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SELECTING THE I.D. DIAMOND BLADE FOR SEMICONDUCTOR SLICING

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Abstract: *Although improvements in wafering techniques have produced great savings in device manufacture, further advances in both wafer quality and productivity can be achieved by a system approach to the slicing operation. This article describes some recent developments in the design of annular diamond blades (I.D. blades) for semiconductors slicing, and gives practical advice on methods of tensioning, dressing, blade selection and use in order to obtain optimum results.*
Key words: *slicing, cutting, diamond wheels, silicon wafer, wafering techniques*

1. INTRODUCTION

One of the most spectacular improvements came in the early 1960's when slicing saws were converted from O.D. (Outer Diameter) to I.D. (Inner Diameter) cutting. In 1962, R.G. Heinrich of Hamco Machine & Electronic Company patented a vertical spindle I.D. slicing machine with programmed feed and rotating workpiece capability. It was one of the earliest saws for production use which was designed totally around the I.D. blade concept.

With impetus from the semiconductor industry, the I.D. diamond saw blade was developed to reduce kerf losses when slicing these expensive materials. Today's I.D. diamond blade has a 203 to 254 microns thick cutting edge supported by a core 102 microns thick and initial kerf losses are only 267 microns. In addition, an I.D. blade can be made to almost any diameter. Thus, increasing blade diameter in order to increase the depth of cut does not increase blade thickness or kerf loss.

Although even the first I.D. diamond blade vastly improved the economics of semiconductor production, research and development efforts to improve product quality and yield have been continuous.

2. TYPES OF BLADE

With respect to the shape of cutting edge, the most common type of blade is the continuous rim in which the plated surface is uninterrupted. Several variations have also been made in an effort to improve swart removal and cooling (Figure 1). These include the segmented or interrupted blades and scalloped blades in which the cutting surface is interrupted at regular intervals. Another variation is the blade in which the cutting edge is bonded only to the edge or rim of the I.D. without support from the sides of the core.

The interrupted or segmented blade works reasonably well. But, as might be expected, it has a shorter life than one with a continuous rim because of the lower volume of diamond cutting particles.

Scalloped sides perform no useful function. As can be seen, they do not really provide openings for either swart or coolant. Theoretically, the scalloped rim is the best of these cutting edge variations. The valleys, usually about 0.076 mm deep, provide relief for coolant flow and swart removal without drastically reducing the volume of diamond particles available for cutting.

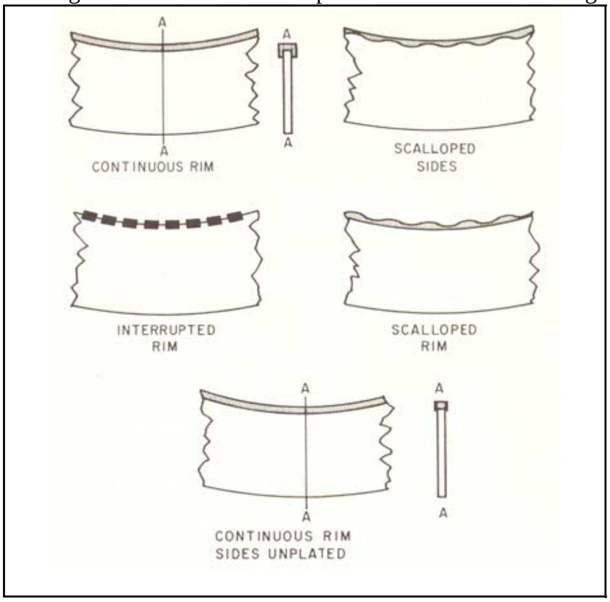

Fig. 1. Variations of the continuous rim I.D. blade

3. TENSION THE KEY

The key to cutting with such a thin blade is the ability to apply tension to the wheel along its outer periphery. The metal core of the blade is stretched under pressure and held under tension. This gives the blade the rigidity necessary to firmly support the cutting edge on its inner diameter without wobble or flutter.

There are a large number of variables in blade design, manufacture and use. Obviously all of them must be closely controlled in order to provide the performance demanded by the semiconductor industry. The thin metal core which supports the inner cutting edge must be capable of withstanding high tensile forces without tearing. Its composition must be such that the resulting stress is distributed evenly across its entire structure. The diamond particles must be firmly bonded to the I.D. in order to cut efficiently, but not so strongly that excessive fracturing occurs. The diamonds themselves must be carefully selected for particle size, shape and strength. Finally, the blade must be skillfully handled. It must be properly mounted, tensioned, dressed and operated. All of these factors contribute to the end result, the efficient and accurate slicing of semiconductor wafers to exacting tolerances with minimum kerf loss and product damage (Dobrescu, 2007).

4. DRESSING

Although most I.D. cutting wheel is predressed, new wheels should be sharpened and broken in on the individual machine.

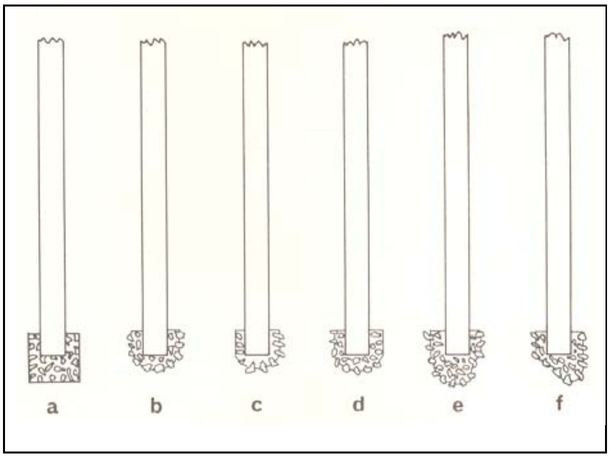

Fig. 2. Effect of proper and improper dressing

Periodic dressing is required during the life of the wheel. Primarily, this is to remove mounting wax or epoxy, which builds up on the cutting edge (Wafering Systems, 1995).

Stick dressing has three functions. It puts a radius on each edge of the I.D.; it trues the side of the blade; and it opens up the bond to expose the diamond particles. Usually a coarse 150 grit silicon carbide stick is used to apply the radius to the cutting edges of the blade. A finer stick, 320 grit, trues the sides and opens the bond.

After dressing, the operator should examine the first slices cut for taper, head cracks and surface finish. If taper is within tolerance and there are not heat cracks, the blade is properly dressed. If this is not the case, the geometry of the taper or the location of the heat cracks will indicate how the blade has been improperly dressed (Dobrescu et al., 2009).

For example, Figure 2.a is a new wheel before dressing and Figure 2.b is a properly dressed wheel. However, in Figure 2.c, only the cutting edge and the crystal side are properly dressed. The bond on the slice side has not been opened up to expose the diamond particles. Coolant cannot flow into that side of the cut and heat cracks will appear on that side of the slice. Figure 2.d represents a similar situation but in this case, the slice side is improperly dressed and the heat cracks will appear on the crystal side of the slice.

Figure 2.e and Figure 2.f show how poor dressing causes taper. The condition illustrated in Figure 2.e will cause the slice to taper toward the crystal. That in Figure 2.f causes taper away from the crystal.

Normal practice is to make three dressing cuts at the normal cutting feed rate after every 200 slices (I.D. Diamond Blades, 1995). The larger the diameter of the material being cut, the more frequently dressing will be required because of the longer arc of contact and reduced coolant flow in the area of contact.

5. OPERATOR

The final variable in the slicing system is the operator. A well trained and conscientious operator is essential to obtain optimum results.

Care exercised in every phase of the operation – in centering, tensioning and dressing the blade, in mounting the crystal and in machine set up – will pay off in terms of reduced rejects, less machine downtime, improved slice quality and higher production yields (Dobrescu, 1998).

Yet, although careful operation will minimize problems, it is too much to expect that troubles will never occur. Table 1 suggests a trouble shooting procedure which may be useful when they do. It lists, in order of probability, the possible causes for five common problems encountered in slicing semiconductor wafers.

Possible Causes	Flipping	Taper	Chipping	Thickness	Frequent Dressing
Blade not centered		6	8		4
Blade out of round			8		
Wax, sludge buildup	5	3	5		1
Excessive coolant	1				
Insufficient coolant		4			3
Intermittent coolant	4		1		
Insufficient tension	6		2	4	
Loose Ingot	3	1	7	2	
Blade not dressed			3		
Excessive wax on ingot					2
Misalignment of ingot		5			
Slices on back side			6		
Indexing incorrect			4	1	
Wrong type of coolant					5
Wax bond to crystal	2				

Tab. 1. I.D. slice troubleshooting

6. CONCLUSION

Yet, even as increased crystal size and the introduction of new, more costly materials impose new processing problems, the semiconductor industry continues to seek increased wafer productivity and improvements in wafer quality. Such improvements are possible only if one views the entire wafering operation as a single, integral system. Normally, slicing higher quality wafers means slow feed rates, resulting in low productivity.

Within a few short years, improvements in the design, manufacture and application of this important tool have contributed significantly to the increased productivity of the semiconductor industry. Even more rapid advancement in the state of the art of I.D. slicing can be expected. These improvements will come as a result of efforts which recognize the fact that I.D. slicing is a total system in which the saw, the blade and the operator are co-equal components.

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