(12) UK Patent (19) GB (11) 2 221 468 (13) B

(54) Title of Invention

Adhesive sheet suitable for use in dicing semiconductor wafers into chips

(51) INT CL[5]; C09J 11/06, H01L 21/68, 21.80

(21) Application No
8916855.3

(22) Date of filing
29 Dec 1986
Date lodged
24 Jul 1989

(30) Priority data

(31) 60295188
60295189
60295190
61045785
61045786
61161680

(32) 27 Dec 1985
27 Dec 1985
27 Dec 1985
3 Mar 1986
3 Mar 1986
9 Jul 1986

(33) JP

(62) Derived from Application No. 8630956.4 under Section 15(4) of the Patents Act 1977

(43) Application published
7 Feb 1990

(45) Patent published
5 Sep 1990

(52) Domestic classification
(Edition K)
C3V VBC VBD
B2E EM E1538 E1739
E423S E423T E436T E489CT
E489CU E489S E489T E489U
D600T E600U E623T

(continued on next page)

(73) Proprietor(s)
FSK Kabushiki Kaisha

(Incorporated in Japan)

Honcho 23-23
Itabashi-ku
Tokyo -to
Japan

(72) Inventor(s)
EBE Kazuyoshi
Hiroaki Narita
Katsuhisa Taguchi
Yoshitaka Akeda
Takanori Saito

(74) Agent and/or
Address for Service
Frank B Dehn & Co
Imperial House
15-19 Kingsway
London WC2B 6UZ

2 221 468 B - continuation

(56) Documents cited
EP 0195767 A1
EP 0194706 A1
EP 0157508 A2

(58) Field of search

As for published application
2221468 A *viz:*
UK CL C3V VBD H1K KMB
Online Databases: WPI
updated as appropriate

2221468

1/2

FIG.1

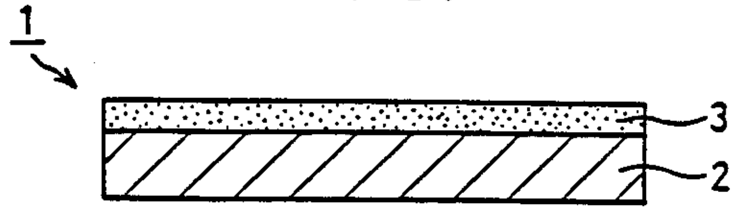


FIG.2

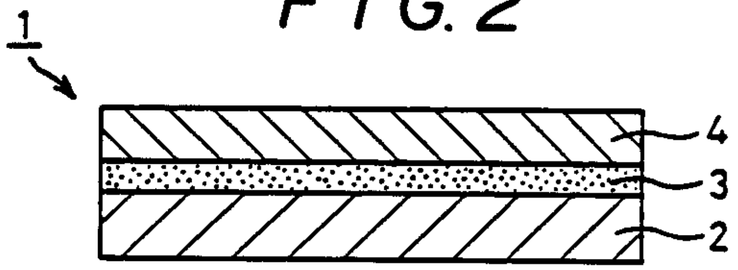


FIG.3

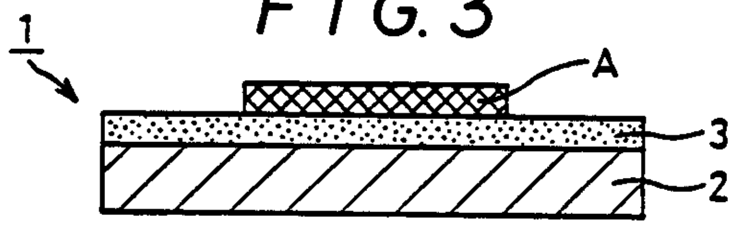


FIG.4

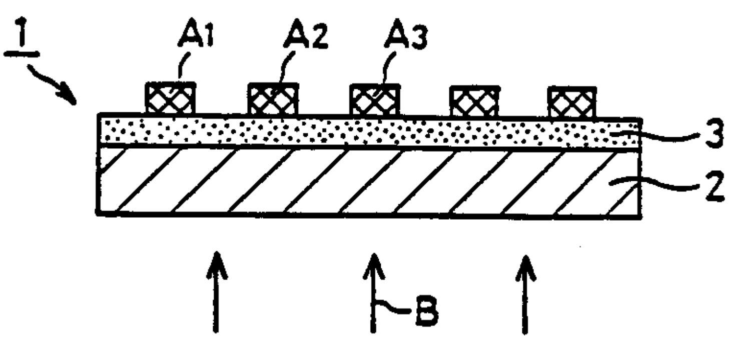


FIG. 5

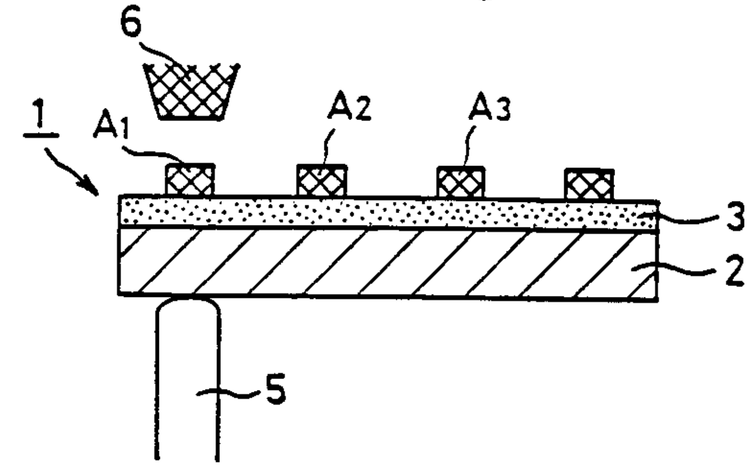


FIG. 6

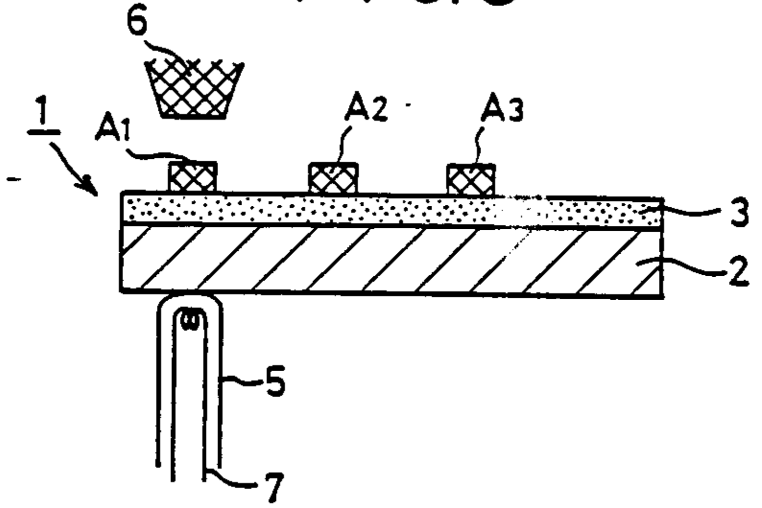
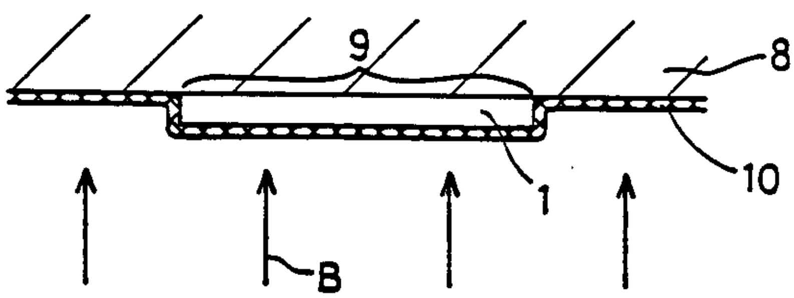


FIG. 7



2221468

Adhesive sheet suitable for use in dicing semiconductor wafers into chips

FIELD OF THE INVENTION

This invention relates to adhesive sheets and, more particularly, to adhesive sheets which are preferably used in dicing semiconductor wafers into chips.

BACKGROUND OF THE INVENTION

Semiconductor wafers of silicon, gallium-arsenic, etc., are normally relatively large in diameter when produced, and the wafers are diced into chips, which are then transferred to the subsequent mounting stage. At this time, the semiconductor wafers are subjected, while still applied to the adhesive layer of an adhesive sheet, to such stages as dicing, rinsing, drying, expanding, picking-up and mounting.

Adhesive sheets which have heretofore been used in the dicing stage of semiconductor wafer manufacture as mentioned above include those which comprise a substrate such as a vinyl chloride or polypropylene film or sheet and thereon an adhesive layer consisting essentially of an adhesive such as an acrylic adhesive or the like. In the adhesive sheets having an acrylic adhesive layer, however, there was involved such a problem that the chips were contaminated on the back side surface thereof with the adhesive which had adhered to and remained thereon.

In order to solve the problem mentioned above, there has been proposed a process wherein the adhesive applied to the surface of an adhesive sheet is minimized by coating a substrate of the adhesive sheet, not wholly but partly, with the adhesive. According to this process, however, there is brought about such a new problem that because of a decrease in adhesion strength between wafer chips and adhesive sheet, the wafer chips peel off from the adhesive sheet during stages subsequent to the dicing stage, such as rinsing, drying and expanding, though the amount of the adhesive used relative to the full number of the chips decreases and thereby lessens contamination of the back side surface of the chips with the adhesive to a certain extent.

Adhesive sheets which are intended for use in the processing stage of semiconductor wafer manufacture, from the dicing stage up to pick-up stage, are desired to be such that the adhesive sheets have an adhesion force sufficient to retain wafer chips thereon in the course of the dicing stage up to the expanding stage, but in the pick-up stage they only retain their adhesion force to such an extent that no adhesive sticks to the back side surface of picked-up wafer chips.

International patent application PCT/US80/00822 discloses normally tacky and pressure-sensitive adhesive including oxirane rings and an ionic photoinitiator characterized in that the epoxy equivalent value of the adhesive is 400-900, and the ionic photoinitiator is selected from the group consisting of radiation-sensitive aromatic onium salts of Group Va or Vla, onium catalysts of Group Va, VI or VIIa, diaryl halonium salts containing Group Va metal hexafluorides and triaryl sulfonium complex salts, said photoinitiator being present in an amount effective to promote the polymerization of oxirane rings, whereby said adhesive is readily detackified by exposure to actinic radiation.

Further Japanese Patent Laid-Open Publications Nos.196956/1985 and 223139/1985 disclose adhesive sheets which are alleged to satisfy the above-mentioned requirements, said adhesive sheets comprising a substrate having coated on the surface thereof an adhesive consisting essentially of a low molecular compound having in the molecule at least two photopolymerizable carbon-carbon double bonds and being capable of exhibiting a three-dimensional network on irradiation with light. The low molecular compounds having in the molecule at least two photopolymerizable carbon-carbon double bonds as exemplified in the above-mentioned publications include trimethylolpropane triacrylate, tetramethylolmethane tetraacrylate, pentaerythritol triacrylate, pentaerythritol tetraacrylate, dipentaerythritol monohydroxy pentaacrylate, dipentaerythritol hexaacrylate, 1,4-butyleneglycol diacrylate, 1,6-hexanediol diacrylate, polyethylene glycol diacrylate, commercially available oligoester acrylates, etc.

We have found that the adhesive sheets comprising a substrate having coated thereon an adhesive layer consisting essentially of such low molecular compounds having in the molecule at least two photopolymerizable carbon-carbon double bonds as exemplified above involve problems as mentioned below.

(1) Such an adhesive sheet as mentioned above can exhibit an excellent performance to a certain extent when a semiconductor wafer to be applied to the adhesive sheet has a fine and smooth surface like a mirror surface. If the wafer surface is rough, however, there is observed such a problem that even when irradiation with such radiation as ultraviolet is effected in the pick-up stage, the adhesion strength between the wafer chips and adhesive sheet does not decrease sufficiently and accordingly the adhesive sticks to and remains on the back side surface of the chips.

(2) Where a semiconductor wafer applied onto the adhesive layer of an adhesive sheet is diced into wafer chips and the diced chips are then picked up, the position of the chip has been detected by means of a photosensor. In the above-mentioned adhesive sheet, however, there is observed such a problem that because

the adhesive sheet reflects the detection beam at the chip's position, the detection operation of the chip cannot be performed with satisfactory accuracy and a failure in the detection operation sometimes occurs.

(3) Where the wafer surface to which the adhesive layer of an adhesive sheet is applied is greyed or blackened for some reason or other, there is involved such a problem that even when the adhesive sheet is irradiated with radiation such as ultraviolet in the pick-up stage of the semiconductor wafer chips, the adhesion force of the portions of the adhesive layer of the adhesive sheet corresponding to the portions of the greyed or blackened portions of wafer does not decrease sufficiently and accordingly the adhesive adheres to and remains on the back side surface of wafer chips.

(4) In the adhesive sheet as mentioned above, there is observed such a problem that the adhesive force certainly decreases but not to the optimum level, thus the larger is the size of chips, the more difficult becomes the pick-up operation.

(5) In the above-mentioned adhesive sheets, there is observed such a problem that because a general-purpose polymer sheet, such as of polyvinyl chloride or polypropylene, is used as a substrate sheet in said adhesive sheets, a tensile force is applied to said adhesive sheets when wafers are applied onto said adhesive sheets or when the thus applied wafers are diced into chips, and the substrate sheet undergoes elongation after the completion of the dicing stage of the wafers, whereby a deflection occurs in the adhesive sheets and the thus deflected adhesive sheets cannot be received by a wafer box for transfer to the subsequent processing operation or the received wafers mutually contact with one another in the wafer box. Furthermore, there is also observed such a problem that when the adhesive sheets, after the completion of the dicing operation of the wafers applied onto said adhesive

sheets, are subjected to irradiation with radiation such as ultraviolet, an elongation or deflection occurs afresh in the irradiated adhesive sheets, or such elongation or deflection which has occurred in the adhesive sheets in the dicing stage of the wafers as mentioned previously is sometimes retained in the irradiated adhesive sheets, and hence said irradiated adhesive sheets cannot be received by a wafer box for transfer to the subsequent pick-up stage, or the received wafers mutually contact with one another in the wafer box.

OBJECTS OF THE INVENTION

The present invention is intended to solve such technical problems associated with the prior art as mentioned above and its objects are as in the following.

A first object of the invention is to provide adhesive sheets which are suitable for use in semiconductor wafer dicing operations, said adhesive sheets being such that even if the wafer surface to be applied onto an adhesive layer of the adhesive sheets is rough, the adhesion force of the adhesive layer sufficiently decreases when the adhesive sheets are subjected in the pick-up stage of semiconductor wafer chip manufacture to irradiation with such radiation as ultraviolet and accordingly no adhesive sticks to and remains on the back side surface of wafer chips as picked up.

A second object of the invention is to provide adhesive sheets which are suitable for use in semiconductor wafer dicing operations, said adhesive sheets being such that when wafer chips are picked up from the adhesive sheets, the detection of the chips by means of a photosensor can be performed with satisfactory accuracy and accordingly no failure in operation for positioning the wafer chips occurs;

moreover, the adhesive layer of the adhesive sheets has a sufficient adhesive force before ultraviolet irradiation of the adhesive sheets but retains a sufficiently decreased adhesion force after the irradiation such that no adhesive sticks to the back side surface of the wafer and, furthermore, an operator supervising the dicing operation can easily ascertain whether or not the adhesive sheets have been irradiated, thereby preventing possible troubles in operation before they happen.

A third object of the invention is to provide adhesive sheets which are suitable for use in semiconductor wafer dicing operations, said adhesive sheets being such that even when the wafer surface to which an adhesive layer of the adhesive sheets is applied is greyed or blackened for some reason or other, the adhesion force of the adhesive layer at the portions thereof corresponding to the greyed or blackened portions of the wafers sufficiently decreases in the pick-up stage of semiconductor wafer chip manufacture where the adhesive sheets are subjected to irradiation with such radiation as ultraviolet and accordingly no adhesive sticks to and remains on the wafer chip surface and, moreover, said adhesive layer has a sufficient adhesion force before the ultraviolet irradiation of the adhesive sheets.

A fourth object of the invention is to provide adhesive sheets which are such that in the wafer dicing stage, no elongation or deflection occurs in a substrate sheet of the adhesive sheets onto which the wafers have been applied, no elongation or deflection occurs afresh in the adhesive sheets having the diced wafer chips thereon even when said adhesive sheets are irradiated and, moreover, even when a slight elongation or slight deflection occurs in the substrate sheet in the dicing stage, said deflection disappears by virtue of passing the adhesive sheets through the irradiation operation and the resulting adhesive sheets can be received with accuracy by a receiving box.

SUMMARY OF THE INVENTION

The adhesive sheets of the present invention comprise a substrate having coated on the surface thereof an adhesive layer which layer comprises an adhesive and a radiation polymerizable compound, characterized in that a radiation color developable compound has been incorporated in the adhesive layer, or has been coated on at least one side of the substrate, or has been incorporated in the substrate itself.

BRIEF DESCRIPTION OF THE DRAWINGS

Figs. 1 and 2 are sectional views of the adhesive sheets of the present invention, and Figs. 3-6 are illustrations showing said adhesive sheets used in the course of semiconductor wafer manufacture from the dicing stage up to the pick-up stage of diced wafers. Fig. 7 is an illustration showing said adhesive sheet used in the course of masking for coated products.

DETAILED DESCRIPTION OF THE INVENTION

The adhesive sheets of the present invention are illustrated below in detail with reference to the accompanying drawings.

As can be seen from its sectional view shown in Fig. 1, the present adhesive sheet is composed of a substrate 2 and an adhesive layer 3. Before use of this adhesive sheet, it is preferable to tentatively apply a strippable sheet 4 as shown in Fig. 2 in order to protect the adhesive layer 3.

The present adhesive sheet may be shaped into any forms such as a tape-like, label-like or other form.

Suitable as the substrate 2 are materials which are low in electrical conductivity and excellent in water resistance as well as in heat resistance, and on this view, synthetic resin films are particularly useful. As will be stated later, the present adhesive sheet is, when used, irradiated with such radiation as EB or UV, and hence the substrate 2 is not required to be transparent when said adhesive sheet is subjected to EB irradiation but must be transparent when said adhesive sheet is subjected to UV irradiation.

Practically speaking, usable as the substrate 2 are films of such synthetic resins as polyethylene, polypropylene, polyvinyl chloride, polyethylene terephthalate, polybutylene terephthalate, polybutene, polybutadiene, polyurethane, polymethyl pentene, ethylene vinyl acetate, etc.

Where the present adhesive sheet requires, after the dicing of semiconductor wafers, an expansion treatment, it is preferable to use as a substrate in the conventional manner a synthetic resin film of polyvinyl chloride, polypropylene or the like which has extensibility in the machine and cross machine directions. However, substrates having no extensibility are also usable in the case of the treatment processing of semiconductors, automobile body masking or the like where no such expanding treatment is needed.

When a crosslinked film is used, particularly as the substrate 2, there are obtained such great advantages that no extension or deflection occurs in the adhesive sheet having wafers thereon when the wafers are diced, no deflection occurs afresh in the adhesive sheet when said adhesive sheet is irradiated with radiation and moreover, even when a slight deflection occurs in the adhesive sheet in the wafer dicing stage, said slight deflection diminishes on irradiation of the substrate sheet with radiation and accordingly the adhesive sheet bearing the diced wafers thereon can assuredly be received by a receiving box wherein no mutual contact of the adhesive sheets is observed. Moreover, when the diced wafer chips are picked up after irradiation, the substrate sheet sufficiently extends at the time of expanding, and hence the wafer chips can be picked up with accuracy.

The crosslinked films which are preferably used, particularly as the substrate in the present invention are those which have been obtained by irradiating synthetic resin films having crosslinking sites with radiation or those which have been obtained by incorporating crosslinking-reaction-initiators into starting polymers which are then chemically crosslinked. Usable as the crosslinked films as mentioned above are films of crosslinked polyolefin, crosslinked polydiene, crosslinked ethylene-vinyl acetate copolymers or crosslinked polyolefin-polydiene copolymers.

Such crosslinked films used as the substrates in the present invention are subjected to expanding treatment at the time when diced wafer chips are picked up, and these films have extensibility sufficient to meet the expanding treatment, whereby the wafer chips can be picked up with accuracy.

In addition synthetic resin films having a carboxyl-group containing monomer as a principal constituent monomer unit are preferably used as the substrate 2. Such synthetic resin films having a carboxyl group-containing monomer as a principal constituent monomer unit include ethylene (meth)acrylic acid copolymer and ethylene-vinyl acetate-(meth)acrylic acid copolymer. In addition, a laminate film comprising the synthetic resin film having a carboxyl group-containing monomer as a principal constituent monomer unit and a general synthetic resin film such as polyethylene, ethylene-vinyl acetate copolymer, polypropylene, polybutene, polybutadiene, polyvinylchloride, polyurethane, polymethyl pentene may be used.

On the substrate 2 as illustrated above is provided the adhesive layer 3 which is composed of an adhesive and a radiation polymerizable compound.

Acrylic adhesive are preferably used as the adhesives in the present invention, though a wide variety of conventionally known adhesives are usable. Practically speaking the acrylic adhesives referred to in the present invention are acrylic polymers selected from homopolymers and copolymers comprising acrylic esters as principal constitutive monomer units, copolymers of acrylic esters and other functional monomers, and mixtures thereof. The preferred polymers are those containing, as acrylic ester monomers, ethyl methacrylate, butyl methacrylate, 2-ethylhexyl methacrylate, glycidyl methacrylate, 2-hydroxyethyl methacrylate, etc., and the above-mentioned monomers containing acrylic acid esters instead of methacrylic acid esters are also preferred.

Furthermore, in order to enhance miscibility with the oligomers which will be mentioned later, the above-mentioned polymers may be those obtained by copolymerization of such monomers as (meth)acrylic acid, acrylonitrile and vinyl acetate. The above-mentioned (meth)acrylic type polymers used as the adhesives in the present invention conveniently have a molecular weight of up to 10.0×10^5, preferably 4.0×10^5 to 8.0×10^5.

In the present invention urethane acrylate oligomers are preferably used as the radiation polmerizable compound. The molecular weight of the urethane acrylate oligomer is 3,000-10,000, preferably 4,000-8,000. The molecular weight referred to above is a value as an average molecular weight of polystyrene as measured by gel permeation chromatography (GPC).

The urethane acrylate oligomers are obtained by reacting terminal isocyanate urethane prepolymers obtained by the reaction of polyester or polyether type polyol compounds with polyvalent isocyanate compounds, for example, 2,4-tolylene diisocyanate, 2,6-tolylene diisocyanate, 1,4-xylylene diisocyanate and diphenylmethane 4,4'-diisocyanate, with (meth)acrylates having hydroxyl groups, for example, 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, polyethylene glycol (meth)acrylate, etc. The urethane acrylate oligomers as obtained above are radiation polymerizable compounds having in the molecule at least one carbon-carbon double bond.

Radiation polymerizable compounds other than urethane acrylate oligomers include trimethylolpropane acrylate, tetramethylol-methane tetraacrylate, pentaerythritol triacrylate, pentaerythritol tetraacrylate, dipentaerythritol monohydroxy pentaacrylate, dipentaerythritol hexaacrylate, 1,4-butyleneglycol diacrylate, 1,6-hexanediol diacrylate, polyethylene glycol diacrylate, commercially available oligoester acrylates.

It is not preferable to use the urethane acrylate oligomers having a molecular weight of less than 3000. This is because, though no serious problem is brought about when semiconductor wafers used have a fine or smooth surface, when the wafers have a rough surface, the adhesion strength between the wafer chips and adhesive sheet does not decrease sufficiently even when the adhesive sheet is irradiated with radiation and the adhesive sometimes adheres to and remains on the back side surface of the wafer chips when they are picked up. The fact that when the urethane acrylate oligomer having a molecular weight of less than 3000 is used the adhesive adheres to the back side surface of wafer chips when the wafer has a rough surface is considered ascribable to the following reason. That is, the rough surface of the wafer means that a large number of fine grooves are present on the wafer surface, and when the urethane acrylate oligomer is brought into contact with the rough surface of the wafer, said oligomer intrudes into these fine grooves if said oligomer is low in molecular weight. On that account, it is considered that even when such oligomer is sufficiently cured by irradiation with radiation, the adhesion strength is kept at a high level by the anchoring effect of the adhesive and accordingly the adhesive adheres to and remains on the back side surface of wafer chips when the chips are picked up.

Thus, we found first the above-mentioned problem concerning the molecular weight of urethane acrylate oligomers, and it is almost a truism to say that all compounds concretely disclosed, for example, in the aforementioned Japanese Patent Laid-Open Publications Nos. 196956/1985 or No. 223139/1985, as the low molecular compounds having in the molecule at least two photopolymerizable carbon-carbon double bonds have a molecular weight of less than about 1500. The fact that these compounds low in molecular weight have heretofore been used is considered accountable for poor coatability of the compounds having excessively high molecular weights or deterioration in the surface gloss of coatings formed from such high molecular compounds.

In this connection, the urethane acrylate oligomers used in the present invention possess markedly excellent properties, as compared with low molecular compounds having in the molecule at least two photopolymerizable carbon-carbon double bonds as disclosed in Japanese Patent Laid-Open Publications Nos. 196956/1985 and 223139/1985. For instance, adhesive sheets prepared by the use of the present urethane acrylate oligomers show that the adhesive layer of the thus prepared adhesive sheets has a sufficient adhesion force before irradiation of said sheets with radiation but after the irradiation the adhesion force decreases to such a level that the adhesive does not adhere and hence the chips can simply be picked up. In contrast thereto, adhesive sheets prepared by the use of dipentaerythritol monohydroxy pentaacrylate as disclosed in the examples of Japanese Patent Laid-Open Publication No. 196956/1985 show that the adhesive layer of the thus prepared adhesive sheets exhibits a sufficient adhesion force before irradiation of said sheets with radiation but does not decrease in adhesion force sufficiently even after irradiation and the adhesive adheres to and remains on the back side surface of wafer chips when the chips are picked up.

In the adhesive layer of the adhesive sheet in accordance with the present invention, the acrylic adhesive and the urethane acrylate oligomer are used preferably in the proportion of 100 to 50-900 parts by weight. In that case, the adhesive sheet obtained is high in initial adhesion force and, moreover, the initial adhesion force greatly decreases after irradiation of said sheet with radiation and hence the wafer chips can readily be picked up from the adhesive sheet.

In the adhesive sheets of the present invention, the adhesive layer 3 contains therein a radiation color developable compound in addition to the acrylic adhesive and radiation polymerizable compound mentioned above, or the substrate 2 of the above-mentioned adhesive sheet is coated at least on one side thereof with a radiation color developable layer containing a radiation color developable compound. Under certain circumstances, a radiation color developable compound may be incorporated in the substrate 2.

The radiation color developable layer containing the radiation color developable compound may be formed on the side of the substrate 2 on which the adhesive layer 3 is not formed, or may be formed between the substrate 2 and the adhesive layer 3.

The radiation color developable compounds used in the present invention are compounds which are colorless or pale-colored before irradiation but develop color on irradiation with radiation, and preferred examples of such compounds are leuco dyes. Preferably usable as the leuco dyes are those which are conventionally used compounds such as triphenyl methane, fluoran, phenothiazine, Auramine, and spiropyrane compounds. These compounds include, for example, 3-[N-(p-tolylamino)]-7-anilinofluoran, 3-[N-(p-tolyl)-N-methylamino]-7-anilinofluoran, 3-[N-(p-tolyl)-N-ethylamino]-7-anilinofluoran, 3-diethylamino-6-methyl-7-anilinofluoran, crystal violet lactone, 4,4',4"-trisdimethylaminotriphenyl methanol, 4,4',4"-trisdimethylaminotriphenyl methane, etc.

Developers preferably usable in combination with the above-mentioned leuco dyes are those which have heretofore conventionally been used, such as initial polycondensation products of phenol-formalin resins, aromatic carboxylic acid derivatives and electron acceptors such as activated clay, and further when the developed color is intended to vary in color tone, various known color formers can also be used in combination therewith.

The radiation color developable layer containing the radiation color developable compound mentioned above can be formed at least on one side of the substrate 2 by coating a solution of said compound in an organic solvent either on one side or both sides of the substrate 2.

The radiation color developable layer may be formed by incorporating the radiation color developable compound in a subbing composition and then coating the subbing composition at least on one side of the substrate 2. Though suitably selected according to the type of the substrate 2 used, the subbing compositions mentioned above include those consisting essentially of vinyl acetate-vinyl chloride copolymers, polyurethane resins, polyester resins, polyamide resins or epoxy resins.

In another aspect, the above-mentioned solution of the radiation color developable compound in an organic solvent may be incorporated in the substrate 2 by using said solution at the time when the material for the substrate 2 is formed into a sheet-like product. Under certain circumstances, the radiation color developable compound may also be incorporated in the form of fine powder into the substrate 2.

By virtue of incorporating the radiation color developable compound into the adhesive layer 3, or coating said compound at least on one side of the substrate 2, or by incorporating said compound into the substrate 2 in the manner now described, the adhesive sheet 1 is sufficiently colored on irradiation with radiation, whereby the detection accuracy is enhanced at the time of detecting wafer chips by means of a photosensor and a possible failure in the operation to pick up the wafer chips from the adhesive sheet 1 is prevented.

By coating the radiation color developable compound at least on one side of the substrate 2, there is also obtained such an advantage that in comparison with the case of incorporation in the adhesive layer 3 of said compound, there is no possibility of exerting an adverse effect on the expected decrease in adhesion force of the adhesive layer 3 by irradiation with radiation.

In one embodiment of the adhesive sheet of the present invention, the adhesive layer 3 preferably contains therein powder of a light scattering inorganic compound in addition to the adhesive and the radiation polymerizable compound and dye.

The light scattering inorganic compounds referred to above are such compounds as are capable of irregular reflection of ultraviolet (UV) or electron beam (EB) radiation, which concretely include, for example, silica powder, alumina powder, silica alumina powder or mica powder. The light scattering inorganic compounds are preferably those which reflect such radiation as mentioned above almost perfectly, but those which absorb the radiation to a certain extent are of course usable.

Preferably, the light scattering inorganic compounds are in the form of powder and have a particle diameter of 1-100 μm, preferably about 1-20 μm. In the adhesive layer, this light scattering inorganic compound is desirably used in an amount of 0.1-10%, preferably 1-4% by weight. The use of this light scattering inorganic compound in an amount exceeding 10% by weight is not preferable since the compound may then sometimes reduce the adhesion force and, on the other hand, the use of said compound in an amount less than 1% by weight is also not preferable since the adhesive layer does not sufficiently lower the adhesion force even when radiation is applied to the portions of the adhesive layer corresponding to the greyed or blackened portions of the semiconductor wafer surface, if any, and the adhesive adheres to and remains on the wafer chip surface when the chips are picked up from the adhesive sheet.

Even when semiconductor wafers having the surface greyed or blackened for some reason or other are applied to adhesive sheets having an adhesive layer containing a powder of the above-mentioned light scattering inorganic compound in addition to the adhesive and radiation polymerizable compound, the adhesion force of this adhesive layer sufficiently decreases even at the portions corresponding to the greyed or blackened portions of the wafer surface when irradiated with radiation, and the reason for this is considered to be probably found in the following discussion. That is, the adhesive sheet 1 of the present invention has thereon the adhesive layer 3, and when this adhesive layer 3 is irradiated with radiation, the radiation polymerizable compound contained in the adhesive layer 3 comes to cure and this adhesive layer 3 decreases in adhesion force. In that case, however, the semiconductor wafers to be applied to the adhesive layer 3 have sometimes on the surface thereof portions greyed or blackened for some reason or other. In that case, when the adhesive layer is irradiated with radiation, the radiation passes through the adhesion layer to reach the wafer surface, however, if the wafers have greyed or blackened portions, the radiation is absorbed by said portions and does not reflect. On that account, it follows that the radiation which is to be utilized to cure the adhesive layer 3 is absorbed by the portions corresponding to the greyed or blackened portions of the wafer surface, and this adhesive layer 3 does not cure sufficiently and does not sufficiently decrease in adhesion force. Accordingly, it is considered that the adhesive adheres to and remains on the back side surface of wafer chips when the chips are picked up from the adhesive sheet.

When powder of the light scattering inorganic compound is incorporated into the adhesive layer 3, however, the radiation as irradiated comes into irregular reflection and is altered in its direction before reaching the wafer surface. On that account, even if greyed or blackened portions are present in the wafer chip surface, the irregularly reflected radiation sufficiently permeates into the upper region of the portions of the adhesive layer corresponding to said greyed or blackened portions and accordingly the corresponding portions of the adhesive layer cure sufficiently. By virtue of incorporating the light scattering inorganic compound powder into the adhesive layer, even when portions greyed or blackened for some reason or other are present in the semiconductor wafer surface, the adhesive layer does not cure insufficiently at its portions corresponding to the greyed or blackened portions of the wafer chip surface and accordingly the adhesive will not adhere to and remain on the chip surface when the chips are picked up from the adhesive sheet.

Furthermore, the initial adhesive force of the above-mentioned adhesive layer can be altered to any desired level by incorporating an isocyanate type hardener into said adhesive layer. Usable as the isocyanate type hardeners in the above case are polyvalent isocyanate compounds, for example, 2,4-tolylene diisocyanate, 2,6-tolylene diisocyanate, 1,3-xylylene diisocyanate,1,4-xylylene diisocyanate, diphenylmethane-4,4'-diisocyanate, diphenylmethane-2,4'-diisocyanate, 3-methyl-diphenylmethane diisocyanate, hexamethylene diisocyanate, isophorone diisocyanate, dicyclohexyl-methane-4,4'-diisocyanate, dicyclohexylmethane-2,4'-diisocyanate and lysine isocyanate.

Furthermore, the above-mentioned adhesive layer may be incorporated with a UV curing initiator when said layer is subjected to UV irradiation, thereby shortening the polymerization curing time by U.V. irradiation and minimizing the amount of UV irradiation.

Concrete examples of such U.V. curing initiators include, for example, benzoin, benzoin methyl ether, benzoin ethyl ether, benzoin isopropyl ether, benzyl diphenyl sulfide, tetramethylthiuram monosulfide, azobisisobutyronitrile, dibenzyl, diacetyl, β-chloroanthraquinone, etc.

The adhesive sheet of the present invention is illustrated below with respect to the method of use thereof (reference numbers refer to the accompanying drawings).

Where the strippable sheet 4 is provided on the adhesive sheet 1, said sheet 4 is first removed and the adhesive sheet 1 is placed, turning the adhesive layer 3 upward. On the face side of this adhesive layer 3 is applied the semiconductor wafer A to be subjected later to dicing. The wafer A is subjected in this state to such processing operations as dicing, rinsing, drying and expanding. In that case, the wafer chips will not fall off from the adhesive sheet 1 during each operation because the wafer chips are sufficiently attached to and held on the adhesive sheet 1 by means of the adhesive layer 3.

Subsequently, the wafer chips are picked up from the adhesive sheet 1 and mounted on a given support substrate. In that case, before the pick-up operation or at the time when the pick-up operation is carried out, the adhesive layer 3 of the adhesive sheet 1 is irradiated with an electrodissociative radiation such as ultraviolet light (UV) or an electron beam (EB) to cure the radiation polymerizable compound contained in the adhesive layer 3. When the radiation polymerizable compound contained in the adhesive layer 3 is polymerized to cure by irradiating the adhesive layer 3 with radiation, the adhesion force of the adhesive contained in the adhesive layer 3 greatly decreases, leaving only a slight adhesion force.

The irradiation of the adhesive sheet 1 is preferably effected from the side of the substrate 2 on which the adhesive layer 3 is not formed. Accordingly, as mentioned previously, the substrate 2 must be light transmittable when UV is used but the substrate 2 need not always be light transmittable when EB is used.

In the manner now described, the portions of the adhesive layer 3 on which the wafer chips A_1, A_2 ... ... are provided is irradiated with radiation B to lower the adhesion force of the adhesive layer 3. Thereafter, the adhesive sheet 1 having this adhesive layer 3 is transferred to a pick-up station (not shown) wherein the chip A_1 ... ... is pushed up according to the usual way from the back side of the substrate 2 by means of a pushing rod 5, and the pushed-up wafer chips A_1, A_2 ... ... are picked up by picking up means 6, for example by means of an air pincette, and are mounted on a given support substrate. By picking up the wafer chips A_1, A_2 ... ... in this manner, all the wafer chips can be simply picked up without any adhesion of the adhesive to the back side surface of every wafer chip, thereby obtaining chips of good quality free from contamination. Furthermore, the irradiation may be effected in the pick up station, as well.

The irradiation need not always be effected at once on the whole surface of the water A, and may be effected partially in several times, for instance, only the portion of the substrate 2 corresponding to each of the wafer chips A_1, A_2 ... ... is irradiated from the back side of the substrate 2 by means of an irradiating tube to lower the adhesion force of the adhesive corresponding to the irradiated portion of the substrate 2, and thereafter the wafer chips A_1, A_2 ... ... are pushed up by means of the pushing rod 5 and then the pushed-up chips are successively picked up from the adhesive sheet 1. Fig. 6 shows a modification of the above-mentioned irradiation method, wherein the pushing rod 5 is made hollow in the interior thereof and a radiation source 7 is provided in the hollow portion of the pushing rod 5 so that the radiation irradiation and pick up operations can be effected at the same time, thus the apparatus can be simplified and, at the same time, the time necessary for the pick-up operation can be shortened.

In the above-mentioned treatment of semiconductor wafers, the wafer chips A_1, A_2 ... ... may be subjected to pick-up treatment immediately after dicing, rinsing, and drying without effecting an expanding operation.

The adhesive sheet 1 of the present invention is preferably used in the processing of semiconductor wafer, from dicing operation up to pick-up operation, as illustrated hereinbefore. This adhesive sheet 1 may also be used in masking an object to be coated with coating materials. As shown in Fig. 7, in the case of an object 8 to be coated, for example, an automobile body, onto the surface 9 not to be coated with a coating material is applied the adhesive sheet 1 of the present invention, and a coating 10 is formed on the object 8 to be coated, as it is. Thereafter, the adhesive sheet 1 is irradiated from upside with radiation B to lower the adhesion force of said adhesive sheet 1, followed by peeling off the irradiated adhesive sheet 1 from the object 8 to be coated. In this way, there is obtained such an excellent effect that no adhesive will remain on or deposit on the surface of the object 8 to be coated.

The present invention is illustrated below by means of examples, but it should be construed that the invention is in no way limited to those examples. Parts are given by weight

Example 1

An adhesive layer forming composition was prepared from a mixture comprising 100 parts of an acrylic adhesive (a copolymer of n-butyl acrylate and acrylic acid), 100 parts of urethane acrylate oligomer (a product of Dainichi Seika Kogyo K.K., sold under the trade name SEIKA BEAM EX 808), 25 parts of a hardener (a diisocyanate type hardener) and 10 parts of a UV curing initiator (a benzophenone type initiator), said mixture additionally containing 5 parts of 4,4', 4"-trisdimethylaminotriphenylmethane, a leuco dye, as a radiation color developable compound.

The composition thus prepared was coated on one side of a polyethylene film substrate of 80 μm in thickness in such a manner that an adhesive layer to be formed thereon may have a thickness of 10 μm, and the thus coated substrate was then heated at 100°C for 1 minute to prepare an adhesive sheet.

The adhesive layer of the adhesive sheet thus obtained was irradiated for 2 seconds with ultraviolet radiation (UV) from a air-cooling high pressure mercury lamp (80 W/cm, irradiation distance 10 cm).

By virtue of the UV irradiation, the adhesive sheet which had been transparent assumed a bluish-purple color. The color difference $E(L^*a^*B^*)$ before and after the UV irradiation was measured by means of an SM Color Computer (manufactured and sold by Suga Testers K.K.), whereupon the color difference as measured was 26.8.

A silicon wafer applied onto the adhesive layer surface of this adhesive sheet was diced into wafer chips and then subjected to UV irradiation under the conditions mentioned above to detect the wafer chips by means of a photo-sensor (manufactured and sold under the trade name SX-23R by Thanks K.K.), whereupon the wafer chips could easily be detected and no error in the picking-up performance was observed.

Comparative Example 1

An adhesive sheet was prepared in the same manner as in Example 1 except that no UV irradiation color developable compound was used, and the color difference of the adhesive sheet owing to UV irradiation was measured as in Example 1. The color difference $E(L^*a^*B^*)$ of the irradiated adhesive sheet as measured was less than 2.0, thus no coloration caused by the UV irradiation was observed.

A silicon wafer applied onto the adhesive layer surface of this adhesive sheet was diced into wafer chips and then subjected to UV irradiation to effect detection of the wafer chips by means of a photosensor, whereupon a failure of detection was partly observed. Further, the wafer chips were picked up while using the photosensor, whereupon errors in the picking-up performance were observed.

Example 2

An adhesive sheet was prepared in the same manner as in Example 1 except that in place of the urethane acrylate oligomer, there was used pentaerythritol acrylate having a molecular weight of about 580, and the color difference of the adhesive sheet owing to UV irradiation was measured in like manner.

The color difference $E(L^*a^*B^*)$ of the adhesive sheet as measured before and after the UV irradiation was 25.0.

A silicon wafer applied onto the adhesive layer of this adhesive sheet was diced into wafer chips and then subjected to UV irradiation under the conditions mentioned above to effect detection of the wafer chips by means of a photo-sensor, whereupon the wafer chips could be detected without failure in detection. Further, the wafer chips were picked up while using the photosensor, whereupon no error in the pick-up performance was observed at all.

Example 3

To 100 parts by weight of an undercoating composition comprising a vinyl acetate-vinyl chloride copolymer as a principal ingredient was added 5 parts by weight of 4,4',4"-trisdimethylaminophenylmethane as a UV irradiation color developable leuco dye. The resulting undercoating composition was coated and dried on one side of a polyethylene terephthalate film substrate of 50 μm in thickness in such a manner that an undercoat layer to be formed thereon may have a dry thickness of 1-2 μm.

On the undercoat layer thus formed was coated and dried, a mixture comprising 100 parts by weight of an acrylic adhesive (a copolymer of n-butyl acrylate and acrylic acid), 100 parts by weight of a urethane acrylate oligomer having a molecular weight of 3,000-10,000, 25 parts by weight of a hardener (a diisocyanate type hardener) and 10 parts by weight of a UV irradiation curing initiator (a benzophenone type initiator) so as to form an adhesive layer having a dry thickness of 10 μm, and the thus coated substrate was heated at 100°C for 1 minute to obtain an adhesive sheet of a triple layer structure according to the present invention.

The adhesive layer of the adhesive sheet thus obtained was irradiated for 2 seconds with ultraviolet radiation (UV) from an air-cooling high pressure mercury lamp (80W/cm, irradiation distance 10 cm). By virtue of the UV irradiation, the adhesive sheet which had been transparent assumed a bluish purple color. The color difference $E(L^*a^*B^*)$ of the adhesive sheet at the time of UV irradiation was measured by means of an SM Color Computer (manufactured and sold by Suga Testers K.K.). whereupon the color difference as measured was 21.6.

Furthermore, a silicon wafer applied onto the adhesive layer surface of this adhesive sheet was diced into wafer chips and then subjected to UV irradiation under the conditions mentioned above to effect detection of the wafer chips by means of a photo-sensor, whereupon the wafer chips could easily be detected. The wafer chips were then picked up while using the photosensor, whereupon no error in the picking-up performance was observed at all.

<u>Comparative Example 2</u>

An adhesive sheet was prepared in the same manner as in Example 3 except that an undercoat layer incapable of coloration on UV irradiation was formed on the substrate, and the color difference of the adhesive sheet which is due to UV irradiation was measured. The color difference $E(L^*a^*B^*)$ of the adhesive sheet as measured before and after the UV irradiation was less than 2.0, thus no coloration due to the UV irradiation was observed.

Further, a silicon wafer applied onto the adhesive layer surface of this adhesive sheet was diced into wafer chips and then subjected to UV irradiation to effect detection of the wafer chips by means of a photo-sensor, whereupon the detection could not be performed sufficiently in some cases.

Furthermore the wafer chips were picked up while using the photosensor, whereupon error in the picking-up performance was observed in some cases.

Attention is directed to the inventions claimed in our copending applications nos. 2184741, 2221469 and 2221470.

CLAIMS:

1. An adhesive sheet comprising a substrate having coated on the surface thereof an adhesive layer which layer comprises an adhesive and a radiation polymerizable compound, characterized in that a radiation color developable compound has been incorporated in the adhesive layer.

2. The adhesive sheet according to claim 1 wherein the radiation color developable compound is a leuco dye.

3. The adhesive sheet according to claim 2 wherein the leuco dye is 4,4',4"-trisdimethylaminotriphenylmethane.

4. The adhesive sheet according to claim 1 wherein the radiation polymerizable compound is a urethane acrylate oligomer having a molecular weight of 3,000-10,000.

5. An adhesive sheet comprising a substrate having coated on the surface thereof an adhesive layer which layer comprises an adhesive and a radiation polymerizable compound, characterized in that a radiation color developable compound has been coated on at least one side of the substrate.

6. The adhesive sheet according to claim 5 wherein the radiation color developable compound is a leuco dye.

7. The adhesive sheet according to claim 6 wherein the leuco dye is 4,4',4"-trisdimethylaminotriphenylmethane.

8. The adhesive sheet according to claim 5 wherein the radiation polymerizable compound is a urethane acrylate oligomer having a molecular weight of 3,000-10,000.

9. An adhesive sheet comprising a substrate having

coated on the surface thereof an adhesive layer which layer comprises an adhesive and a radiation polymerizable compound, characterized in that a radiation color developable compound has been incorporated in the substrate.

10. The adhesive sheet according to claim 9 wherein the radiation color developable compound is a leuco dye.

11. The adhesive sheet according to claim 10 wherein the leuco dye is 4,4',4"-trisdimethylamino-triphenylmethane.

12. The adhesive sheet according to claim 9 wherein the radiation polymerizable compound is a urethane acrylate oligomer having a molecular weight of 3,000-10,000.

13. A method for attaching an adhesive sheet to a surface, wherein the sheet is readily released from the surface following irradiation of the adhesive, which comprises using as the sheet an adhesive sheet as claimed in any preceding claim.

14. A method for preparing semiconductor chips from a semiconductor wafer which comprises

a) attaching the said wafer to an adhesive sheet as claimed in any of claims 1 to 12.

b) processing the said wafer to form semiconductor chips; and

c) irradiating the adhesive layer of the said sheet whereby the semiconductor chips may readily be released from the said sheet.

REGISTER ENTRY FOR GB2221468

Form 1 Application No GB8916855.3 filing date 29.12.1986

Lodged on 24.07.1989

Priorities claimed:
27.12.1985 in Japan - doc: 60295188
27.12.1985 in Japan - doc: 60295189
27.12.1985 in Japan - doc: 60295190
03.03.1986 in Japan - doc: 61045785
03.03.1986 in Japan - doc: 61045786
09.07.1986 in Japan - doc: 61161680

Earlier Application Under Section 15(4): GB8630956.4 Pubn. No GB2184741 filed on 29.12.1986

Title ADHESIVE SHEET

Applicant/Proprietor
FSK KABUSHIKI KAISHA, Incorporated in Japan, Honcho 23-23, Itabashi-ku, Tokyo-to, Japan [ADP No. 00462267001]

Inventors
EBE KAZUYOSHI, Shiraoka-machi, Minamisaitama-gun, Saitama-ken, Japan [ADP No. 04318119001]

HIROAKI NARITA, Yoshikawadanchi 1-1-502, Yoshikawa-cho, Kitakatushika-gun, Saitama-ken, Japan [ADP No. 03868288001]

KATSUHISA TAGUCHI, Chuo 2-14-18, Warabi-shi, Saitama-ken, Japan [ADP No. 03868296001]

YOSHITAKA AKEDA, Tuji 7-7-3, Urawa-shi, Saitama-ken, Japan [ADP No. 03868304001]

TAKANORI SAITO, Kamiko-cho 318-310, Ohmiya-shi, Saitama-ken, Japan [ADP No. 03868312001]

Classified to
C3V B2E C3W U1S
C09J H01L

Address for Service
FRANK B DEHN & CO, Imperial House, 15-19 Kingsway, LONDON, WC2B 6UZ, United Kingdom [ADP No. 00001660001]

Publication No GB2221468 dated 07.02.1990

Examination requested 24.07.1989

Patent Granted with effect from 05.09.1990 (Section 25(1)) with title ADHESIVE SHEET SUITABLE FOR USE IN DICING SEMICONDUCTOR WAFERS INTO CHIPS

02.10.1990 Application under Section 32 filed on 28.09.90
Entry Type 10.1 Staff ID. DG Auth ID. EO

02.10.1990 Notification of change of Applicant/Proprietor name of
FSK KABUSHIKI KAISHA, Incorporated in Japan, Honcho 23-23,
Itabashi-ku, Tokyo-to, Japan [ADP No. 00462267001]
to
LINTEC CORPORATION, Incorporated in Japan, Honcho 23-23,
Itabashi-ku, Tokyo, Japan [ADP No. 05717103001]
dated 01.04.1990. Official evidence filed on GB2221470
Entry Type 7.2   Staff ID. DG   Auth ID. F20

**** END OF REGISTER ENTRY ****

RENEWAL DETAILS

PUBLICATION NUMBER	GB2221468

PROPRIETOR(S)

LINTEC CORPORATION, Incorporated in Japan, Honcho 23-23,
Itabashi-ku, Tokyo, Japan

DATE FILED	29.12.1986
DATE GRANTED	05.09.1990
DATE NEXT RENEWAL DUE	29.12.1992
DATE NOT IN FORCE	
DATE OF LAST RENEWAL	17.12.1991
YEAR OF LAST RENEWAL	06
STATUS	PATENT IN FORCE