of this versatile silver-white metal. Indium is used in a wide variety of applications, based on its unique attributes.

Soldering

When indium is included in solder compositions, many advantages are realized. Compared to conventional tin-lead solders, indium alloys exhibit lower crack propagation and improved resistance to thermal fatigue. Indium will reduce gold scavenging that can occur with tin-based solder on gold or gold-plated parts. Its ductility will allow some materials with different coefficients of thermal expansion to be joined together. In spite of the metal’s softness, it can strengthen materials it is alloyed with.

Bonding

The unique properties of indium make it an ideal bonding material, especially when bonding non-metals such as quartz, glass, and glazed ceramics. Indium can also be cold welded to itself. It easily deforms under pressure and will fill voids between two surfaces, even at cryogenic temperatures.

Structure

Face centered tetragonal at 25°C:
a = 0.32525 nm and c = 0.49465 nm

Mass Characteristics

Atomic weight:	114.82

Density:

°C	gm/cc
20	7.30
164	7.026
194	7.001
228	6.974
271	6.939
300	6.916

Volume change on freezing, 2.5% contraction

Thermal Properties

Melting point:	156.6°C
Boiling point:	2080°C

Coefficient of thermal expansion:
Linear, 24.8µm/m•K at 20°C

Specific heat:

°C	J/kg•K
25	233
127	252
156.63 (solid)	264
156.63 (liquid)	257
227	256
327	255
427	254

Latent heat of fusion:	28.47 kJ/kg
Latent heat of vaporization:	1959.42 kJ/kg
Thermal conductivity:	83.7 W/m•K at 0°C

Vapor pressure:

°C	kPa
1215	0.1013
1421	1.013
1693	10.13
2080	101.3

Electrical Properties

Electrical resistivity:

°C	nΩ-m
 20	3.38 K — Super conducting 84
154	291
181	301
222	319
280	348

Electrochemical equivalent:	Valence 3, 396.4µg/C
Electrode potential:	$In^{0} \rightarrow In^{3+}$ + 3e, 0.38V
Electronegativity:	1.7 Pauling's

Magnetic Properties

Magnetic susceptibility, Volumetric: 7.0 x 10^{-6} mks

Nuclear Properties

Natural isotope distribution:

Mass Number	%
113•115	4.3
115	95.7

Thermal neutron cross section For 2.2 km/s neutrons:	absorption,190± 10b; scattering, 2.2± 0.5b
Valences shown:	3 also 2 and 1
Atomic radius/Goldschmidt:	0.157nm
Atomic number:	49
Photoelectric work function:	4.12eV
Electronic structure:	$Kr4d^{10}5s^{2}5p^{1}$
First ionization energy:	133k-cal/g-mole

Mechanical Properties

Tensile strength:

K	MPa
295	1.6
76	15.0
4	31.9

Compressive strength:	2.14 MPa
Hardness:	0.9HB
Elastic modulus at 20°C:	12.74 GPa in tension
Poisson's at 20°C:	0.4498
Bulk modulus:	35.3 GPa
Tensile modulus:	10.6 GPa

Low-Temperature Alloys

Indium is also the basis for many low melting point fusible alloys. These alloys are often used to hold products, such as eyeglass lenses or turbine blades, while the products are being worked on. Then the alloy can be removed with minimal heat, keeping the product from being damaged. Indium is also used with gallium to create alloys that are liquid at room temperature.

Thin Films

Thin films of indium-tin oxide (ITO) on clear glass or plastic function as transparent electrical conductors and/ or infrared reflectors. Typical uses of thin films of ITO include LCD flat panel displays, touch screen CRT's, EL lamps and displays, EMI shields, solar panels and energy efficient windows. Aircraft and automobile windshields are coated with ITO for demisting and deicing. Other indium chemicals are used in alkaline batteries, replacing toxic mercury compounds.

High-Purity Indium

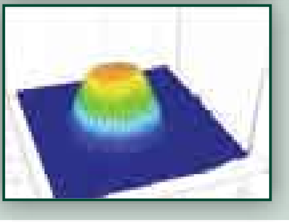
High-purity indium (99.9999 and 99.99999) is used in III-V compound semiconductors such as laser diodes.

Technical Support

Indium's Process Simulation Lab

provides Applications Engineers with the tools to work with you and industry partners on designed experiments to fully characterize SMT assembly materials and their use in leading-edge technology applications, including:

- Solder Paste Response-To-Pause Testing and Transfer Efficiency Calculations
- Voiding Analysis and Characterization on BGA and CSP Components Using Solder Paste, Epoxy Flux, and No-Flow Underfill Materials in Micro Via-In-Pad Applications
- Feasibility Studies for New Technologies and Materials
- Reflow Profile Optimization



Indium's Process Simulation Lab Capabilities:

- Stencil Printing
- Precision Syringe Dispensing
- Fully Automated 3D Solder Paste Inspection
- Component Placement
- Forced Air Convection and Infrared Reflow
- Wave Soldering
- X-Ray Analysis
- Acoustic Microscope Inspection
- Temperature-Humidity-Bias Testing (SIR & ECM)
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- And More...

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Confidentiality

Indium Corporation recognizes the importance of confidentiality in the design of solutions. As a trusted partner, our engineers will work with you to help you find the right solution for your assembly problems. We can help you find the right alloy for performance and the best solder form for ease of assembly.

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