(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 714 773 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
05.06.1996 Bulletin 1996/23

(51) Int Cl.[6]: **B41J 2/16**

(21) Application number: **95308614.7**

(22) Date of filing: **29.11.1995**

(84) Designated Contracting States:
DE FR GB

(30) Priority: **01.12.1994 US 347634**

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(54) Bonding process for ink jet silicon chips

(57) A process for bonding an ink jet silicon chip to the pen body of an ink jet printer by first coating the chip with a silane adhesion promoter, then a high temperature curing epoxy in a very thin layer, and finally attaching the coated chip to the pen body with a low temperature curing epoxy.

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Description

FIELD OF THE INVENTION

The present invention is concerned with a process for bonding a silicon chip to the pen body of an ink jet printer.

BACKGROUND OF THE INVENTION

Modern ink jet printing has placed many unprecedented demands upon materials and processes for assembling them. The present invention is concerned with a solution for one such demand, namely a process for bonding the silicon chip to the pen body of the ink jet printer.

The bond between the ink jet silicon chip and the pen body of the ink jet printer is subject to very severe attack, especially because in usage the temperature is very high and the bond is exposed to aqueous-base liquid inks commonly containing organic cosolvents and also having very high (alkaline) pH. Not only does the bond have to serve to attach the chip to the pen body, but it also has to form a leak resistant bond around the chip to prevent ink transfer to the user.

The bonding material also must be such that it does not change the properties of the ink used in the system, and in modern color printers three different inks are commonly used. Additionally, the cure temperature of the adhesive material must be below the glass transition temperature of the plastic which forms the pen body. To build a multicolor ink jet pen, the vias in the chip must be separated, generally by an adhesive, which serves as a barrier or sealant around each via to prevent ink mixing. Furthermore, the adhesive must serve as a gasket around the chip to prevent ink mixing. Furthermore, the adhesive must serve as a gasket around the chip to prevent inks from leaking to outside the body. Increasingly closer via spacing to provide ever-higher dots-per-inch (dpi) print resolution puts extreme demands on an adhesive to make a reliable bond in a very harsh environment.

A method for improving adhesion at the adhesive to silicon interface is necessary to prevent two failure possibilities. If an adhesive failure occurs at that interface, then the primary colors will flow freely, thereby resulting in ink mixing. Secondly, if the adhesive to chip interface fails at the perimeter, the ink will leak, and ink can be transferred to the user through routine handling. Both types of failures would be considered reliability failures.

DISCLOSURE OF THE INVENTION

The present invention solves the problems mentioned above. According to this invention, the silicon chip is first covered with a thin coating of a silane coupling agent. This coating is applied on the side of the chip that does not contain the electronic circuitry. The coating of the silane coupling agent is in turn coated with a thin (about 0.5 to about 5.0 microns) layer of an epoxy resin, which is then cured at a temperature of about 175°C.

In a preferred mode of carrying out the present invention, the above steps are carried out on a multi-chip silicon wafer, which can then be subjected to subsequent manufacturing operations. Hundreds of chips can be treated on a single silicon wafer.

In the final step of the process of the present invention, the chip is attached to the pen body using an epoxy which cures at a temperature of 100°C or less.

DESCRIPTION OF THE DRAWINGS

Understanding of the invention will be facilitated by reference to the accompanying drawings.

Figure 1 is a cross-sectional view, not to scale, of a coated silicon wafer.

Figure 2 is a cross-sectional view, not to scale, of an ink jet print head chip and pen portion.

In Figure 1, 1 is a silicon wafer; 2 is the circuitry on one side of the wafer; 3 is a layer of adhesion promoter; and 4 is a layer of epoxy resin.

In Figure 2, 1 is the pen body of the ink jet printer nozzle; 2 is the ink jet silicon chip; 3 is an acrylate based polymer thick film; 4 is the nozzle plate; 5 is a layer of rapid/low temperature cure epoxy adhesive; 6 is two thin layers, one of adhesion promoter and one of an epoxy resin; and 7 is the ink via.

BEST MODE EXAMPLE

A preferred silane coupling agent is Dow Corning Z6032, a vinylbenzylamine functional silane. The commercial material is prehydrolyzed by adding 5% water by weight to the silane solution. It is then diluted to a 1% functional silane solution using ethanol. This solution is spread on the non-circuitry bearing side of the stationary silicon wafer and allowed to sit for 20-30 seconds. The wafer is then spun for 45 seconds at 2,000 RPM to remove the excess and dry the wafer surface.

A preferred high temperature cure epoxy is a tertiary amine cured compound such as Ablebond 968, from the Ablestik Co. This material is used without filler. It is first diluted with gamma butyrolactone in a 1 to 1 ratio. Approximately 2 mL of this solution is deposited in the center of the wafer after the silane has been deposited. The wafer is spun at 2,500 RPM for 45 seconds. This results in a uniform film of epoxy approximately 0.8 microns thick on the wafer. The wafer is then baked for 2 hours at 175°C to cure the epoxy.

Finally, the wafer is cut into individual chips, which are attached to the pen body by means of a polybenzimidazole low temperature curing epoxy, such as Emerson-Cuming LA3032-78, an epoxy which is cured at about 100°C.

For inkjet pen products, as they are consumable (often disposable) products, the manufacturing processes must incorporate low cost material that can be manufactured at high throughputs. Pen bodies are most commonly injection molded thermoplastic materials such as modified polyphenylene oxide (PPO). The elevated temperature resistance of such material sets a maximum cure temperature allowable for subsequent processes, such as attachment of the inkjet chip and nozzle assembly to the body.

Materials are available that cure in the 100°C or less range, and in short times, and that are resistant to ink formulations in bulk exposure. However, premature adhesion failures at the silicon to diebond adhesive interface are commonly observed. By applying the silane/ultrathin epoxy layer at an early stage of manufacture, (at the wafer level) hundreds of chips are coated and protected simultaneously. At this stage high purity, highly stoichiometric epoxies can be thoroughly cross-linked at the higher temperature (at least 175°C resulting in a much better attachment to the silane/silicon die). A method of enhancement of product life is then achieved while maintaining throughput economically.

The process of the present invention is characterized by the use of two different epoxy resins, the first of which cures at a temperature above the heat distortion temperature of the plastic pen body, and the second of which cures at a temperature below the heat distortion temperature of the plastic pen body. When attached to the pen body, the chips have an ink via extending into the chips bounded by the coupling agent, the first epoxy resin and the second epoxy resin.

Other features of this invention are the following: Insensitivity to manufacturing line interruption/processes (as a silane alone would be), and the ultrathin usage provides minimal thermal barrier addition to heat removal from the die.

Claims

1. A process for bonding an ink jet silicon chip to the plastic pen body of an ink jet printer, said process comprising the steps of:

1) applying to the non-circuitry containing side of said chip a thin coating of a silane coupling agent;
2) applying on top of said coupling agent a thin coating of a first epoxy resin;
3) curing said first epoxy resin at a temperature above the heat distortion temperature of the plastic pen body;
4) attaching the coated chip to the plastic pen body by means of a second epoxy resin which is cured at a temperature below the heat distortion temperature of the plastic pen body

2. A process for bonding an ink jet silicon chip to the pen body of an ink jet printer, said process comprising the steps:

1) applying to the non-circuitry containing side of said chip a thin coating of a silane coupling agent;
2) applying on top of said coupling agent a thin coating of a first epoxy resin;
3) curing said first epoxy resin at a temperature of about 175°C; and
4) attaching the coated chip to the pen body by means of a second epoxy resin which is cured at a temperature of 100°C or less.

3. A process as claimed in claim 1 wherein the thin coating of the silane coupling agent and the thin coating of the first epoxy resin are each applied by a spinning process.

4. A process as claimed in claim 1 wherein the application of the thin coating of a silane coupling agent and the application of the thin coating of the first epoxy resin are carried out on a multi-chip silicon wafer.

5. A process as claimed in claim 1 wherein the thin coating of the first epoxy resin is about 0.5 to about 5.0 microns thick.

6. A process as claimed in claim 1 wherein the silane coupling agent is a vinylbenzylamine functional silane.

7. A process as claimed in any preceding claim wherein said chip, when attached to the pen body, has an ink via extending into said chip bounded by said coupling agent, said first epoxy resin and said second epoxy resin.

8. A process for bonding ink jet silicon chips to the pen body of an ink jet printer, said process comprising the steps:

1) spin coating the non-circuitry containing side of a multi-chip silicon wafer with a thin coating of a vinylbenzylamine functional silane;
2) spin coating said thin coating with a coating about 0.8 microns thick of a first epoxy resin;
3) curing said first epoxy resin at a temperature of about 175°C;
4) separating said multi-chip silicon wafer into individual chips; and
5) attaching said individual chips to the pen body by means of a second epoxy which is cured at a temperature of 100°C or less.

9. A process as claimed in claim 8 wherein the chips, when attached to the pen body, have an ink via extending into said chips bounded by said coupling agent, said first epoxy resin and said second epoxy resin.

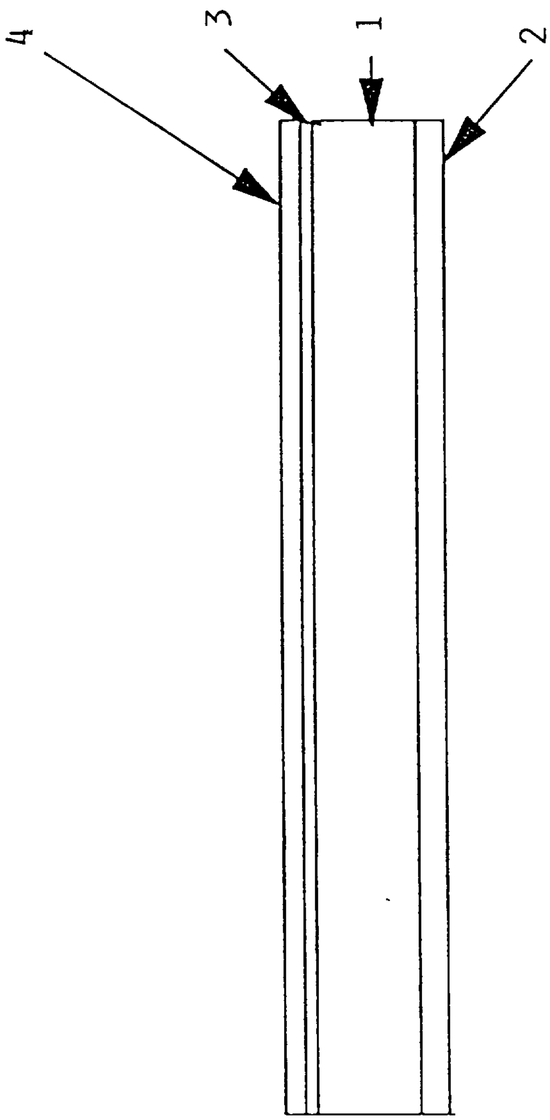

FIG. 1

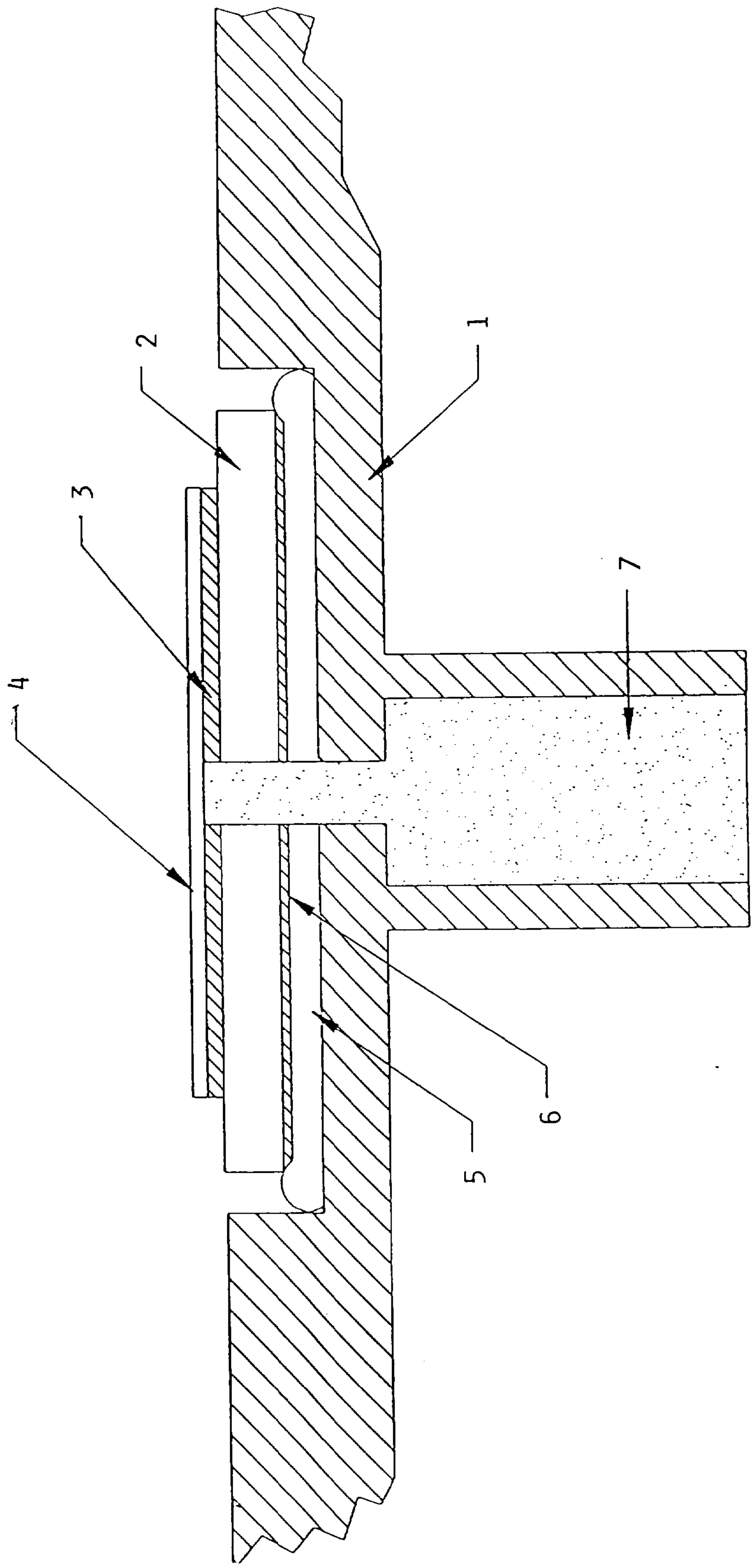

FIG. 2