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GLOBAL PATENT ACTIVITY IN ELECTRICALLY CONDUCTIVE ADHESIVES

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SUMMARY

During the past two years there has been a significant increase in the number of registered patents associated with anisotropic conducting adhesives. This activity is being led by Japanese companies. In contrast there has been little patent activity concerned with isotropic conductive adhesives that may reflect the 'maturity' of these formulations or limitations in the perceived market for these materials.

Patents associated with anisotropic conducting adhesives are addressing issues of improved conductivity, reworkability, resistance to thermal cycling fatigue and shock as well as new procedures for manufacturing films and tapes. These properties are achieved by incorporating thermoplastic elastomers into the formulations and through novel designs of the conducting particles.

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Approved on behalf of Managing Director, NPL, by Dr C Lea,
Head of Centre for Materials Measurement & Technology

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INTRODUCTION

Anisotropic conductive adhesives (ACA's) are used in a variety of applications including bonding or connecting of flexible circuits to PCB's, tape carrier packages to liquid crystal displays and flip chips onto substrates such as glass or epoxy based circuit boards. Flip chip packages comprising of bare semiconductor devices are conventionally solder bumped on the conductor pads located on its surface. These devices are flipped over and soldered onto corresponding solder coated conductive pads located on the substrate. Encapsulation of the flip chip provides protection from the environment. This process can be simplified by using ACA's since the use of these adhesives circumvents the need for solder bumping of the flip chip. The drive towards minaturisation of electrical components such as semiconductor chips can lead to bridging problems between closely spaced bumps or pins using conventional solder techniques. These can allegedly be circumvented by using anisotropic conductive adhesives that permit finer pitch junctions to be formed.

Isotropic conducting adhesives (ICA's) based on curable epoxies or thermoplastics polyimides are typically used to attach semiconductor devices such as silicon dies or chips to a substrate such as a lead frame or printed circuit board where the pitch is akin to that of solder mounted devices.

2 GLOBAL PATENT ACTIVITY

Current global activity in the area of electrically conducting adhesives continues to be dominated by new claims for different formulations of anisotropic conducting adhesives or assembly processes based on these materials. One of the most useful internet sites for accessing patent information can be found at www.ec.espacenet.com which provides access to world patents. Searching this database using the keywords 'Anisotropic conductive adhesive' generated 189 'hits' (Listed in Annex 1).

Figure 1 shows the dominance in this area of research by Japanese companies. Clearly these materials are seen as having significant potential in electronics markets despite the fact that many of the applications are concerned with coupling liquid crystal or plasma displays with powering circuitry or in mounting semiconductor devices. A similar search of the database for 'isotropic conducting adhesives' was significantly less productive with only a small number of patents being concerned with formulation or assembly techniques. These findings may reflect the 'maturity' of the formulations used in isotropic conductive adhesives. Other patents identified by the search engine involved assembly of functional devices such as liquid crystal displays or smart cards. US patent US4428867 describes an unusual application of an isotropic conducting adhesive as a material that limits lightning damage to military aircraft. In this particular application the isotropic adhesive is used as a structural material in the door assembly that giving access to the aircraft fuel tanks. This places special demands on the adhesive that must be able to

withstand structural loads of up to 35 MPa without failure and be able to conduct currents of approximately 200,000 A.

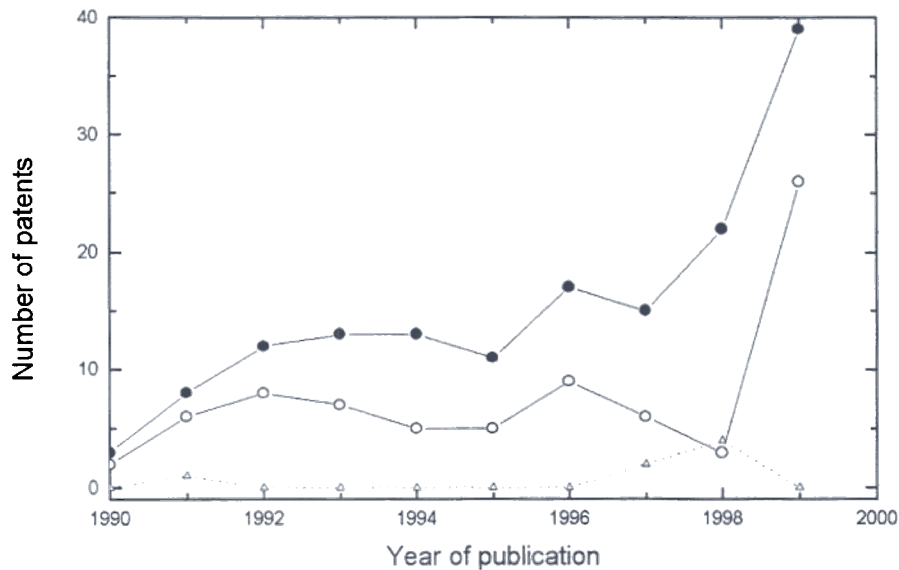


Figure The number of patents registered globally during the past decade for 'anisotropic conductive adhesive' (●) compared with patents registered for this subject in Japan (○). Global patent activity for 'isotropic conductive adhesive' (△).

Patents describing changes in the formulation of anisotropic electrically conducting adhesives are focussed on improving the design of:

- Adhesive carrier systems to improve, for example, impact performance, or the ability to rework crosslinked resin systems.
- Manufacturing techniques for curing adhesives
- Conducting balls to improve electrical conductivity or to facilitate testing functionality of interconnects prior to final assembly.
- Bumps and electrodes to facilitate electrical conductivity, limit bridging and improve the performance of the adhesive as an underfill.

Several measurement issues are identified by the patents that are principally associated with the manufacture of adhesively and electrically coupled device/substrate combinations.

3 FILM/PASTE DESIGN AND MANUFACTURE

Anisotropically conducting films are used to adhesively and electrically couple for example IC's or flexible printed circuits (FPC's) to indium/tin oxide terminals formed on

the glass substrate of a liquid crystal panel. Transparent films are desirable in assisting with accurate positioning of the electrodes. Typically anisotropic conductive films comprise of conductive particles dispersed in an adhesive containing epoxy or phenol based resins and a hardener. These conventional ACA formulations are prone to low adhesive strength, poor workability and susceptibility to heat or humidity. The goal is therefore to develop new formulations that remove these limitations and are cured rapidly at relatively low temperatures.

3.1 Low temperature cure formulations

Epoxy or phenol resin based ACA's need to be cured at temperatures of at least 150°C. However newer formulations cured by UV or based on different chemistries can be cured at temperatures below 130°C (EP0883329). Fast curing of the adhesive is essential for production lines manufacturing products for mass markets and this can be achieved in formulations that contain cyanate esters that can be cured at around 180°C in 20s. Unfortunately formulations containing cyanate esters are prone to moisture ingress that can lead to a decrease in peel strength after humidity ageing.

3.2 Manufacture of ACA films with uniformly distributed conductors

The concentration and location of conducting particles is an important issue for ACA films. Patent JP10302926 describes a method for manufacturing a 'low' density conducting film whereby conducting particles are dry sprayed onto an adhesive which is subsequently sandwiched between layers of base material in a lamination process. This method of processing can lead to defects such as air bubbles being locked into the film. This problem has been addressed in patent JP11067410 where a method for producing defect free ACA films composed of an adhesive layer containing conducting particles sandwiched between two adhesive layers is described.

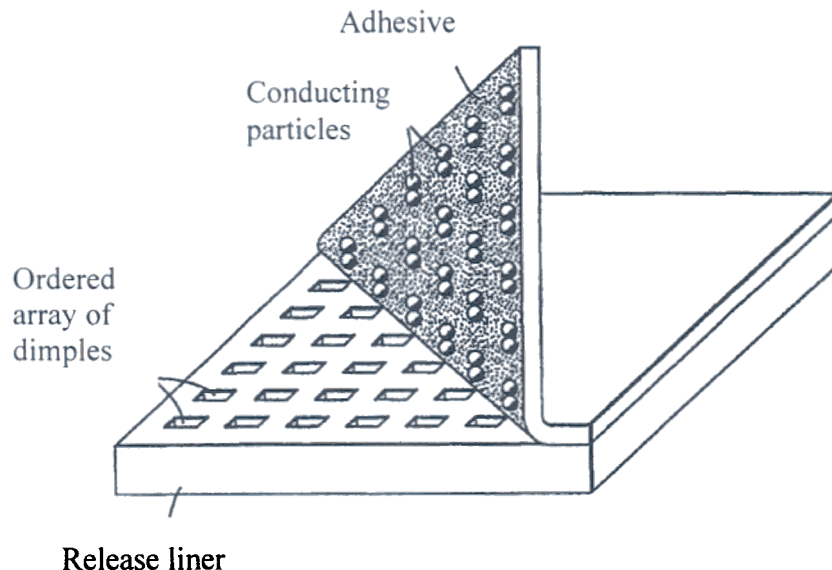


Figure 2: Using a dimpled substrate can help to ensure even positioning of conducting balls (From patent WO00/00563).

Attempts to maximize conductivity in the Z direction of ACA's often leads to shorting or bridging in the XY plane. A number of patents address this issue. Patent WO00/00563 describes a procedure for manufacturing ACA films containing a relatively high density of conducting particles. The method involves coating a dimpled substrate with adhesive particles such that the wells are filled with conducting balls as shown in Figure 2. Excess balls are removed and the dimpled surface is laminated with an adhesive matrix. During application the dimpled surface acts as a release liner and can be removed prior to forming electrically conducting joints. Patent WO97/45893 describes a method for producing ACF film whereby the electrically conducting particles are arranged in an hexagonal array. These layers are then sandwiched such that in Z direction of the assembled film any one of the conducting particles is located at the centre of a square defined by four adjacent particles.

Patent US5438223 (also registered as EP0560072A2) relies on electrical connections being established through a regular array of metallic columns that pass through an insulating film of thermoplastic as shown in Figure 3. A laser is used to manufacture an

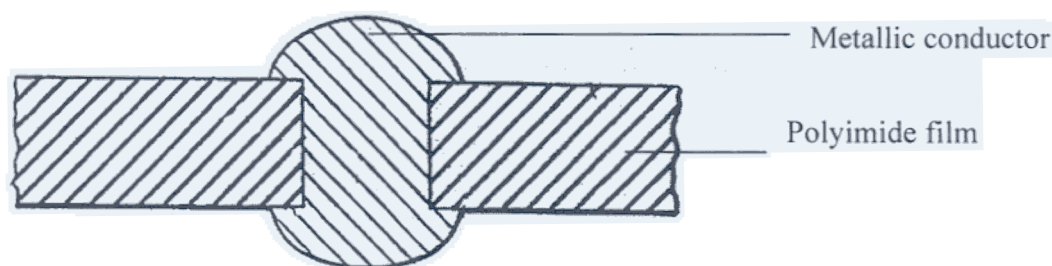


Figure 3: A conducting metal is used to fill 60 μm diameter holes in a polyimide film. The bumped ends enhance electrical conductivity (Patent US5438223 (also registered as EP0560072A2)).

array of fine holes 60 μm in diameter in the thermoplastic (polyimide) film with a pitch of 200 μm . These holes are then filled with metal such that the metal forms bumps on both the upper and lower surfaces of the thermoplastic film. The height of the bumps ranges from 5 to 60 μm .

3.3 Particle alignment by magnetic fields

An alternative approach to controlling the distribution of conducting balls is described in patent US 5769996 whereby substantially non-magnetic electrically conducting particles suspended in a ferrofluid are ordered in a regular pattern by the application of a magnetic field. (A ferrofluid is a colloidal suspension of ferro-magnetic particles suspended in a non-magnetic carrier.). This idea has been reversed such that paramagnetic or ferromagnetic particles made from iron, nickel or cobalt suspended in a non-magnetic

adhesive are aligned by applying a magnetic field across the assembly (US4170677) (Figure 4). This field is then maintained during the period of adhesive curing. This concept has been further developed in patent US5045249 whereby the conducting paths are formed by magnetically aligned spherical electrically conducting particles as shown in Figure 5. A magnetic field is applied during the period in which the supporting

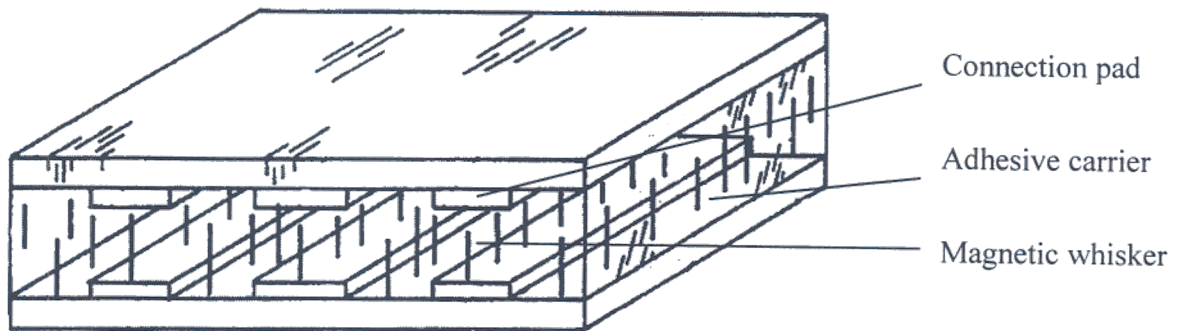


Figure 4: Electrically conducting whiskers can be aligned by a magnetic field (patent US 5045249).

medium is partially cured such that the spherical particles form chain like structures that protrude from the surfaces of the adhesive. This arrangement allegedly provides superior electrical conductivity. Patent US6011307 describes a method for applying a magnetic field across an assembly of two electronic components separated by an adhesive containing ferromagnetic particles. From the drawing supplied with the patent the conducting particles appear to be rod like. A similar idea has been patented in patent WO9520820 where spherical conducting particles are dispersed in a colloidal ferromagnetic fluid.

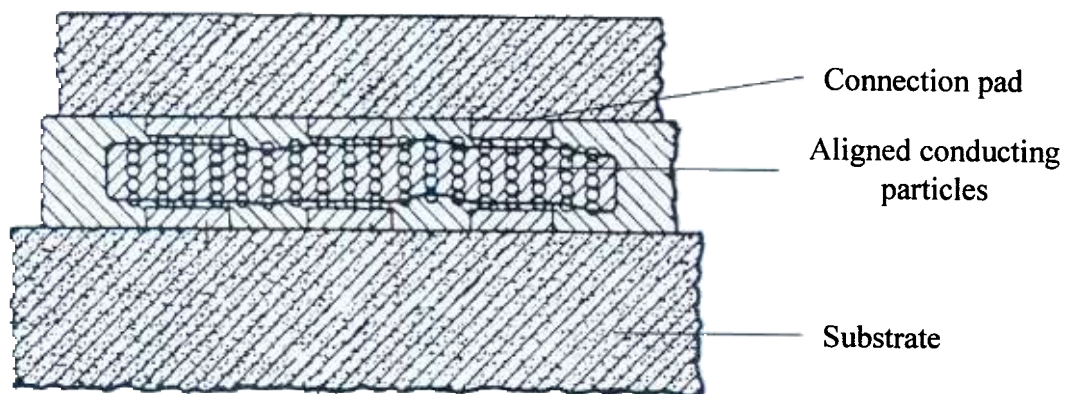


Figure 5 : A magnetic field is used to align spherical conductor particles to form electrically conducting chains (from Patent US5045249).

3.4 Reducing thermal mismatch and improved impact resistance

Most ACA formulations have a significant mismatch in thermal expansion coefficient between the conducting particles and the adhesive matrix that can lead to changes in electrical conductivity during service. Typically the thermal expansion coefficient is greater for the matrix than for the conducting particle, hence the in-service heating and cooling of assembled boards leads to forces being generated that can result in movement of the conducting particles and loss of conductivity. The Minnesota Mining and Manufacturing Company has proposed a solution (US5686703, also registered as WO9301248) to this problem whereby the coefficient of thermal expansion of the matrix is lowered by the addition of glass spheres. The glass spheres are small (0.1 to 1 μm) and typically form 10 to 30% by volume of the ACA.

Appendix 2 shows that many of the new formulations for ACA's contain thermoplastic elastomers that are able to withstand shock. Thermoplastic elastomers unlike conventional rubber like materials are reworkable when heated. These materials usually derive their properties from their ability to stop crack propagation at the interfaces of the rubbery regions that exist within the glassy matrix. One patent (WO9727646 also registered as US5842273) describes an isotropic adhesive formulation based on silicone rubber which although difficult to rework does offer considerable flexibility. This is a highly desirable property in preventing joint failure through either impact or as a result of thermal cycling fatigue. Patent JP11185526 describes a method for isolating bound piezoelectric elements from the influence of vibration. This is achieved by formulating an adhesive with a relatively high concentration (10-25 wt%) of an unspecified rubbery material or rubber mixed resin.

3.5 Reworkability of adhesive carriers

Rework processes to replace defective chips usually involves applying heat to both the underneath of the substrate and the top of the device whilst applying a shearing force to the device to dislodge it from the board to which it is attached can result in damage to the substrate that needs to be repaired before a new device can be mounted. The ability to rework the adhesive is therefore highly desirable. Several patents describe new formulations based on crosslinked resins that can be reworked at elevated temperatures (100°C to 250°C) e.g. US5912282 (also logged as US5973052 and WO9827178) that are based on producing a reworkable crosslinked resin based on a dienophile having a functionality in excess of one and a 2,5-dialkyl substituted furan containing polymer. It is claimed that this resin system is reworkable even when the loading of conductive particles approaches 60% by weight. An alternative approach is to base the adhesive on a thermoplastic substrate eg WO9301248 that also contains a percentage of epoxy resin.

4 CURING OF THE ADHESIVE

Curing of thermoset based ACA's is usually achieved by heating the adhesive through the component that is to be attached to a substrate. Two methods, the constant heat and pulse heat techniques are currently used to cure thermoset based ACA's that require exposure to heat and pressure for their functionality. In the constant heat method the

temperature of the thermocompressing head is maintained during the period that the device, adhesive, substrate combination is compressed. In this process control of the temperature of the adhesive is limited. This can cause problems if specific thermal profiles need to be applied to certain combinations of device and substrate. In the thermal pulse method the assembly is subjected to a pulse of heat during the period it is under compression. Heating of the adhesive is rapid but can result in movement of the device with respect to the contact points of the substrate and hence failed connections. Patent US5810959 describes a machine for curing ACA bonded assemblies that involves a two stage heating process. During the initial phase of heating the thermocompressor head is rapidly heated to the temperature at which the adhesive begins to soften whereupon the rate of heating is reduced until the curing temperature is reached. This thermal profile allegedly inhibits flow of the adhesive out of the sandwich structure thereby improving electrical conductivity.

Patent DE4335524 describes a U shaped bracket that is used to attach flexible conductor track film to a printed circuit board via an isotropic conductive adhesive using a combination of temperature and pressure to effect the cure. A novel method for forming electrical interconnects is discussed in patents WO9727646 and US5842273 whereby an isotropic adhesive is dispensed onto conducting pads of a substrate. The device or second substrate is then accurately positioned thus completing the interconnect. The isotropic adhesive is composed of a silver filled silicone which remains compliant after curing. Whilst the conducting adhesive is still wet or partially cured the space between the device and the substrate is filled with a non-conducting unfilled adhesive that acts as a lower viscosity underfill. The whole assembly is then fully cured. Shrinkage of the underfill adhesive pulls the device closer to the substrate thus enhancing the conducting capability of the interconnect and removing the need for external clamping.

5 BALL DESIGN

In ACA's conductive particles are usually spherical or substantially spherical in shape and manufactured from metals such as gold, nickel or silver or plated insulating materials such as plastics or glass beads. The particle size distribution, distribution and density of particles contained within the supporting insulating matrix is tightly controlled to maintain functionality of the 'package'. There is always a potential problem with lateral shorting of connections in ACA's that can be minimized by limiting the particle concentration to below approximately 25 vol%. Patent JP11126516 describes a method for further reducing the capability of ACA's to short circuit that involves the manufacture of fine conducting particles coated with an insulating layer of polymer. The diameter of the conducting particles can range from 0.3 μm – 50 μm . The addition of the coating increases the overall particle size to 0.6 to 1 times that of the core conductor. This principle may also be found in patents JP11134935 and JP11134936 where metal balls ranging in size from 0.3 μm to 25 μm and having an aspect ratio of less than 1.5 are 'provided with projections' (JP11134935) and coated in resin to limit shorting and enhance conductivity. A similar concept is discussed in US patent US5613862 where the issue of oxide penetration is discussed. Typically the conducting elements of substrates

and devices are coated with insulating oxide layers such as indium/tin. The formulations described in patent US5613862 and shown in Figure 6.

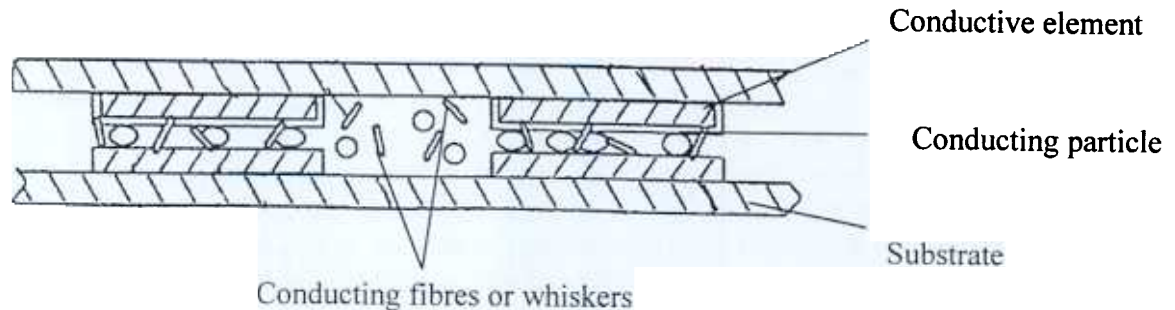


Figure 6: An ACA formulation containing a mixture of both conducting spheres and whiskers or fibres. The whiskers or fibres are able to penetrate oxide coatings that form on the conducting elements during assembly that leads to improved electrical conductivity.

contain whiskers of carbon, titanium diboride or tungsten that are able to penetrate these oxide layers such that they make contact with the underlying metal. This process happens as the adhesive is cured under pressure. The conducting particles are squashed in this process which improves their electrical conductivity. These whiskers are also able to penetrate stable oxides such as those formed by aluminium.

Changing the shape of the conducting balls has also been considered in patent JP1134934 to improve the reliability of connections over a long period of time. This is achieved by mixing two populations of conducting balls that have different shapes and mechanical properties. The first type of ball is covered with 'multiple protrusions' and is only compressible under relatively high stresses. The second type of ball is spherically shaped, has a smooth surface and is less resilient to compressive stresses. From the information given in the patent it is not clear how long term functionality of the joint is assured by this particular formulation. The idea of having two different ball designs is also discussed in patent US5586892. Here resin coated balls are mixed with uncoated balls as shown in Figure 7 such that when the assembly is sandwiched between two conductors the resin coating fractures leaving the metallic core to indent the conductors. The remains of the resin coating surrounding some of the particles acts as an insulator preventing shorting. This method is attractive in that it provides a means of increasing the density of conducting particles without increasing the probability of shorting.

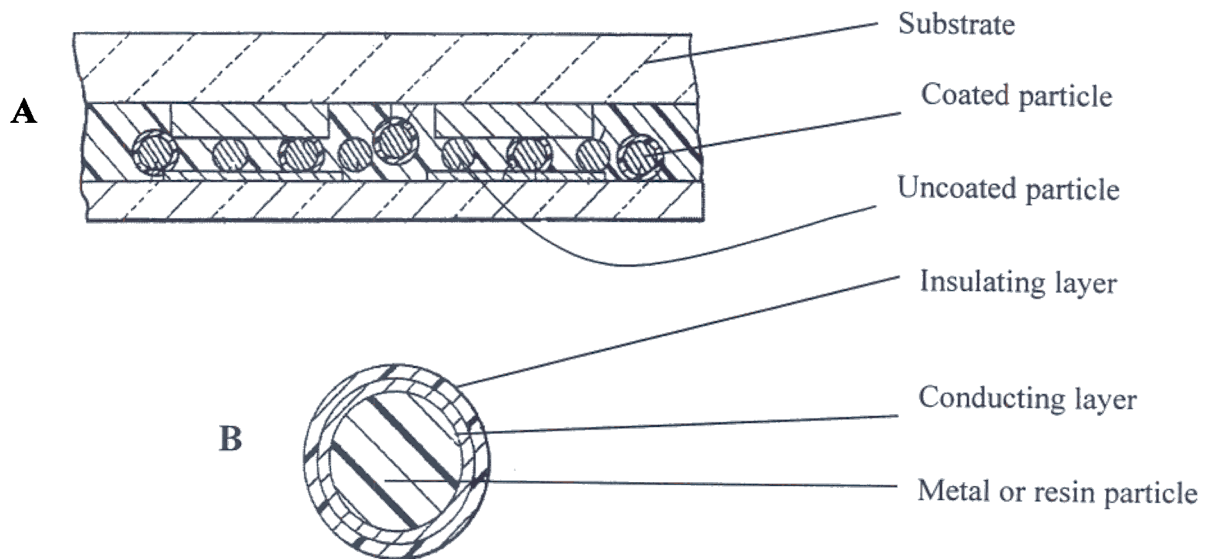


Figure 7: Patent US5586892 describes an ACA formulation composed of a mixture of coated and uncoated conducting particles (A). The detailed structure of a coated particle is shown in B.

Since reworking of thermoset based ACA's is difficult it is important to ensure that connections between IC devices and electrode pads for example located on an LCD are fully functional after the curing cycle has been completed. Patent JP11135561 describes a design for an anisotropic conductive adhesive where the conducting spheres are larger than the supporting adhesive matrix. This allows the performance of the IC device to be checked before a permanent bond is established. This success of this concept relies on the elasticity of the conducting particles.

Patent JP11219982 proposes a novel design for conducting balls based on metal coated metal cores as illustrated in Figure 8. The metal core has a higher melting temperature than the coating material. During curing at elevated temperature and under pressure the conducting balls are brought into contact with conducting pads. The metal coating of the ball is designed to melt at the curing temperature of the adhesive so wetting the conducting pads forming not only an electrically conducting joint but also one that is mechanically coupled.

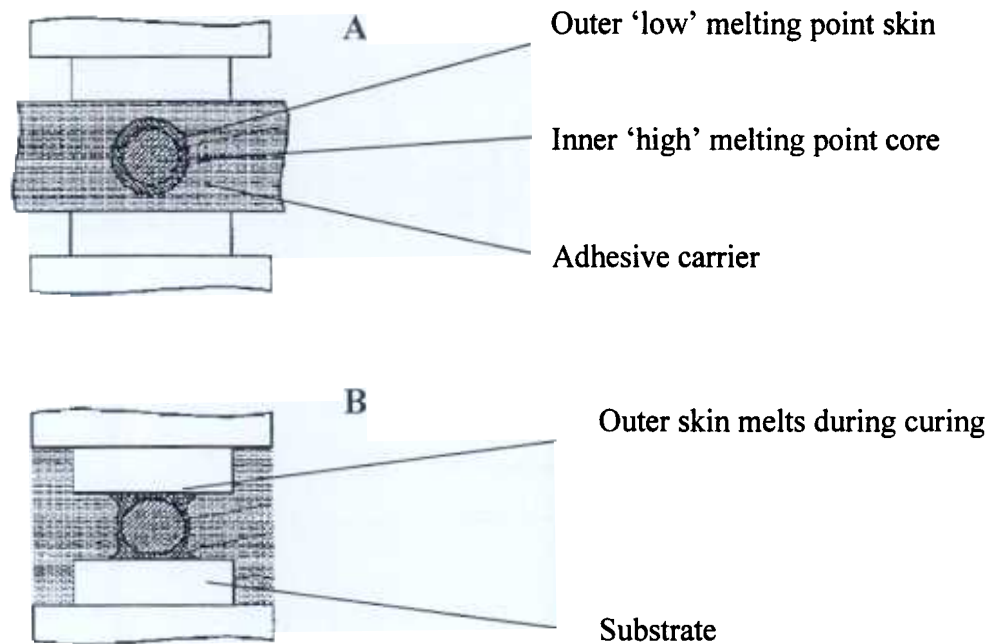


Figure 8: A 'low' melting point metal coating covering an inner core (A) melts as the adhesive is cured to form a metal joint between opposing conductive pads (B). From patent JP11219982.

A similar concept has been discussed in US patent US5136365 which describes an ACA formulation that contains a fluxing agent and metal particles. During the curing process the heat applied promotes adhesion of the metal particles to the substrate metallized area and the corresponding one on the component such that a continuous path of fused particles is formed. The adhesive then acts as a supporting underfill.

6 DESIGN OF BUMPS AND ELECTRODES

Careful design of contact members can improve the efficacy of ACA's. Patent US6002180 describes a design that has raised contact members that are configured to correspond to the location of bond pads on a semiconductor dice as shown in Figure 9. This arrangement not only provides electrically conducting links but also provides a more substantial underfill layer for securing the dice to the substrate.

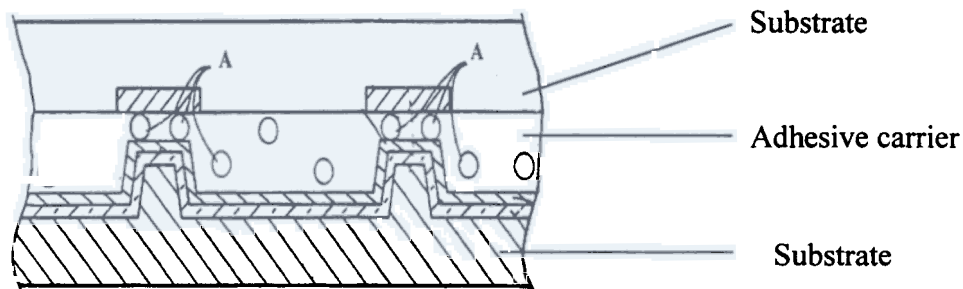


Figure 9 : Raised contact members on a substrate function as bumps for the electrodes of, for example, a semiconductor die. The conducting particles are denoted by A (Redrawn from patent US6002180).

The electrical conductivity of ACA bonded assemblies can be improved by coating the metal pads of the substrate and devices with a layer of metal that is softer than the conducting particles as shown in Figure 10 (US5225966 and GB2269059). Two ball sizes are included in the ACA formulation one much larger than the other such that when the conducting joint is formed the large balls indent into the soft metal layer providing a sound electrical contact. This is then supported by the additional contact made by the smaller conducting balls.

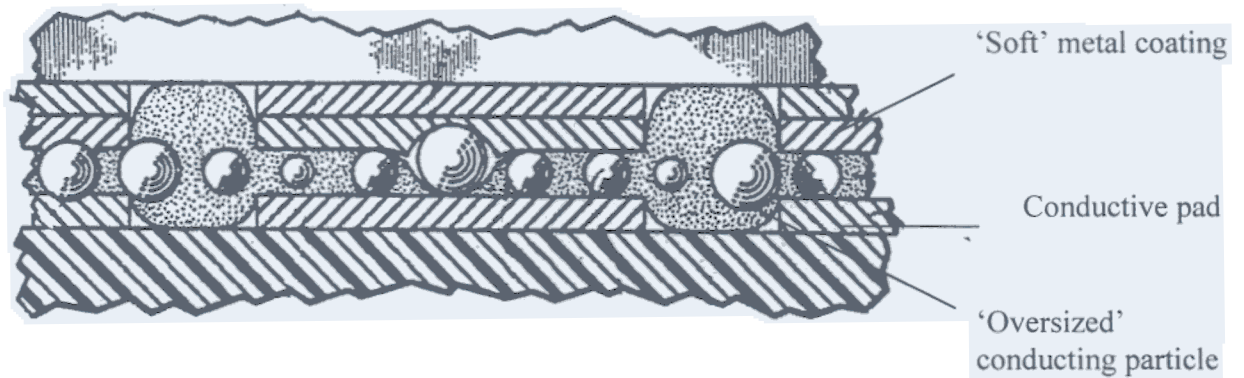


Figure 10: 'Oversized' conductive particles indent a 'soft' metal coating applied one surface of the conductive pads to form superior electrically conducting joints (Patent US 5225966).

7 MEASUREMENT ISSUES

Errors in positioning can and do occur in bonding IC chips (Chip sized packages) to flat panel such as LCD's or plasma displays. Typically bumped IC components are temporarily bonded to a glass substrate coated with ACA using a pressure tool. Image inspection of the IC component is used to assess whether or not the device is correctly aligned before it is finally fixed in position. If the alignment is beyond specification then the component is discarded and replaced by a new IC device. Positional errors can arise during curing of the ACA as the viscosity of the adhesive falls as it is heated during the curing phase of the process. Further errors can be caused by warpage of the display that can occur if the pressurizing tool is not parallel with the display. Measurement of the parallelism of the IC device and pressure tool with respect to the display has been achieved by measuring the dimensions of the conducting particles as they are deformed during pressure curing. The hue of the bumps attached to the electrodes of the IC device has also been used to measure parallelism. The latter technique apparently requires that the microscope should also be aligned in a parallel configuration with the display and the IC device and pressure tool. The interpretation of interference colours is subjective and hence there is uncertainty in the data. Patent US5858806 describes a method for accurately positioning IC devices onto a glass substrate based on the information gathered by two cameras positioned above and to one side of the display screen. The method described incorporates a feedback loop to compensate for movement of the IC device during curing.

The details of the thermal/pressure profile applied to the ACA during cure is of critical importance in ensuring that the adhesive cures as rapidly as possible and at a low temperature. Low temperature cures are desirable to minimize damage both to the devices and substrates. There is therefore a need to establish the link between the applied thermal/pressure profile and in service performance in terms of thermal fatigue to optimise the manufacturing process. It would also be advantageous to examine the performance of formulations containing elastomeric compounds with respect to resistance to thermal fatigue and impact. The use of cyanate esters in ACA formulations to improve the rate at which adhesives can be cured increases their susceptibility to moisture ingress and hence loss of peel strength. This aspect of material performance should be investigated to ensure that electronic devices continue to perform under a wide range of environmental conditions.

In addition to the manufacturing issues described above there also measurement issues that have long been associated with both the performance of both isotropic and anisotropic conducting adhesives in the following areas:

- Resistance to thermal fatigue
- Impact resistance
- Long term electrical conductivity.

8 CONCLUSIONS

The past two years has seen a significant increase in the level of patent activity concerned with anisotropic conducting adhesives, predominantly by Japanese owned companies. These patents are addressing the technical, manufacturing and performance issues that have been associated with ACA's and in particular how to improve:

- Resistance to thermal fatigue
- Impact resistance
- Electrical conductivity coupled with reduced bridging in the XY plane
- Reworkability of cross linked resin carriers
- The rate at which adhesive carriers can be cured.

Resistance to thermal fatigue and improved impact resistance have been achieved by incorporating elastomers into the adhesive carriers. The inclusion of very small glass balls into the adhesive matrix has been used to lower the effective coefficient of thermal expansion of the matrix. This helps to minimize differences in thermal expansion or contraction between the substrates and the ACA film. Electrical conductivity coupled with reduced bridging in the XY plane can be achieved by using mixed populations of conducting particles some of which are coated with an insulating resin. Similar improvements in conductivity can also be obtained by better control of particle distribution during manufacture. The reworkability of cross-linked resin systems has been enhanced by the addition of small amounts of thermoplastic resin into epoxy based resin systems.

9 ACKNOWLEDGEMENTS

This work was funded by the United Kingdom Department of Trade and Industry as part of a programme supporting the 'Measurements for the Processability of Materials' aspects of the Electronics Interconnection Industry.

ANNEX : Current patents that contain the words 'Anisotropic Conductive adhesive'

Number

JP11073817 CONDUCTIVE PARTICLE, ANISOTROPIC CONDUCTIVE ADHESIVE MATERIAL, AND LIQUID CRYSTAL DISPLAY
JP11067410 MANUFACTURE OF ANISOTROPIC CONDUCTIVE ADHESIVE FILM
JP11060899 CONDUCTIVE EPOXY RESIN COMPOSITION, ANISOTROPIC CONDUCTIVE ADHESIVE FILM, AND ELECTRICAL CONNECTION METHOD
DE19740722 Electric cable e.g. for coaxial cable
JP11035913 ANISOTROPIC CONDUCTIVE ADHESIVE
DE19725717 Ultrasonic transducer for a liquid flowmeter
US5858806 Method of bonding IC component to flat panel display
JP10308121 CONDUCTIVE PARTICULATE, ANISOTROPIC CONDUCTIVE ADHESIVE AND CONDUCTIVE CONNECTING STRUCTURE BODY
JP10302926 MANUFACTURE OF ANISOTROPIC CONDUCTIVE ADHESIVE FILM
JP10298525 ANISOTROPIC CONDUCTIVE ADHESIVE RESIN COMPOSITION AND ANISOTROPIC CONDUCTIVE ADHESIVE FILM
EP0883329 Anisotropic conductive film
US5840215 Anisotropic conductive adhesive compositions
US5837957 Electric discharge machining apparatus
US5834337 Integrated circuit heat transfer element and method
WO9846811 CONDUCTIVE PARTICLES AND METHOD AND DEVICE FOR MANUFACTURING THE SAME, ANISOTROPIC CONDUCTIVE ADHESIVE AND CONDUCTIVE CONNECTION STRUCTURE,
US5810959 Thermocompressing bonding method and thermocompressing bonding apparatus
AU5761498 Anisotropic conductive adhesive compositions
WO9838701 CONNECTING STRUCTURE, LIQUID CRYSTAL DEVICE, ELECTRONIC EQUIPMENT, ANISOTROPIC CONDUCTIVE ADHESIVE, AND METHOD FOR MANUFACTURING THE ADHESIV
WO9838261 ADHESIVE, LIQUID CRYSTAL DEVICE, METHOD OF MANUFACTURING LIQUID CRYSTAL DEVICE, AND ELECTRONIC APPARATUS
US5789278 Method for fabricating chip modules

<u>AU2454199</u>	Fine pitch anisotropic conductive adhesive
<u>US6039896</u>	Anisotropic conductive adhesive and method for preparation thereof and an electronic apparatus using said adhesive
<u>CN1242403</u>	Anisotropic conductive adhesive and method for preparation thereof and electronic apparatus using said adhesive
<u>US6036813</u>	Method of making anisotropic conductive adhesive interconnects for head attachment in rigid disc drive device for manufacturing a groove bear
<u>CN1240469</u>	Anisotropic conductive adhesive compositions
<u>US6011307</u>	Anisotropic conductive interconnect material for electronic devices, method of use and resulting product
<u>JP11345517</u>	ANISOTROPIC CONDUCTIVE ADHESIVE
<u>JP11339559</u>	ANISOTROPIC CONDUCTIVE ADHESIVE
<u>JP11339558</u>	ANISOTROPIC CONDUCTIVE ADHESIVE AND CONDUCTIVE CONNECTION STRUCTURAL BODY
<u>JP11329542</u>	ANISOTROPIC CONDUCTIVE ADHESIVE
<u>JP11329069</u>	ANISOTROPIC CONDUCTIVE ADHESIVE FILM
<u>JP11329060</u>	CONDUCTIVE CORPUSCLE, ANISOTROPIC CONDUCTIVE ADHESIVE AND CONDUCTIVE CONNECTION STRUCTURE
<u>JP11329075</u>	ANISOTROPIC CONDUCTIVE ADHESIVE
<u>US6002180</u>	Multi chip module with conductive adhesive layer
<u>JP11319626</u>	WET TYPE FINE SPHERE CLASSIFYING METHOD, CONDUCTIVE PARTICULATE, ANISOTROPIC CONDUCTIVE ADHESIVE AND CONDUCTIVE CONNECTING STRUCTURE
<u>WO0000563</u>	FINE PITCH ANISOTROPIC CONDUCTIVE ADHESIVE
<u>KR149721</u>	A METHOD OF SETTING PRINTED CIRCUIT BY USING ANISOTROPIC CONDUCTIVE ADHESIVE
<u>EP0966031</u>	Substrate for mounting a semiconductor chip
<u>CN1217828T</u>	Connecting structure, liquid crystal device, electronic equipment, anisotropic conductive adhesive and method for manufacturing the adhesiv
<u>JP11253886</u>	FINE SPHERE PNEUMATIC SORTING METHOD, CONDUCTIVE FINE PARTICLE, ANISOTROPIC CONDUCTIVE ADHESIVE AND CONSECUTIVELY CONNECTED STRUCTURE

JP11241049 ANISOTROPIC CONDUCTIVE ADHESIVE FILM WIND-UP ROLL
JP11236540 ANISOTROPIC CONDUCTIVE ADHESIVE
EP0944684 ANISOTROPIC CONDUCTIVE ADHESIVE COMPOSITIONS
JP11191320 ANISOTROPIC CONDUCTIVE ADHESIVE FILM
JP11185526 ANISOTROPIC CONDUCTIVE ADHESIVE, ELECTRONIC
CIRCUIT PARTS, AND PIEZOELECTRIC PARTS, AND BONDING
METHOD FOR ELECTRIC PARTS
JP11134934 ANISOTROPIC CONDUCTIVE ADHESIVE
JP11134936 CONDUCTIVE FINE GRAINS, ANISOTROPIC CONDUCTIVE
ADHESIVE, AND CONDUCTIVE CONNECTING STRUCTURE
JP11134935 CONDUCTIVE FINE GRAIN, ANISOTROPIC CONDUCTIVE
ADHESIVE, AND CONDUCTIVE CONNECTING STRUCTURE
JP11135561 ANISOTROPIC CONDUCTIVE ADHESIVE FILM, ITS
MANUFACTURE, FLIP-CHIP MOUNTING METHOD, AND FLIP-
CHIP PACKAGING BOARD
JP11126964 FLEXIBLE CIRCUIT BOARD WITH ANISOTROPIC CONDUCTIVE
ADHESIVE AND ITS MANUFACTURE
JP11126516 ANISOTROPIC CONDUCTIVE ADHESIVE AND CONDUCTIVE
CONNECTION STRUCTURE
JP11219982 CONDUCTIVE PARTICLE AND ANISOTROPIC CONDUCTIVE
ADHESIVE AGENT PROVIDED THEREWITH
JP11116778 CONDUCTIVE EPOXY RESIN COMPOSITION, ANISOTROPIC
CONDUCTIVE ADHESIVE FILM, AND METHOD FOR
ELECTRICALLY CONNECTING CONDUCTORS
WO9937001 IC SOCKET AND METHOD FOR MANUFACTURING IC
US5918113 Process for producing a semiconductor device using anisotropic
conductive adhesive
EP0930657 Two-dimensional image detector and process for manufacturing
the same
DE19848834 Applying integrated circuit flip-chip to substrate
HK1006849 Anisotropic conductive adhesive film
EP0905833 Optical device structure and fabrication method thereof
JP11073818 CONDUCTIVE PARTICLE, ANISOTROPIC CONDUCTIVE
ADHESIVE AND LIQUID CRYSTAL DISPLAY DEVICE

- GB2255219 BONDING COMPONENTS IN A LIQUID-CRYSTAL DISPLAY DEVICE.
- GB2238432 Method of producing electrically conductive anisotropic heat sealing connector members
- WO9642107 SEMICONDUCTOR DEVICE, WIRING BOARD FOR MOUNTING SEMICONDUCTOR AND METHOD OF PRODUCTION OF SEMICONDUCTOR DEVICE
- WO9520820 COMPOSITIONS AND METHODS FOR PROVIDING ANISOTROPIC CONDUCTIVE PATHWAYS AND BONDS BETWEEN TWO SETS OF CONDUCTORS
- WO9516998 ANISOTROPIC, ELECTRICALLY CONDUCTIVE ADHESIVE FILM
- WO9407264 A THIN MULTICHIP MODULE
- WO9301248 ANISOTROPIC CONDUCTIVE ADHESIVE FILM
- WO8606573 CIRCUIT PANEL WITHOUT SOLDERED CONNECTIONS AND METHOD OF FABRICATING THE SAME
- KR9500710 ANISOTROPIC CONDUCTIVE ADHESIVE COMPOSITIONS
- EP0737935 Non-contact IC card and process for its production
- EP0735404 LIQUID CRYSTAL DISPLAY, ITS MOUNTING STRUCTURE, AND ELECTRONIC DEVICE
- EP0734576 ANISOTROPIC, ELECTRICALLY CONDUCTIVE ADHESIVE FILM
- EP0641019 A flexible printed polymer lead-frame.
- EP0632683 Rigid-flex board with anisotropic interconnect and method of manufacture.
- EP0594644 ANISOTROPIC CONDUCTIVE ADHESIVE FILM.
- EP0562571 Conductive ink for use with printed circuit modules.
- EP0562569 Anisotropic adhesive for fixing an electronic component to a printed circuit module.
- EP0560072 Anisotropic electrically conductive adhesive film and connection structure using the same.
- EP0475655 Anisotropic conductive adhesive compositions.
- EP0303384 Flexible connector tape.

JP7105725 ANISOTROPIC CONDUCTIVE ADHESIVE AGENT
JP3110711 ANISOTROPIC CONDUCTIVE ADHESIVE COMPOSITION
JP60140608 ANISOTROPIC CONDUCTIVE ADHESIVE SHEET
JP60133079 ANISOTROPIC ELECTRICALLY CONDUCTIVE ADHESIVE
JP60130004 TRANSPARENT CONDUCTIVE ANISOTROPIC ADHESIVE SHEET
JP63089584 ANISOTROPIC ALLY CONDUCTIVE ADHESIVE FILM
JP4115407 ANISOTROPIC CONDUCTIVE ADHESIVE COMPOSITE
JP8095073 ANISOTROPIC CONDUCTIVE ADHESIVE AND LIQUID CRYSTAL DISPLAY DEVICE USING THE ADHESIVE
JP60117504 CONDUCTIVE ANISOTROPIC ADHESIVE SHEET FOR CONNECTING HIGH CURRENT CIRCUIT
JP62079281 ANISOTROPIC ELECTRICALLY CONDUCTIVE ADHESIVE
JP62076268 ANISOTROPIC CONDUCTIVE ADHESIVE
JP9031427 ANISOTROPIC CONDUCTIVE ADHESIVE AND METHOD FOR CONDUCTIVELY CONNECTING ELECTRONIC PARTS USING THE SAME
JP9031419 ANISOTROPIC CONDUCTIVE ADHESIVE FILM
JP6052715 ANISOTROPIC CONDUCTIVE ADHESIVE COMPOSITE
JP62062874 ELECTROCALLY CONDUCTIVE ANISOTROPIC ADHESIVE
JP6045024 ANISOTROPIC CONDUCTIVE ADHESIVE FILM
JP60084718 CONDUCTIVE ANISOTROPIC ADHESIVE SHEET
JP8045337 ANISOTROPIC CONDUCTIVE ADHESIVE
JP3046774 ANISOTROPIC CONDUCTIVE ADHESIVE, METHOD OF ELECTRICAL CONNECTION BETWEEN ELECTRODES USING SUCH ADHESIVE, AND ELECTRIC CIRCUIT BASE FORMED IN
JP5021094 ANISOTROPIC ELECTRIC CONDUCTIVE ADHESIVE AGENT

<u>EP0268412</u>	Flexible jumper with anisotropically conductive adhesive.
<u>EP0265077</u>	An anisotropic adhesive for bonding electrical components.
<u>EP0232127</u>	Anisotropic electrically conductive film connector.
<u>DE19510186</u>	Connection method e.g. for flexible conductors joined to substrate contact surfaces
<u>CA2113090</u>	Anisotropic Conductive Adhesive Film
<u>CN1137324</u>	Anisotropic, electrically conductive adhesive film
<u>JP5182516</u>	ANISOTROPIC CONDUCTIVE ADHESIVE AND CONDUCTIVE CONNECTION STRUCTURE
<u>JP5174889</u>	ANISOTROPIC CONDUCTIVE ADHESIVE MEMBRANE FOR ELECTRIC CIRCUIT CONNECTION
<u>JP1169808</u>	ANISOTROPIC CONDUCTIVE ADHESIVE
<u>JP8176320</u>	ANISOTROPIC CONDUCTIVE ADHESIVE FILM
<u>JP5159622</u>	ANISOTROPIC CONDUCTIVE THERMAL ADHESIVE
<u>JP8055514</u>	CONDUCTIVE PARTICLE AND ANISOTROPIC CONDUCTIVE ADHESIVE USING IT
<u>JP3153788</u>	CONDUCTIVE ANISOTROPIC ADHESIVE
<u>JP7147177</u>	CONNECTING METHOD USING ANISOTROPIC CONDUCTIVE ADHESIVE
<u>JP62135579</u>	ANISOTROPIC CONDUCTIVE HOT-MELT ADHESIVE
<u>JP8113654</u>	CONDUCTIVE PARTICLE AND ANISOTROPIC CONDUCTIVE ADHESIVE
<u>JP8124425</u>	ANISOTROPIC CONDUCTIVE ADHESIVE AND DISPLAY DEVICE
<u>JP7109445</u>	ANISOTROPIC CONDUCTIVE ADHESIVE
<u>JP6103819</u>	ANISOTROPIC CONDUCTIVE ADHESIVE FILM
<u>JP3112011</u>	ANISOTROPIC CONDUCTIVE MATERIAL, ANISOTROPIC ADHESIVE, ELECTRICALLY CONNECTING METHOD OF THE ADHESIVE APPLIED ELECTRODE, AND ELECTRIC CIRCUIT

JP61047760 ANISOTROPIC ELECTRICALLY CONDUCTIVE ADHESIVE
JP4062714 ANISOTROPIC CONDUCTIVE ADHESIVE
JP4363811 ANISOTROPIC CONDUCTIVE ADHESIVE FILM AND MOUNTING
STRUCTURE WITH IT
JP57085873 PRODUCTION OF ANISOTROPIC ELECTRICALLY CONDUCTIVE
ADHESIVE
JP5012916 CONDUCTIVE PARTICLE OF ANISOTROPIC CONDUCTIVE
ADHESIVE
JP4355004 THERMOSETTING ANISOTROPIC CONDUCTIVE ADHESIVE
FILM AND MANUFACTURE THEREOF
JP6333965 ANISOTROPIC CONDUCTIVE ADHESIVE SHEET
JP63308880 ANISOTROPIC CONDUCTIVE ADHESIVE
JP4366630 ANISOTROPIC CONDUCTIVE ADHESIVE TAPE
JP8007658 ANISOTROPIC CONDUCTIVE ADHESIVE FILM
JP61276873 ELECTRICALLY CONDUCTIVE ANISOTROPIC ADHESIVE
JP61277179 CONDUCTIVE ANISOTROPIC ADHESIVE SHEET
JP8306415 ANISOTROPIC CONDUCTIVE ADHESIVE FILM AND
CONNECTING STRUCTURE USING THE FILM AND
CONNECTING METHOD
JP8288624 DEVICE FOR CUTTING AND REMOVING ADHESIVE LAYER ON
ANISOTROPIC CONDUCTIVE FILM
JP3285977 ANISOTROPIC ELECTRICALLY CONDUCTIVE FILMY ADHESIVE
JP4314386 METHOD OF INTERCONNECTING CIRCUIT BY ANISOTROPIC
CONDUCTIVE ADHESIVE
JP60216411 METHOD OF PRODUCING ANISOTROPIC CONDUCTIVE
ADHESIVE FILM
JP4306279 ANISOTROPIC ELECTRICALLY CONDUCTIVE ADHESIVE AND
METHOD FOR JOINING THE SAME
JP7247467 ADHESIVE HAVING ANISOTROPIC ELECTRICAL
CONDUCTIVITY AND CONDUCTIVE CONNECTION
STRUCTURE PRODUCED BY USING THE ADHESIVE
JP7268303 ANISOTROPIC ELECTRICALLY-CONDUCTIVE ADHESIVE
COMPOSITION

- WO9827178 ANISOTROPIC CONDUCTIVE ADHESIVE COMPOSITIONS
- US5769996 Compositions and methods for providing anisotropic conductive pathways and bonds between two sets of conductors
- EP0851723 METHOD FOR MOUNTING ELECTRONIC PARTS
- SG46717 Anisotropic conductive adhesive film
- US5751553 Thin multichip module including a connector frame socket having first and second apertures
- US5731633 Thin multichip module
- US5710612 Liquid crystal device and manufacturing method therefor with anisotropic conductive adhesive connecting glass substrate and glass auxiliary
- US5708297 Thin multichip module
- JP9306235 ANISOTROPIC CONDUCTIVE ADHESIVE
- JP9306234 ANISOTROPIC CONDUCTIVE ADHESIVE
- WO9748259 METHOD FOR MOUNTING ELECTRONIC PARTS
- WO9745893 ANISOTROPIC CONDUCTIVE FILM
- JP9237517 CONDUCTIVE PARTICLE FOR ANISOTROPIC CONDUCTIVE ADHESIVE FILM, ITS MANUFACTURE AND ANISOTROPIC CONDUCTIVE ADHESIVE FILM
- US5686703 Anisotropic, electrically conductive adhesive film
- DE19707696 Processing device for materials by electric discharge e.g. for manufacture of tool electrodes
- EP0798772 Process for realizing a deposition on a detachable support, and realized deposition on a support
- US5661339 Thin multichip module
- US5661042 Process for electrically connecting electrical devices using a conductive anisotropic material
- JP9115335 ANISOTROPIC CONDUCTIVE ADHESIVE FILM
- US5631191 Method for connecting a die to electrically conductive traces on a flexible lead-frame
- JP5196956 METHOD FOR CONNECTING ELECTRODE TERMINAL BY ANISOTROPIC CONDUCTIVE ADHESIVE
- JP2206670 HEAT CONDUCTIVE ADHESIVE COMPOSITION FOR CONNECTING CIRCUIT AND HEAT CONDUCTIVE BONDING FILM HAVING ANISOTROPIC ELECTRIC CONDUCTIVITY
- JP6243727 ANISOTROPIC CONDUCTIVE ADHESIVE FILM
- JP62181379 ANISOTROPIC ELECTRICALLY CONDUCTIVE ADHESIVE SHEET
- JP62181378 ANISOTROPIC ELECTRICALLY CONDUCTIVE ADHESIVE SHEET
- JP3223380 ANISOTROPIC CONDUCTIVE ADHESIVE
- JP62177082 ANISOTROPIC ELECTRICALLY CONDUCTIVE ADHESIVE
- JP4237903 ANISOTROPIC ELECTRICALLY CONDUCTIVE ADHESIVE
- JP2195663 CONNECTION METHOD BY ANISOTROPIC CONDUCTIVE ADHESIVE
- JP5067480 ANISOTROPIC ELECTRICALLY CONDUCTIVE ADHESIVE RESIN LAYER AND MANUFACTURE THEREOF

US5613862 Anisotropic electrical connection
US5586892 Electrically connecting structure
US5501004 Outer-lead bonding apparatus and method therefor
US5438223 Anisotropic electrically conductive adhesive film and connection structure using the same
US5375003 Method of connecting a tab film and a liquid crystal display panel
US5330684 Anisotropic conductive adhesive film
US5311341 Connection structure between a tab film and a liquid crystal panel
US5304460 Anisotropic conductor techniques
US5291062 Area array semiconductor device having a lid with functional contacts
US5225966 Conductive adhesive film techniques
US5162087 ANISOTROPIC CONDUCTIVE ADHESIVE COMPOSITIONS
US5136365 Anisotropic conductive adhesive and encapsulant material
US5001302 Connecting structure for an electronic part
US4958050 Flexible printed circuit board
US4889980 Electronic memory card and method of manufacturing same
US4795895 Multi-layered electronic card carrying integrated circuit pellet and having two-pad layered structure for electrical connection thereto
US4745334 Electroluminescent element and method for connecting its terminals
US4659872 Flexible flat multiconductor cable
US4170677 Anisotropic resistance bonding technique
GB2269059 Insulation displacement anisotropic electrical connection.

ANNEX 2 : Patented generic formulations for conducting adhesives

Patent	Company	Component 1	Component 2	Component 3	Conductive particle (Conc)	Advantages
WO9301248	Minnesota Mining and MFG (US)	Cyanate ester +catalyst	Thermoplastic resin	Epoxy	0.1-20% conductive particles	Film with rapid curing speed, high heat and humidity resistance. Excellent repairability.
JP10298525	Matsushita Electric Works Ltd	Epoxy (bisphenol A)	Polyphenylene	Curing agent + elastomer (SBR)	0.1-15 vol% conductive particles	High connecting and insulation reliability.
JP11035913	Sumitomo Bakelite Co Ltd	(Meth) acryloylated novolak resin	Organic peroxide	Thermoplastic elastomer		Provides electrical connections between fine circuits such as between LCD and TCP (tape carrier package) or TCP's and PCB's. Can bond at low temperature. Good storage stability, adhesion, connection reliability and working performance.
JP11060899	Minnesota Mining and MFG Co	Alicyclic epoxy resin	Thermoplastic styrenic elastomer with epoxy groups	Uv cationic polymerisation initiator		Rapid curability, resistant to heat and moisture. Impact strength and storage stability.
JP11236540	Sumitomo Bakelite Co Ltd	(Meth) acryloylated novolak resin	2-hydroxy-3-phenoxypropyl acrylate	Organic peroxide and thermoplastic elastomer		For fine pitch connections eg TCP and LCD or TCP and PCB. Rapid curing at low temperatures, excellent adhesive properties, connection reliability, storage stability and repairability.
US6039896	Sumitomo Bakelite Co Ltd	Radical polymerisation resin	Thermoplastic elastomer	Phosphoric ester		
WO9301248	Minnesota Mining and MFG Co	Thermoplastic resin	Epoxy resin + catalyst	Cyanate ester	0.1 to 20% conductive particles	Anisotropic conductive film having a rapid curing speed, high heat and humidity resistance, long shelf life excellent repairability.