Description

The present invention relates to a method of forming passivation films which serve to protect circuits and/or circuit elements on semiconductors and IC (integrated circuit) chip surfaces. In particular, the present invention relates to a method of forming films that feature extremely high levels of reliability and production rate and which are suitable for use as passivation films on high-integration chips incorporated in LSIs (large-scale integrated circuits), VLSIs (very large-scale integrated circuits) and microcomputers.

In the fabrication of semiconductor devices, in particular resin-molded semiconductor devices, inorganic passivating films are deposited to protect circuits on semiconductor chip surfaces from handling and contamination during processing. Such passivating films are typically made of phosphosilicate glasses (PSG) or silicon nitride (Si_3N_4) in single layers or in two stacked layers of PSG and Si_3N_4.

In conventional IC fabrication, a prepared wafer provided with the necessary circuit or circuit elements on the surface is subsequently protected by a thin passivating film which is formed of PSG or Si_3N_4 or a laminate thereof by sputtering or other suitable film-deposition techniques. In these cases, the bonding pads which should not be covered would also be covered with the passivating film. Therefore, in order to open windows in the areas corresponding to the bonding pads, a photoresist is applied to the same wafer, which, after pre-baking, is positioned on an aligner and the areas above the windows are exposed to ultraviolet radiation (if the resist is positive-working) to make them more soluble than unexposed area. Thereafter, the resist on the windows is solubilized and stripped by an etching solution and the thin PSG or Si_3N_4 film is removed by dry plasma etching. In addition, the resist remaining in the areas other than those on the windows is solubilized and stripped by a rinse solution, forming the desired inorganic passivation film, such as PSG and/or Si_3N_4.

But, the integrity of the so formed passivation film is not complete in the strict sense of the term because upon closer examination it has pinholes and/or microcracks at stepped portions. In order to increase its reliability, the passivation film is usually covered with an organic thin film. However, if this is done by spin coating as a step in wafer preparation, windows must also be opened in the areas corresponding to bonding pads and procedures which are essentially the same as those employed after the formation of the inorganic passivating film must be repeated: application of a polyimide (PI), silicone or epoxy varnish by spin coating; baking; application of a photoresist (by spin coating) and pre-baking; setting on an aligner for aligning purposes; and exposure to ultraviolet radiation (in the areas of the windows such as for bonding pads if the photoresist is positive-working) so as to make the selected areas more soluble than the other areas. Subsequently, the unwanted areas of the photoresist are solubilized and stripped by an etching solution. The etchant also serves to open windows in the overlying organic passivation film made of PI or silicone or epoxy varnish. The remaining resist film is solubilized and removed by a rinse solution, then the organic passivation film forming the desired overcoat is subjected to post-baking until it hardens completely. These procedures complete the formation of the overall passivating film.

Being formed by the method described above, the conventional passivating film has pinholes and microcracks at stepped portions. In addition, the thin inorganic passivation film is so brittle that cracks will easily develop upon receiving mechanical shock during assembly of parts or mechanical or thermal stresses during packaging with molding resins. This has been one of the major causes of lowered reliability of the final product.

As already mentioned, the reliability of the thin inorganic passivation film can be increased by protecting it with an organic thin film which is made from PI, silicon, expoxy or silicon ladder polymer by spin coating, screen printing, potting or any other suitable techniques. However, these approaches still involve such complicated and numerous steps that not only huge capital investment is required but a considerable drop also occurs in the production rate. In addition, the chance of wafer or chip damage during materials handling or dirt or dust buildup or subsequent fouling of the device is increased and this is another factor that causes lower reliability and yields.

The Japanese Patent Public Disclosure No. 56-27936 discloses a process for manufacturing a semiconductor device in which a PSG film is coated on the whole surface of a silicon substrate including the surface of a wiring layer. A positive type photo-resist film having openings for bonding pad portions is formed on the PSG film which is then selectively removed by using the photo-resist film as a mask. The photo-resist film is heated and polymerized at 400-480 °C at an atmosphere of N_2 to form a vitrified photo-resist film.

The present invention has been accomplished in order to eliminate the aforementioned problems of the prior art techniques and the primary object of the invention is to provide an efficient and cost-effective method of forming a passivation film which has such a high level of reliability that it can be satisfactorily employed in the fabrication of LSIs and VLSIs by application of most modern micromachining technology.

In accordance with the method of the present invention, the resist film which is used in patterning is employed as part of the passivating film. By so doing, a strong passivation film is formed and not only is the process of its formation simplified to provide higher productivity but also the reliability of the passivation film is improved.

The major advantages of the method of the present invention are that it solves all the problems of the prior art methods of forming a passivation film and that the passivating film formed by this method is comparable to that of the film protected by a thin organic overcoat. According to the most basic feature of the method of the present invention, the resist film which is used for patterning purposes is left intact. This method solves all of the problems encountered in the prior art techniques, such as low productivity and poor reliability and yields due to wafer or chip damage or subsequent fouling of the device. In addition, the running cost and capital investment which are necessary for implementing the method are very low.

Materials which may be used with particular advantage in the present invention instead of the conventional resist materials are those which can be patterned and which have such desirable properties as high resistance to heat and moisture, good mechanical properties, high purity and good adhesion to wafers, chips and molding resins. Examples of such preferable materials are light-sensitive silicon resins, epoxy resins and silicon ladder polymers.

The passivation film formed by the method of the present invention may be coated thereon with a variety of thin organic films as in the prior art techniques. In order to fabricate a resin-molded semiconductor device having increased reliability, the windows on bonding pads are commonly closed by potting the device with an organic material such as a silicone resin after wire bonding. The superiority of the present invention in terms of productivity and cost will not be lost even if it is applied to the fabrication of such resin-molded semiconductor devices because the method does not involve any step of stripping the initially applied resist film.

Examples

The advantages of the present invention will become more apparent by reading the following examples and comparative examples in conjunction with Table 1 which shows the results of evaluation of resistance to moisture and heat cycling with respect to the passivation films formed by the method of the present invention and those formed by conventional techniques.

In Examples 1 and 2,a number of passivation films containing the lower Si_3N_4 layer were formed by performing all the steps in the method of the present invention using a positive-acting resist, OFPR-800 (product of Tokyo Ohka Kogyo Co., Ltd.; Example 1), or a light-sensitive silicon ladder polymer (Example 2). The so formed passivation films were applied to 64 K (D) RAM memory chips, from which resin-molded semiconductor devices were fabricated. The moisture resistance of the devices was evaluated in a pressure cooker test (PCT) which was conducted at 121 °C, 2 atm. pressure and 100 % R.H. The devices were also subjected to a heat cycling test wherein one cycle consisted of cooling at -65 °C x 30 minutes and heating at 150 °C x 30 minutes.

In Comparative Example 1, a 64 K (D) RAM memory chip having a Si_3N_4 passivation film was prepared using a conventional photoresist. The passivation film had windows opened for bonding pads. In Comparative Example 2, the chip of Comparative Example 1 was mounted on a lead frame, wire-bonded, potted with a silicone resin and overlaid with a thin silicone film having a thickness of about 10 µm. Both chips were molded in a resin which was of the same type as used in the fabrication of semiconductor devices in Examples 1 and 2. The so molded semiconductor devices were subjected to tests for evaluating their resistance to moisture and heat cycling as in Examples 1 and 2.

Table 1

Run No.	Moisture resistance	Resistance to heat cycling
	Failure rate (%) after 3,000 hours (n = 100)	Failure rate (%) after 2,000 cycles (n = 200)
Example 1	11	2
Example 2	6	7
Comparative Example 1	57	19
Comparative Example 2	28	63

Table 1 shows that the semiconductor devices fabricated by employing the method of the present invention for forming a passivation film had much better resistance to moisture and heat cycling than the products obtained by using the conventional techniques. It is obvious that the present invention contributes to the streamlining of the overall process of fabricating semiconductor devices, thereby attaining the advantages of higher productivity, lower cost, faster access and lower capital investment.

The materials that can be used in the present invention are in no sense limited to those employed in Examples 1 and 2 and it should be understood that even fully inorganic materials may be used so long as they fit the process and object of the present invention.

Claims

1. A method of forming a passivation film on a circuit and/or circuit elements formed on the surface of a semi-conductor ship, wherein the resist film used in patterning the passivation film is employed as part of said passivation film, and wherein the upper layer of said passivation film is made of a material selected from the group consisting of a light-sensitive silicone resin, epoxy and silicone ladder polymer.

2. A method according to claim 1 wherein the semiconductor ship having the passivation film is mounted on a lead frame, wire-bonded and then entirely reinforced inclusive of all windows opened in said passivation film.

Revendications

1. Procédé pour former un film de passivation sur un circuit et/ou des éléments de circuit formés à la surface d'une microplaquette de semi-conducteur, dans lequel on emploie le film de résist utilisé pour configurer le film de passivation comme partie intégrante dudit film de passivation, et dans lequel la couche supérieure dudit film de passivation est composée d'un matériau choisi dans le groupe constitué par une résine de silicone photosensible, une résine époxy et un polymère échelle de silicone.

2. Procédé selon la revendication 1, dans lequel on monte la pastille de semi-conducteur sur laquelle se trouve le film de passivation sur un cadre en plomb, on connecte ses circuits et on la renforce ensuite complètement, y compris toutes les ouvertures pratiquées dans ledit film de passivation.

Patentansprüche

1. Verfahren zum Bilden eines Passivierungsfilms auf einer Schaltung und/oder Schaltungselementen, die auf der Oberfläche eines Halbleiterchips gebildet sind, dadurch gekennzeichnet, daß der beim Bemustern des Passivierungsfilms verwendete Abdeckfilm als Teil des Passivierungsfilms benutzt wird und daß die obere Lage des Passivierungsfilms aus einem Material hergestellt wird, das aus der Gruppe ausgewählt wurde, die aus einem lichtempfindlichen Silikonharz, Epoxy- und Silikonleiterpolymer besteht.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß der Halbleiterchip mit dem Passivierungsfilm auf eine Leiterplatte montiert, drahtgebondet und dann zur Gänze verstärkt wird einschließlich aller im Passivierungsfilm geöffneter Fenster.

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