

## Wirebondable Finishes for Semiconductor, Sensor & Power Package Leadframes

### 1.0 - Wirebond Interconnection

Connecting micro-electronic components, in particular Semiconductor Chips or MEMS devices, requires a process that can provide a low cost yet rugged, robust and reliable method of interconnection. Wire bonding is generally considered the most cost-effective and flexible interconnect technology, and is used to assemble the vast majority of semiconductor packages. It is the primary method of making interconnections between the integrated circuit (IC) and the package leadframe (LF) or printed circuit board (PCB) substrate during semiconductor device assembly. However, successful wire bonding is absolutely dependent upon the surface finish of both the component and the substrate.

Electroplating of wirebondable surface finishes is the most widely available process. A number of surface precious metal finish options are offered, such as Gold, Silver, Nickel, Copper, Palladium and combinations of these, that can be utilized for a range of wirebond options of Gold, Aluminium and Copper through to Platinum and other specialist interconnection requirements.

#### a. Background

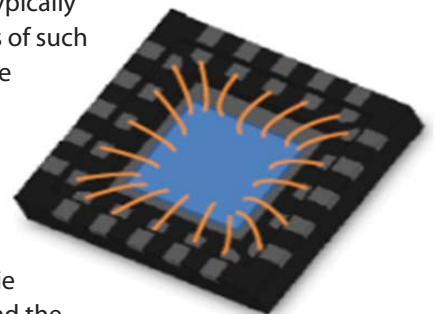
The supply chain in the interconnection industry provides a number of product types capable of different levels / methods of interconnecting techniques during electronic device packaging. Many electronic systems are demanding fully Integrated, modular, 'plug & play' package units with multiple internal connection platforms that allow a combination of interconnecting technologies starting from the Chip level through to mini-board with a minimum of interconnection levels, which can be optimized to match application performance needs. The surfaces of the materials used require plating finishes that will enable reliable and efficient connection, at all interconnect levels.

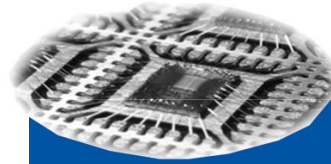
In terms of package development, the interconnection steps or links can be defined as individual interconnect levels:

- Level 0: Gate-to-gate interconnections on a monolithic semiconductor chip.
- Level 1: Packaging of semiconductor chips into assorted packages (ceramic, plastic, metal modules with feed-throughs), DIPs (dual in line), SOICs (small outline integrated circuit), chip carriers, etc. and chip-level TAB (Tape-automated bonding) interconnects the chip to the lead frames.
- Level 2: Printed circuit board (PCB), level of interconnections. Etched metal conductor traces connect electronic device leads to PCBs and to the electrical edge connectors for off-the-board interconnection.
- Level 3: Connections between PCBs, including PCB to PCB interconnections or PCB card to "motherboard" interconnections.
- Level 4: Connections between two subassemblies: one assembled electronic module to another assembled electronic module.
- Level 5: Connections between physically separate systems via cables such as an auxiliary device to a machine interface; computer to a printer or to a monitor.

However, no longer can the industry be 'level selective' as emerging systems are demanding a combination of multiple levels of interconnection in the same module or package unit.

Therefore, housings or packages that are specifically designed for Sensors, MEMs devices and semiconductor chip devices will incorporate the need for die attach technology as well as wirebond technology to interconnect the components, typically bare die. The small sizes of such housings dictate that the surface finish of the die attach location and the output leads / contacts for wirebonding should be the same and work for different die attach (solder, epoxy) and the wirebonding ( ultrasonic-sonic; thermo-sonic; thermo-compression) techniques, despite the differences of the attachment and materials technologies.





## b. Advantages of Wirebonding

Wire bonding is probably the most popular and dominant interconnect technology for microelectronics due to the fact that it offers a versatile, flexible, and robust connection method with proven performance, and reliability. It is a connection process that can be used on a variety of substrates, ranging from metallic frames to multi-layer PCBs and thick-film ceramics to flexible circuits enabling designers to use wire bonding to provide a robust and reliable interconnect in most electronics applications.

Other technologies like flip chip can allow for reduction in overall package dimensions, but wire bonding remains more cost effective and offers a greater variety of application solutions. It remains as the viable technology in the design and manufacture of microelectronic components. Additionally, wire bonding equipment manufacturers and semiconductor assembly houses continue to push this interconnect technology and continually develop the advantages with advances in ultra-fine-pitch wire bonding that allow both package-size reduction and higher interconnect densities.

On the other hand, large wire bonding, defined here as bonding aluminium wires in the range of 4-20mils (100-500 microns), or Ribbon (wire) bonding for power devices as used in the Semiconductor Industry, is a critical part of the assembly. Not only does it ensure adequate power handling in terms of current capacity, but it also plays a big role in such power products, taking up CTE mismatch between die and packages the die is mounted in.

## c. Wirebond types

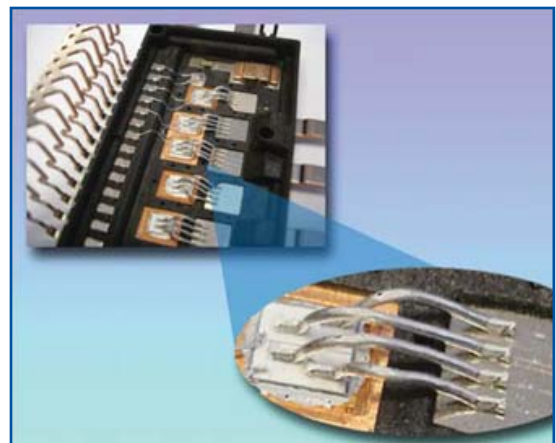
There are number of methods for “wire” bonding:

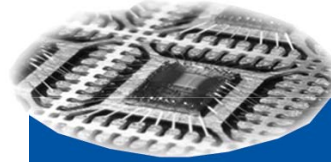
- Ball bonding
- Wedge Bonding
- Ribbon Bonding
- Clip Bonding
- TAB Bonding

Generally, in each type of bonding, the wire is attached at both ends using some combination of heat, pressure, and ultrasonic energy to make a weld.

**Ball bonding** is the process used for most IC devices, MEMS and other component package interconnects. Gold or Copper wire can be used and often Nitrogen or Forming Gas is used as a cover gas to prevent oxides from forming during the wire bonding process. Virtually all ball bonding processes use a combination of heat, pressure, and ultrasonic energy to make a weld at each end of the wire. Typically, a Ball is formed at the start and welded to the chip bond pad. The wire is then pulled over to the leadframe or substrate pad where it is stitched or terminated via crescent bond to complete the connection. Ball bonding can be done in any direction.

**Wedge bonding** is a solution for performing low profile or fine pitch interconnects and is also well suited for running stitch interconnects (also known as die-to-die bonding and chain bonding), and ribbon bonding. Assembly / Designs that require interconnecting from die to die or from a substrate to a die, also called reverse bonding, tend to use a wedge bond. The Wedge Bonding process is to weld the wire to the surface with a wedge tool pressing the wire between the substrate and the tip of the wedge tool and applying Ultrasonic energy to make the bond. Wedge bonding can use either gold, copper or aluminium wire, with only the gold or copper wire requiring a heated surface.





**Ribbon bonding** uses a flatform wire (ribbon) rather than the standard circular cross-section wire. A flat wire can be a more appropriate geometry for the interconnecting link when high frequency AC signals, e.g. microwaves, or higher power signals are passed along the conducting link. Ribbon bonding is a wedge bond process and typically the wire bonding machines operate with rectangular cross-section ribbon (or tape) and have special bond heads to allow for alignment and positioning. Ultrasonic welding is not the only method available for welding fine ribbon. Resistance welding (Pulse or Parallel Gap) can be used for these applications, enabling joining of ribbon as thin as 10µm (0.0004”).

**Clip bonding** is a form of bonding, used in power packages which uses a formed copper metal structure or ‘clip’ to connect from the chip surface to the substrate. The clip allows a higher level of current flow than a wire and also provides a better method of heat transfer from the chip. The clip is either spot welded, or more often re-flow soldered, to the die pads and the substrate pads.

**Tape-automated bonding (TAB)** is a process that places bare IC die onto a printed circuit board (PCB) by first attaching them to a structured metallized film (polyamide or polyimide) tape. The mounting is done such that the bonding sites of the die, usually in the form of bumps or balls made of gold or solder, are connected to the fine conductors on the tape, which provide the means of connecting the die to the package or directly to external circuits. Historically, TAB was created as an alternative to wire bonding and finds common use by manufacturers in LCD display driver circuits and other high end applications.

#### d. Bondwires – Cu, Al, Au

The wires available for the wirebond process usually employ one of the following materials:

- Gold
- Aluminium
- Copper



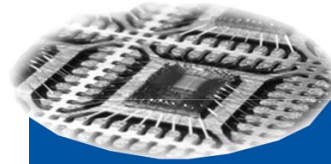
Wire diameters start at 12.5 µm (0.0005”) and can be up to several hundred micrometers for high-powered applications.

**Gold wire** is doped with controlled amounts of beryllium and other elements and is normally used for Thermosonic ball bonding, using heat, pressure and ultrasonic energy, referred to as Thermosonic Bonding. The most common approach in Bonding is to ball-bond to the chip, then stitch-bond (crescent bond) to the substrate. Junction size, bond strength and conductivity requirements typically determine the most suitable wire size for a specific wire bonding application. Typical manufacturers make gold wire in diameters from 12.5 µm (0.0005”) and larger.

**Aluminium Alloy** wires (such as 1% silicon-aluminium) are generally preferred to pure aluminium wire (except in high-current devices) because of fine sizes and higher pull-test strengths in finished devices. Pure aluminium and 0.5% magnesium-aluminium are most commonly used in sizes larger than 100 µm (0.004”). Aluminium is particularly suitable for ultrasonic bonding and is the preferred choice for power devices.

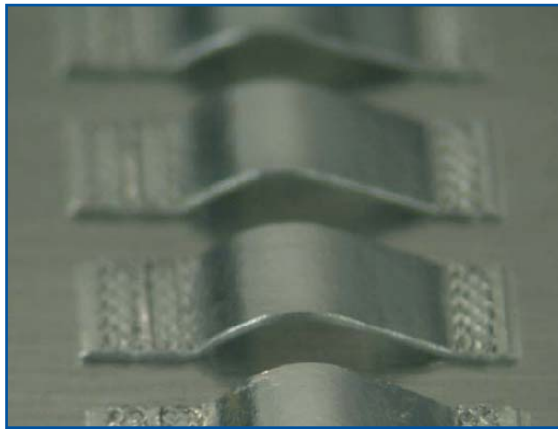
The ‘all aluminium’ interconnection system in semiconductor fabrication eliminates the Kirkendall effect also known as “purple plague”. This is a brittle gold-aluminium intermetallic compound and void formation that is sometimes associated with pure gold bonding wire on Aluminium metal die pads.

**Copper wire**, due to cost, is the preferred material for wire bonding interconnects in new semiconductor and microelectronic applications, and is now used in about 25% of all IC packages. Copper is used for fine wire ball bonding in sizes up to 75 µm (0.003”). Copper wire has the ability of being used at smaller diameters providing the same performance as gold without the high material cost. Copper wire does pose some challenges in that it is harder than both gold and aluminum, so bonding parameters must be kept under tight control. The formation of oxides is inherent with this material, so storage and shelf life are issues that must be considered. Copper wire can be successfully wedge bonded with the proper set-up parameters. Large diameter copper wire up to 250 µm (0.010”) can replace aluminium wire where high current carrying capacity is needed or where there are problems with complex geometry.



**e. Bond Ribbon**

In applications such as RF, “ribbon” rather than wire is often used. The increased surface area of ribbon wire better accommodates the skin effect, induced when high frequency AC signals, e.g. microwaves, are passed along the conducting link. Ribbon bonding wedge tools are available to fit most Gold wire bonders, and can accommodate ribbon up to 500µm wide and 50µm thick.



The increasing demands for transmitting high currents in electronic power devices have driven the industry to develop alternative interconnect solutions. Ultimate reliability and high robustness, together with improvements in productivity are making Aluminium ribbon bonds the choice for power electronic applications that carry high electrical loads. Ribbons can replace a significant number of wires and are a key to cost and space saving in future electronic housing concepts. It should be noted that Aluminium Ribbon bonding usually requires a specialised equipment.

**Gold, Silver and Platinum Bonding Ribbon.**

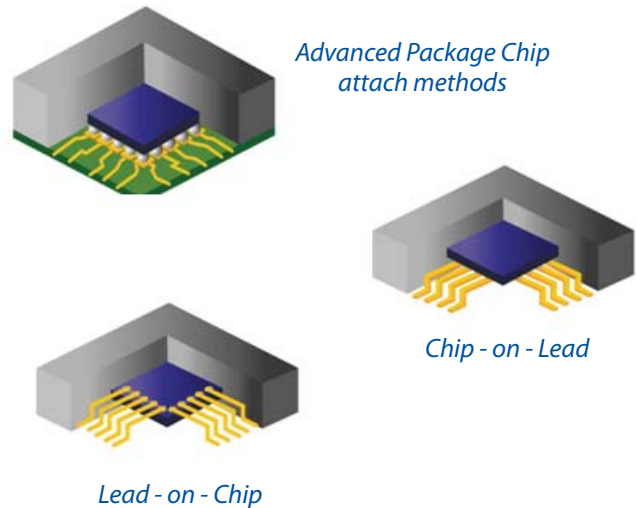
Precious metal (PM) bonding ribbons of gold, silver and platinum are used for electrical interconnections in high frequency and microwave devices. Controlled high purity and defined additives provide the basis for ribbons of high precision in dimensional and mechanical characteristics and looping behavior. Typically PM ribbons are from 100 µm to 1000 µm wide with thicknesses from 6 µm to 100 µm depending upon profiles selected.

**Aluminium Bonding Ribbon**

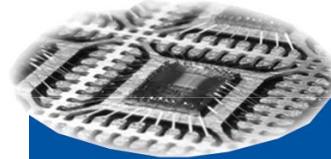
Aluminium ribbons with a large cross section equivalent to several wires are now widely utilized for power devices. Ribbons from 500 µm to 2000 µm with cross section from 75 µm to 300 µm are available however the format of 2000 µm width and 200 µm thickness (0.080” by 0.008”) has been established as a de-facto standard for bonders used in IGBT, Power device and High current applications.

**f. Next Generation Interconnection**

With the development of “smaller, faster, cheaper” electronics, there is a move away from wirebonding to direct chip attach methods for which flip-chip(FC), Lead-on-chip(LoC) and Chip-on-lead (CoL) technologies have been developed . However the substrate surfaces still require a [wire] “bondable” finish in order to ensure a reliable interconnect joint. Likewise, some RF and Power semiconductors such as Amplifiers, Switches and IGBT devices are utilizing copper “clip” bonding, rather than Aluminium wirebonding but here again the substrate contact points for the interconnections require a bondable surface finish.







## 2.0 Surface Finish Technologies

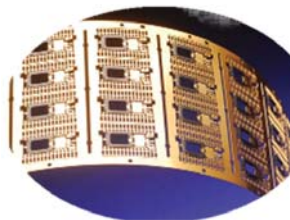
Successful wirebonding is totally dependent upon the state of the surfaces of the locations where bonding will take place. Bonding to gold has long been deemed the only acceptable substrate or surface finish for providing reliable bonds as it is not susceptible to interface corrosion. However surface bondability can be severely impeded by any porosity or any contamination and impurities from plating of the surfaces. The need for a high volumes and a very high level process quality, as well as the ever increasing cost of the precious metal has led to the development of a number of alternative processes which include, Silver, Nickel Palladium and Nickel Phosphorous materials and various Nickel / Palladium / Gold plating schemes.

Surfaces for a PC Board are somewhat different to those required for metallic leadframes and other metal based substrates. For the PCB fabricator there are concerns about the long process sequence as well as the cost effectiveness of providing a consistent nickel/gold surface. For the assembler there is also some debate of the effect of gold on overall solder joint reliability. Also of some concern using selective electroless nickel/immersion gold (ENIG) processes, is the random breakdown of alkaline developable photoimageable soldermasks. Recently considerable work has been done investigating the use of electroless nickel/palladium (ENEPIG) and immersion palladium over copper for wire bonding and soldering applications. This technology seems slow to be accepted as the process sequence is as lengthy as ENIG and there appears to be little cost savings. There is also little history of the metallurgy of wire bond formation, solder joint reliability and any of the failure mechanisms using palladium in these applications.

### a. Types of Surface Finishes for Wire Bonding:

#### i. Wirebondable Gold

Gold surface finish and gold wire bonds have provided the best long term reliability for device performance. Soft gold or pure gold ( 99% purity and a hardness 90 knoop or less) was the original choice of the telecommunication and high end choice of legacy automotive safety sensor devices market place for reliable bonding solutions. It still remains a preferred option for Aerospace and Hi-Rel (defense) applications.



#### ii. Silver

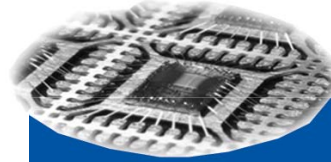
The use of silver in microelectronics is well documented as silver has been used as the base substrate for bonding to semiconductor leadframes and thick film hybrids for many years. Silver has also been used as a substitute for gold wire for ball bonding integrated circuits. It has shown to be effective providing strong sound bonds with both gold and aluminium. The concern of silver wire bonding has been oxide/sulfide formation during storage prior to wire bonding and ensuring adequate cleaning. Silver is also used in a variety of other electronic applications from soldering alloys, contacts and widely researched for use in lead free alloys. A new silver based coating has been developed that provides flat planar pads for surface mounting and has shown evidence that it provides excellent wire bondability for direct attachment. It is coupled with a very thin (10 angstroms) organic inhibitor that provides excellent thermal stability and eliminates any oxide formation during storage. For the assembler this dispels any concern for silver migration. For wire bonding this ensures a sulfide free surface that is readily bondable and possibly may eliminate or significantly reduce the plasma cleaning operation.

#### iii. Nickel Palladium (Palladium with nickel under plate)

Nickel Palladium (NiPd) electroplated surfaces for leadframes have, to the contrary, become established as the only finish for pre-plating semiconductor package frames prior to package assembly as it suits die attach, wirebond and next level assembly via soldering. Most of NiPd surfaces have a very thin Gold covering (1.0 micro-inch / 0.02  $\mu\text{m}$ ) to prevent oxidation and provide added surface protection during package processing / soldering operations.

#### iv. Copper

Despite the increased use of Copper for wire bonding, Electrolytic Copper plating is a process more widely used on PCB's than leadframes, as it is a low cost method of making electrically conductive interconnects on insulating substrates. It is particularly good for Ceramic (Alumina) based boards. High-density copper-plated ceramic is utilized for parts which require both 'chip-and-wire' and solder assembly, particularly when ceramic chip-carriers and chip-capacitors are involved. Selective-plating of the copper gives excellent wire-bonding characteristics and the combination of bulk-metal and substrates with good thermal conductivity provides good solderability. The ability to make 50 $\mu\text{m}$ -wide tracks allows wire-



bond sites to be placed close to semiconductor devices. For TAB applications, the copper tracks are finished with plated tin-lead, enabling multi-lead connections as fine as 100µm track and gap to be soldered without the formation of solder balls or solder bridges.

#### v. Nickel Phosphorous

Auto catalytic electroless nickel/phosphorus plate has long been used for bonding large diameter wire and aluminium tape applications to replace the expensive aluminium inlay alternative. However, the electroless nickel process is a slow expensive process when compared to the alternative of electrolytic nickel and nickel phosphorous. This has led to development of more efficient electrolytic nickel phosphorous processes. These are proving to be a very reliable and inexpensive alternative to aluminium inlay or electroless nickel for aluminium wire applications when wire or ribbon dimensions are greater than 1500 µm (0.060") diameter or width.

#### b. Plating Processes

A number of plating process choices are available for a wirebondable finish for Semiconductor, Sensor & Power Package Leadframes. For high volume, low cost applications such as standard semiconductor leadframes the preferred choice is silver spot plate onto copper frames. These devices tend to use a post assembly tin plate for solderable surfaces. Many higher performance semiconductor devices prefer to use pre-plated frames in the assembly, and here use of one of the many available "NiPd" options is the process of choice. This process provides a wirebondable and a solderable surface and removes the need for any post assembly plating of package external leads.

Moving up the complexity scale, to multi-chip packages, System in Package (SiP), sensor housings and hybrid/power modules, more complex internal surfaces are involved. For such package options, it is usual that a range of external interconnections are involved so there is no possibility to "post-plate" after assembly. Also there is possibility that a number of types of devices will require different bonding surfaces such as Aluminium and/or Gold. The leadframe surfaces must therefore be pre-plated and the choices for these are typically:

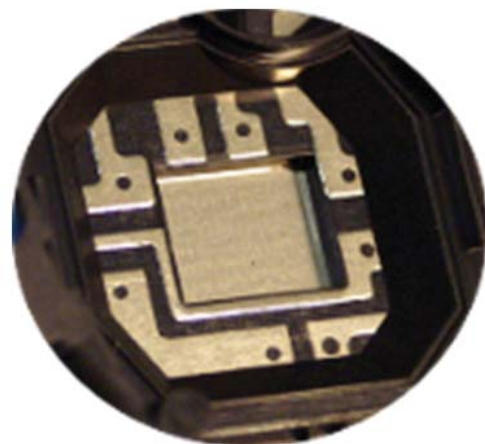
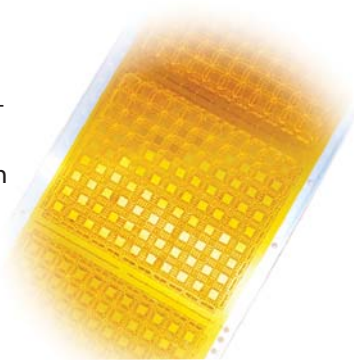
1. Selective Spot and Stripe Wirebondable Soft Gold over Nickel.
2. Selective Stripe and Full Coverage Thin Palladium or Gold Flash/Palladium over Nickel.
3. Selective Stripe and Full Coverage Nickel Phosphorous/ Nickel Metallurgy to Replace Aluminium Inlay Materials in Aluminium Wirebond Applications.

These processes have been uniquely developed for Reel to Reel Plating and a range of specialist finishes in various thicknesses or compositions can be utilized.

For other interconnection aspects a more complete range of plating options can be utilized. In many cases these can be processed along with wirebondable finishes in order to provide a complete interconnection module substrate. These additional options are:

- Silver
- Hard Gold
- Ni (Bright & Matte)
- Tin-Lead (90/10,70/30,60/40)
- Pure Tin
- Tin Copper
- Tin Bi
- Ni Teflon
- Crome 3+ Selective deposition

The surfaces required are very much dependant upon the application and need to be considered at an early stage of the product design cycle.





### 3.0 Selection (Design Choice)

Packages that are specifically designed for Sensors, MEMS devices and semiconductor chip devices will incorporate the need for die attach technology and wirebond technology to interconnect the components, typically bare die, to one another. Many of these devices will have more than 1 functional component and often also incorporate passive devices such as chip capacitors.

Further, Integrated package modules will incorporate level 1 and level 2 interconnections that will have leads, connectors and pads for wirebonds as well as options for "push-fit" connections and other plated metallic frame parts for bus-bars and internal interconnects.

Typically for cost purposes, high volume Semiconductor and MEMS sensor packages limit the content to similar IC or sensor chips and external interconnections. The key elements required for such a package are die pads with the correct surface finishes to enable die bond and bond pads with a wirebondable surface finish to meet the need to interconnect the functional dies and other components to the next level in the system.

The leadframe of the package will therefore need to be plated according to the product specification and design, the application requirements, the capability of the assembly process and of course the most cost effective process.

#### a. Requirements for Die Attach

The choice of die attach depends upon the need of the die to be electrically and / or thermally conductive and also the subsequent assembly operations after the die attach. For example, packaged devices which need to undergo a reflow solder process, need to ensure the die attach process is not affected by the elevated temperatures of the soldering process.



The Die attach "bonding" process requires a flat clean surface to enable a reliable interconnection. The type of leadframe surface finish must also match the process chosen in order to ensure a workable, reliable joining process, thermal compatibility and conductivity. The Die will be attached typically using one of 4 methods:

#### 1. Eutectic Bonding:

This process is required for components that need a good thermal interconnection and/or ground connection to the die pad or device mounting area. The process is not simple as it requires a precise force delivery and controlled uniform temperature to control reflow of the eutectic material. The eutectic bond is produced by heating the frame and the component to be mounted, then scrubbing it against a gold foil/metallization or by introducing a eutectic foil into the joint.

There are 3 eutectic options, determined by the device type and/or needs:

- Gold Silicon (97% Au 3% Si) typical process temp 390-420°C
- Gold Tin (80%Gold 20%Tin) typical process temp 300-320°C
- Gold Germanium (88% Au 12% Ge) typical process temp 300-320°C

#### 2. Soldering:

This process is mainly used on high power devices because of its good thermal/electrical conductivity and ability to absorb stresses due to expansion mismatch. For this the material and process is typically:

- Soft Solder pre-form (Lead-free and/or Tin-Lead) typical process temp 200-260°C

#### 3. Conductive Adhesive Epoxy:

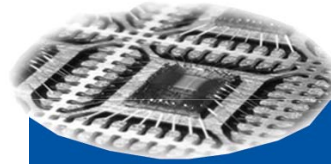
Use of conductive epoxy is widely used as it is a less aggressive process, enabling highly accurate die locations and stress free mounting. The thermal and electrical conductive properties are the limiting factor to choice. 2 types of epoxy are available:

- Silver filled - Isotropic (ICA), which are fully conductive adhesives, cured at around 150°C
- Anisotropic (ACA), where the conduction is in one direction (Z axis) enabled by a pressure application. Mainly used for LCD or other optical assemblies.

#### 4. Non Conductive Epoxy:

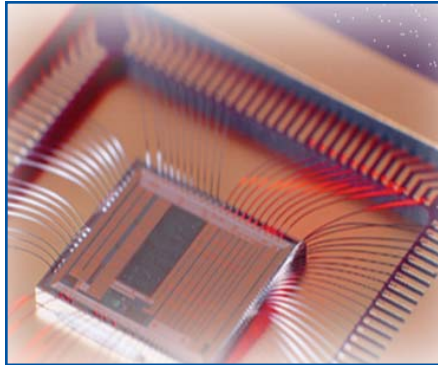
There are a wide variety of epoxy materials available and choice will also be determined by process requirements, chemical outgassing issues and surface finish. Typical materials are Epoxy thermoset resins, Acrylic thermoplastic resins or Silicone resins.





### b. Finishes for Wire bonding

Depending upon the application, typically governed by the power handling (current carrying capability) or the frequency (in RF for examples), the wire bonding process will use:



- Copper wire - Gaining popularity for lower cost reasons (at high volume only)
- Gold wire – The most common, widely adaptable interconnect process
- Gold Ribbon – RF applications, Microwave devices
- Aluminium Wire – Power devices
- Aluminium Ribbon – High current applications
- Precious Metal wire/ribbon – Specialist Sensors

The choice of Wire Bond material is generally determined by a number of factors:

- Application
- Component Materials (process)
- Semiconductor Type (chip)
- Power ratings
- Design layout
- Number of I/O (size related)
- Bondpad sizes on Chip
- Next level Materials

The necessary Wire Bondable surface finish is further determined by a number of other factors, such as type of wire, materials, environment, cost and process. A number of solutions can be utilized, such as:

- Silver
- Au (Hard & Soft)
- Pd-Ni
- Copper
- Nickel Phosphorous

### c. Plating process

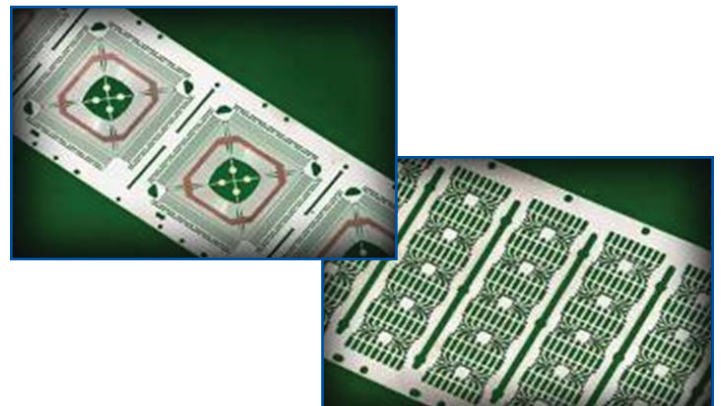
The choice of finish will depend upon the volumes of parts and the applicable process. For reel to reel deposition there would be a choice of high speed continuous overall plating, Stripe plating, Spot Plating or Step & Repeat Spot Plating to yield cost effective, high performance. However for low volumes, the process would more likely be limited to a Selective Stripe or a simple overall bath plating process.

## 4.0 Application Examples

Depending upon the application environment (harsh or benign), the electrical parametric requirements and the need for hermeticity (or moisture resistance), the selection of a suitable surface finish of the substrate is a key factor in determining the right wirebond process. In all cases, the bonding surface finishes will be selected to match the wire bond processes needed. Further, an application may require a combination or mixture of Lead free surfaces, Silver, Gold, Copper, Nickel, Palladium and Aluminium to ensure good interconnection within the packages.

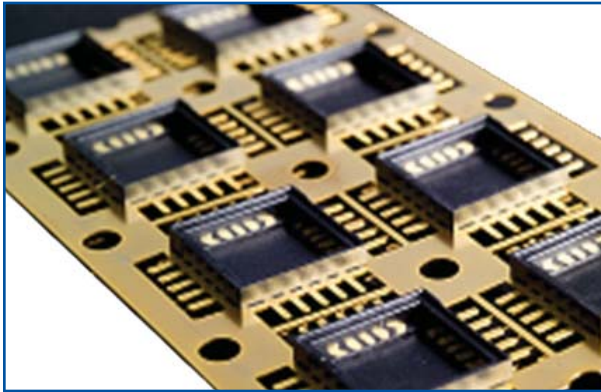
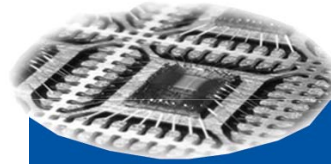
### a. Chip Packages

The majority of Semiconductor devices manufactured today utilise either a stamped or etched leadframe in the assembly process. Most applications utilise spot plated silver for the die attach pad (dap) and wirebond pad areas. Large die frames tend to be pre-plated Nickel Palladium Gold combinations (NiPd).



The pictures above show a high leadcount QFP and a 'standard' PDIP package leadframe with all over NiPDAu plating. The appearance does not look gold, even though the plated parts are finished with a 0.2 microinch thick Gold "flash".

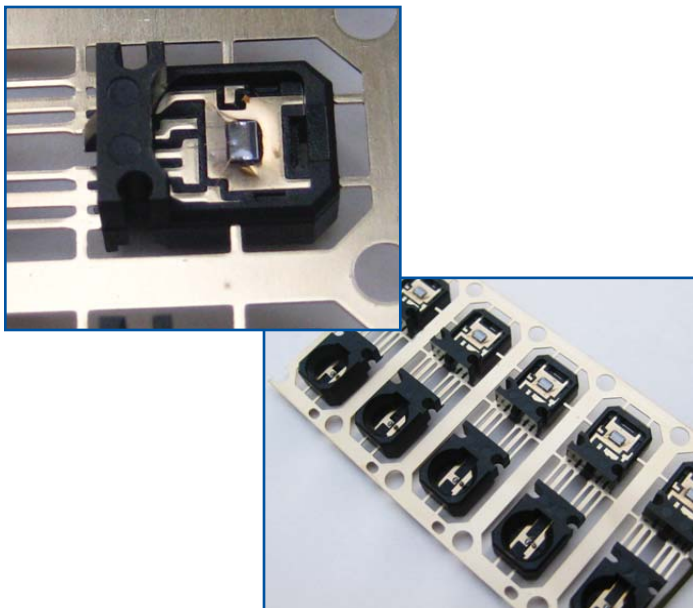




Premolded packages for Semiconductor applications such as those shown here, should also have their leadframes plated with a system that will allow both wire bond and die attach. These parts are finished with a 30 microinch Gold over Nickel plating that allows use in high temperature die attach processes.

### **b. Sensor parts**

Sensors and MEMS devices are one of the fastest growth application areas requiring specialised often open cavity packages. Most packages are application specific and require non-standard surface finishes to suit the type of sensing medium as well as to interconnect the sensor within the package housing.



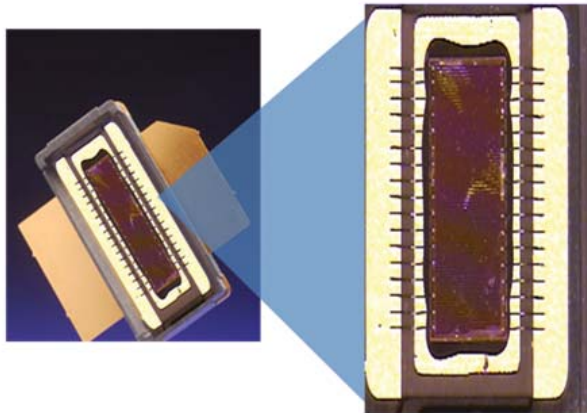
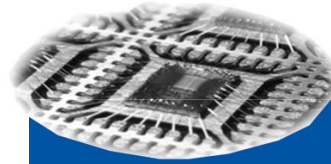
The application example here is for a high volume, low cost optical sensor module used in a wide range of printers to detect the presence of a sheet of paper. The detector chip and LED emitter are wire bonded to the frames which have overall NiPD - Au flash surfaces.



Multi component sensor packages are now widely used for applications such as Automotive or Industrial systems. These types require a wirebondable surface compatible with the sensor technology and that of the control chip technology. For such applications a wirebondable Gold surface is the prime choice.

### **c. RF Components**

Most Microwave and RF devices utilize Gold plated, copper or Kovar substrates with multiple gold wire or ribbon bonding for low inductive, low resistance bonding. Ribbon bonding is used as the primary interconnect method in the manufacturing of RF MCMs, connecting an array of active/passive devices to substrates/packages using low loop, short span ribbons. Since the demands of the design to achieve maximum RF performance drive the components to have small bond pads and limits the ability to have redundant interconnects, a single ribbon bond interconnect is the choice. Designing and validating the bond type and configuration based on the CTE of the interconnect surface base material and housing as compared to the environmental extremes of the RF MCM to meet end of life strength conditions is a critical phase in the development of the product. The main surface finish for wirebonds is gold, however new designs are utilizing copper substrates and these can be plated in a variety of lower cost finishes.



Packages such as LDMOS power devices as shown, are now available with plastic rather than ceramic housings. However the need here is for cost reduction and multi bonding of standard gold wires can be utilized for a cost effective connection solution. Currently the plated surfaces are wirebondable gold for the leadframes with gold plated copper substrates enabling high temperature die attach processes.

#### **d. Opto and Photonic Components**

To reduce the size of electronic and opto-electronic parts, the packaging industry has tried to miniaturize bonding media features. Opto-electronic applications also require high resolution alignment of optical paths and fine geometry for die placement and wirebonds. Fine gold bonding is the method of choice for interconnects and the plated surfaces are gold to ensure consistent high performance interconnections in extremely small locations.

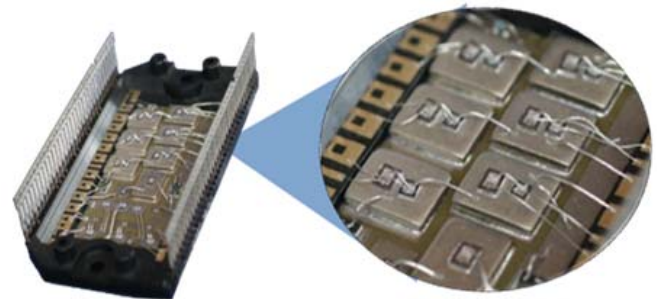


On the other hand, LED parts need to adopt the most cost effective solutions and as they require a limited number of bonds (typically 1 or 2 only) low cost Silver plate is utilized in the die attach wirebond areas.

#### **e. Power Modules**

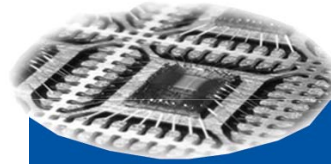
Aluminium wire bonding continues to grow as a means of producing strong, reliable interconnects so power devices tend to utilise aluminium wire and ribbon bond methodologies, usually with multiple bonds. The substrates used will also be designed to have high thermal conductivity using thick copper or aluminium alloy frames.

Heavy wire bonding has been used in volume production for many years with a wire thickness of up to 500  $\mu\text{m}$  or so. This is why for high currents, e.g. in power modules, multiple wires and stitch bonds have been required. The parallel wires and serial bonds have the disadvantage of reducing bond throughput sharply and so increasing the cost of bonding. For this reason, aluminium ribbons with a large cross section equivalent to several wires are now becoming more widely utilized.



The surface finish of leadframe bond pads is a critical factor. The industry standard for many years has been to use substrate materials of high thermal conductivity, such as Aluminium but inlay these with a nickel material to allow a reliable bond process.

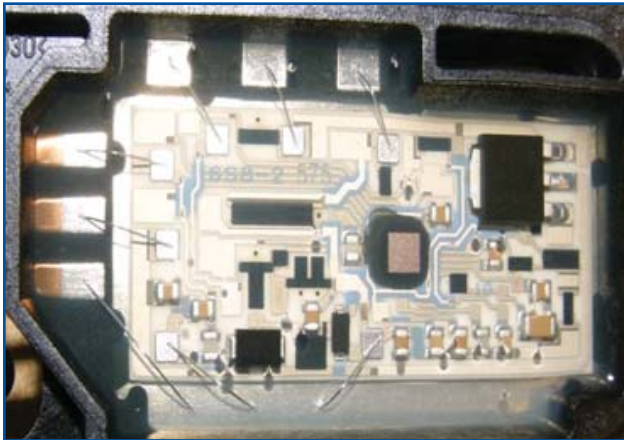
Great care is taken during the manufacturing process of these aluminium inlay clad products, as well as during the subsequent stamping and molding processes, however, this soft aluminium surface is still prone to surface imperfections. The development of high performance Nickel Phosphorous plating offers an alternative high performance finish for the bonding process.



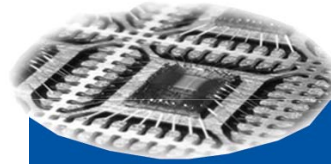
**f. Integrated modules.**

Putting Control, MEMS (sensors) and power together in one package and or even onto one complex chip chip, drives specialized packaging needs. Most modules are an arrangement of 3 dimensional structures requiring complex interconnect processes.

The example shown is a complex hybrid sensor control circuit that utilizes aluminium wirebonding for both power and control circuit interconnections. To enable this interconnection the surfaces are an arrangement of Nickel Phosphorous and Gold plating for the main connections and copper with Aluminium inlay for the grounding plane. This part also provides thermal management for the module.











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