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(54) IMPROVEMENTS IN AND RELATING TO ROLLER ARRANGEMENTS

(71) We, ASSOCIATED SEMICONDUCTOR MANUFACTURERS LIMITED, of Abacus House, 33 Gutter Lane, London, E.C.2, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to roller arrangements suitable for fracturing into pieces a scored plate of material, particularly, but not exclusively, slices of semiconductor material. The invention further relates to methods of fracturing into pieces a plate of material having substantially parallel major surfaces and a set of score lines on one major surface extending along the plate substantially parallel to one another and determining lines of fracture.

In British Patent Specification No. 925,016 there is described and claimed a method of separating into pieces a plate of brittle material having substantially parallel major surfaces and a plurality of score lines extending along the plate substantially parallel to one another and determining lines of separation, comprising the step of moving the plate in a continuous movement relative to at least one of the two members so that contact occurs between the plate and the two members in a plane substantially at right angles to the two major surfaces of the plate and passing progressively along the plate, the relative movement and the shape and surface resilience of the two members being such that during said contact a bending moment which moves progressively along the plate is exerted on the plate whereby separation is effected by the said bending moment along each score line in turn.

A particular embodiment describes one of the members as a rubber pad and the other as a cylindrical roller, the plate of brittle material being a germanium or silicon body having two orthogonal sets of substantially

parallel diamond scribed score lines on one major surface. After fracturing along one set of score lines, the semiconductor body is re-orientated through 90° and fractured along the other set of score lines so producing from the semiconductor body a plurality of semiconductor pieces, which are also called dice. It is stated, as an example, that for score lines spaced 2mm. (2,000 microns) apart a roller diameter of about half an inch (approximately 12.5 mm.) is satisfactory.

In present day semiconductor technology it is necessary to fracture semiconductor slices into dice having a major surface area of 350 microns × 350 microns. For fracturing such a semiconductor slice, a roller of very small diameter is required to achieve a suitable bending moment. Even with a roller of diameter as small as 5 mm., the bending moment is such that the semiconductor slice tends to fracture along certain, but not all, of the score lines, and this often results in as many as three semiconductor dice remaining joined in one fractured semiconductor piece, and fractures occurring across a semiconductor dice damaging or destroying its electrical circuit elements.

In addition the semiconductor slice may be supported between the roller and the pad on a plastic or synthetic resin foil during fracturing. The use of a roller having a diameter of 5 mm. to fracture semiconductor slices supported on such a film can often produce drag on the film resulting in damage to the semiconductor dice.

For satisfactory fracture of such a semiconductor slice having score lines with a mutual separation of 350 microns a roller having a diameter of 2 mm. or less is preferable. It is exceedingly difficult, if not impossible, for a roller of such a diameter to be satisfactorily pivoted with journalled ends in bearings.

According to a first aspect of the inven-

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tion, a roller arrangement suitable for fracturing into pieces a scored plate of material comprises first and second backing rollers, a smaller diameter working roller of magnetic material which in use is situated between said backing rollers, the axes of rotation of the backing rollers and the working roller being substantially parallel and magnetic means for subjecting the working roller to a magnetic field applied across said backing rollers to hold the working roller in rolling surface contact with said backing rollers.

It is preferable for the backing rollers to be of a magnetic material, so forming a magnetic circuit with the working roller. In this case the working roller and backing rollers may be of hardened steel, which material can give adequate support to the rollers so as to reduce sagging along their length.

The working roller and backing rollers may be substantially cylindrical, the backing rollers each having substantially the same dimensions.

The magnetic means may comprise an electro-magnet, if the working is comparatively heavy. However, if the working roller is comparatively light it is often preferable to dispense with the electrical circuitry and for the magnetic means to comprise a permanent magnet, the magnetic axis of which is substantially perpendicular to the axes of rotation of the working roller and the backing rollers and lies substantially within a plane parallel to the said plane in which are situated the axes of rotation of the backing rollers.

In this case, the backing rollers and permanent magnet may be mounted in a brass container, the backing rollers having journalled ends mounted in bearings in supporting blocks of the container, at least that part of the peripheral surface of the working roller most remote from the plane in which are situated the axes of rotation of the backing rollers extending beyond the brass container.

In the case where the backing rollers are of a magnetic material, and the working roller and backing rollers are substantially cylindrical, the backing rollers being of substantially the same dimensions as each other, the first and second substantially cylindrical backing rollers of a magnetic material may be situated between the working roller and third, fourth and fifth substantially cylindrical backing rollers, which third, fourth and fifth backing rollers each have substantially the same dimensions as the first and second backing rollers, the axes of rotation of the working roller and the first, second, third, fourth and fifth backing rollers being substantially parallel, the first backing roller being situated between, and held by said magnetic field in rolling surface contact with,

the third and fourth backing rollers, the second backing roller being situated between, and held by said magnetic field in rolling surface contact with, the fourth and fifth backing rollers. In this case it is possible for the cross-sectional diameter of the working roller to be even smaller.

The cross-sectional diameter of the working roller may be, for example, at most 2 mm.

According to the second aspect of the invention, in a method of fracturing into pieces a plate of material having substantially parallel major surface and a plurality of score lines on one major surface extending along the plate substantially parallel to one another and determining lines of fracture, relative motion is effected between a roller arrangement according to the first aspect of the invention and the opposite major surface of the plate in a direction substantially perpendicular to the score lines, and pressure applied such that the working roller exerts on the plate a bending moment which moves progressively along the plate whereby fracture across the plate substantially perpendicular to the major surfaces is effected by said bending moment along each score line in turn.

The plate of brittle material may comprise a semiconductor slice having two substantially orthogonal sets of substantially parallel score lines on the one major surface, fracture may first be effected along one set of score lines, thereafter the plate may be re-orientated through substantially 90° and fracture may be effected along the other set of score lines.

In this case, for example, the diameter of the working roller may be at most 2 mm. and the distance between two parallel score lines may be at most 350 microns.

The opposite major surface of the plate may be attached to a supporting film, which film during fracture of the plate is situated between the working roller and the plate, the pieces produced by fracturing the plate remaining attached to the film subsequent to the fracturing so that their position and orientation are substantially maintained. In this case the opposite major surface of the plate may be attached to the film prior to forming the score lines on the one major surface, and the elasticity of the film may be such as to permit the stretching of the film in the plane substantially parallel to the major surfaces of the plate so as to separate in that plane from contact with one another the pieces attached to the film subsequent to the fracturing of the plate. The opposite major surface of the plate may be attached to the film by an adhesive, in which case the pieces produced by fracturing may need subsequent cleaning. A preferred alternative is for the film to be elec-

trically insulating synthetic resin, the opposite major surface of the plate being attached thereto by electro-static attraction.

An embodiment of the invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings, in which:—

Figure 1 is a side view of a roller arrangement in accordance with the first aspect of the invention.

Figure 2 is a plan view of a scored semiconductor slice attached to a portion of supporting film and suitable for fracturing into pieces using the roller arrangement shown in Figure 1, and Figure 3, is a cross-sectional view of the roller arrangement shown in Figure 1 along the line III—III of Figure 1 when used to fracture a scored semiconductor slice such as shown in Figure 2.

The roller arrangement shown in Figures 1 and 3 comprises first and second cylindrical backing rollers 1 and 2 of hardened steel having a diameter of 5 mm. A cylindrical working roller 3 of 2 mm. diameter and also of hardened steel is situated between the backing rollers 1 and on one side of the plane A B in which are situated the axes of rotation of the backing rollers 1 and 2. The axes of rotation of the working roller 3 and the backing rollers 1 and 2 are substantially parallel to each other.

The cylindrical permanent magnets 5 and 6 are present on the other side of said plane A B and apply to the working roller 3 a magnetic field to hold the working roller 3 in rolling surface contact with the backing rollers 1 and 2. The magnetic axis of each magnet 5 and 6 is substantially perpendicular to the axes of rotation of the working roller 3 and the backing rollers 1 and 2, and each magnetic axis lies substantially within a plane parallel to the plane A B.

Since the rollers 1, 2 and 3 are of hardened steel, a magnetic material, they together form a magnetic circuit for the magnetic flux from the magnets 5 and 6. In this way the working roller 3 can maintain a position entirely without end bearings between the backing rollers 1 and 2 and also be free to rotate. Since the diameter of the working roller 3 is 2 mm., it would be exceedingly difficult, if not impossible, to pivot satisfactorily this roller with journalled ends in bearings.

The backing rollers 1 and 2 and the permanent magnets 5 and 6 are mounted in a brass container 11. Each backing roller 1 and 2 has journalled ends 7 and 8 mounted in bearings in brass supporting blocks 9 and 10 of the container 11. The blocks 9 and 10 are detachable, being screwed to the remainder of the container 11, so that the backing rollers 1 and 2 may be replaced or readjusted in their bearings. That part 4 of the peripheral surface of the working

roller 3 most remote from said plane A B extends beyond the brass container 11, and it is this part 4, of the peripheral surface of the working roller 3 that constitutes the working surface of the working roller.

The length of each backing roller 1 and 2, excluding the journalled ends 7 and 8, is 55 mm., and the length of the working roller 3 is 60 mm. The hardened steel of these rollers 1, 2 and 3 gives such adequate support that sagging along the length of each roller is reduced. The cylindrical permanent magnets 5 and 6 are each of cross-sectional diameter 17.6 mm. and length 11 mm., and these are mounted in corresponding apertures in the brass container 11 with their centres spaced by 30 mm. Those parts of the peripheral surface of each backing roller 1 and 2 nearest the magnets 5 and 6 are separated therefrom by an air gap of minimum width 1 mm., and the axis of rotation of the backing rollers 1 and 2 are held at a distance apart of 5.5 mm. In this way, the frictional resistance between the rotating rollers is small.

The roller arrangement of Figure 1 may be used for fracturing into pieces a semiconductor slice 11 such as is shown in Figure 2. The slice 11 has parallel major surfaces and comprises a plurality of regions 13 each containing therein a semiconductor device in the form of an integrated circuit at or adjacent one major surface of the slice 11. The slice 11 is fractured into pieces, so as to separate the regions 13 from each other and form individual semiconductor dice, in the following way:—

The opposite major surface of the slice 11 is attached to a supporting film 12, the film 12 being previously charged by friction so that the slice 11 is attached thereto by electrostatic attraction.

The film 12 consists of a material commercially available under the trade name of "Genotherm 100". Two sets of mutually parallel score lines 14 and 15 are scribed on the one major surface of the slice 11 between the regions 13 using diamond scribes. The two sets of score lines 14 and 15 intersect one another at right angles and determine lines of fracture. The distance between the two adjacent lines in each plurality is approximately 350 microns.

The semiconductor slice 11 attached to the film 12 is transferred to a resilient rubber supporting layer 16 which bears on a surface of a rigid support 17. The one major surface of the slice 11 rests on, and in contact with, the layer 16. The rolling arrangement of Figure 1 is moved under suitable pressure and with a suitable velocity across the opposite major surface of the slice 11 in a direction substantially perpendicular to one set of score lines 14 (see Figure 3, where the movement of the roller arrangement is indi-

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cated by arrows 8). The film 12 is situated between the working roller 3 and the semiconductor slice 11. The relative motion, surface resilience and shape of the layer 16 and the working roller 3 and the pressure applied are such that the working roller 3 exerts on the slice 11 a bending moment which moves progressively along the slice 11. Fracturing across the slice 11 substantially perpendicular to the major surfaces is effected by said bending movement along each score line 14 in turn. The arrows associated with rollers 1, 2 and 3 indicate their direction of rotation during fracturing of the slice alone the score lines 14.

The slice 11 is then turned through substantially 90° and the roller arrangement again moved under the same pressure and with the same velocity across the opposite major surface of slice 11, but now the movement is in a direction substantially perpendicular to the other set of score lines 15. In this way fracturing is effected along each score line 15 in turn.

The semiconductor slice 11 as a result of fracturing along the two sets of score lines 14 and 15 comprises a plurality of divided, but as yet unspaced, semiconductor pieces. Even though adjacent score lines in the slice 11 were spaced apart by only 350 microns, the majority of these pieces so formed are whole semiconductor dice 13 each containing therein a substantially undamaged semiconductor device. This is a consequence of being able to apply a suitable bending moment by employing a working roller of a diameter no greater than 2 mm. Furthermore the small diameter of the working roller 3 exerts less drag on the film 12 with which it is in direct through moving contact, hence reducing damage to patterns on the semiconductor dice 13.

The semiconductor pieces formed by fracturing the slice 11 remain attached to the foil 12 subsequent to fracturing, so that their position and orientation are maintained substantially as in the slice 11.

The elasticity of Genotherm 100 is such as to permit the stretching of the film 12 in the plane substantially parallel to the major surfaces of the slice 11, so as to separate in that plane from contact with one another the divided but unspaced dice 13 attached to the film 12. After inspection and marking of damaged dice, approved dice 13 are subsequently removed from the film 12 by means of a pick-up head or needle having a reduced pressure connection and further processed.

60 WHAT WE CLAIM IS:—

1. A roller arrangement suitable for fracturing into pieces a scored plate of material comprising first and second backing rollers, a smaller diameter working roller of magnetic material which in use is

situated between said backing rollers, the axes of rotation of the backing rollers and the working roller being substantially parallel, and magnetic means for subjecting the working roller to a magnetic field applied across said backing rollers to hold the working roller in rolling surface contact with said backing rollers.

2. A roller arrangement as claimed in Claim 1, wherein the backing rollers are of a magnetic material.

3. A roller arrangement as claimed in Claim 2, wherein the working roller and backing rollers are of hardened steel.

4. A roller arrangement as claimed in any of the preceding Claims, wherein the working roller and backing rollers are substantially cylindrical, the backing rollers each having substantially the same dimensions.

5. A roller arrangement as claimed in any of the preceding Claims, wherein the magnetic means comprise a permanent magnet, the magnetic axis of which is substantially perpendicular to the axis of rotation of the working roller and said backing rollers and lies substantially within a plane parallel to the plane in which are situated the axis of rotation of the backing rollers.

6. A roller arrangement as claimed in Claim 5, wherein the backing rollers and permanent magnet are mounted in a brass container, the backing rollers having journalled ends mounted in bearings in supporting blocks of the container, at least that part of the peripheral surface of the working roller most remote from the plane in which are situated the axes of rotation of the backing rollers extending beyond the brass container.

7. A roller arrangement as claimed in Claim 4, where appendant to Claim 2, wherein the first and second substantially cylindrical backing rollers of magnetic material are situated between the working roller and third, fourth and fifth substantially cylindrical backing rollers, which third, fourth and fifth backing rollers each have substantially the same dimensions as the first and second backing rollers, the axes of rotation of the working roller and the first, second, third, fourth and fifth backing rollers being substantially parallel, the first backing roller being situated between, and held by said magnetic field in rolling surface contact with, the third and fourth backing rollers, the second backing roller being situated between, and held by said magnetic field in rolling surface contact with, the fourth and fifth backing rollers.

8. A roller arrangement as claimed in any of the preceding Claims, wherein the diameter of the working roller is at most 2 mm.

cated by arrows 8). The film 12 is situated between the working roller 3 and the semiconductor slice 11. The relative motion, surface resilience and shape of the layer 16 and the working roller 3 and the pressure applied are such that the working roller 3 exerts on the slice 11 a bending moment which moves progressively along the slice 11. Fracturing across the slice 11 substantially perpendicular to the major surfaces is effected by said bending movement along each score line 14 in turn. The arrows associated with rollers 1, 2 and 3 indicate their direction of rotation during fracturing of the slice along the score lines 14.

The slice 11 is then turned through substantially 90° and the roller arrangement again moved under the same pressure and with the same velocity across the opposite major surface of slice 11, but now the movement is in a direction substantially perpendicular to the other set of score lines 15. In this way fracturing is effected along each score line 15 in turn.

The semiconductor slice 11 as a result of fracturing along the two sets of score lines 14 and 15 comprises a plurality of divided, but as yet unspaced, semiconductor pieces. Even though adjacent score lines in the slice 11 were spaced apart by only 350 microns, the majority of these pieces so formed are whole semiconductor dice 13 each containing therein a substantially undamaged semiconductor device. This is a consequence of being able to apply a suitable bending moment by employing a working roller of a diameter no greater than 2 mm. Furthermore the small diameter of the working roller 3 exerts less drag on the film 12 with which it is in direct through moving contact, hence reducing damage to patterns on the semiconductor dice 13.

The semiconductor pieces formed by fracturing the slice 11 remain attached to the foil 12 subsequent to fracturing, so that their position and orientation are maintained substantially as in the slice 11.

The elasticity of Genotherm 100 is such as to permit the stretching of the film 12 in the plane substantially parallel to the major surfaces of the slice 11, so as to separate in that plane from contact with one another the divided but unspaced dice 13 attached to the film 12. After inspection and marking of damaged dice, approved dice 13 are subsequently removed from the film 12 by means of a pick-up head or needle having a reduced pressure connection and further processed.

60 WHAT WE CLAIM IS:—

1. A roller arrangement suitable for fracturing into pieces a scored plate of material comprising first and second backing rollers, a smaller diameter working roller

of magnetic material which in use is situated between said backing rollers, the axes of rotation of the backing rollers and the working roller being substantially parallel, and magnetic means for subjecting the working roller to a magnetic field applied across said backing rollers to hold the working roller in rolling surface contact with said backing rollers.

2. A roller arrangement as claimed in Claim 1, wherein the backing rollers are of a magnetic material.

3. A roller arrangement as claimed in Claim 2, wherein the working roller and backing rollers are of hardened steel.

4. A roller arrangement as claimed in any of the preceding Claims, wherein the working roller and backing rollers are substantially cylindrical, the backing rollers each having substantially the same dimensions.

5. A roller arrangement as claimed in any of the preceding Claims, wherein the magnetic means comprise a permanent magnet, the magnetic axis of which is substantially perpendicular to the axis of rotation of the working roller and said backing rollers and lies substantially within a plane parallel to the plane in which are situated the axis of rotation of the backing rollers.

6. A roller arrangement as claimed in Claim 5, wherein the backing rollers and permanent magnet are mounted in a brass container, the backing rollers having journalled ends mounted in bearings in supporting blocks of the container, at least that part of the peripheral surface of the working roller most remote from the plane in which are situated the axes of rotation of the backing rollers extending beyond the brass container.

7. A roller arrangement as claimed in Claim 4, where appendant to Claim 2, wherein the first and second substantially cylindrical backing rollers of magnetic material are situated between the working roller and third, fourth and fifth substantially cylindrical backing rollers, which third, fourth and fifth backing rollers each have substantially the same dimensions as the first and second backing rollers, the axes of rotation of the working roller and the first, second, third, fourth and fifth backing rollers being substantially parallel, the first backing roller being situated between, and held by said magnetic field in rolling surface contact with, the third and fourth backing rollers, the second backing roller being situated between, and held by said magnetic field in rolling surface contact with, the fourth and fifth backing rollers.

8. A roller arrangement as claimed in any of the preceding Claims, wherein the diameter of the working roller is at most 2 mm.



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9. A roller arrangement substantially as herein described with reference to Figures 1 and 3 of the accompanying drawings.

10. A method of fracturing into pieces a plate of material having substantially parallel major surfaces and a plurality of score lines on one major surface extending along the plate substantially parallel to one another determining lines of fracture, in which relative motion is effected between a roller arrangement claimed in any of the preceding Claims and the opposite major surface of the plate in a direction substantially perpendicular to the score lines, and pressure applied such that the working roller exerts on the plate a bending moment which moves progressively along the plate whereby fracture across the plate substantially perpendicular to the major surfaces is effected by said bending moment along each score line in turn.

11. A method as claimed in Claim 10, wherein the plate of material comprises a semiconductor slice having two substantially orthogonal sets of substantially parallel score lines on the one major surface, fracture first is effected along one set of score lines, thereafter the plate is re-orientated through substantially 90° and fracture is effected along the other set of score lines.

12. A method as claimed in Claim 11, wherein the diameter of the working roller is at most 2 mm., and the distance between two parallel score lines is at most 350 microns.

13. A method as claimed in any of Claims 10 to 12, wherein the opposite major surface of the plate is attached to a sup-

porting film, which film during the fracturing of the plate is situated between the working roller and the plate, the pieces produced by fracturing the plate remaining attached to the film subsequent to the fracture so that their position and orientation are substantially maintained.

14. A method as claimed in Claim 13, wherein the opposite major surface of the plate is attached to the film prior to forming the score lines on the one major surface.

15. A method as claimed in Claim 13 or Claim 14, wherein the elasticity of the film is such as to permit the stretching of the film in a plane substantially parallel to the major surfaces of the plate so as to separate in that plane from contact with one another the pieces attached to the film subsequent to the fracturing of the plate.

16. A method as claimed in any of Claims 13 to 15, wherein the film is of electrically insulating synthetic resin, the opposite major surface of the plate being attached thereto by electrostatic attraction.

17. A method of fracturing into pieces a plate of material substantially as herein described with reference to Figures 2 and 3 of the accompanying drawing.

18. Pieces when formed by a method claimed in any of Claims 10 to 17.

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