A method is for removing residue of plastic from metal parts of plastic packages of semiconductor devices, e.g., heat-sinks and terminals. The surfaces to be treated are subjected to pulsed laser radiation. The wavelength is chosen in such a way that residue of plastic in thin films have good transparency to the radiation, and the metal has a high absorption capacity with respect to the radiation. Moreover, the intensity and duration of application of the radiation causes the formation of plasma at the point of impact of the radiation with the surface to be treated.
METHOD FOR REMOVING MOLDING RESIDUES IN THE FABRICATION OF PLASTIC PACKAGES FOR SEMICONDUCTOR DEVICES

FIELD OF THE INVENTION

[0001] The present invention relates to the fabrication of semiconductor devices and, more particularly, to a method for removing residue molding material from metal parts of plastic packages for semiconductor devices.

BACKGROUND OF THE INVENTION

[0002] As is known, many semiconductor power devices (e.g., discrete transistors, integrated circuits) are contained in packages including a plastic body with terminal conductors protruding from the plastic body, and a metal plate. The function of the metal plate is to dissipate heat produced by the device during its operation. Also, the metal plate promotes the transfer of heat to the exterior, and it is usually mounted in contact with a flat surface of an external sink of large dimensions.

[0003] For the fabrication of a device of this type, a chip of semiconductor material is fixed to the metal plate which acts as a heat-sink. A metal frame is then mounted on the plate electrically insulated therefrom. The frame, obtained by stamping from sheet metal, comprises metal strips which will become the terminals of the device, and interconnection bars between the strips. Thin wires are soldered to appropriate areas of the chip and to the ends of the metal strips. The resulting structure is mounted, together with other identical structures, in a special mold with one face of the heat-sink in contact with a flat surface of the mold.

[0004] Next, a plastic, such as a thermosetting epoxy resin, is introduced in the liquid state into the mold. After polymerization of the resin, a body of solid plastic is extracted from the mold. This body encloses the whole structure, with the exception of a surface of the heat-sink that has remained in contact with the flat surface of the mold. Also not enclosed are parts of the metal strips and of the interconnection bars between them. These latter items are cut off in a subsequent manufacturing phase.

[0005] During the molding operation, in many cases, the liquid-state resin penetrates between the heat-sink and mold on account of small irregularities in the surfaces in contact. This is due, for example, to a slight curvature of the heat-sink, or to the wearing of the mold. Therefore, after extraction from the mold, the package may exhibit residue of molding material, i.e., of cured resin, on the heat-sink. Similar infiltrations may occur on the metal strips with the consequent formation of residue on these also, especially near the plastic body.

[0006] The residue of plastic on the heat-sink has to be removed since it would otherwise reduce the surface of contact with an external sink, or with a metal plate of a printed circuit to which the heat-sink is to be soldered. The residue on the terminals also has to be eliminated since it impedes the cutting off of the interconnection bars and the subsequent operation of bending the terminals.

[0007] Various methods for removing such residue of molding material are known. For example, electrical or chemical treatments are known which can be used with advantage on the terminals, but which do not lend themselves to being used on the heat-sinks. Sandblasting treatments are also known which enable even thick residue to be removed from the heat-sink and from the terminals. But, because of their very energetic mechanical action, they do not lend themselves to being used in the treatment of plastic packages of small dimensions with very thin and very closely spaced terminals.

SUMMARY OF THE INVENTION

[0008] An object of the present invention is to provide a method for removing residue of molding material from metal parts of plastic packages which does not mechanically stress the parts to be treated and can therefore also be used in the treatment of plastic packages with thin terminals.

[0009] The present invention uses laser radiation, i.e., coherent monochromatic radiation, for the controlled application of high-intensity energy. Although the use of lasers in the treatment of materials and in industrial manufacture has been known for some time, it has not before been contemplated with respect to the removal of residue of molding material from plastic packages. This is probably because it was deemed unsuitable for the purpose. Indeed, direct application of laser radiation to the residue to be removed is problematic on account of the difficulty of controlling the action of a laser pulse with the necessary accuracy to act only on the heat-sink or only on its terminals, i.e., without also attacking the plastic body.

[0010] The method according to the invention does not require great accuracy or location of the laser beam since the effect which causes the removal of the residues is due basically to an alteration of the surface state of the metal part due to the radiation. The attack on the molding material is selective and limited essentially to the residue remaining on the metal part.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The invention and the advantages which derive therefrom will become clear from the following description of an illustrative and hence non-limiting implementation thereof, given in conjunction with the attached drawings, in which:

[0012] FIG. 1 is a perspective view of a plastic package as it appears after molding; and

[0013] FIG. 2 shows a cross-section of the plastic package of FIG. 1, and illustrates an apparatus for practicing the method of the invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] The package represented in the drawings comprises a body 10 made of plastic. For example, an epoxy resin with carbon particles as an additive. The package also comprises a plurality of terminal conductors 11, made of copper or nickel-plated copper, for example, and a metal plate, made of copper or nickel-plated copper, for example, whose function is to dissipate heat and to support a chip of semiconductor material. The latter is not visible since it is completely enclosed within the plastic body.

[0015] The terminals 11 are joined together by interconnection bars 13 intended to be eliminated by a subsequent
cutting operation. Normally, in this manufacturing phase, the terminals 11 of the package are linked to the terminals of other packages formed by the same operation and the same mold, and are separated only in the subsequent cutting operation. However, so as not to needlessly complicate the drawing, the terminals of a single package are represented. For the same reason, a package with ten terminals only has been represented. In many practical cases, there are many more terminals. For example, a typical package, having a width of 12 mm, a length of 15 mm and a height of 3 mm, has 36 terminals arranged in two rows of 18 terminals, each terminal being 0.3 mm wide and 0.25 mm thick.

[0016] Residue 14 of plastic due to the infiltration of resin in the liquid state during molding are shown on the face of the heat-sink 12 which is intended to be mounted in contact with a flat metal element. These residues take the form of more or less thin films of material. Since the carbon particles added to the resin usually have, for the most part, dimensions greater than 10 μm, and when the film is very thin, i.e., less than 10 μm thick, the carbon particles are practically absent and the film is almost transparent to visible light. Residues 14 are shown also on some terminals near the body 10.

[0017] In FIG. 2, the package of FIG. 1 is represented in a side view, with the plastic residues 14 shown with a deliberately exaggerated thickness. The apparatus for removing the residue of plastic 14 include a laser 20, a block 21 for frequency conversion and for splitting and deflecting the laser pulses, an optical scanning device 22, and a synchronization unit 23.

[0018] In one embodiment of the invention, the laser 20 is of the neodymium YAG type consisting basically of a neodymium-doped yttrium and aluminium crystal in the form of a rod furnished with mirrors at its ends. The laser 20 provides an output pulse having a wavelength of 1,064 nm (infrared light). Pulse durations are between 6 and 8 ns and have an energy of approximately 800 mJoules per pulse. The pulse repetition frequency is around 30 Hz. The output pulses from the laser 20 are applied to a frequency converter 21a, including a KH₂PO₄ (deuterated potassium dihydrogen phosphate) crystal. With a conversion efficiency of around 30-35%, the frequency converter 21a provides an output pulse with double the frequency of an input pulse. In other words, the wavelength is reduced one-half, i.e., from 1,064 nm (infrared light) to 532 nm (green visible light). A dichroic mirror 21b separates the double frequency pulse from the residual pulse at the output of the laser, by diverting it onto a mirror 21c which, in turn, diverts it to the scanning device 22. The latter includes an optical system capable of controllably directing the 532 nm laser pulse onto predetermined areas of the surface to be treated. In this example, the regions of the heat-sink 12 covered with residue 14 of plastic are to be treated. The synchronization unit 23 synchronizes the emission of the laser pulses with the scanning.

[0019] With the operating conditions indicated above, epoxy resin films thinner than 10 μm exhibit a transparency of around 20% and the metal used for the heat-sink (copper) exhibits an absorption of around 50%. The laser pulse has such an intensity, i.e., an energy per unit area, so as to cause the formation of plasma with each pulse. The plasma originates from the transformation of the metal atoms and metal oxide atoms located on the surface of the item to be treated (e.g., heat-sink) using high-intensity radiation. The formation of plasma is associated with vaporization of at least part of the residue 14 material present on the impact surface in a circular area of around 2 mm in diameter. The radiation also has an effect of direct attack on the resin, and particularly on residues of thickness equal to or greater than 10 μm which are able to absorb the radiation to a large extent.

[0020] Since the degree of removal of material is dependent on the energy absorbed at the point of impact, the duration of application of the radiation, i.e., the number of pulses applied per unit area, is calculated as a function of the thickness of the residues to be eliminated. Thin plastic films (1-10 μm) are eliminated with a single pass of the pulse in successive steps of 1 mm. Thicker residues (10-25 μm) require from 2 to 4 passes. The heating up of the heat-sink is negligible.

[0021] The direct action of the laser pulse on the plastic surfaces of the plastic body struck by the pulse on account of being immediately adjacent to the heat-sink are negligible. Therefore, accurate control of the scan area is not necessary. Indeed, with the method according to the invention, the physical phenomenon for determining the removal of molding material through vaporization caused by the formation of plasma on the metal surface owing to the strong absorption of energy by the metal has a greater effect than direct attack due to the pulse incident on the molding material.

[0022] Clearly, the method of the invention lends itself equally well to the removal of the residues of plastic from the terminals. It should be noted that this method is used to treat the heat-sink and when used to treat the terminals, does not cause any significant mechanical stress on the terminals. In other words, they do not suffer any deformation in this phase of manufacture.

[0023] Whereas a single realization of the invention has been illustrated and described, it is clear that numerous variations and modifications are possible within the scope of the same inventive concept. For example, it is possible to use laser devices of a different type to that described above, such as a krypton fluoride excimer laser which irradiates with pulses 25 ns wide with a wavelength of 248 nm (ultraviolet). Other types of pulsed laser are acceptable, preferably with a wavelength of between 180 and 700 nm and with pulses of between 3 and 30 ns wide.

That which is claimed is:

1. Method for removing residues of molding material from metal parts of plastic packages of semiconductor devices, characterized in that at least one surface region of a metal part (12) covered with residues (14) of molding material is subjected to pulsed laser radiation, the wavelength of which is chosen in such a way that the molding material, when it forms residues of a thickness less than a predetermined value, is at least partially transparent to the radiation and in that the metal parts are at least partially absorbent in respect of the radiation, the intensity of the radiation and the duration of application of the radiation being chosen in such a way that the radiation causes the formation of plasma at the point of impact with the said surface region.
2. Method according to claim 1, in which the wavelength of the laser radiation is chosen also in such a way that the molding material, when it forms residues (14) of a thickness equal to or greater than the said predetermined value, is able to absorb the radiation to a large extent, the intensity of the radiation and the duration of application of the radiation being moreover chosen in such a way that the radiation causes a direct attack of the molding material.

3. Method according to claim 1 or 2, in which the laser radiation has a wavelength of between 180 and 700 nm.

4. Method according to any one of the preceding claims, in which the pulses of the laser radiation have a duration of between 3 and 30 ns.

5. Method according to any one of the preceding claims, in which the operation of subjecting to laser radiation at least one surface region of a metal part comprises a scanning of the laser radiation over the surface region and the duration of application of the radiation is determined by the number of radiation pulses applied per unit area.

6. Method according to claim 5, in which the scanning motion is synchronized with the emission of the pulses.

7. Method according to any one of the preceding claims, used in the fabrication of plastic packages with metal parts (11, 12), in which the molding material is an epoxy resin with carbon particles as additive.

8. Method according to claim 7, in which the carbon particles have for the most part dimensions greater than 10 \( \mu \text{m} \) and in which the said predetermined value of the thickness of the molding material is around 10 \( \mu \text{m} \).

9. Method according to any one of the preceding claims, in which the metal parts (11, 12) comprise copper parts.

10. Method according to any one of the preceding claims, in which the metal parts comprise nickel-plated copper parts.

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