

## Dicing Through Hard and Brittle Materials in the Micro Electronic Industry

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A high percentage of micro electronics dicing applications require dicing completely through the substrate. While partial dicing is relatively easy, dicing through hard and brittle materials creates both mounting and quality problems. The following article discusses various mounting techniques and quality problems related to the dicing process. Recommendations are made to try solve these problems.

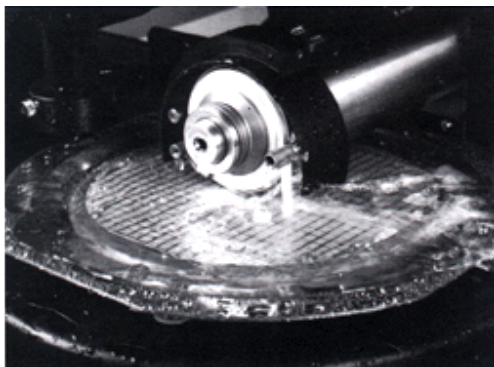
### Mounting Methods

The main methods employed in the industry include:

- Tape mounting
- Wax and adhesive mounting
- Wax and adhesive on carriers
- Mechanical fixturing

### Tape Mounting

This is the most common method being used for thin substrates (figure 1).



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Figure 1 - Silicon Wafer on Tape

Tape mounting is mainly implemented on production lines employing die bonding techniques after the dicing process. The tape serves as a carrier for both the dicing and the die bonding process.

Tape is used as a carrier in many applications. But the main applications are silicon wafers **.005" (0.127mm)** up to .025" (0.63mm) thick and hard alumina substrates .010" (0.25mm) up to .080" (2.03mm) thick. The most commonly used tape is a P.V.C. .003" (0.076mm) thick with a combination of P.V.C. sheet and an adhesive applied to the top side of the tape (figure 2). Thicker tapes are available, up to .010" (0.25mm). These tapes are designed for special applications, but they cannot be used on die bonding systems. This topic will be discussed in more detail later in this article).

Tapes are available with different adhesives or what is called "tackiness characteristics." The adhesion characteristics of the most common tapes are 215-315 gr/25mm.

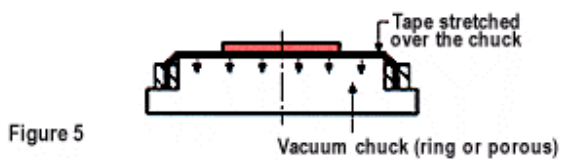
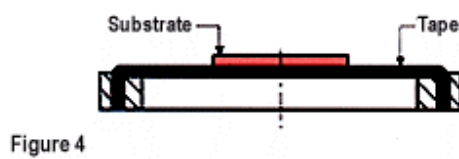
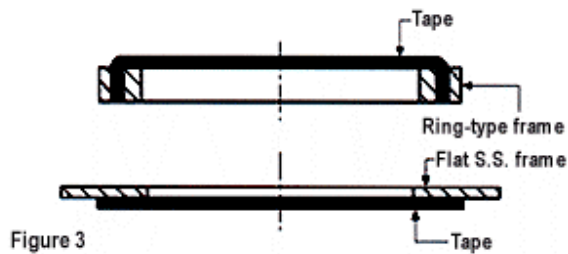
Every application should be optimized to determine exact tackiness requirements. If tackiness is "too low" it can result in losing dies in the dicing process. If it is "too high", it may cause problems in the die bonding process.

The following is a schematic flow of the process:

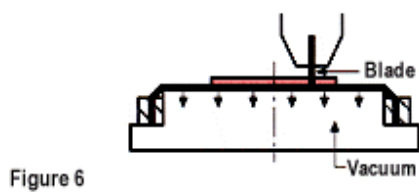
- a. Tape mounting to round frames (ring or flat type - figure 3).
- b. Substrate being mounted to the tape (figure 4). In some applications the tape is heated for five to ten minutes after the mounting to about 65°. This improves the adhesion.
- c. Frame is being mounted on the saw chuck (figure 5).



Figure 2



- d. Dicing through the substrate into the tape (figure 6).
- e. Expanding the tape after the dicing process to separate the die (figure 7).
- f. Die attaching on a die bonder (figure 8).



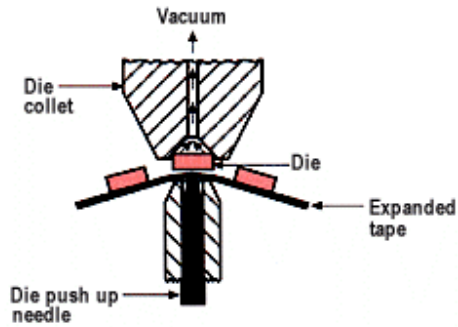


Figure 8

## **Tape Mounting in the Dicing Process - Related Problems and Recommendations**

For the purpose of discussion, we will focus on the most common substrates, silicon wafers and hard alumina substrate. Other substrates behave similarly.

**Problem A:** Loosening small die during dicing.

### ***Recommendations***

1. Reduce the feed rate.
2. Lower the cooling flow pressure.
3. Use a tape with better adhesion characteristics.
4. Improve mounting technique to eliminate air gaps between the substrate and the tape.
5. Optimize tape curing process (heating the tape) to improve wafer-to-tape adhesion.

**Problem B:** Chipping at the bottom of the die when using ring type vacuum chuck (figure 9).

1. Chipping at the contact between the wafer and the tape is a well known phenomena when using a ring type vacuum chuck (figure 10). The chipping results from internal stress created during the cutting process at the ring vacuum groves.

### Recommendations

Change the ring type chuck to a porous type chuck (figures 11, 12 and 13). The porous chuck will perform with a much more uniform vacuum clamping. This will eliminate the ring stress effect.

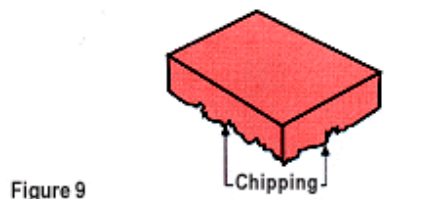


Figure 9

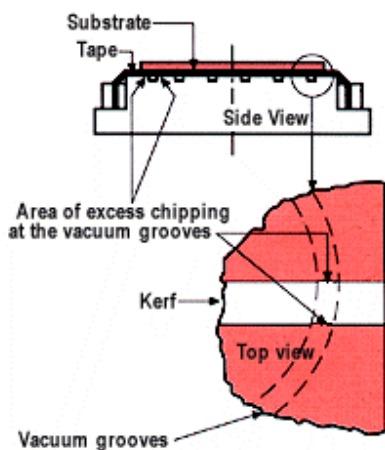


Figure 10

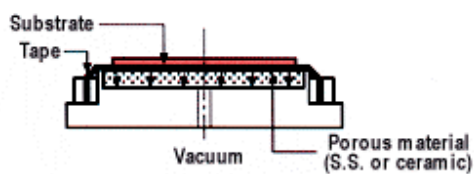


Figure 11



Figure 12 - Ring type chuck



Figure 13 - Porous type chuck

**Problem C:** Chipping and large cracks at the wafer contact with the tape (figure 14) not related to ring type vacuum chucks.

### ***Recommendations***

1. On silicon application using nickel type blades it is important to cut .001" - .0015" into the tape (figure 15). Cutting less than .001" into the tape can cause an overload situation because of contact between the blade edge and the tape adhesion. Overloading the cutting process will create high temperatures, resulting in excess to much chipping and cracking.
2. Improve your mounting technique to eliminate air gaps between the substrate and the tape.



3. On the hard alumina applications using resinoid blades, the chipping cracks phenomena at the contact point with the tap is caused mainly because of high blade wear (figure 16).

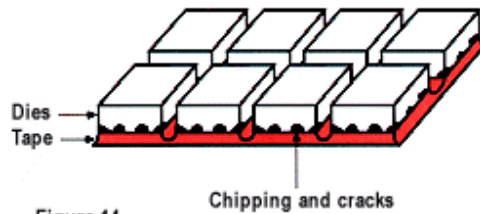


Figure 14

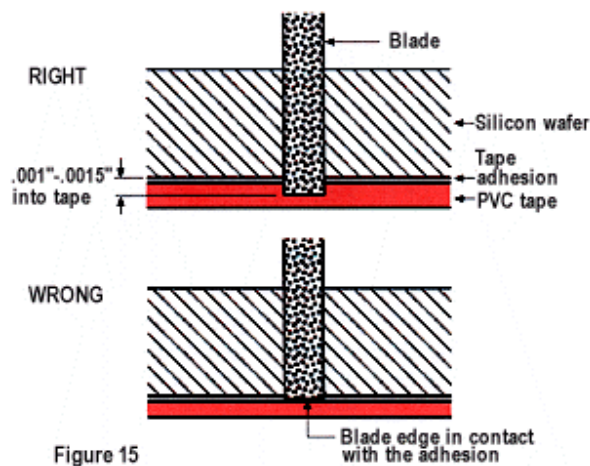


Figure 15

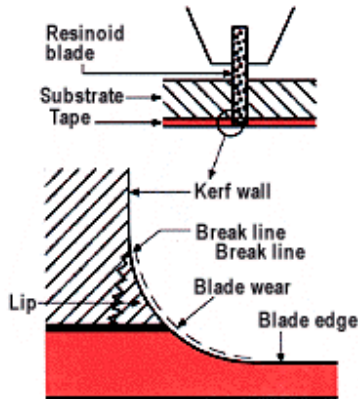


Figure 16

Blade wear occurs mainly at the blade edge corners, which become rounded. This causes a small lip on the substrate at the contact point with the tape. The lip breaks off the substrate during the cutting process or during die separating process.

Using a thicker tape and cutting deeper into the tape .005" to .010" will eliminate the lip effect, the die will have a straight edge and the round part of the blade edge will be inside the tape (figure 17).

Cutting with resinoid blades on thicker tapes is an improvement. But the operator still should check and compensate the blade wear to eliminate the lip effect. A good method to do this is by calibrating the cut depth with the HEIGHT SENSOR on the saw. A zero calibration button is an excellent feature available **on All ADT dicing saws** (figure 18).

The zero calibration button, located outside the cutting area, is programmable through the saw. This enables height calibrations after any number of cuts, without the need of taking the substrate off the saw.

4. Improve your mounting technique to eliminate air gaps between the substrate and the tape.
5. If possible, change the mounting process from tape to wax mounting. (Wax mounting will be discussed further later in this article.)



**Problem D:** Chipping and large cracks on the top of the substrate mainly at the die corners caused by die movement during the cutting process (figure 19).

### ***Recommendations***

1. Check the tape adhesion. If not strong enough change tape to a stronger adhesion. Or improve the tape handling process.
2. Slow the feed rate.
3. Check blade thickness and blade exposure. Using a thicker blade and a smaller exposure will minimize vibrations and improve the cut quality (figure 20).
4. Check the cooling nozzle alignment and the cooling flow pressure, make corrections if needed. \*
5. Dressing the blade might be an improvement. A new blade, or a blade after many linear inches of cutting, does not have sharp diamonds exposed, and could have powder residue between the diamonds. This will result in overloading the cutting process, and will cause chipping due to high temperatures. \*
6. If possible, change to a wax mounting process.

*\* Numbers 4 and 5 are not related directly to the tape mounting but should be checked before making any tape changes.*

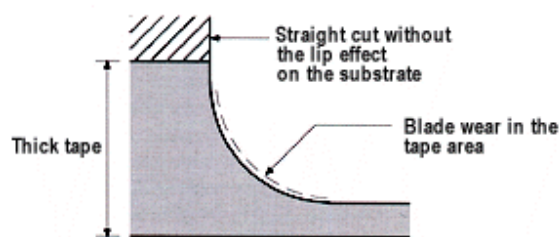


Figure 17

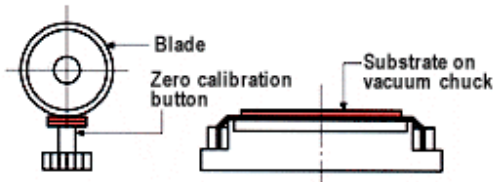


Figure 18

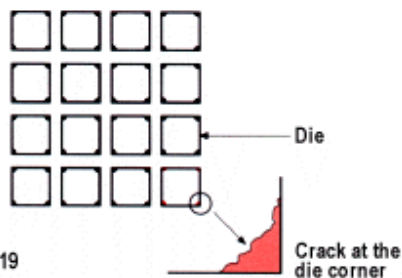


Figure 19

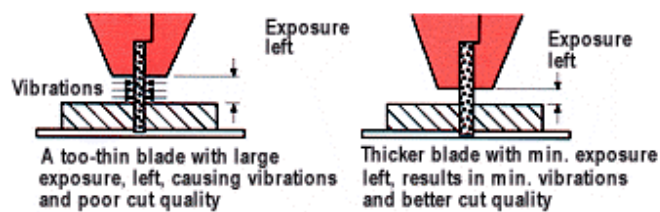


Figure 20

**Problem E:** Soft metalizations on the backside of the substrate are not diced completely through (figure 21). This problem is caused mainly by deflection of the soft metalization in the soft tape. Another problem related to the deflection is a peel-off effect of the metalization from the substrate.

### Recommendations

1. The best way to eliminate this effect is in the substrate design stage. The backside of the substrate should be designed with a pattern that will eliminate any soft metalization at the dicing area (figure 22).
2. A harder more rigid tape should be used to eliminate the deflection effect.

3. If possible, change to a wax mounting process. The substrate is mounted with wax to a solid glass or lava (or others), which eliminates the deflection effect during the process (figure 23).

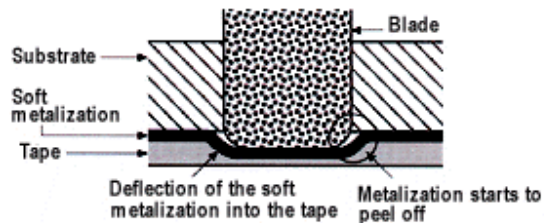


Figure 21



Figure 22

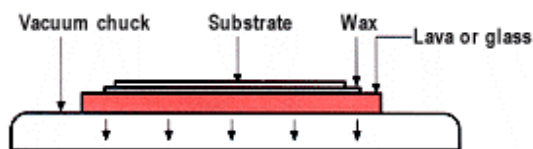


Figure 23

## Wax and Adhesive Type Mounting

Wax and other adhesive mounting is a very common method for applications requiring superior cut quality especially on very thin and brittle materials.

Many different adhesives are used for mounting substrates: various types of epoxy, fast glues, ultraviolet type adhesives, thermoplastic polymers (crystal bond) and others.

In this article we will concentrate only the most common method, wax mounting.

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Most wax materials are comprised of natural materials - animal, insect, minerals and vegetable. Some are made from synthetic materials.

The large variety of wax products are available in lumps, molded bricks, flakes, chips, powders. They vary in:

- Melting point
- Flash point
- Specific gravity
- Structure
- Hardness
- Brittleness
- Flexible and elastic characteristics
- Surface characteristics (like dry, sticky, oily, slippery)
- Others

The waxes used in the micro electronic industry for mounting substrates usually have a low melting point of about 65°C. Their mechanical characteristics are such that they generally will provide for easy handling, accurate mounting and facile wax removal with various solvents.

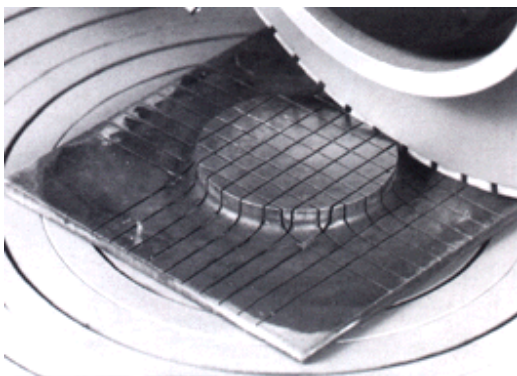


Figure 24 Wax mounting

### Advantages

The main advantage of using wax materials is not the wax itself acting as a super clamping media but the ability to mount a delicate substrate to a thick and flat supporting substrate. This substrate provides good support and the ability to make a deep cut into the supporting substrate. This eliminates the lip effect and the cracks at the bottom of the substrate. In this case the blade wear is far from the substrate (figure 25 - see also figures 16 and 17).

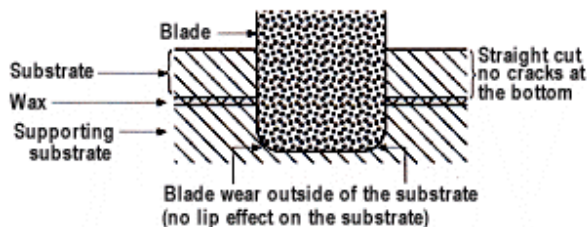


Figure 25

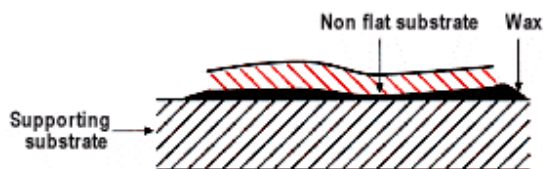


Figure 26

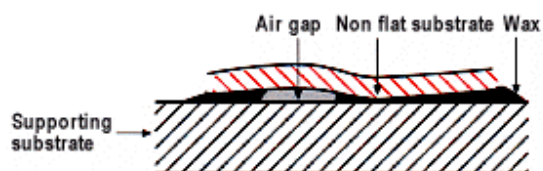


Figure 27

Common supporting substrates are: sintered lava, glass, unfired ceramics, ferrites and others.

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A lava substrate also acts as a cleaning media to clean and open the diamond blade.

Another advantage is the ability of the wax to flow and fill the gaps of a non flat substrate. This sometimes is the only method to clamp such substrates (figure 26).

### **Disadvantages**

Handling the wax process, mainly dismounting and cleaning the substrate (dies) after the cutting process, is the main disadvantage.

Compared to tape mounting, which is a clean process which can also be automated, wax mounting is slower. It requires a heating cycle of the substrate. Handling is relatively messy.

In some applications heating the substrate or cleaning with solvent after the dicing is damaging to the product. Therefore, the wax process cannot be used. It also cannot be used for all applications requiring a die attach process (figure 8).

### **Dicing Problems Related to Wax Mounting and Recommendations**

**Problem A:** Loosening small die during the dicing.

#### ***Recommendations***

1. Make sure there is adequate coolant flow and proper nozzle alignment. High temperatures during the dicing can soften the wax and cause the dies to move.
2. Slow the feed rate
3. Lower the coolant flow. Too high water flow can loosen the dies.
4. Improve the wax mounting technique to eliminate air gaps between the substrate and the supporting substrate.
5. Consult with your wax supplier to find a wax with better bonding characteristics.

**Problem B:** On nonflat substrates wax does not fill all the gaps between the substrate and the supporting substrate, causing poor cut quality mainly at the bottom of the substrate (figure 27).



### ***Recommendations***

1. Use higher temperatures for better wax flow characteristics.
2. Improve your mounting technique; use higher pressure.
3. Consult with your wax supplier to find a wax that will flow better.

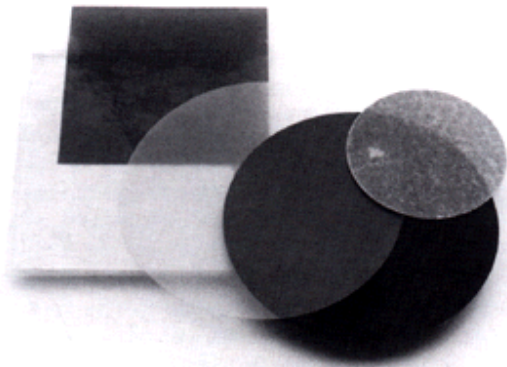


Figure 28 Typical wax/adhesive materials on carriers

### **Wax / Adhesive on Carriers**

A few products are available providing wax or other adhesives on carriers. These products are activated by temperatures ranging from 80° - 150°C. The carriers are hard mylar .002" up to .015" thick, paper carriers, mesh type reinforcement and others (figure 28).

While the mesh type materials are homogeneous with a mesh reinforcement in the center, the mylar type consists of a layer of wax/adhesive on one side or both sides.

Handling the wax/adhesive carriers is easier mainly because they are ready to use with outside dimensions close to the substrate size and the fact that the wax/adhesive layer is uniform.

The mounting process can be performed either manually on a hot plate or with additional mechanical fixtures for better accuracy.

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The main concern is to eliminate air gaps and to achieve parallel clamping of the substrate to the carrier.

Small bench-type instruments are available for substrate mounting. They are designed for better accuracy and to optimize the bonding process between the substrate and the carrier.

Problems and recommendations of the wax/adhesive carriers are very similar to the wax process. (See problems in the dicing process related to the wax mounting and recommendations).

To summarize this section, the wax/adhesive carrier method is easier to handle. It offers some advantages in accuracy. But it is more expensive to use. On the other hand, the mylar material in some cases overloads the dicing process, especially when dicing only into thick mylar and not completely through into a supporting substrate (figure 29).

Any dicing process that can handle substrates with regular wax mounting is probably more economical to use. But it is a good idea to evaluate both options during the optimization period of the process.

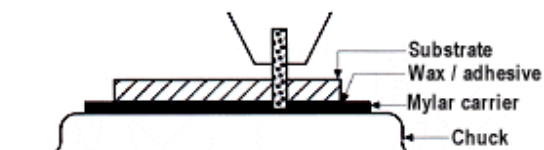
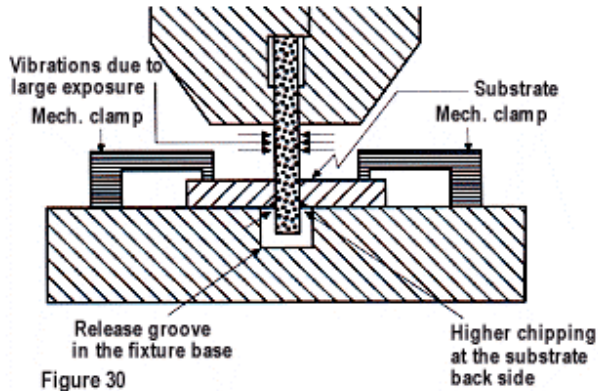


Figure 29

## Mechanical Fixturing

Mechanical fixturing is used on complicated parts with a geometry that makes conventional clamping very difficult or impossible. Other special mechanical fixturing is used on high productivity applications where the load and unload cycle time is a major factor in a mass production mode.

Cutting completely through parts that are only mechanically clamped creates quality problems mainly chipping at the bottom of the cut. Figure 30 describes a typical cut through on a substrate clamped mechanically. The blade cuts through the substrate into a release groove in the fixture base. The main problem is the back side of the substrate not having a firm support at the cutting area and therefore chipping is higher.



Another problem related to mechanical clamping is too much exposure due to the mechanical clamps thickness over the substrate. This can cause vibrations and will affect the cut quality (figure 30). To minimize the vibrations, the thickest possible blade should be used.

### Examples of Mechanical Clamping

The following is a discussion of two typical applications requiring unique mechanical clamping.

- **Hard Alumina trimming:**

This is a high volume mass production application. The request is to trim a hard alumina 99.6% .025" thick on 4x sides to a given dimension (figure 31).

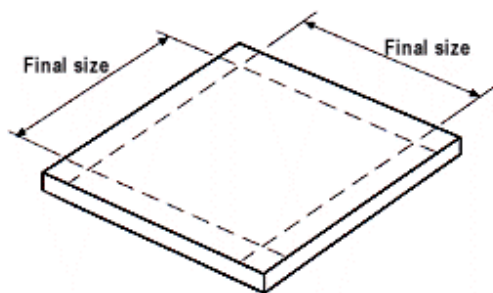


Figure 31

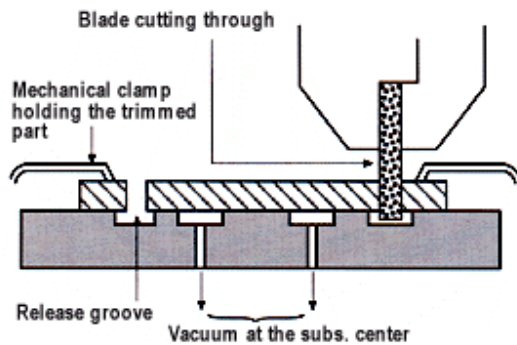


Figure 32

The conventional clamping of tape mounting or wax/adhesive mounting cannot be used in this case because of the long handling cycle time.

For this application a special mechanical chuck was designed with a vacuum at the center of the substrate to clamp the final alumina substrate; in addition, a set of mechanical clamps were used to clamp the outside trimmed parts. The mechanical clamps are activated by small air pistons. This clamping is important to eliminate any movement of the trimmed parts that can damage the blade during the cutting process. At the cutting area grooves were machined in the chuck to accommodate the blade during the cutting process (see also figure 30).

Figures 32 and 33 illustrate this special chuck. Figure 32 is a principal sketch and figure 33 is a photo of the actual chuck mounted on an ADT 780/4 saw.

- **Fiber optic trimming:**

This unique application requires a length trimming of thin flexible fiber optic to a very accurate length dimension. Since the fibers are flexible and not straight, a special mounting technique was designed to mount the fibers in a perfectly straight line.

A V-groove principle was used for this application to hold the fibers in a straight position. Figure 34 illustrates the fibers before the mounting and figure 35 after the mounting in a V-groove.

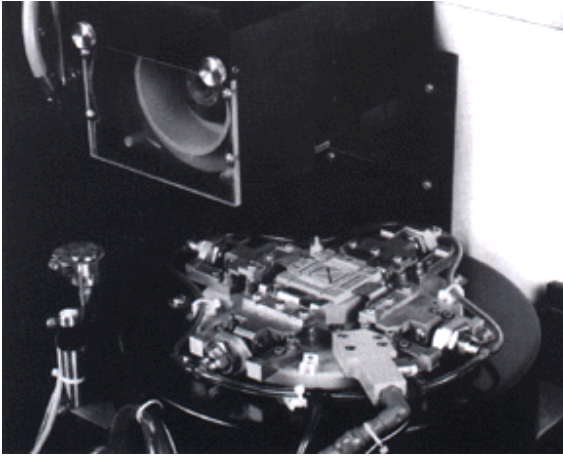


Figure 33

### Process Flow

- A heavy gauge glass plate was used as a holder and a number of V-grooves were diced into the glass plate with a Micro-Swiss .050" thick resinoid blade ground to a 90° V shape. The depth of the V-groove was calculated so when mounting the fibers in the V-grooves the top of the fibers are about .010" above the plate surface (figure 36).
- The fibers were wax mounted in the V-grooves (figure 37).
- A second glass plate was waxed on top of the fibers (figure 38).
- The two plates with the fibers waxed in between were aligned and diced on an ADT 780/4 saw with a Micro-Swiss 4.6" O.D. x .020" thick resinoid blade to the final accurate length dimension (figure 39).
- The fibers were dismantled and rinsed for inspection.



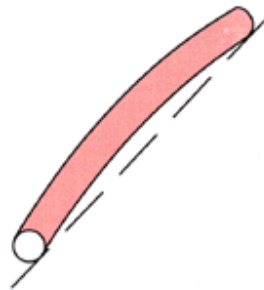


Figure 34

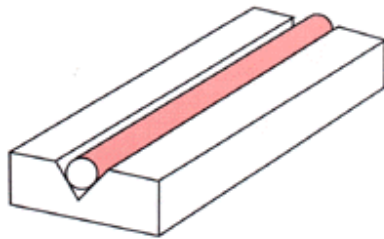


Figure 35

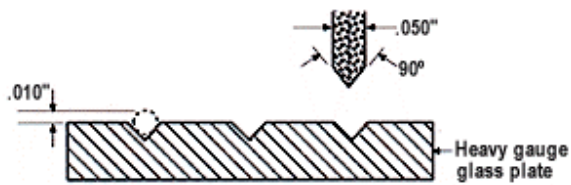


Figure 36

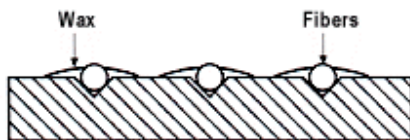


Figure 37



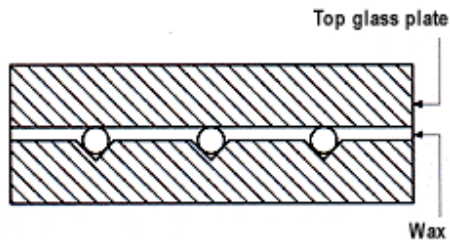


Figure 38

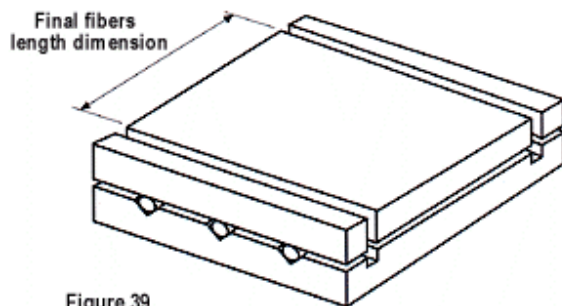


Figure 39

This article covered the most common mounting techniques used when dicing through microelectronic substrates. It highlighted the advantages, disadvantages and problems. Some recommendations were made.

The following parameters are of major importance when dicing through:

- Use a solid-supporting substrate that will hold the diced substrate firmly.
- Use a supporting substrate that will not overload the blade during the dicing.
- Use a mounting technique that will eliminate any air gaps throughout the substrate.
- If possible cut always deep enough to eliminate the lip effect on the bottom side of the substrate.

The above are general basic recommendations. Since every application is unique, with different quality and production requirements, a process optimization should be carried out to find the best tailor-made process parameters.

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