

[54] **ARTICLE TRANSFER METHOD**

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[52] U.S. Cl. **156/155, 156/230, 156/235, 156/236, 156/282, 156/305, 156/311**

[51] Int. Cl. **B32b 31/00**

[58] Field of Search 156/155, 17, 236, 237, 156/344, 235, 241, 325, 326, 309, 160, 305, 3, 80, 230, 152; 161/406; 29/589

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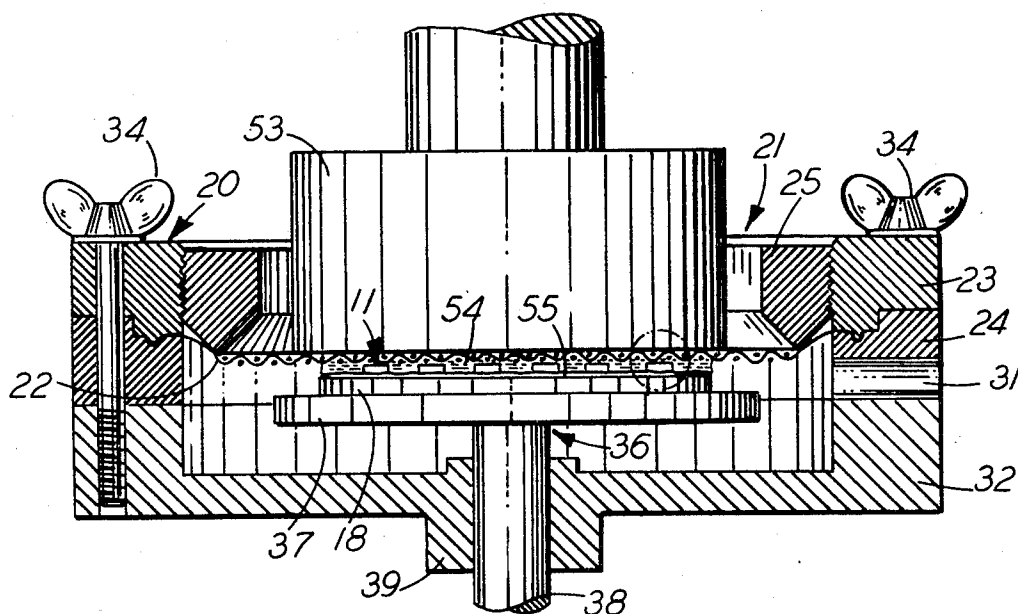
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[57]

ABSTRACT

An array of articles, for example, semiconductor chips, is transferred from a wax-coated sapphire disc to a glass disc by bonding the array to a support, melting the wax to release the array from the sapphire disc, substituting the glass disc for the sapphire disc, clamping the glass disc to the support and releasing the bond between the articles and the support. A substance, such as eicosane, is then introduced in its liquid phase to the clamped combination of the glass disc, the array of articles and the support. Upon hardening, the substance bonds the articles to the glass disc and the support. The support is then unclamped. By liquefying a layer of the substance adjacent to the support, the bond between the support and the array is weakened. The support is then removed without disturbing the array of articles being held to the glass disc by another, still hard layer of the substance.

7 Claims, 8 Drawing Figures



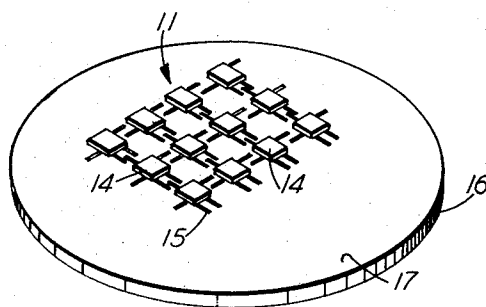


FIG.-1

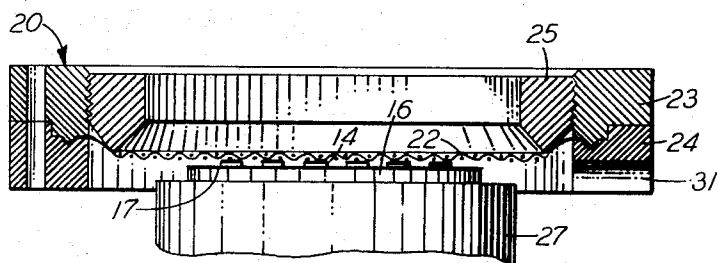


FIG.-2

SHEET 2 OF 3

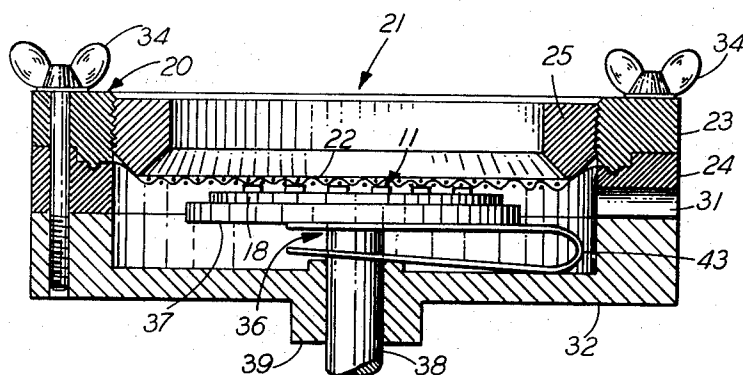


FIG-3

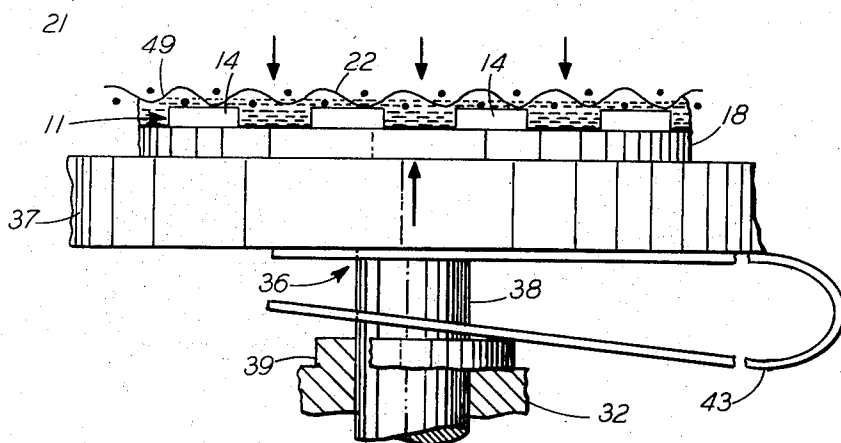


FIG-4

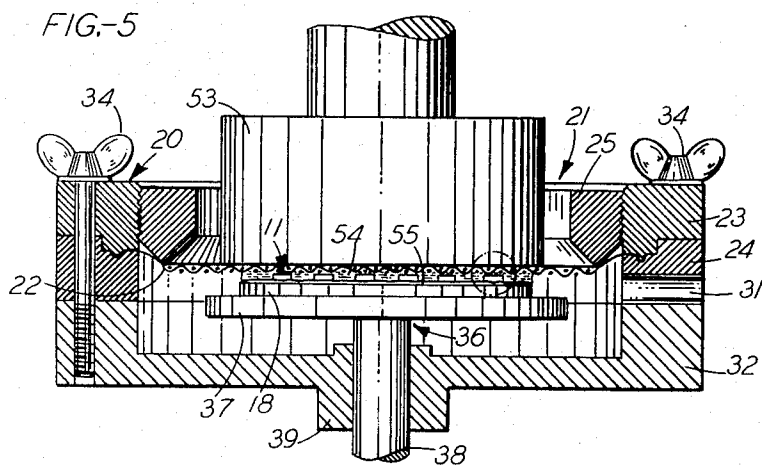


FIG. 6

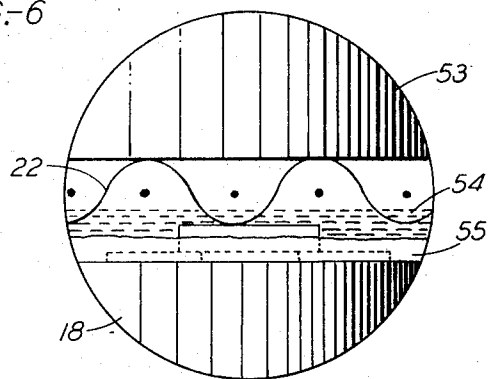


FIG. 7

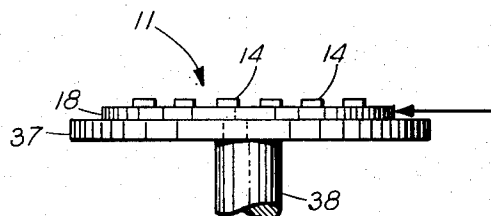
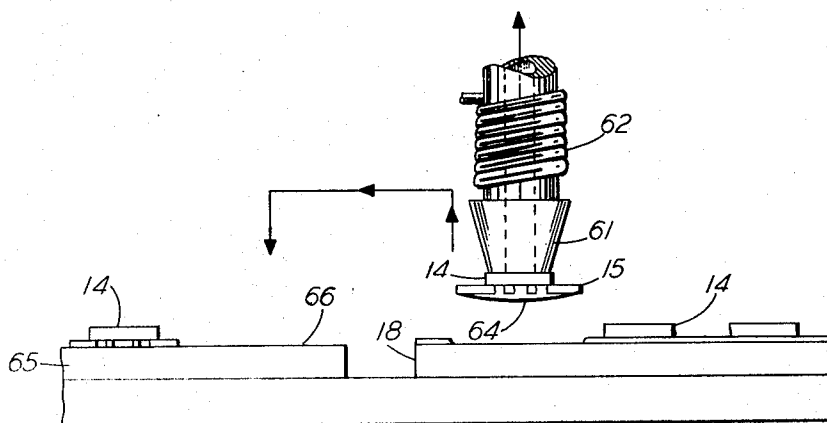


FIG. 8



ARTICLE TRANSFER METHOD

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to methods of and apparatus for transferring articles and, more particularly, to methods of and apparatus for transferring an array of semiconductor chips from a wax-coated sapphire disc to a glass disc upon which the array is to be held in position by a substance, such as solidified eicosane.

2. Discussion of the Prior Art

Economical methods of manufacturing various semiconductor devices, such as hybrid integrated circuits or the like, depend largely on efficient mass production of extremely small semiconductor components, commonly referred to as chips, which are ultimately bonded to substrates to incorporate the chips in circuits. A precursor of the chips is a semiconductor wafer. A series of steps including masking, photoresist exposing and developing, etching, doping and other operations performed on a single one of such slices yields hundreds of small chips. The following discussion pertains to handling of the chips after their manufacture and before they are bonded to substrates. The discussion treats, in particular, handling of beam-lead chips, even though it applies equally well to handling other types of chips or to handling small articles in general.

After a final manufacturing step, beam-load chips are held in an interdigitated array on a wax-coated sapphire disc. In the array the chips are closely spaced such that beam leads extending from adjacent chips are interdigitated relative to each other. The circuit-and-beam sides or active sides of the chips face and are embedded in the wax.

The adhesive qualities of commercially available wax for holding such an array during manufacturing operations are excellent. On the other hand, and partially because of the holding qualities of the wax, it is difficult to remove chips from the wax with a vacuum pickup needle of a commercially available chip transfer machine.

Also, chemical properties of, and impurities contained in the wax have proved detrimental to bonding the chips to substrates in a further production step. More specifically, wax tends to pyrolyze and form residues rather than to vaporize during bonding of the beam leads of the chips to metallized patterns on the substrates. Such residues tend to contaminate the bonds and the chips and thereby affect the operation of circuitry incorporating the chips. It is therefore desirable to remove all traces of wax from the chips before the bonding of the chips.

In a known process (see U.S. Pat. No. 3,690,984 to W. R. Wanesky) the chips are transferred from the wax-coated sapphire disc to a glass disc coated with a commercially available silicone rubber resin. Such a resin is, for example, available from the Dow Corning Corporation under the trade designation "Sylgard."

The transfer of the array from the wax-coated sapphire disc to the resin-coated glass disc is accomplished with a fixture having a screen portion that is brought into contact with the top side of the array of chips. Then, the chips are securely bonded to the screen to preserve the orientation of the chips in the array. Following this bonding to the screen, the fixture with the

disc and the array of chips is immersed into a degreasing apparatus to dissolve the wax and, thereby, release the disc from the array.

After the wax has been dissolved and the sapphire disc has been removed, the resin-coated glass disc is pressed into contact with the array to secure the chips to the resin of the glass disc. The resin-coating appears to be tacky to the touch but the mechanism securing the chips to the resin is believed to be a partial vacuum established between the resin and the chips. After securing the chips to the resin-coated disc, the bond between the screen of the fixture and the chips is broken and the glass disc holding the array of chips is separated from the fixture. Hence, the chips have been transferred from the sapphire disc to the glass disc. This transfer process eliminates problems caused by wax residues on the chips during bonding of the chips to substrates.

However, the adhesive properties of the rubber resin may vary from disc to disc. For example, at times the adhesion between the resin and the chips may be so weak that chips become dislodged from their positions during normal handling. At other times the adhesion between the resin and the chips can be so strong that chips are likely to be damaged when they are being removed from the array.

Strong adhesion between the chips and the resin particularly affects the efficiency of removing the chips with commercial transfer machines.

Vacuum activated pickup needles of such transfer machines move in rectilinear motion, raising the chips vertically from the discs. Frequently, however, the adhesive force between the chips and the resin is greater than the vacuum force of the pickup needles. Thus, in attempting to raise the chips from the resin-coated discs the needles separate from such chips leaving the chips adhering to the discs.

Only a slight lateral displacement of such adhering chips is required to break the adhesive force between the chips and the resin to permit such chips to be removed from the discs. While known transfer machines do not provide such motion, a trained operator manipulating a vacuum-operated manual pickup needle is capable of separating the adhering chips from the discs with a small twisting motion of the needle. Manual removal of chips from resin-coated discs is, therefore, still common practice.

On the other hand, chips have been removed consistently with commercial chip transfer machines from arrays held to discs by eicosane. Eicosane is a straight chain alkane hydrocarbon $[\text{CH}_3(\text{CH}_2)_{18}\text{CH}_3]$ that is solid at room temperature and has a melting point at a temperature of 38°C , slightly above room temperature. Upon being elevated to bonding temperatures of about 300°C , eicosane vaporizes as it reaches 205°C . This vaporization results without leaving residues which would tend to deteriorate the bonds between the chips and a substrate, or which would tend to contaminate the chips. Eicosane has been disclosed in an application for patent by M. L. White, Ser. No. 169,305, dated Aug. 5, 1971, now Pat. No. 3,752,717 and assigned to the Bell Telephone Laboratories, as a material for temporarily mounting semiconductor devices.

It is, therefore, desirable to transfer chips after their manufacture from wax-coated discs to discs coated with a vaporizable substance such as eicosane. Moreover, it is desirable to reduce production costs of semi-

conductor devices by simplifying the handling of chips prior to bonding.

SUMMARY OF THE INVENTION

An object of the invention is, therefore, to provide new and improved methods of handling semiconductor chips.

Another and more specific object is to eliminate manual handling of individual chips.

In furtherance of these objects, an array of chips is bonded to a first support. A second support is then urged into contact with the array. While the contact pressure of the second support holds the array fixed between the first and second support, the bond between the array and the first support is released. A liquid substance is then introduced interstitially between the first support, the array of chips and the second support. The substance is hardened to bond the array to the first support. By liquefying a portion of the substance adjacent the first support, the first support is released from the array while another portion of the substance in its hardened condition retains the chips in position in the array.

In another aspect of the invention, a handling fixture to implement such a method includes a first support, such as a taut screen, a frame holding the screen and having an opening which is substantially coplanar with the screen. A second support, such as a pedestal is mountable parallel to and adjacent the screen, and a provision is made for urging the pedestal toward the screen to frictionally retain the array of semiconductor chips between the pedestal and the screen.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects and advantages of the invention may be more clearly understood by reference to the following detailed description of the drawing, wherein:

FIG. 1 is an isometric view of a wax-coated sapphire disc and a number of chips comprising a portion of an array;

FIG. 2 is a cross-sectional view of a screen portion of a transfer fixture contacting the array of FIG. 1;

FIG. 3 is a cross-sectional view of the screen portion of FIG. 2 along with a base portion of the transfer fixture of FIG. 2;

FIG. 4 is a cross-sectional view of an assembly of the screen, the array of chips and a glass disc backed by a pedestal of the fixture;

FIG. 5 is a cross-sectional view of the fixture and a block for applying heat to the screen portion of the fixture, a portion of FIG. 5 being set out by a circle drawn in phantom outline;

FIG. 6 is a greatly enlarged view of the portion of FIG. 5 enclosed by the circle;

FIG. 7 is a side view of the pedestal of FIG. 5, the glass disc and the chips being held on the glass disc by a substance; and

FIG. 8 is a side view of a vacuum pickup needle of a commercial chip transfer machine lifting a chip from an eicosane-coated disc and transferring it to another adjacent disc.

DETAILED DESCRIPTION

Referring now to FIG. 1, an array, designated generally by numeral 11, is shown as including a plurality of beam lead semiconductor chips 14 having beam leads 15 extending therefrom. The leads 15 are interdigitated

relative to each other. The chips 14 are mounted to a sapphire disc 16 by means of a coating 17 of wax that partially embeds the chips 14. The coating 17 retains the orientation of the chips in the array on the disc 16.

The array 11 is to be transferred from the sapphire disc 16 to a glass disc 18, shown in FIG. 3. It is desirable to remove all traces of wax coating 17 from the chips 14 before they are transferred from the sapphire disc 16 to the glass disc 18. The removal of all of the wax avoids problems which may otherwise occur in further processing the chips 14.

Referring now to FIG. 2, a screen portion 20 of a transfer fixture (which is generally designated in its entirety by numeral 21 in FIG. 3) includes a screen 22. Preferably, the screen is an 18-8 stainless steel screen with a 230 mesh weave of 0.0014 inch diameter wire. The screen 22 has a circular configuration and is clamped near its periphery between a first clamping ring 23 and a second clamping ring 24. A brass ring 25 is movably mounted concentrically within the screen portion 20. Advantageously, the ring 25 is threaded within the portion 20 so as to be movable toward and away from the screen 22. The ring 25 when moved toward the screen 22 stretches it until taut.

To transfer the array 11 from the wax coating 17 of the sapphire disc 16 to the glass disc 18, the sapphire disc 16 is placed on a holding block 27 with the chips 14 facing upward. The screen portion 20 is placed over the holding block 27 to bring one side 28 of the screen 22 into contact with the chips 14.

An adhesive 29 in liquid form is applied through the screen 22 to fill voids and openings between the chips 14 of the array 11 and the screen 22. During the application of the adhesive 29 to the screen 22 and to the chips 14, the weight of the clamping rings 23 and 24 and of the brass ring 25 keeps the screen 22 in intimate contact with the chips 14 of the array 11. As the adhesive 29 dries it forms a secure bond between each of the chips 14 and the screen 22.

While the adhesive 29 may be any of a plurality of different adhesive substances, preferably it is a solution of cellulose nitrate in acetone. One part of cellulose nitrate to 1 part of acetone by volume yields a mixture of satisfactory consistency. The acetone in such a mixture evaporates in approximately two minutes after application to the screen 22 to bond the chips 14 to the screen.

Upon drying, the adhesive 29 hardens to form a secure bond between each of the chips 14 and the screen 22.

The screen 22 acts as an intermediate support, which temporarily holds the array 11 and permits the sapphire disc 16 to be removed from the array 11. To remove the disc 16, heat is applied through the screen 22 and the adhesive 29 to melt the wax coating 17. The disc 16 is then removed from the screen portion 20 by sliding the disc 16 laterally away from the array 11 toward a cutout 31 in the clamping ring 24.

The position of the cutout 31 is substantially coplanar with the screen 22 and with the disc 16. The length and the width of the cutout 31 are of sufficient size to permit the removal of the disc through the cutout 31.

Sliding the disc 16 through the cutout 31 is accomplished without exerting forces on the chips 14. This is in contrast to lifting the disc 16 away from the screen

22 and the chips 14, which may subject the chips to substantial vacuum forces which damage the chips 14 or displace the chips 14 in the array 11.

Removal of the disc 16 exposes the wax coating 17. The exposed coating 17 is now quickly and completely removed by placing the screen portion 20 into a commercial degreasing apparatus (not shown).

Removal of the sapphire disc 16 prior to placing the screen portion 20 into the degreasing apparatus is an improvement over the known prior art. Formerly the fixture 21 was placed into the degreasing apparatus to dissolve the wax 17 prior to removing the disc 16. Dissolving the wax 17 without first removing the disc 16 required a substantial amount of time. In addition, the chips 14 still had to be cleaned of residues of wax 17 after the disc 16 had been removed.

Referring now to FIG. 3, a base portion 32 of the fixture 21 is shown assembled to the screen portion 20. In assembling the base portion 32 to the screen portion 20, any convenient fastening means, such as wing screws 34 may be used. The screws 34 extend through the first and second clamping rings 23 and 24 and fasten into the base portion 32 to draw it against the clamping ring 24.

A pedestal 36 includes a disc-like pedestal top 37 and a shaft 38 which extends coaxially and perpendicular from the top 37. The shaft 38 is slidably mounted in a bushing 39 in the base 33 to permit a sliding motion of the pedestal 36 toward and away from the screen 22.

After the wax coating 17 is removed, a clean glass disc 18 is inserted into the transfer fixture 21 (FIG. 3) through the cutout 31. The insertion of the fixture 21 places its top surface against the array 11. For reasons which will become apparent, it is desirable to secure the glass disc 18 to the pedestal top 37 while the base portion 32 is being assembled to the screen portion 20. To so secure the disc 18, the base portion 32 is heated and eicosane is applied to the pedestal top 37.

Eicosane has been described in the above-referred to patent application by M. L. White as a substance for temporarily mounting semiconductor bodies onto substrates. An advantage of the use of eicosane for temporarily mounting semiconductor bodies or chips 14 is that the eicosane completely vaporizes at temperatures used in bonding the chips to circuits (not shown). Eicosane is commercially obtainable as a substantially pure substance.

After an application of eicosane to the heated pedestal top 37, the base portion 32 is assembled to the screen portion 20. The pedestal top 37 is held away from the screen 22, until such time that the base portion 32 has been secured squarely to the screen portion 20, as, for example, by tightening the wing screws 34. The pedestal top 37 is then advanced toward the screen 22 and a U-shaped leaf spring 43 is inserted into a gap 44 between a lower surface 46 of the pedestal top 37 and an opposed surface 47 of the bushing 39 in the base 33.

The array 11 is now uniformly contacted by the glass disc 18. A force exerted by the spring 43 is transmitted through the pedestal top 37 and to the glass disc 18. Ultimately, the force exerted by the spring 43 is distributed against each of the chips 14 in the array 11. Thus, the force exerted by spring 43 holds the chips 14 between the disc 18 and the screen 22.

The adhesive 29 which is still holding the chips 14 to the screen 22 can now be removed without disturbing the positions of the chips 14 in the array 11. The assembled fixture 21 is immersed into a solvent for the adhesive 29. If the adhesive 29 is cellulose nitrate, the solvent is advantageously acetone. The fixture 21 is left in the solvent until the adhesive 29 is completely dissolved.

In FIG. 4, a portion of the pedestal top 37 is shown urged toward the screen 22, as indicated by the arrow. The screen 22, in turn, urges the glass disc 18 against the chips 14. Temporarily, the chips 14 of the array 11 are held by the frictional forces between the screen 22 and the glass disc 18, the adhesive 28 previously having been dissolved and removed from the screen 22 and from the chips 14.

A quantity of heated eicosane is now introduced in its liquid phase through apertures 49 of the screen 22 to flow into the fixture 21 (as indicated by the arrows in FIG. 4). The apertures 49 provide access for the eicosane to the array 11 and to the disc 18 to fill all voids and crevices between the chips 14, the screen 22 and the disc 18. For the eicosane to flow freely into such voids and crevices between the chips 14 of the array 11, the assembled fixture 21 is advantageously heated to a temperature slightly above the melting point of eicosane prior to the introduction of the eicosane into the fixture 21. The eicosane fills the spaces between the screen 22 and the disc 18 and, in doing so, attaches itself to the screen and also substantially fills the apertures 49 in the screen.

As the eicosane cools below its melting point, it solidifies and bonds the array 11 to the glass disc 18 and to the screen 22. The solidification of the eicosane maintains the chips 14 oriented in the array 11. At this stage in the operation the function of the spring 43 to generate a friction force between the chips 14, the disc 18 and the screen 22 has become redundant. Consequently, the spring 43 is removed from the fixture 21, leaving the screen 22, the array 11, the glass disc 18 and the pedestal top 37 bonded together by the eicosane.

To complete the transfer of the array 11 from the sapphire disc 16 to the glass disc 18, the glass disc with the array thereon has to be separated from the screen portion 20. Such separation is accomplished without disturbing the orientation of the chips 14 in the array 11.

FIG. 5 shows an arrangement for separating the screen 22 from the array 11. Except for the bond by the eicosane the pedestal 36 is free to move with respect to the fixture 21 and, consequently, with respect to the screen 22.

A block 53 preferably formed of aluminum, is heated and placed in direct contact with the screen 22. The block 53 transfers heat directly to the screen 22. The heat from the screen 22 and from the block 53 melts a portion 54 of the eicosane adjacent the screen. The melted eicosane loses its bond strength and releases the screen 22 from the bond to the array 11 and the glass disc 18. The pedestal 36 being free to move, drops under its own weight toward the base portion 32 and pulls the array 11 and the glass disc 18 away from the screen 22.

In FIG. 6, a remaining portion 55 of the eicosane on the glass disc 18 is still solid just before the pedestal 36 separates the glass disc with the array 11 from the

screen 22. The heat transfer from the block 53 and the screen 22 to the eicosane stops immediately upon separation of the screen 22 from the glass disc 18 and the array 11. The remaining portion 55 of the eicosane remains solid after the influx of heat to the eicosane stops, and this solid portion 55 continues to bond the now exposed array 11 to the disc 18.

In FIG. 7, the screen portion 20 has been removed from the array 11. The disc 18 supporting the array 11 is still bonded to the pedestal top 37. The glass disc 18 is preferably separated from the pedestal top 37 by mechanical means. For instance an application of a lateral shearing force (indicated by an arrow in FIG. 7) conveniently breaks the bond between the top 37 and the disc 18 and separates the disc from the top.

The exposed chips 14 held by the eicosane to the disc 18 may now be transferred from the disc by a machine transfer process. In FIG. 8, a heated vacuum tip 61 of a commercial chip transfer machine (not shown) has attached to it one of the chips 14 removed from one of the interdigitated arrays 11 (shown in FIG. 1). By contacting one of the chips 14 in the array 11, the tip 61 transfers heat from a heat source 62 through the chip 14 and melts the eicosane surrounding the chip 14. By melting the eicosane the bond between the chip 14 and the disc 18 is released and the chip 14 can be lifted by the tip 61 without damage to the chip or the beam leads 15.

A small amount of eicosane 64 remains attached to the underside of the chip 14. Because of heat transferred through the chip 14 the eicosane 64 remains liquid during the transfer from the disc 18 to another support or disc 65.

The disc 65 is conveniently maintained at room temperature, lower than the melting temperature of eicosane. As the chip 14 is lowered against a clean support surface 66 of the disc 65 the eicosane 64 contacts the surface 66, cools and solidifies, bonding the chip 14 to the disc 65.

Further contact of the tip 61 with the chip 14 would result in a reheating and melting of the eicosane 64. However, immediately upon depositing the chip 14 on the disc 65, the vacuum force holding the chip 14 is released and the tip 61 separates from the chip. With the separation of the tip 61 from the chip 14, further heat transfer to the chip 14 is interrupted and the chip remains attached to the disc 65 by the eicosane 64.

The described process of transferring the array 11 of the semiconductor chips 14 from a wax-coated disc to an eicosane coated disc is performed without subjecting the delicate chips 14 to damaging forces. The process further insures that all residues of wax are removed from the chips 14 to minimize the danger of contaminating circuits on the chips 14.

During the transfer of the chips 14 to the disc 18, rapidly heating a portion of the eicosane through the screen 22 permits the screen 22 to be quickly separated from the array 11. This interrupts further heat transfer to the remaining solid portion 55 of eicosane after such separation, allowing the chips 14 to be retained by such a solid portion 55. These chips 14 are readily machine-transferrable, eliminating a need for transferring a number of the chips 14 in a manual transfer process.

Improvements of the transfer fixture 21 permit the wax coating 17 to be readily exposed and dissolved, thus shortening the processing time. Sliding the disc 16 from the array 11 minimizes the danger of damage to

the chips 14. Furthermore, to facilitate subsequent handling of the chips 14, they are retained in their oriented array by the spring 43 that urges the pedestal 36 toward the screen 22.

It should be understood that the above-detailed description is intended to be merely illustrative. The above-described transfer process and specific features of the described transfer fixture 21 may be modified without departing from the spirit and scope of the invention.

What is claimed is:

1. A method of handling an array of articles, comprising:

forming a bond between the array and a support to secure the array to such first support;
clamping a second support to the side of the first support having the array bonded thereto to hold the array between the supports;
dissolving the bond between the array and the first support while continuing to clamp the array between the supports;
introducing a liquid substance interstitially between the supports;
hardening the substance to bond the array to the supports and to fix the positions of the articles within the array with respect to each other in such substance;
unclamping the supports; and
liquefying a portion of the substance adjacent the first support to release the first support from the array while maintaining another portion of the substance adjacent the second support in its hardened condition to retain the array bonded to the second support.

2. A method according to claim 1, wherein the array is initially bonded to one side of a third support, and the exposed side of the array is contacted by the side of the first support, the method further comprising:

dissolving the bond between the third support and the array after the bond between the first support and the array has been formed;
laterally sliding the third support out of contact with the array to expose the array bonded to the first support; and
removing a bonding agent of the dissolved bond between the third support and the array after the sliding of the third support out of contact with the array and before clamping the second support to the first support.

3. A method according to claim 1, wherein the liquefied substance is hardened by cooling it and wherein liquefying a portion of the substance comprises applying heat to the substance in contact with the first support to melt the portion of the substance adjacent the first support to release the first support from the array.

4. A method according to claim 3, wherein unclamping the supports comprises:

applying a force to the second support to urge the second support away from the first support, whereupon liquefaction of a portion of the substance adjacent the first support forces the first support away from the array and the second support.

5. A method according to claim 4, wherein the applied force is a gravitational force including the weight of the second support.

6. In a method of transferring an array of articles from a first support to a second support, including the steps of contacting the array with an intermediate support, forming a bond between the articles of the array and the intermediate support, and substituting the second support for the first support while holding the array by the bond to the intermediate support, an improvement comprising:

urging the second support toward the intermediate support and against the array to frictionally clamp the articles in position between the second and intermediate supports;

dissolving the bond between the articles and the intermediate support;

introducing a molten substance between the second and the intermediate supports, the substance substantially engulfing the articles of the array;

solidifying the substance to bond the articles to the second and to the intermediate supports;

releasing the urging force against the second support; and

liquefying a portion of the substance adjacent the intermediate support to dissolve the bond holding the intermediate support to the array and the second support and to release the intermediate support from the array while maintaining the array bonded to the second support by another portion of the substance adjacent the second support.

7. A method of transferring an array of articles from a first support to a second support, including the steps of contacting the array with an intermediate support, forming a bond between the articles of the array and

the intermediate support, and substituting the second support for the first support while holding the articles bonded to the intermediate support, wherein an improvement comprises:

urging the second support toward the intermediate support and into frictional contact with the articles to clamp the articles in position between the intermediate support and the second support;

dissolving the bond between the articles and the intermediate support;

introducing a molten substance through apertures in the intermediate support to fill spaces between the intermediate and second supports and substantially engulf the articles of the array;

solidifying the substance to bond the articles to the second and to the intermediate supports and the supports to each other;

after the substance has been solidified, urging the second support away from the intermediate support;

applying heat to the intermediate support and to the substance in contact therewith to melt a portion of the substance adjacent to the intermediate support to cause the intermediate support to release the articles and the second support; and

withdrawing the second support and the array of articles bonded thereto by the remaining portion of the substance from the intermediate support, whereby the application of heat to the remaining portion of the substance is terminated and the array of articles remains bonded to the second support.

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