Wafer Backside Coating Of Die Attach Adhesives New Method Simplifies Process, Saves Money

By Tony Winster, Craig Borkowski, and Alan Hobby

For decades the semiconductor industry has used adhesive pastes to attach die to leadframes and other substrates. Typically, adhesive has been dispensed through needles from syringes, or for smaller dots, applied by the pin-transfer method. Some manufacturers, notably in the automotive hybrid industry, have applied adhesive by screen printing.

What's the problem?

Actually, there are several problems.

Speed. In the highly competitive semiconductor industry, time is money. In some cases, dispensing adhesives may be a limiting factor in the production rate. If adhesive can be applied faster, then production lines run faster and costs can be reduced. In principle there are ways to speed up the dispense process, but none has made much impact thus far.

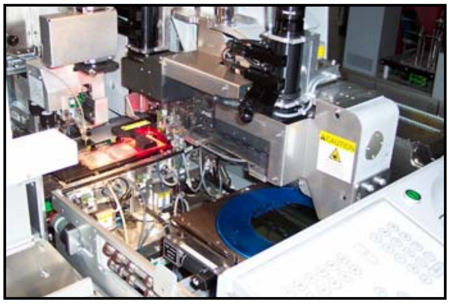

Figure 1. High-speed die bonder dispenses adhesive

Size. With traditional paste die attach, the adhesive forms a fillet around the chip. This is a useful visual indicator to confirm that sufficient adhesive has been applied. It also increases the die shear strength by supporting the side of the die. However, the fillet effectively increases the footprint area of the chip, which means that any packaging must be slightly larger than the die itself. This extra area can be quite substantial after adding the tolerances that account for variations in fillet size due to differences in paste volume, flow, and misplacement of paste and die. Since all paste adhesives are prone to resin bleed, space must be left to ensure that surrounding bond pads are not affected by excessive bleed.

Quality/Reliability. Placing a chip into a dot of adhesive paste is a delicate operation. The force and time must be controlled to ensure that the adhesive has completely covered the underside of the die, yet the force must not be so high that the adhesive is squeezed from the bondline. Level placement of the chip is also extremely important. Any residual tilt may hamper the wirebonding process or impact reliability by creating regions of high stress where the bondline is thinnest. In addition, any lack of control of the above parameters can impact short or long-term reliability.

What's Changed?

As designers try to make packages smaller and thinner, and as manufacturing plants try to reduce costs by speeding up assembly, all the above issues become increasingly important. Often solving one problem only makes another one worse. For example, die tilt variations may be solved with a higher specification die bonder, but this may not be cheaper or run at higher speed than the existing bonder.

Another trend is to place more than one chip inside a package. These can sit side by side, in which case determination of the proper adhesive will permit optimal spacing of the dice. Alternatively chips can be stacked on top of each other. Here the dice are usually very thin, and so tight control of fillet heights is essential to prevent adhesive from contaminating the die surface.

Clearly an alternative to traditional paste adhesive application would be attractive. One solution already in place is to use adhesive in the form of a dry film. This is supplied at a controlled thickness. It can either be punched into preforms or applied to the back of a silicon wafer before dicing into individual die. When each die is picked, it carries its own adhesive with it to the leadframe or substrate. Some heat and pressure are needed to attach the adhesive to the leadframe, but the adhesive remains sufficiently hard to prevent the formation of large fillets and to prevent any significant die tilt.

This approach is widely used in die-stacking applications, where cost is not yet a major factor. Unfortunately the cost of manufacturing and packaging a film is higher than a paste. Thus, this approach is difficult to implement in very high volume, cost-sensitive applications

What's the Solution?

One very practical solution is wafer backside coating (WBC). In WBC the adhesive is supplied as a specifically designed paste, which is applied to the back of a wafer and dried. This method leads to a number of extremely desirable practical advantages. These include:

- Paste is 20-30% cheaper than film
- Bondline thickness can be controlled to customer specs

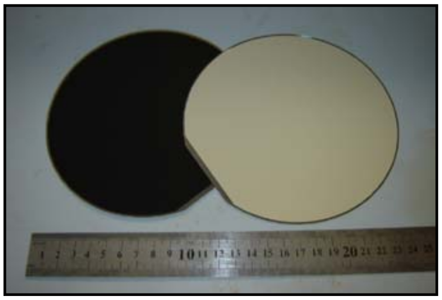

Figure 2. Screen or stencil printing can be used to coat the backside of semiconductor wafers in preparation for curing and subsequent die attach

- Fillet control is very similar to that of a film product
- Dispense operation is eliminated, which affords higher units per hour (UPH)
- Coated wafer can be stored until required

As shown below in Figure 3, the wafer can be attached to conventional dicing tape and diced with standard saws. The only modification that may be required to a standard die bonder is to fit a heater under the stage to ensure that the adhesive softens sufficiently to wet the surface.

What's Needed to Print the Adhesive?

The adhesive can be applied quickly using a screen-printing platform such as those used in surface-mount production lines to deposit solder pastes. The platforms are readily

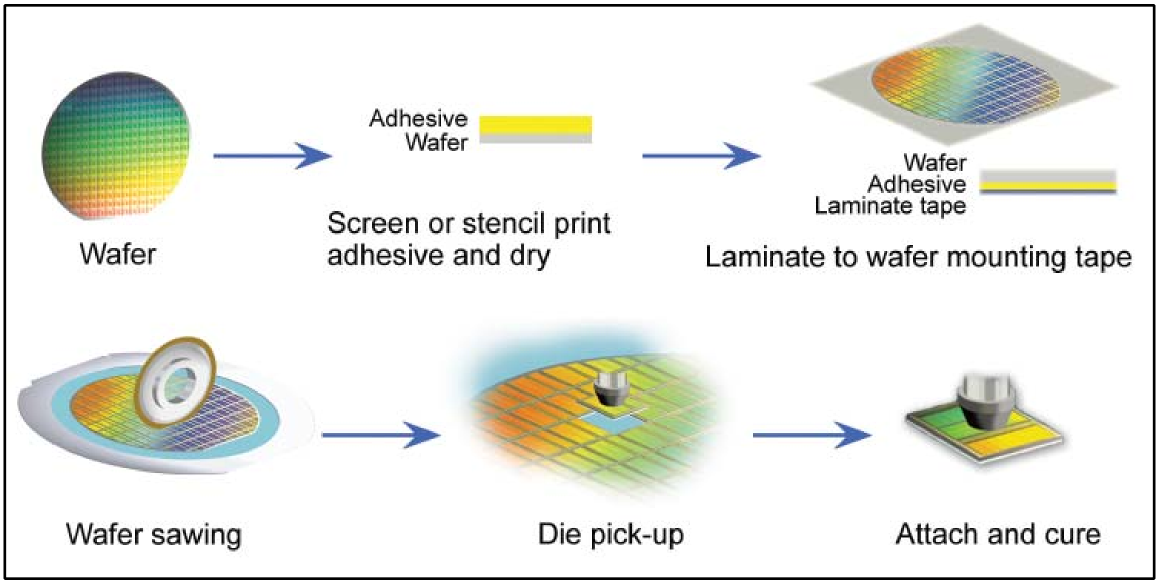

Figure 3. Schematic of WBC Process Route

Figure 4. Screen or stencil printer used in Wafer Backside Coating applications

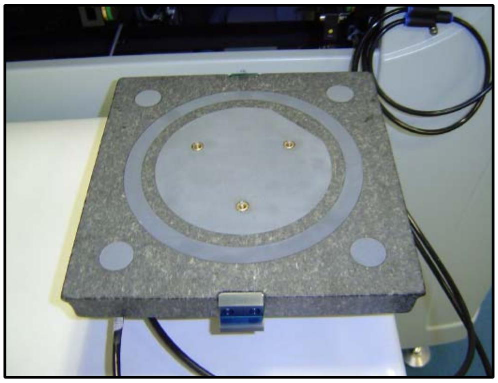

Figure 5. Wafer pallet featuring porous vacuum inserts

available at reasonable cost and deliver sufficient accuracy and repeatability to enable complete coverage of the wafer with minimal waste.

Using such a printer, a concentric adhesive layer can be deposited on the wafer backside with little variation in thickness. The entire process typically takes 10-15 seconds to complete, using a suitable combination of stencil and squeegee. An emulsion screen may provide a suitable alternative to a metal stencil, depending on the adhesive characteristics.

Automated wafer loaders/unloaders have also been developed to support wafer-level, screen/stencil printing processes. Available units are compatible with wafers in all standard sizes up to 300mm and larger. These integrate directly with standard wafer-storage formats such as JEDEC cassettes or front-opening universal pods, which are widely used throughout the semiconductor-processing industry. After unloading the coated wafer, it can be returned to the cassette/pod or transported directly into the curing oven. A typical loader/unloader uses industry-standard SMEMA protocols to communicate with related equipment.

The design and construction of suitable stencils have been adapted from technology developed in the surface-mount industry. Highly satisfactory results have been achieved using a stainless steel stencil with a single, large aperture. The effectiveness of stencils as thin as 37 microns has been achieved. A purpose-designed squeegee, which is very rigid to avoid scooping adhesive out of the aperture as it passes, produces a thin and uniform coating.

Modifications to the tooling and handling mechanisms of a standard printer enable wafer backside coating. These include tooling revisions to support extremely thin wafers. The wafer must remain very flat throughout the process in order to prevent excessive variations in the thickness of the adhesive layer. A pallet, having comparable flatness to a surface plate for metrology applications, is used to hold the wafer. A vacuum is applied to the wafer through porous ceramic inserts in the pallet to hold the wafer without incurring damage.

Non-contact measuring equipment can accurately measure the thickness of the adhesive layer, but is not suitable for rapid inspection of each wafer in a volume production environment. Thus, after calibrating the process using a profilometer, it is most practical to test samples at regular intervals during production.

Once correctly set up, there is no reason for the process to vary widely, since screen or stencil printing equipment and processes are very robust. A complete turnkey system, including printer, wafer handler, and inline oven costs about $320,000 and provides a throughput of 60-85 wafers per hour (UPH), based on the use of an 203 mm wafer.

What Are the Additional Benefits?

In addition to the solutions to the basic problems outlined above, WBC also affords additional benefits. These include:

- Reduction of paste adhesive volume by a factor of ten on die less than 0.5 x 0.5 mm by eliminating the fillet.
- Improved inventory control by concentrating the application of wet adhesive in a dedicated print area within the user’s facility. This also reduces the need for expensive engineering and safety controls where chemicals are being handled. In fact, it may be possible to print the adhesive at the wafer fab facility, thus eliminating the need to handle wet paste adhesives in the packaging or "back-end" facility.
- Additional inventory control advantages because only one paste formulation satisfies every need rather than the multiple thicknesses and widths currently necessary with films.

What Is the Status of WBC?

First generation WBC products are currently available in both electrically conductive and electrically insulating versions. Second generation materials with improved printability and thermal properties will be available this year. In parallel with materials development, improvements are being made in wafer handling to allow faster throughputs and to enable processing of thinner wafers. In fact, 150 mm wafers that are just 30 microns thick have been successfully coated. Thus, current indications are that, as the process is improved even further, wafer backside coating will take its place in the pantheon of standard semiconductor processing.

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