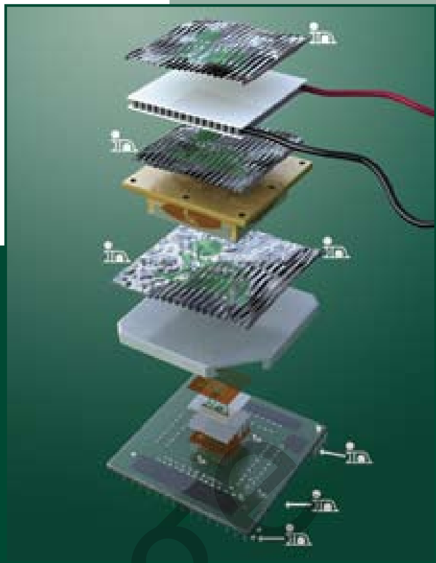
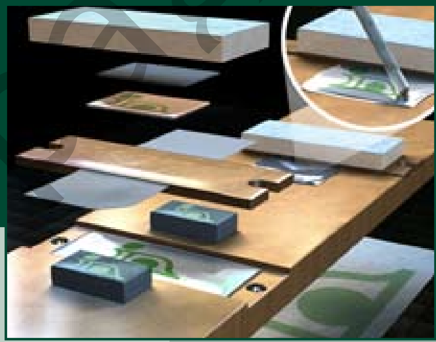
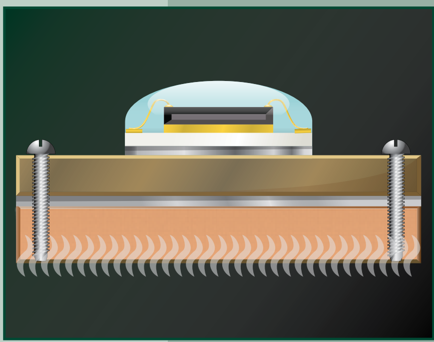
Metal Thermal Interface Materials



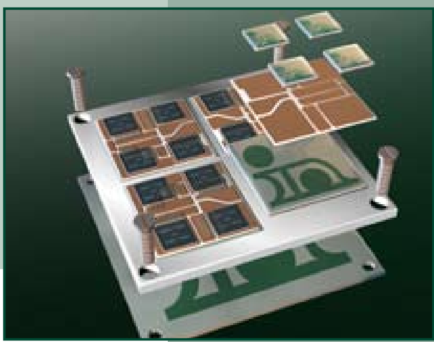


- **Liquid Metal**
- **Compressible Metal**
- **Solder**



Products

- AuSn Solder
- InPb Solders
- SAC Pb-Free Solders
- Pure Indium
- InFORMS®
- Heat-Spring®
- Flux-Coated Preforms



86W/mK

From One Engineer To Another®

INDIUM CORPORATION®

Introduction

Metal Thermal Interface Materials

Indium Corporation sells and manufactures **metal thermal interface materials (TIMs)** for various markets and applications. Our 100% metal TIMs are segmented into two categories: reflowable and non-reflowable. Reflow TIMs include solder preforms, InFORMS®, solder wire, and solder paste. Non-reflowable TIMs include compressible metals, Heat-Springs®, and phase-change metals, i.e., metals that are liquid at room temperature. Indium Corporation's strength in thermal applications is in the depth of our knowledge of the materials and the applications where they are utilized. We have a global technical service team that is eager to assist you in person, or by phone, email, or online chat.

Please visit www.indium.com/TIM for additional information.

Markets we serve

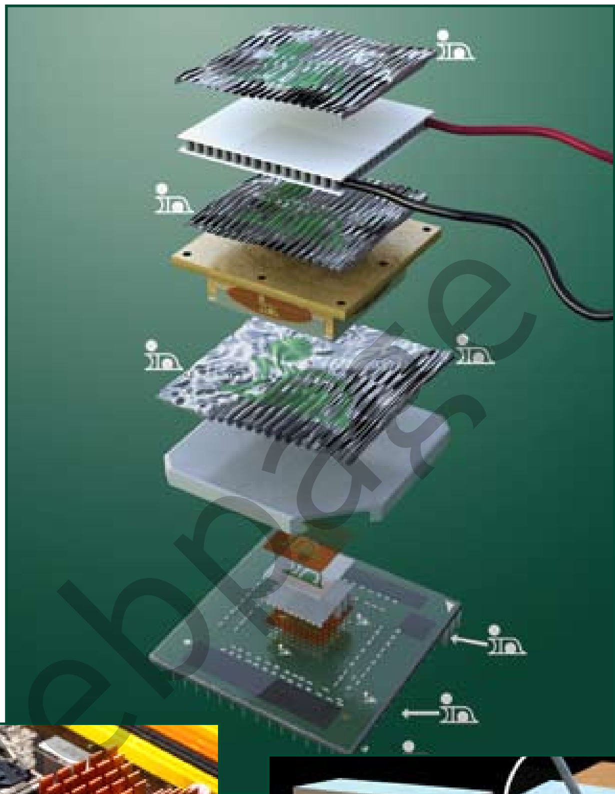
- LEDs
- Laser Diodes
- Microprocessors
- Power Devices and IGBT
- RF Infrastructure

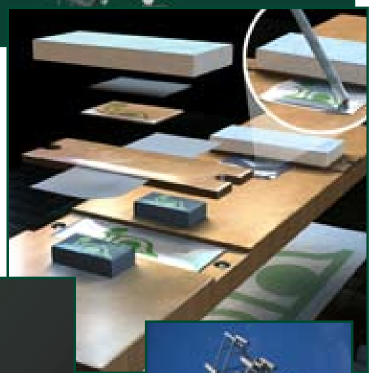
Products

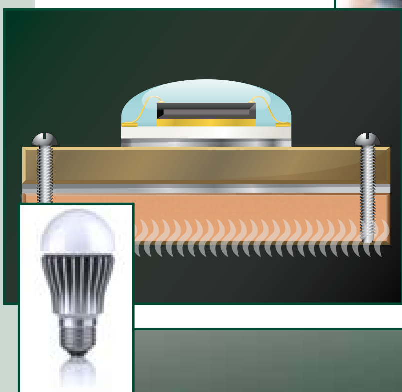
- Pure Indium Solder
- Indium Alloy Solder
- AuSn for Die-Attach
- Pb-Contained and Pb-Free Solders
- Flux-Coated Preforms
- Heat-Spring® Compressible Metals
- Liquid Metals
- InFORMS®
- Compressible Metals for Burn-in

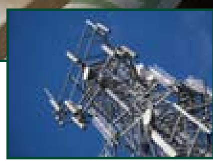
A **QR** (quick response) **code** is a pixilated, typically square barcode that contains encoded data.

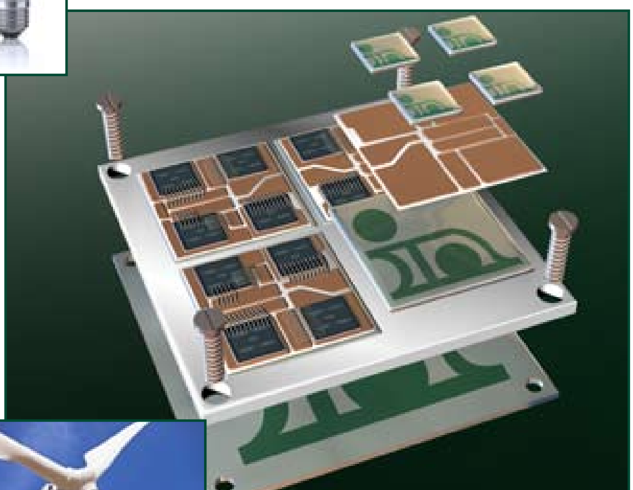
When scanned with a smart phone's camera (via a QR reader application), it can direct the viewer to a specific URL or text message.



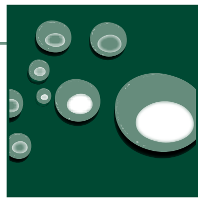








Liquid



For more information on liquid metal visit http://indium.us/F024

Indalloy® Alloys Liquid at Room Temperature

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 that surpass ordinary non-metallic liquids. This makes the use of these materials ideal 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

Gallium-based alloys will wet to most metallic surfaces once oxides are 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]

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

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

Liquid Metal Thermal Interface

Perhaps one of the best applications for liquid metals is as a thermal interface material. The thermal resistance of a liquid metal interface is 0.02°C cm2C/W and because it is liquid, it is virtually unharmed by large variations in the coefficient of thermal expansion (CTE). For proof-of-concept builds and testing, liquid metal is sometimes used to determine the absolute best cooling solution because its resistance is so low. Gallium is corrosive to some metals, including aluminum, so it is not recommended for

long-term experiments with an aluminum interface. However, liquid metal is safe with polymers, as well as nickel, copper, ceramic, and silicon. When storing liquid metal, it is important to keep it contained and limit its exposure to oxygen so that it does not develop dross. Materials such as silicone or DuPont™ Krytox® can be used to contain it.

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/in³	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

Find more information on Heat-Spring® at http://indium.us/F025

Compressible Metal SMA-TIM Heat-Spring®

Introduction

Indium Corporation's **Soft Metal Alloy Thermal Interface Materials (SMA-TIM)** exhibit superior thermal conductivity, compressibility and ease of application. **SMA-TIM Heat-Springs®**, made from indium metal, are a highly effective choice for high-end cooling devices.

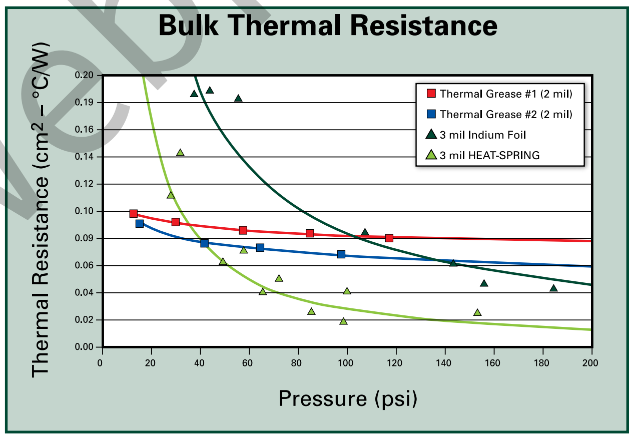
Specifications

Typical Dimensions	25.4mm x 25.4mm x .05-.3mm (1" x 1" x .003"-.012") up to 4"x 6"
Application Pressure	>30psi
Alloy Purity Level	99.99% In, 52In/48Sn
Max. Operational Temp.	140°C
Thermal Conductivity	86W/mK

Compressed Interface Application

Heat-Springs offer uniform thermal resistance at lower applied stresses in compressed interfaces. The malleability of indium minimizes surface resistance and increases heat flow. Our patented Heat-Spring technology further reduces the thermal resistance.

Heat-Spring technology takes an already good performing flat indium metal shim and enhances it to compensate for non-planer surfaces. This is demonstrated in the bulk thermal resistance chart to the right. The two curves show the thermal resistance of a flat foil as compared to a textured indium metal Heat-Spring. The shift in resistance allows Heat-Springs to perform better than flat foil at the same pressures. This is due to Indium Corporation's patented technology. Normally, at approximately 45psi, a flat indium shim has about 30% contact on an interface that is relatively flat (about 0.002mils per inch flatness). However, with a Heat-Spring, that contact area is spread uniformly and increased. Therefore, you will see a lower thermal resistance using the same foil thickness.



Benefits

- Ease of use
- No residue
- Easy to handle
- No outgassing
- Ease of handling
- The "Creep Factor"
- Set it and forget it

Reliability

Indium Corporation's high-end thermal interface materials deliver superior performance. As Heat-Springs are made of metal, they do not experience pump out, even under power cycling. Heat-Springs, which do not contain silicone, will conform to surface irregularities, thereby reducing thermal resistance through the life of the TIM. Due to its solid state, Heat-Springs also resist bake-out as shown in the bulk thermal resistance diagram.

Applications:

- Mounting of power amplifiers
- Burn-in and test applications
- LED arrays and modules
- Laser diodes and power modules

Heat-Springs outperform materials such as thermal greases, gels, and phase change materials in applications where >30psi is needed to create a bond.

Bond Line Sensitivity

Because the Heat-Spring is a full metal TIM, there is little negative effect from increasing the bond line of the TIM. Pure indium metal has a conductivity of 86W/mK; therefore, increasing the thickness of the preform does not affect performance as much as a lower bulk conductivity TIM.

Outgassing and Pump-out

Heat-Spring is ideal for applications where reliability and outgassing are a concern. The Heat-Spring is not liquid, so it creates a clean and stable bond. The melting point of indium is 157°C. Below that temperature, the Heat-Spring will show no pump-out.

Lower temperatures confirm the superiority of Indium Corporation's Heat-Spring® TIM vs. thermal grease.

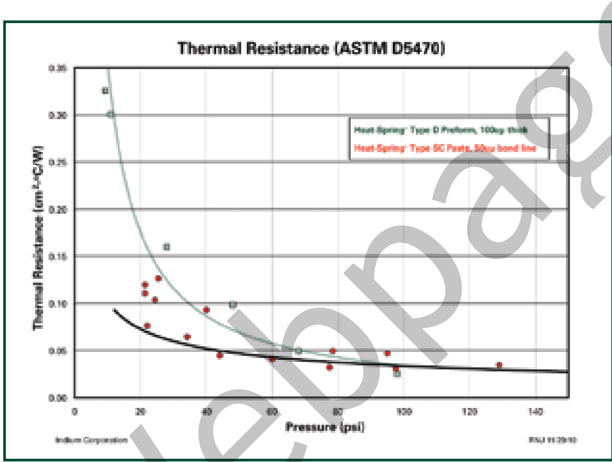
Heat-Spring® SC Thermal Paste

Find more information on Heat-Spring® SC at http://indium.us/F026

Heat-Spring® SC is a printable or dispensable material that exhibits thermal properties similiar to, or better than, our successful Heat-Spring D thermal interface preform.

Indium Corporation's Heat-Spring material exhibits superior thermal conductivity, compressibility, and ease of application. Heat-Springs are a highly effective choice for high-end cooling devices.

Under a compressive load, the **Heat-Spring® SC** shows less than 0.05 cm^{2}C/W of resistance. When comparing the **Heat-Spring® SC** to competitive, high performing silicone-based thermal greases, Heat-Spring products are highly stable and exhibit no pump-out or bake-out.



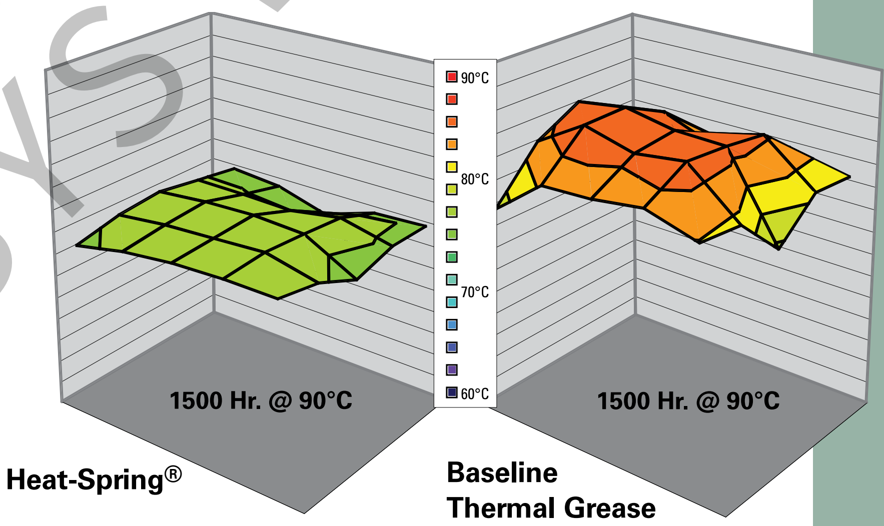
Specifications

Application Pressure	Greater than 25psi
Alloys	Indalloy®1e and Indalloy 4
Max. Operational Temp.	~140°C (validated at 30 minutes)
Thermal Conductivity	34 to 86W/mK

Compressed Interface Application

Heat-Spring® SC offers uniform thermal resistance at lower applied stresses in compressed interfaces. The malleability of indium minimizes surface resistance and increases heat flow. Our patented Heat-Spring technology further reduces the thermal resistance.

Indium SMA-TIM vs. Thermal Grease



Features and Benefits

- RoHS compliant
- Room temperature storage
- No pump-out or bake-out
- No silicone
- Minimal bond strength
- Not an epoxy adhesive
- Good tack for component holding
- Easily printed or dispensed
- Direct replacement for grease
- Reworkable

Packaging

Heat-Spring® SC is packaged in syringes. Other packaging is available upon request.

Ease of Handling and Recycling

Heat-Springs are packaged in tape & reel for pick & place applications. They can be packed in tape as small as 10mm square and as large as 4 inches by 6 inches. Unfortunately, this material is not available as foil or ribbon. Heat-Springs are clean and easy to handle; however, you should avoid folding, puncturing, or tearing the pieces. Since Heat-Springs are 100% solder, they are completely recyclable. Some applications, such as burn-in and test, will sacrifice the Heat-Spring in order to perform an analysis of the component. If this is the case, the Heat-Spring can be used and re-used until the surface is back to a flat form. At that point, the Heat-Spring can be returned and recycled for credit.

Time Zero and Conditioning

Because Heat-Springs are made of indium metal, a material that is 4 times softer than lead, the bond does need some conditioning time to reach its full effectiveness. A general rule is to allow the indium preform to sit in the interface for 500-1000 minutes to allow it to burn-in or condition to the interface. This "creep effect" is what allows the Heat-Spring to perform so well. The Heat-Spring performs best if the interface does not exceed 280psi. Pressure over 280psi could cause detrimental effects from creep.

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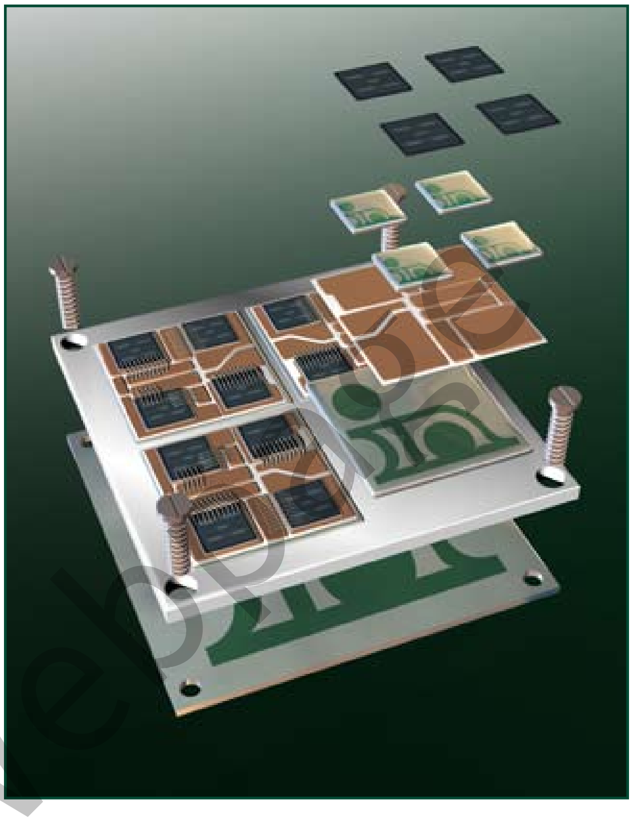
Solder Metal TIMs

See more information on solder metal TIMs at http://indium.us/F027

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 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")

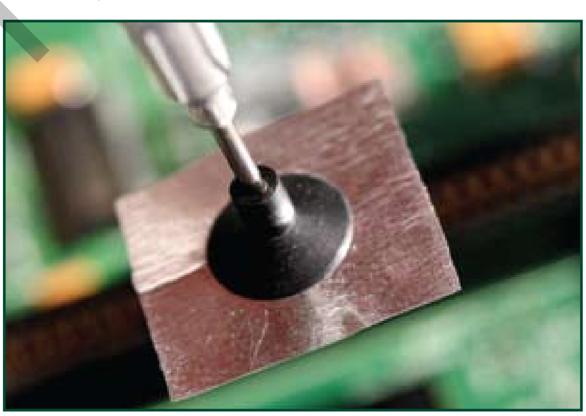
Applications

Indium preforms may be used in a variety of processes.

- **Compressed Between Two Surfaces Without Reflow**
  Heat-Spring®
  The extreme malleability of indium allows it to minimize surface resistance, thereby increasing heat flow.
- **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. The indium-coated surfaces can be 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

Metal TIM preforms come in a variety of packaging, including tape & reel and custom adhesive carriers for direct-attach to heat-sinks. To minimize excessive handling and oxidation due to air exposure, keep TIM preforms in their original container in a cool dry place. Indium **metal TIMs**, when exposed to air, will self-passivate to approximately 10 nanometers and will have a useful life of at least six months. **Metal 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/mK) (@ 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.

Solder Preforms

Find more information on solder preforms at http://indium.us/F028

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 0.254mm (.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, and 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 which solder is most compatible with them. For example, tin–based solders will scavenge the gold from gold-plated parts, forming brittle intermetallics. Therefore, indium-based solders are generally recommended in these cases.
3. Metals and alloys have different characteristics that can affect the ease in 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 can 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 to choose. We can also create a set–up specifically for your application. Using an existing preform size can eliminate the 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")

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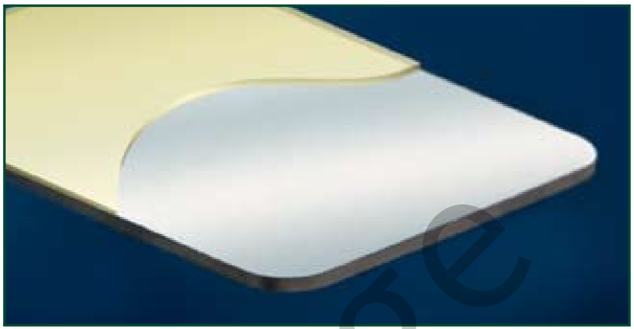
Find more information on these products at http://indium.us/F029

Flux-Coated Preforms

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.



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

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.

Re-usable and Recyclable TIMs for Burn-in and In Line Test

Indium Corporation offers:
Heat-Spring® – Metal thermal interface designed to fit your burn-in head to optimize performance.

Adhesive TIM Tabs (made with Kapton®) – holds the Heat-Spring® in place on the burn-in head.

(Kapton® is a registered trademark of DuPont™)

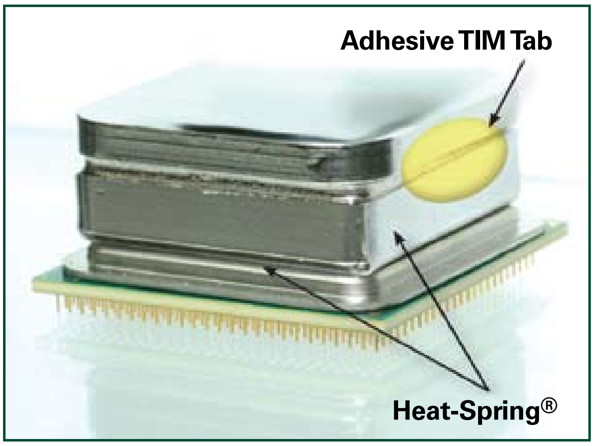
Heat-Spring®

- Repeated use saves time and money – can be inserted well over 1000 times, depending on the application design and process settings.
- Easy to use – just pick and place with tweezers or vacuum nozzle
- Clean – no messy residue
- Environmentally friendly – recyclable and reclaimable

Common alloys:
Indalloy #4 - 99.99% indium
Indalloy #1E - 52In/48Sn
Indalloy #3 - 90In/10Ag
Indalloy #290 - 97In/3Ag

Note: When using gold or copper, custom cladding is available to act as a diffusion barrier

Common form factors:
Squares 0.5", 1.0", 1.5" and 2.0"
Rectangles
Custom cross shapes



Adhesive TIM Tab

(made with Kapton®):

- Ensures that the metal thermal interface material is intimate with the burn-in head
- Can withstand temperatures up to 260°C (500°F)
- No residue
- Low-static
- Available in 3/4" or 1" discs (specialty sizes and shapes available upon request)

Technical Support

From One Engineer to Another®

Indium Corporation's research scientists, application engineers, and technical support engineers work closely with our customers to develop custom solutions to their technical problems and optimize their processes.

Indium Corporation's PhD scientists and engineers are certified by many of the top industry organizations, including the SMTA and the IPC. In addition, our Six Sigma Green Belt- and Black Belt-certified staff are trained in advanced process management methods to help you to:

- Increase yields
- Improve customer satisfaction
- Increase revenues
- Reduce defects
- Increase profits
- Deliver high value and return on investment

Learn about our technical support at http://indium.us/F030

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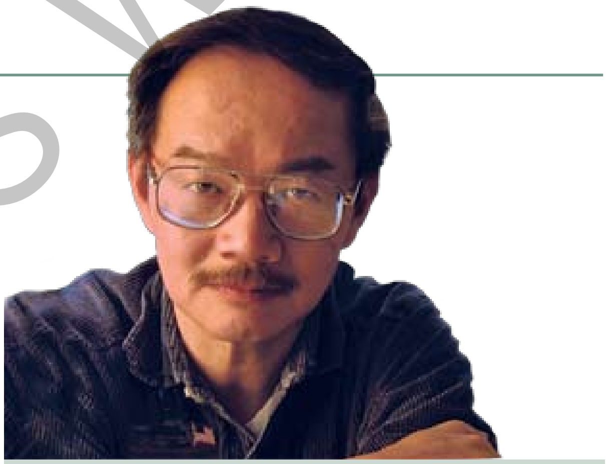
Research Labs

Indium Corporation performs research worldwide. We operate dedicated research laboratories in the USA and China.

Process simulation lab: provides the tools for our engineers to work with you on designed experiments to fully characterize materials and processes in leading-edge technology applications.

Thermal lab: analyzes the thermal resistance and conductivity of materials and applications to help optimize the best thermal interface materials for our customers' assembly processes.

Research and development labs: provide research scientists with the tools to advance material science for the creation of new and unique products for electronics, semiconductor, thermal management, and solar photovoltaics.



Indium Corporation's R&D team is headed by Dr. Ning-Cheng Lee, an SMTA Member of Distinction, author, and well-known expert in materials science and SMT assembly.

Technical Specifications

Find more information on our alloys at http://indium.us/F031

Material	Indalloy Number	Thermal Conductivity W/mK at 300K	Thermal Conductivity W/mK 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

Material	Indalloy Number	Thermal Conductivity W/mK at 300K	Thermal Conductivity W/mK at 85C	Liquidus (C)	MP/E	Solidus (C)
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. Indium Corporation was the first to begin commercial development of indium in 1934, 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

Indium, when included in solder compositions, offers many advantages. 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.

Physical Constants

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/mK 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/mK 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
	3.38 K — Super conducting
20	84
154	291
181	301
222	319
280	348

Electrochemical equivalent: Valence 3, 396.4µg/C
Electrode potential: In^0gIn^{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. The alloy can then 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.

High-Purity Indium

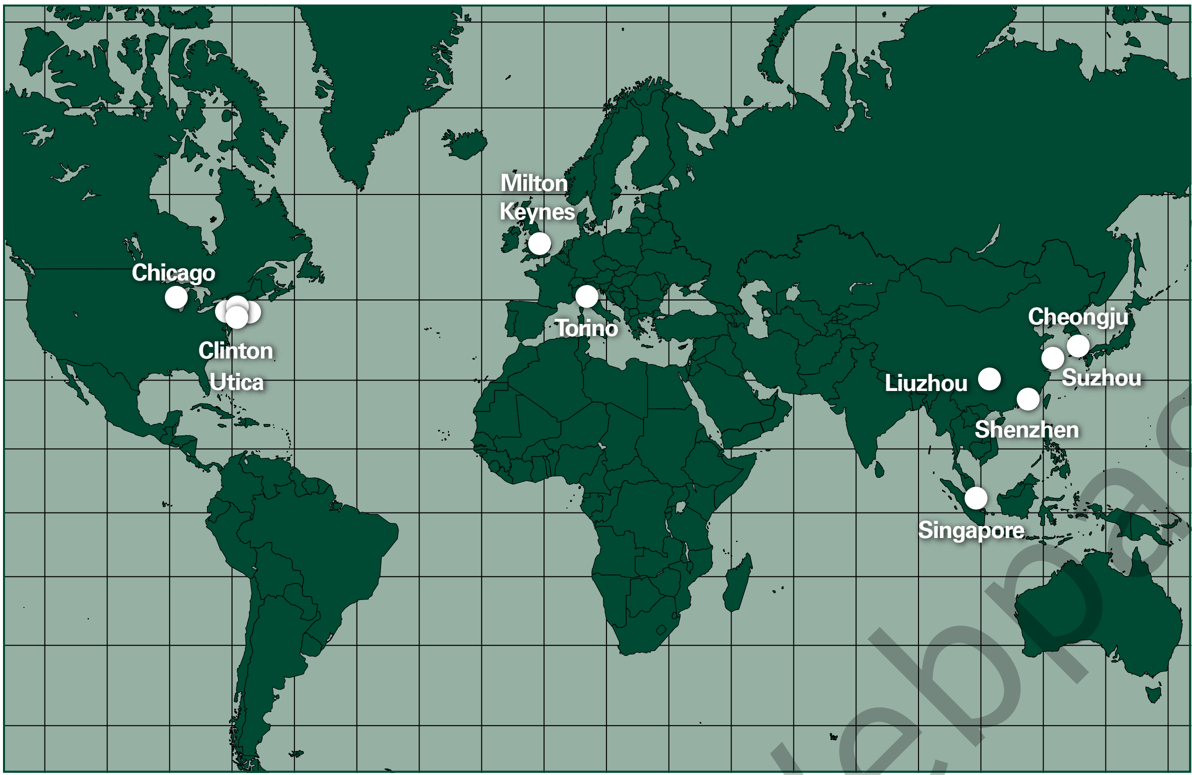
High-purity indium (99.9999 and 99.99999) is used in III-V compound semiconductors such as laser diodes.

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 CRTs, 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.

INDIUM CORPORATION

Locations Worldwide



- Electronics Assembly Materials
- Engineered Solders & Alloys
- Metals & Compounds
- Metal Thermal Interface Materials
- Nanotechnology
- Semiconductor Assembly Materials
- Solar Energy Materials

Our Goal

Increase our customers' productivity and profitability through premium design, application, and service using advanced materials.

Our basis for success:

- *Excellent product quality and performance*
- *Technical and customer service*
- *Cutting-edge material research and development*
- *Extensive product range*
- *Lowest cost of ownership*

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