WINTER

Diamond ID saw blades for the semiconductor industry

Contents

Introduction

The ID saw blade consists of a thin circular steel core, which is tensioned at its outside diameter (OD) and has its diamond cutting edge electrodeposited on the inside diameter (ID).
In comparison with conventional saw blades, which are mounted at the center and have their cutting edge at the OD, the ID saw blade is capable of cutting the same materials with considerable reduction in sawing loss (kerf).
In addition, the stability and high tension of the ID saw blade core enable it to cut thinner slices than possible with conventional saw blades.

ID saw blades were initially used for slicing germanium and silicon semiconductor materials. These materials still account for the major usage of ID blades, but recently there has been an increase in the slicing of materials such as GGG, samarium cobalt, sapphire and quartz.

WINTER has been making ID saw blades since 1958. The early blades had an OD of 8 1/8 inch and were capable of slicing the small diameter germanium and silicon materials available at that time. Over the past two decades blade technology has been continuously updated to keep pace with the ever increasing tempo of silicon crystal development.
In 1979, WINTER became the first blade manufacturer to sell 27 inch diameter ID blades to the electronics industry, permitting the slicing of crystals up to 6 inches in diameter.

At the Productronica trade fair in Munich in 1983, WINTER achieved a world „first“ at that time new 34" ID saw blade. Development of these blades has progressed so that they are used for slicing 8" silicon wafers.

WINTER will continue to work together closer with the key end-users and original equipment manufacturers on further developments of ID sawing technology.

Considerable experience is required in the selection and proper usage of ID saw blades. The present catalogue contains helpful information but does not claim to answer all questions which arise. For further information please contact the WINTER company or your local
WINTER sales representative.

WINTER diamond ID saw blade development

The production of blades is dependent on proper quality control of the steel core, diamond quality and grit size, and electroplating baths, and on strict adherence to the controlled process parameters. A computer assisted process checking system is conducted in order to ensure uniform quality.

WINTER has a well equipped research and development laboratory available for investigation of the electroplating process and plating material. This development set-up is used to test various types of diamond and bonds and to determine the type best suited for ID saw blades.

The WINTER Technology Center, worldwide responsible for application developments, possesses among other an ID sawing machine equipped with instrumentation for measuring cutting force, deflection, and instrument for deflection adjustment by pneumatic; this permits investigation of machine parameters for the slicing of different materials and also investigation of coolants.

(In 1976 WINTER developed a rotating ingot fixture that made slicing of sapphire possible). Another important achievement was the development of a samarium cobalt slicing process, involving the optimization of slicing parameters and the introduction of a special coolant). This method has been improved several times in recent years.

The work of the WINTER research & development laboratory has produced detailed knowledge of the sharpening / dressing process for ID saw blades. The resulting recommendations for dressing/ sharpening are given in the section on “Dressing and sharpening ID saws”, starting on page 20.

Publications.

Cutting Sapphire with Annular Saw Blades, Industrial Diamond Review, 37 (1977), No. 2

Trennen von Samarium-Kobalt mit Diamant-Innenlochsägeblättern (Cutting of Samarium Cobalt with ID Saw Blades), Industrie Diamanten Rundschau 12 (1978) No. 3

Diamantwerkzeuge für die Elektronikindustrie (Diamond Tools for the Electronics Industry), Feinwerktechnik und Meßtechnik 1985, No. 3

Schärfen von Innenlochsägen - Untersuchung des Einflusses der stofflichen Parameter von Schärfsteinen auf die Diamanten und die Bindung an der Innenlochsäge (Sharpening ID Saw Blades - investigation of the influence of material parameters of dressing sticks on diamonds and bond of the ID saw blade) Diploma thesis by Michael Kleinert, 1988

The diamond ID saw blade

1 Saw Blade Dimensions and Basic Data

Structure of ID sawblade

The ID saw blade is characterised by a thin, ring-shaped core, the inner diameter of which is designed as a cutting edge.

Core

The steel core is made of high strength, cold rolled, stainless steel.
The core thickness has a major effect on the stability of the sawblade and thus on tool life and the quality of the sliced wafers.
The core thickness cannot be increased at all without changing the cutting layer geometry. This means there is a trade-off between kerf loss and tool stability.

Grit

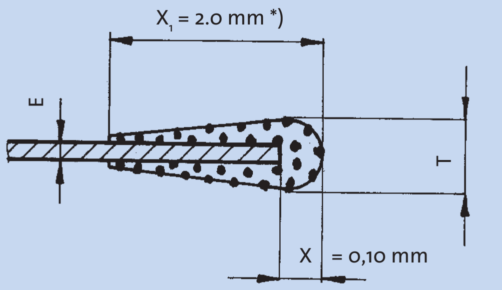
Natural diamond with grit size D46 is recommended for the silicon slicing operation. The grits available are D46 X71, D46B X58, and D46C X50.

Nickel bond

Alternatively it is possible to choose between two bond variants which are different in hardness.
Bond G820 (standard bond) is softer than G825.

Cutting edge geometry

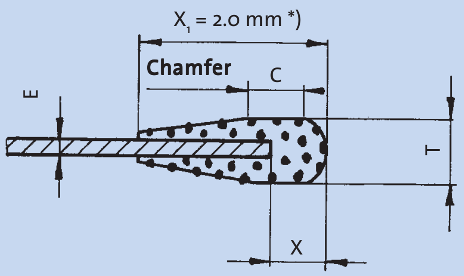
Type S35D



*) Ø 34" : X_1 = 3.0 / 4.0 mm

Winter universal design.
Cutting edge **without** mechanical treatment

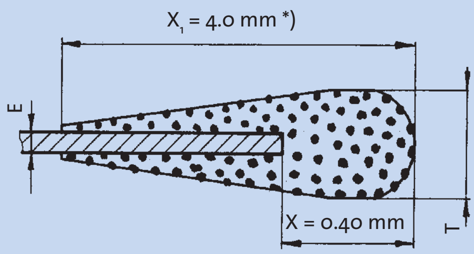
Type S35B & SL35B



*) Ø 34" : X_1 = 3.0 / 4.0 mm

Winter universal design.
Cutting edge thickness with mechanical treatment

Type S35E



*) also 2.2 mm

Winter rugged universal design.
The plating envelops a greater part of the blade core

Figure 1

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2 Layer specification

Alongside variations of geometry, cutting width and core thickness variation, the following possibilities are available for adjustment of ID sawblades to meet customer specifications.

- Bond variation
- Concentration variation
- Grit variation

2.1 Bond

Nickel bonds are distinguished by hardness. Measurement of bond hardness is effected in the bond structure, which is permeated with the grit. In unfavourable cases that means there is grit directly behind the measuring points, so measurement includes not only the nickel itselve. Thus it is important not to neglect the influence of the grit.

Standard:

G820: This bond is used the most frequently, and is the standard bond for ID sawblades. It retains the grit optimally in the bond.

Hard bond:

G825: This bond is characterised mainly by high wear resistance. It is used in processes where frequent dressing is required for quality reasons.

2.2 Concentration

Concentration specification

The grit concentration, measured in grit particle quantities per gram of nickel deposition, can be varied within a permissible spectrum. The main distinction is between standard concentration and high concentration.

Influence of concentration

Changes in concentration basically have the following effect on process parameters.

	Concentration	
	standard	high
Grit spacing	medium	low
Grit simultaneously in contact	medium	high
Normal force	medium	high
Load per grit	medium	low
Bearing proportion	high	low
Wafer surface	good	very good
Chip space	medium	low

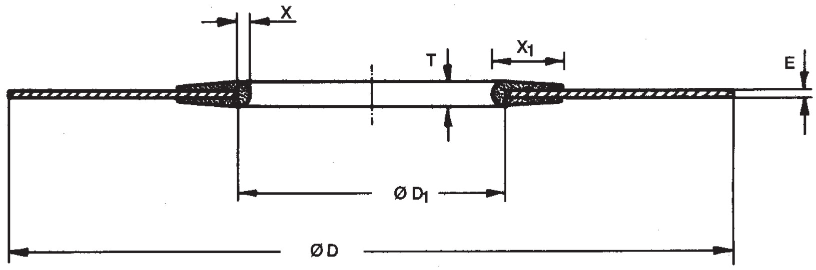
2.3 Grit

Standard grit

Natural grit D46 in various sizes has become established for practical operation in silicon slicing: The finer the grit, the better the surface quality of the wafer, but the smaller the available amount of chip space.

The WINTER standard of natural diamond is based on the FEPA standard for micron powder sizes. The main difference is that WINTER uses closer fractioning. For special applications (rod cropping) bigger grit sizes (up to D181) are available.

ID saw blade program



Legend

D: Outer diameter
D_1: Inner diameter
T: Cutting width
X: Layer height
E: Core thickness
X_1: Length of layer

Type	Ø D		Ø D_1		T	X	E	X_1
	mm	inch	mm	inch	mm	mm	mm	mm
	206	8 1/8	83	3 1/4	0.26	0.15	0.1	2.0
	257	10 1/8	101	4	0.26	0.15	0.1	2.0
	304	12	115	4 1/2	0.26	0.15	0.1	2.0
	422	16 5/8	153	6	0.26-0.29	0.10	0.10	2.0
	546	21 1/2	184	7 1/4	0.27-0.32	0.10	0.12	2.0
			203	8	0.27-0.32	0.10	0.12	2.0
			235	9 1/4	0.30-0.32	0.10	0.15	2.0
S35D	558	22	203	8	0.26-0.32	0.10	0.12-0.15	2.0
			235	9 1/4	0.30	0.10	0.15	2.0
	596	23	203	8	0.27	0.10	0.12	2.0
	690	27 1/6	203	8	0.35	0.12	0.15	2.0
			235	9 1/4	0.26-0.29	0.10	0.10-0.13	2.0
					0.29-0.35	0.10	0.15-0.17	2.0
			240	9 1/2	0.28-0.31	0.10	0.13-0.15	2.0
					0.31-0.34	0.10	0.15	2.0-3.0
	860	34	304	12	0.27-0.33	0.10	0.15	3.0-4.0
					0.32-0.39	0.10-0.12	0.17	3.0
	206	8 1/8	83	3 1/4	0.29	0.1	0.1	2.0
	257	10 1/8	101	4	0.29	0.1	0.1	2.0
	304	12	115	4 1/2	0.29	0.1	0.1	2.0
	422	16 5/8	153	6	0.26-0.29	0.12-0.15	0.10	2.0
S35B	546	21 1/2	184	7 1/4	0.29-0.31	0.15	0.12	2.0
	558	22	203	8	0.27-0.31	0.15	0.12	2.0
	596	23	203	8	0.29	0.15	0.12	2.0
	690	27 1/6	235	9 1/4	0.28-0.31	0.15	0.13-0.15	2.0
			240	9 1/2	0.29-0.30	0.15	0.13	2.0
	860	34	304	12	0.38	0.15	0.17	4.0
	546	21 1/2	184	7 1/4	0.30	0.13	0.12	2.0
SL35B	690	27 1/6	235	9 1/4	0.28-0.30	0.13	0.13-0.15	2.0
			240	9 1/2	0.30	0.13	0.15	2.0
	860	34	304	12	0.30	0.13	0.17	3.0
	422	16 5/8	153	6	0.29-0.35	0.40	0.12	4.0
	546	21 1/2	184	7 1/4	0.35	0.40	0.15	4.0
			203	8	0.40	0.40	0.17	4.0
S35E	558	22	203	8	0.30	0.40	0.12	4.0
	690	27 1/6	235	9 1/4	0.37	0.40	0.17	2.2/4.0
			240	9 1/2	0.25	0.30	0.15	3.0
			290	11 1/2	0.37	0.40	0.17	4.0
	860	34	304	12	0.37-0.43	0.40	0.17-0.20	4.0

Table 1: Other dimensions available on request.

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3 Core material

Main requirements

The WINTER core material has to meet the highest quality requirements:

- Isotropic material
- Stainless steel
- Special chemical composition
- Specific surface quality and measuring system
- High yield strength
- Defined elongation, measured by a special WINTER test
- Defined etching behaviour
- Defined corrosion behaviour
- Low core thickness tolerance

Quality assurance during production

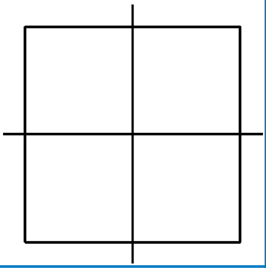
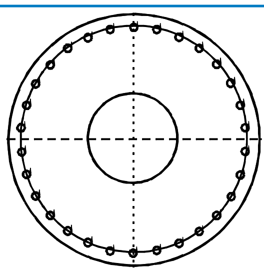
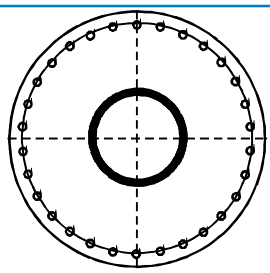
	Coil	Square	Core	Blade
Sketch				
Steps of QA	- Define specification of delivery - Define test procedures - Perform incoming inspection	- Stamp - Mark with WE-No. In roll direction - Visual inspection (colour change, grooves, dents, etc.)	- Special WINTER technology for core production - Drilling - Inspection on special fixtures (centering bores)	- Ni-plating - Process control - Saw inspection - Customer certificates

Figure 2: *Quality assurance during production*

4 Development and innovation

4.1 L-type and LB-type

Continous further development work is in progress, achieving in particular longer blade life, combined with improved wafer surface.
The new development work is based on the proven D-type and B-type.
Optimisation concepts are being realised and tested on the basis of this teardrop geometry.

There is also a newly developed process, the linearisation process (L), giving the following benefits compared with conventional manufacture:

- More consistant builtup of layer structure
- Restriction of cutting width variation within one ID sawblade

This method is used in order to offer a linearised B-type) which is analogous to the B-type (WINTER designation: LB-type). If necessary, the blades may have to be adapted to the customer's process parameters.

With a linearised sawblade, the cutting width is more uniform, which means that there is much less cutting width difference within a sawblade.
Due to the reduction in material losses resulting from axial runout and vibration, the dimensions of the cutting slit are defined more accurately.
In order to ensure good, constant wafer quality linked with long blade life, the kerf loss is reduced, particularly in the startup phase of the blade. This is reflected in higher yield and higher productivity.
First conclusions can be drawn on the applicability of this new type from practical tests. The results led to the latest development of the LB-type. This type was

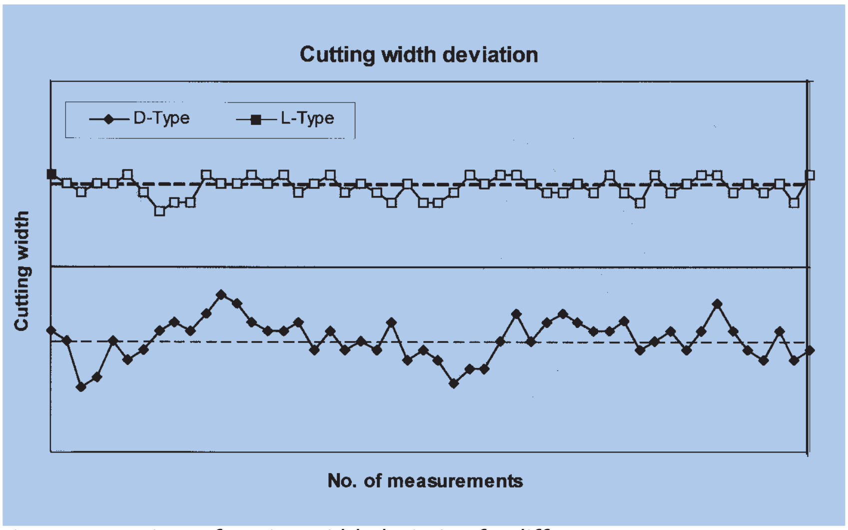


Fig. 3: *Comparison of cutting width deviation for different ID types*

developed specially for thin-kerf applications. It features no-problem starting behaviour, and permits continuous operation. Due to the production process the LB-type has an X-dimension of 0.13mm (the D-type has an X-dimension of only 0.10mm), thus an increase of lifetime of approx. 20% can be expected.

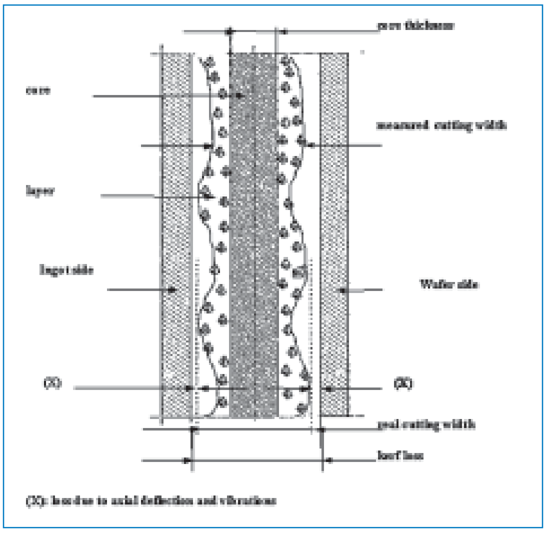


Figure 4: *Tolerances*

4.2. Cutting width improvements

Tolerance
A narrowing of tolerances has become possible thanks to ongoing technical progress. Further research will show more development potentials.

Application of diamond ID saw blades

Handling of ID saw blades

ID saw blades are highly susceptible to damage due to the thinness of their cores, and are hard to handle in the untensioned state due to their low rigidity.
WINTER recommends that ID blades be kept in their original package until usage.
Great care should be taken to avoid kinking blades when handling them. In the event of damage to a blade, WINTER advises that the blade should be scrapped.
Gloves should be worn when handling blades in order to avoid injuries such as cuts, etc.

The sawing machine

Rigid and vibration-free construction of the ID saw is essential. There must be provision for the sawing slurry to escape, since otherwise the accumulation of slurry in the blade mounting head may lead to vibration. To assure elimination of all slurry from the head, it is recommended to install a back flash nozzle which applies coolant in order to keep the core clean.
In addition, the ID sawing machine should fulfill the following requirements:

a) Stepless cutting speed regulation of ingot cross feed into the blade cutting edge
b) Stepless speed control for achieving the optimum blade rotational speed needed for cutting different materials
c) Indication and control of coolant flow
d) Automatic slice removal
e) Slice tracking system
f) System for automatic correction of deflection.

Mounting of the ID saw blade

Expert mounting and tensioning are essential for the proper functioning of the ID blade.

Improper blade mounting can lead to the following production problems:

a) High slice rejection rate
b) Poor product quality
c) Strain on operating personnel
d) Reduction in cutting speed
e) Poor blade stability
f) Short blade life.

Thus it is evident that economical and optimum use of the ID saw can only be achieved through proper blade mounting and tensioning. There are two blade tensioning systems currently in use in the industry: "mechanical tensioning", and "central ring tensioning" (Fig. 5).
These systems will achieve

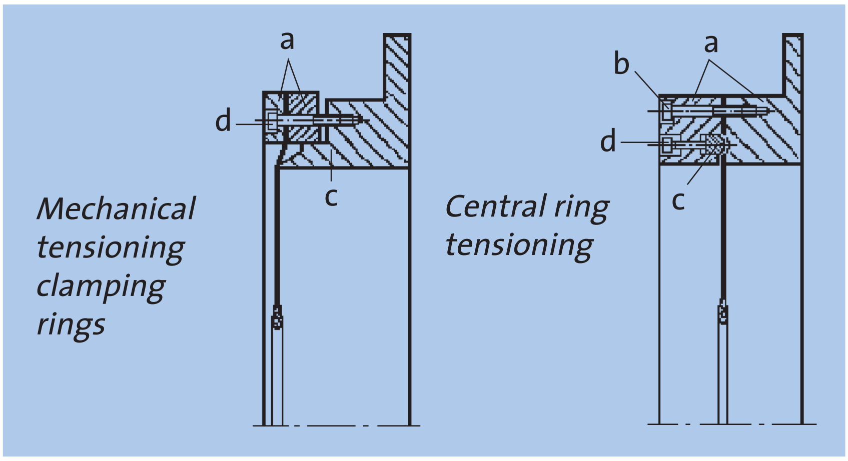


Figure 5:
a = Clamping ring, b = Clamping screw, c = Tensioning ring, d = Tensioning screw.

good results provided that blade set-up is of professional quality.

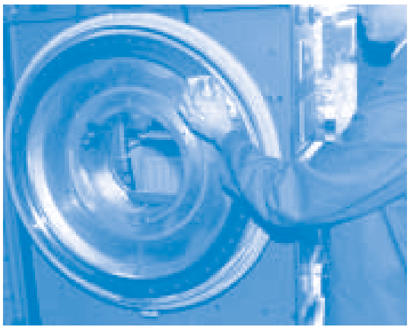
In addition, special attention should be paid to the following steps:

a) Thorough cleaning and degreasing of clamping ring
b) Inspection of tensioning ring for surface defects and remedy if necessary
c) If the saw is fitted with a single-slice removal system, this system must be inspected for proper condition of the pick-up face and for correct setting.

Tensioning of ID blade using central ring tensioning system

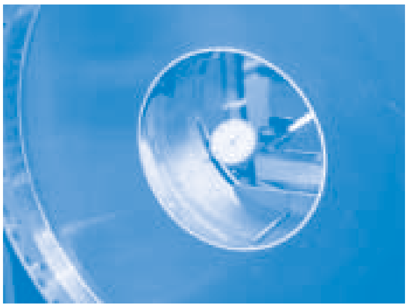
1: Remove clamping ring bleed screw and metal tensioning ring. Reinsert bleed screw and tighten it. Clean and degrease clamping ring surface.

2: Clean and degrease the blade clamping areas (on each side) and position the blade on the clamping ring guide pins.



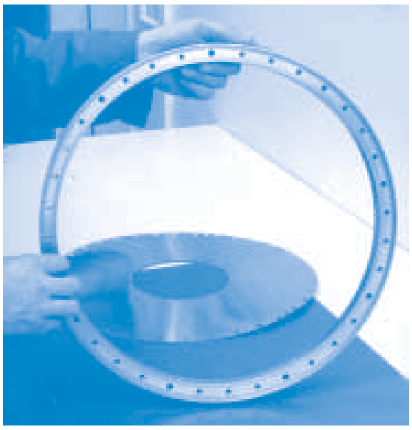
3: Clean metal tensioning ring, cover the tensioning area with a light coat of lubricant and insert ring in the clamping ring groove.

4: Clean and degrease clamping areas. Clean blade tensioning support area and cover the area with a thin coat of lubricant.

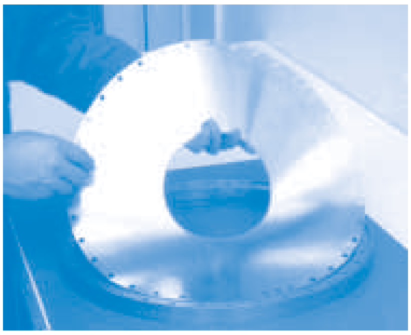


5: Positioning of elongation meter in the ID of the blade.

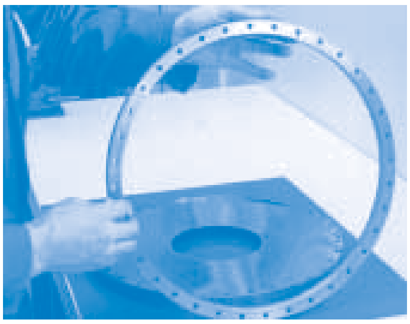
Tensioning of ID blade using mechanical tensioning system (clamping rings)



6: Clean and degrease lower clamping ring.



7: Clean and degrease blade clamping area. Place blade in clamping position on lower clamping ring without touching the cleaned and degreased clamping area.



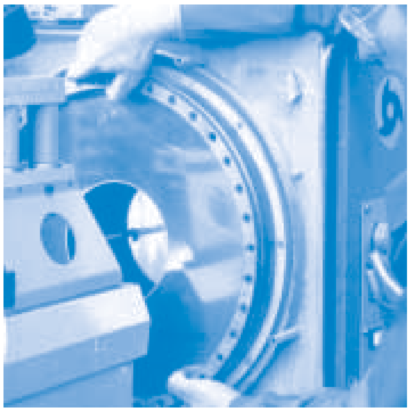
8: Clean and degrease upper clamping ring.

9: Match up balance marks of clamping rings and place upper clamping ring properly aligned on top of blade and lower clamping ring.

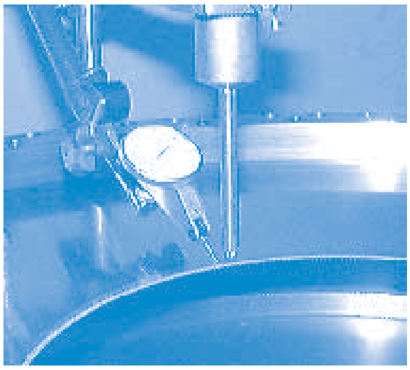
10: Place screws into clamping rings and tighten screws hand-tight.

Tighten clamping screws crosswise using an Allen wrench. Generally the clamping ring screws (M6 property class 12.9) are tightened with a torque wrench to 15 Nm. To avoid screw failure, screws should be replaced at every blade change.

12: Clean tensioning ring and cover it with a thin coat of grease.

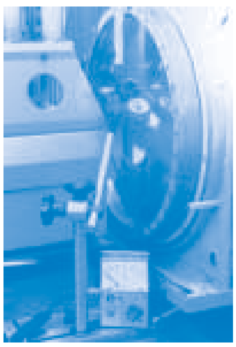


13: Mount clamping rings with saw blade on top of tensioning ring.



14: Set up a dial gage and center blade ID by tightening 4 clamping screws crosswise. Accurate centering at this time is the basis for the final blade set-up and centering accuracy. Tension blade and adjust blade run-out during this operation according to Table 2.

Obtain the proper elongation value from Table 2.



15: Measure blade deflection as shown on page 13. If blade deflection is below the value given in Table 2 further tensioning of the blade is needed.

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Measurement of ID saw blade stability

The ID saw blade receives the required stability through tensioning. Proper blade tension and stability are the most important factors for good slice quality and slice properties.
The stability or rigidity of the blade is the resistance to a side thrust perpendicular to the blade at or near the ID diamond cutting edge.
This ID blade stability and rigidity can be determined using the following methods:

a) Measurement of elongation (hole enlargement)
   Result: inaccurate

b) Measurement of run-out
   Result: very accurate

c) Measurement of blade deflection
   Result: very accurate

Measurement of blade deflection

The resistance of a blade to a force acting perpendicularly on it can be used as an indirect indicator for the internal tensions of the blade. In practice, industry has made this measurement with a constant force and measures the deflection of the blade. This deflection is mainly dependent on the blade geometry and on ID elongation. For successful ID slicing, the various deflection data should be attained as a function of the specific ID saw, depending on production process.

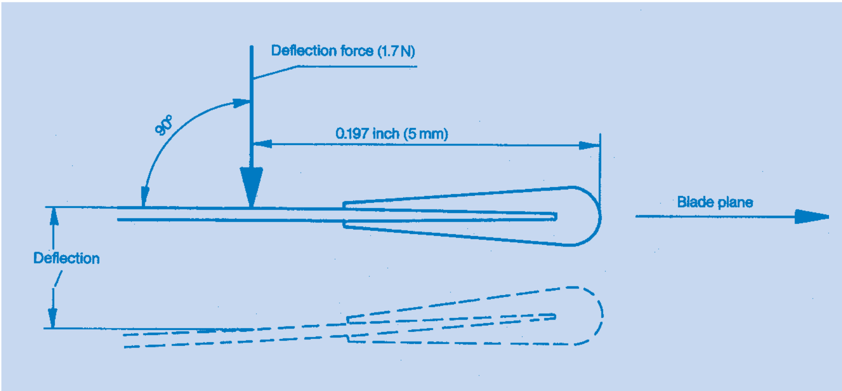

Figure 6

The following points must be defined:

a) ID elongation
b) Measuring point
c) Deflection force
d) Handling.

a) ID elongation

ID elongation is the increase in blade ID that is caused by tensioning of the blade. The increase in ID is measured in micron (inch).

b) Measuring points

The deflection of the ID blade is measured at three points, 120° apart. The distance between the measuring point and the ID is 5 mm, (see Fig. 6).

c)Deflection force

The deflection measuring for internal tensioning tests after the production process is done with a test force of 1.7 N ± 0.02 N. Depending on the arrangement, this force can be applied either by a spring or by a weight, acting perpendicularly to the plane of the blade.

d) Handling

The deflection of the blade is measured by means of a gage, with a force applied perpendicularly to the plane of the blade.

The tip of the gage is placed on the three measuring points, and then calibrated by means of the pretensioning force (0.3 N).

Then the additional testing force (of 1.4 N) is applied by means of a weight or by spring force. The deflection of the blade is read off on the length measuring unit.

The differences between the three readings may not exceed 2 µm. If there is a great difference between the readings, the tension in the blade is not uniform.

Measurement of ID elongation

ID elongation is a result of the tensioning process. As elongation is increased, the tension and also the rigidity of the blade increases. The ID elongation can give an indication about the rigidity of the ID blade; however, this is only an indirect clue, since changes in saw blade design affect the rigidity of the blade, and thus with equal ID elongation the blade will develop different values for the restoring force. If a fixed value of ID elongation is used for blade stability as a standard without deflection measurement, a variation in the performance of the saw blades must be tolerated. Loss of blade rigidity will be experienced over the life of the blade.
Retensioning towards the end of blade life is not normally recommended.

At the same time as ID elongation, radial run-out is also measured. The radial run-out should be as small as possible, and at any rate not more than 0.0008 inch (0.02 mm).

The radial run-out of the ID saw blade has an influence on vibration in the slicing process. The smaller the radial run-out, the lower the vibration level in the slicing process.

Cooling

The coolant generally used for silicon slicing is deonized water with a coolant additive. The dilution range is dependent on manufacturer recommendation.

The coolant additives generally used are surface active fluids and synthetic coolant oils. A coolant additive should always be used unless process difficulties are thereby caused, since the effects on surface quality, yield, blade life and cutting speed are positive.

For other materials, synthetic coolants or cutting oils may be of value. Further information on coolants is given in Table 5 on page 19.

The coolant nozzles should be positioned as indicated in Fig. 6. Coolant nozzles should be positioned in such a way that the coolant flow is evenly split. An even split of the coolant stream will ensure even wear of the blade.

Studies show that the influence of cooling (mode of supply and flow rate) have a considerable influence on the result of the slicing process and the life of the ID saw blades.

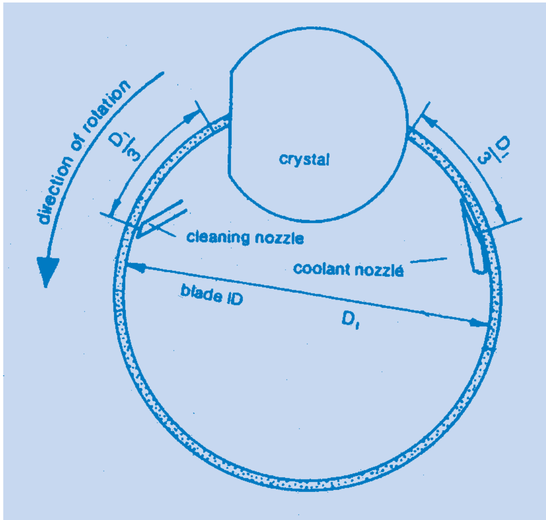

Figure 7

Silicon slicing parameters

The blade manufacturer should confine himself to publishing average performance data which can be obtained with proper use of the blades. The data in the table below are given as guidance and comparison for the user.

Crystal mounting

Many different mounting materials are used e. g. graphite, carbone fibre, ceramic, etc. The right selection of the mounting beam plays a major role in successful slicing, since the blade enters the mounting beam after each cut through the crystal.

Type	Ø D_A		Ø D_I		ID elongation	Further elongation	Infeed	Max. material diameter
	mm	inch	mm	inch	mm	µm	mm/min	mm
S35D	206	8 1/8	83	3 1/4	0.4-0.5	50	30-60	32
	257	10 1/8	101	4	0.5-0.6	50	30-60	40
	304	12	115	4 1/2	0.7-.0.8	50	30-60	51
	422	16 5/8	153	6	1.1-1.2	50	30-70	76
	546	21 1/2	184	7 1/4	1.4-1.5	50	30-70	127
			203	8	1.5-2.0	50	30-70	127
			235	9 1/4	1.5-2.1	50	30-70	127
	558	22	203	8	1.5-2.0	50	30-70	127
			235	9 1/4	1.5-2.1	50	30-70	127
	596	23	203	8	1.5-2.0	50	30-70	127
	690	27 1/6	203	8	1.9-2.0	50	30-70	152
			235	9 1/4	1.9-2.1	50	30-70	152
			240	9 1/2	1.9-2.1	50	30-70	152
	860	34	304	12	2.3-2.4	50	30-70	203
S35B	206	8 1/8	83	3 1/4	0.4-0.5	50	30-60	32
	257	10 1/8	101	4	0.5-0.6	50	30-60	40
	304	12	115	4 1/2	0.7-0.8	50	30-60	51
	422	16 5/8	153	6	1.1-1.2	50	30-70	76
	546	21 1/2	184	7 1/4	1.4-1.5	50	30-70	127
	558	22	203	8	1.5-2.0	50	30-70	127
	596	23	203	8	1.5-2.0	50	30-70	127
	690	27 1/6	235	9 1/4	1.9-2.1	50	30-70	152
			240	9 1/2	1.9-2.1	50	30-70	152
	860	34	304	12	2.3-2.4	50	30-70	203
SL35B	546	21 1/2	184	7 1/4	1.4-1.5	50	30-50	127
	690	27 1/6	235	9 1/4	1.9-2.1	50	30-50	127
			240	9 1/2	1.9-2.1	50	30-50	127
	860	34	304	12	2.3-2.4	50	30-50	203
S35E	422	16 5/8	153	6	0.9-1.0	50	30-70	76
	546	21 1/2	184	7 1/4	1.1-1.2	50	30-70	127
			203	8	1.3-1.6	50	30-70	127
	558	22	203	8	1.3-1.6	50	30-70	127
	690	27 1/6	235	9 1/4	1.5-1.9	50	30-70	152
			240	9 1/2	1.5-1.9	50	30-70	152
			290	11 1/2	1.7-2.0	50	30-70	152
	860	34	304	12	2.0-2.2	50	30-70	203

Table 2: Other dimensions available on request.

The crystal is mounted with epoxy to the mounting beam. Great care must be taken in the mounting of the crystal to assure a strong bond between crystal, epoxy and mounting beam. As soon as the epoxy is hardened, the excess epoxy is removed to avoid any gum-up of the cutting edge. Good results have been obtained with A46 (Hahn & Kolb) and with ARALDITE (CIBA GEIGY).

Slice tolerance

Slicing conditions, performance and life of the ID saw blade are markedly influenced by the required slice tolerance.
In most cases tighter slice tolerances necessitate an increase in blade treatment like dressing and tensioning. Tolerances are generally connected with a certain material diameter. With increased material diameter, slice tolerances need to be looser.
Figure 8 depicts the geometrical features of a slice, that are covered by a tolerance.
Bow tolerance is critical, since this defect could contribute to wafer breakage under certain conditions during the slicing operation.

Bow may be due to various causes:
a) Non-uniform slice surface. Surface irregularities (damage) or saw marks are found to be the cause of bow in 90% of the slices that are affected by bow. Elimination of this defect can be accomplished by etching (see Fig. 9a).
b) Wandering of the blade during slicing.
This defect is caused by low blade tension and / or dull blade (see Fig. 9b).

A distinction is made between positive and negative bow (see Figs. 9c and 9d). The notation positive or negative has been derived from the positive or negative slice contour.

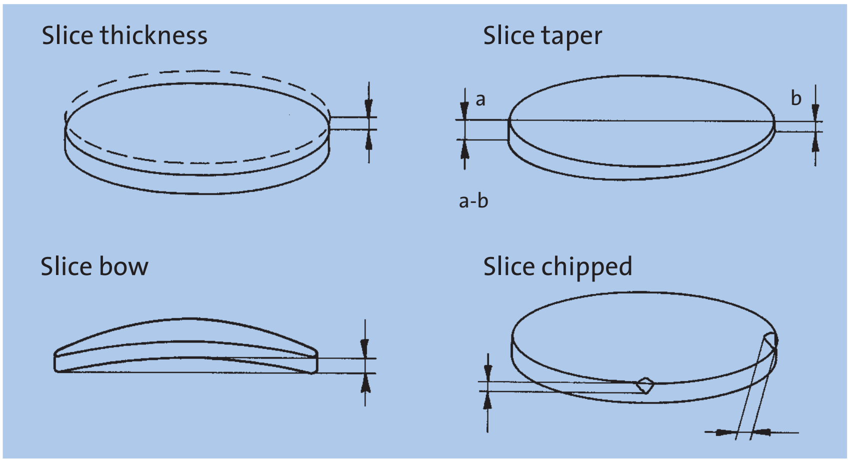

Figure 8

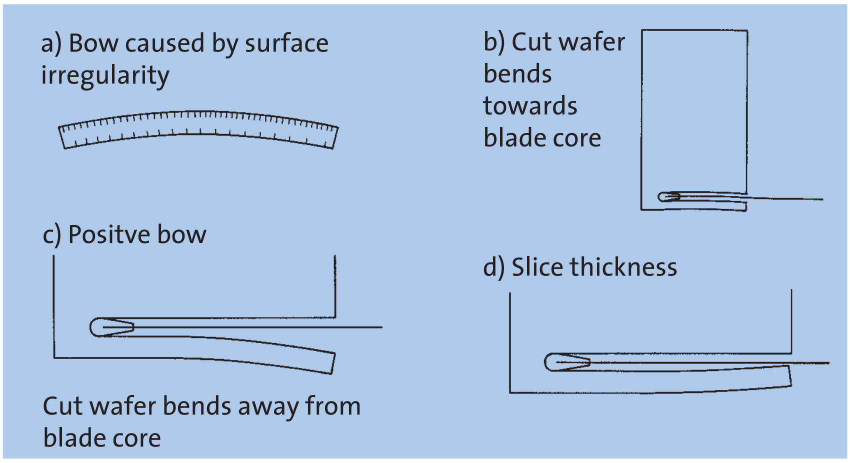

Figure 9

With the positive bow the wafer moves away from the center; for this reason no friction is caused between wafer and crystal. In this case the slice cannot be pulled off, thrown or broken by the blade (see Fig. 9c). With negative bow the wafer bends towards the blade. Friction forces can develop between wafer and blade, and they can be of greater magnitude than the force that holds the slice to the epoxy. In this case the wafer will be pulled off the epoxy and broken.

(For elimination of these defects see Trouble Shooting Guide)

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Blade start-up

The cutting edge of the new ID saw blade has to adjust itself to the slicing conditions, which means that the cutting edge surface structure, characterized by diamond distribution, uneven plating surface and slurry transport grooves, needs adjustment. The adjustment is accomplished during the running-in or start-up period, which extends over a 50 to 200 slice cutting period. The feed rate is gradually increased to the final value over the start-up period; the slice surface indicates the start-up progress.

The running-in of the blade starts with a feed rate of 0.591-0.787 inch/min (15-20 mm/min). As soon as a satisfactory slice quality, preferably with a positive bow, is reached, the feed rate is then increased in 0.197 inch/min (5-10 mm/min) increments until the final value is reached. After every feed rate change, at least 5 cuts need to be made.

If the ID saw blade is sharpened before operation (initial dressing), we recommend using WINTER Stone No. 8a (see also section on "Machine sharpening", page 20).

Problem elimination

All actions that influence the ID saw blade performance by eliminating target deviations are considered corrective measures.

In this catalog only a limited outline for defect elimination is possible, so only the most important defects are listed.

The Trouble Shooting Guide lists the important defects the required corrective action.

Dressing and retensioning and are the most important techniques for correcting blade performance.

The exposure of the blade to a continuous force during the cutting cycle makes it lose some of its rigidity. In order to raise it to its former values, retensioned of approx. 100 µm by elongation of the ID may be neccessary.
Blade dressing should be performed with an aluminium oxide dressing stone, never with a silicon carbide stone. In addition the dressing stick should be held in a fixture. See "Dressing and sharpening ID saws", page 20.

Defect / Possible cause	Cutting edge irregular	Cutting edge dull	Cutting edge too sharp	Infeed rate too high	Blade runout too large	Slurry excess on blade	Blade core damaged	Core tension too low	Cooling flowrate too low	Cleaning flowrate too low	Cooling flowrate irregular	Cooling flowrate too high
Sawmarks												
– overall	x	x	x		x	x	x	x	x	x	x	x
– start of slicing				x	x							
– end of slicing	x		x		x							
Bow												
– convex	x	x		x				x	x			
– concave	x	x		x				x	x			
– taper	x	x	x		x		x	x		x		
Chipping												
– start of slicing				x	x							
– end of slicing		x	x	x								
Wafer breakage												
from mounting beam	x	x		x			x	x				x
during cutting	x	x		x		x	x	x				

Table 3: **Trouble shooting guide**

Slice tracking system

Non-contact sensor systems for blade control and monitoring, known as slice tracking systems, are available from the machine manufacturers.
Their purpose is to show the axial deflection of the ID saw blade, thus in turn indicating whether the blade needs dressing or retensioning.
In future, dressing procedures will be fully automated. The following control cycle will be possible: the information given by the slice tracking system is converted into either a dressing pulse or a shut-off pulse, depending on the size of the deflection. The necessity of retensioning the ID blade could likewise be indicated.

Safety precautions

An ID saw blade can fail through excessive strain (blow, bump, twisting of dressing stick, blade overtensioning). Failure of a saw blade during the slicing operations presents a danger to the operating personnel. Because of the potential danger of injury, the following safety precautions should be observed in the ID saw operation:

- Wear safety glasses.
- Do not touch running ID saw blade.
- Use machine sharpening if possible.
- Remove broken slice from rear of blade only when blade is at rest.
- Safe distance from rotating saw for operator 20 inches (50 cm).

No.	Materials	ID saw type	Grit size	Blade speed (m/s)	Feed rate (mm/min)	Coolant type	Mix (%)	Coolant cleaning (l/h)	Coolant flow (l/h)	Comments
1	Aluminium nitride	E	D91	18	5-25	Water + Syntilo R	10	4	4	
2	Aluminium oxide	E	D91	16	3-10	Water + Meba SKNF	3	6	6	rotating
3	Ferrite	E	D46	18	10-50	Water + '7IC AG" ME 11	3	2-4	2-4	
4	Gallium arsenide (315)	D	D46C	18	10-20	Water + Syntilo R	1	2-6	2-6	
5	Gallium phosphide (315)	D	D46	18	10-20	Water + Syntilo R	1	2-6	2-6	special grit
6	Germanium	D, B	D46	19-21	30-70	Water + Castrol 98117	1	2-6	2-6	
7	GGG	D	D46	18	10-20	Water + Castrol 98117	1	7-12	7-12	XK1
8	Graphite	D	D91	21	250	Air				
9	Indium arsenide	D	D46	18	10-20	Water + Syntilo R	1	2-6	2-6	
10	Indium phosphite	D	D46	18	10-20	Water + Castrol 98117	1	6-8	8-12	
11	Lithium niobate	D	D46	18	20-40	Water + Castrol 9811	1	2-6	2-6	
12	Lithium tantalate	D	D46	20	3-10	Water + Meba SKNF	3	6	6	
13	Optical glass (BK7)	E	D91	15	5-20	Mill-Kut 12 Co	10	8-10	8-10	special grit
14	Quartz	E	D91	12	15-30	Mill-Kut 12 Co	10	8-12	8-12	special grit, rotating
15	Quartz glass	E	D91	15	5~20	Mill-Kut 12 Co	10	8-10	8-10	special grit
16	Samarium cobalt	E	D 911 D46	18	10-30	Water + MebaSKNF	3	-12	7-12	
17	Sapphire	E	D91 .	19	1-5	Meba SKNF	3	10-12	10-12	rotating

Table 4: Guidelines for slicing of different materials

Other materials

ID slicing is currently mainly used for slicing silicon. The trend toward expensive materials and smaller dimensions makes the described technology increasingly attractive also for slicing other materials.

Table 4 gives application guidelines for different materials. New ways had to be found in order to be able to cut these materials (see publications, footnotes on page 4).

Dressing and sharpening ID saws

1. Introduction

Despite optimization of core material, core thickness, cutting width, cutting layer and clamping system, one of the major problems that still exists in ID saw blade technology is that the blade has to be corrected during operation.

The most important correction operations include retensioning the core and in particular dressing/ sharpening. It is very important to note that the optimization of the cutting result and blade life is directly dependent on the operator’s skill in using the dressing stick at the right time and with the right technique.

2. Fundamentals

During the slicing process of monocrystalline silicon (and other materials) with the ID saw blade, the cutting layer changes its surface characteristics and geometry.

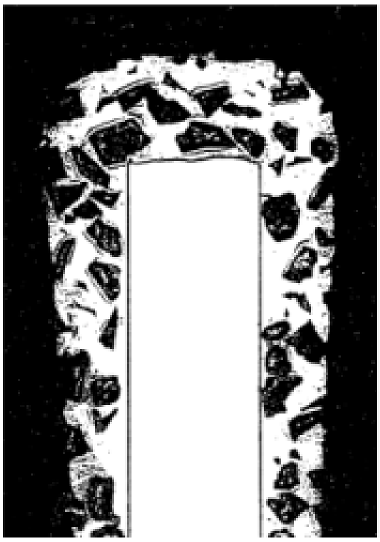


Figure 10: New ID saw

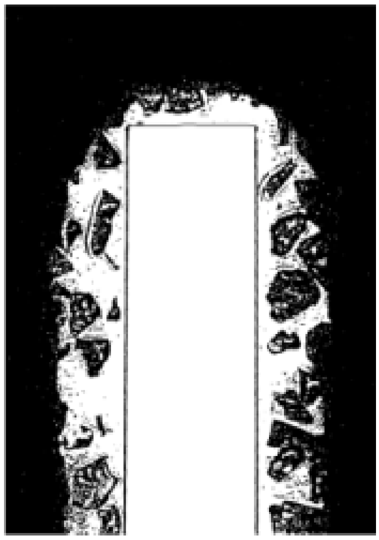
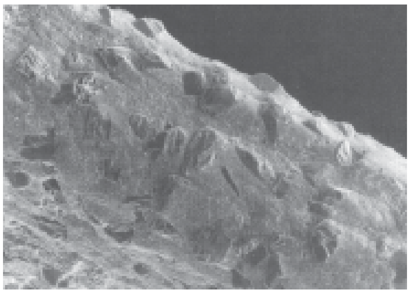


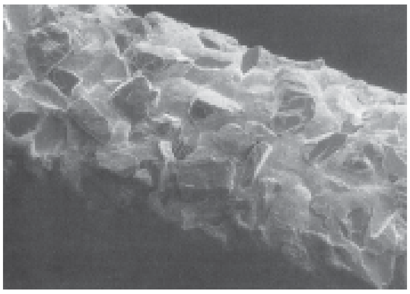
Figure 11: Used ID saw

More precise results on these changes were found in experiments carried out at the WINTER company as part of a diploma thesis, and in practical experience.

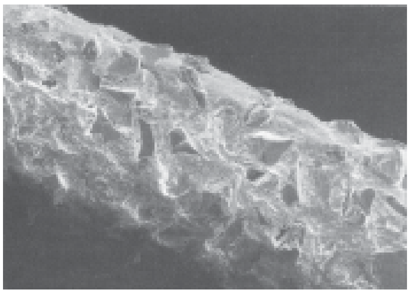
Dressing and sharpening ID saw blades



1. New saw blade



2. Cutting layer after 600 wafers



3. Cutting layer after dressing/ sharpening

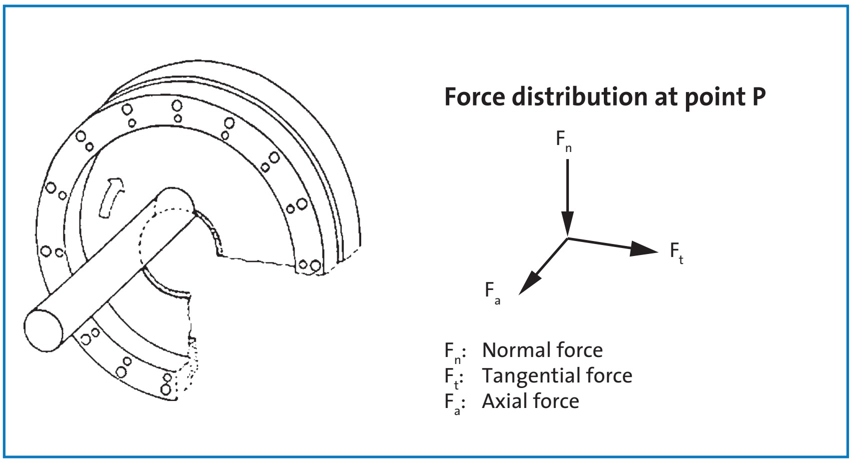


Figure 12: Force distribution

The cutting force F_C can be analyzed into its three components F_N, F_T and F_A

In an ideal slicing process, the workpiece is sliced absolutely plane parallel, with only the force components F_N and F_T.

The change in topography (dulling of diamonds, change in chip space, rougher surface of bond) and the geometry of the cutting layer during the slicing processes may, however, disturb the equilibrium of the system of forces. The imbalance is caused by the continuous increase in forces of F_N and by the appearance of an axial component F_A.

This is expressed by undesired deflection of the ID saw blade, which can be monitored with the aid of the Slice Tracking System.

This deflection ca:uses surface and geometrical errors on the wafers.

The ID saw blade has to be dressed in order to counteract the rise in cutting force components (F_N) and the deflection in axial direction.

The dressing stick must be capable of:

- Generating new cutting edges on the diamond;
- Setting back and cleaning the bond (creating chip space);
- Influencing the geometric shape of the cutting layer.

These equirements inevitably have an influence on blade life.

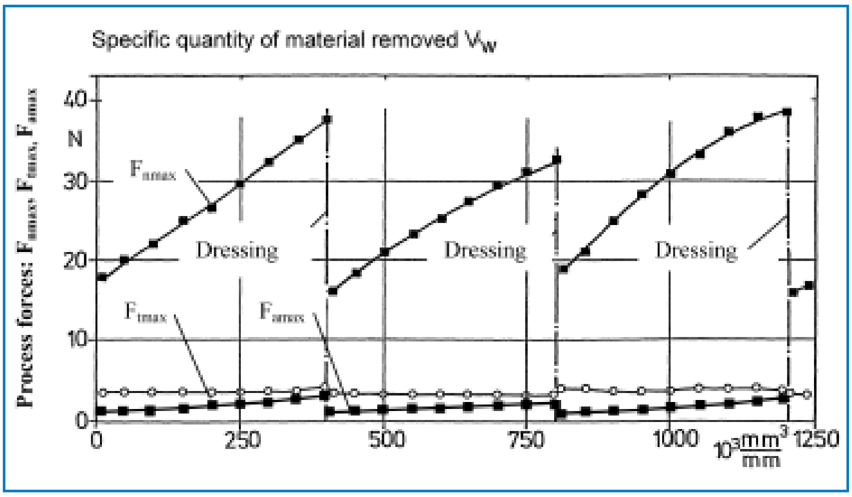


Figure 13: Process forces, influence of dressing

3. Dressing / sharpening methods

Basically, there are two methods:
- Radial sharpening method (machine sharpening)
- Axial dressing method (manual dressing)

3.1 Radial sharpening method (machine sharpening)

With this method, the ID saw blade cuts into or through the sharpening stick. Radial sharpening is mostly carried out with a fixture on the machine. This is mainly accomplished to reduce F_N and F_T. More than three sharpening passes per dressing cycle normally are not advisable, as it is not possible to achieve further improvements in the topography and geometry. Any further sharpening only reduces blade life.

Operating parameters for radial sharpening method:

Speed:	Parameters as slicing process
Feed rate:	
Coolant supply:	

Sharpening stick:
For initial dressing - a hard stone
For process dressing - a softer stone

State of sharpening stick:
wet

Number of sharpening passes:
approx.3

3.2 Axial dressing method (manual dressing)

The axial dressing technique comes into consideration only if the Slice Tracking System shows an axial deflection outside of the specified tolerance, or the geometrical tolerances (bow, warp) are exceeded. In order to counteract this, the ID saw blade has to be dressed side opposite the deflection with an appropriate dressing stick.

If this dressing procedure is done by hand, i. e. without a dressing fixture, dressing has to be done with great caution, in order to avoid possible sources of error such as:

- Excessive changes in geometry
- Core contact
- Layer displacement

and also to avoid danger of injury to the operator.

For this dressing operation, the dressing stick is held at an angle of 45° to the vertical and 45° to the ID saw blade plane, in order to dress only the radius. Dressing is done tangentially to the cutting layer radius. The dressing stick pass (with cross section 6x 6 mm) should last for approx. 3 seconds).

In order to ensure continuous dressing, the roof surfaces of the dressing stick should be symmetrical; the dressing stick should be turned 180° after each dressing operation.

After the dressing operation, wait for at least 3 wafers before checking the grinding result.

Parameters for the axial dressing method (manual dressing):

Speed:
Coolant supply: } Parameters as slicing process

Dressing stick
Soft stone (dimension 6 x 6 x 100 mm)
Number of dressing passes:
depending on deflection, 1 - 3 times

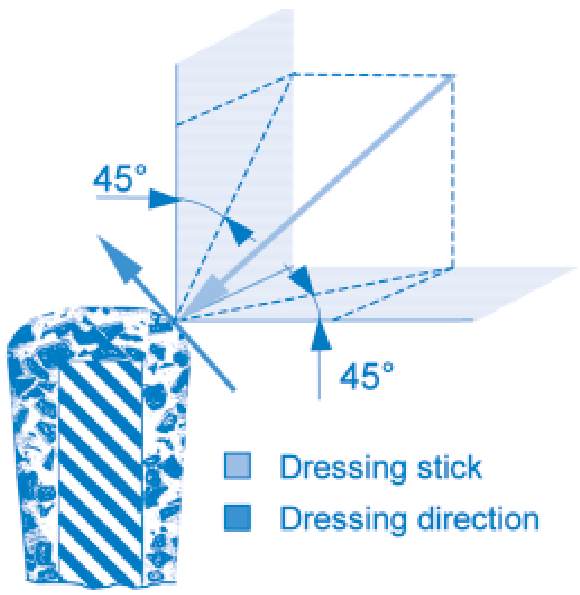


Figure 14: Dressing

At some time in the future the manual dressing will be replaced by automated dressing.

4. Dressing/ sharpening stick

WINTER has various dressing sticks available. In the past, WINTER Stones 2, 6a and 7 have been recommended for ID sawing. Practical experience led to the development of dressing/ sharpening sticks 8 and 8a. These have proven themselves in practice, particularly in uniformity of cutting edge generating and by good setting back of the bond.

The dressing/ sharpening behaviour of these WINTER Stones 8 and 8a may be described as more "gentle" compared with the previous types.

Overdressing is mostly not possible, so that it is easier to control the process.

Questionnaire

The catalogue contains a questionnaire see Annex. The answers to these questions will enable WINTER to give advice for the solution of slicing problems.

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Organization
for the Safety
of Abrasives (oSa)

Certified to
DIN EN ISO 9001:2000,
No. QS-453 HH;
DIN EN ISO 14001, No.
EM-2129 HH;
OHSAS 18001, No. S-2984 HH

LG-Nr. 37 /06 e

Questionnaire

ID saw blade application data

Company :

Address :

Technical advice ☐

Quote ☐

Order ☐

Claim ☐

Please provide below detailed information about intended slicing operation

1	**Machine & wafer**	
1.1	Machine & equipment	
1.2	Machine bow-setting (Limits) [µm]	
1.3	Workpiece material	
1.4	Material size [mm] and thickness [µm]	
2	**Clamping & Tensioning**	
2.1	Clamping force [Nm]	
2.2	Clamping screw characteristics	
2.3	Replacement of clamping screws	
2.4	Blade engraving (ingot-/wafer side)	
2.5	Tensioning procedure (brief explanation)	
2.6	Runout [µm]	
2.7	Deflection weight [g]	
2.8	Maximum deflection [µm]	
2.9	Position of deflection measurement	
2.10	Elongation d/2 [µm]	
3	**Cooling & cleaning**	
3.1	Coolant medium	
3.2	Coolant ratio	
3.3	Coolant flow [l/h or cc/min]	
3.4	Coolant temperature [°C]	
3.5	Cleaning medium	
3.6	Cleaning flow [l/h or cc/min]	
3.7	Cleaning medium temperature [°C]	
3.8	Back flush flow [l/h]	
4	**Sharpening & dressing**	
4.1	Table dress stone specification	
4.2	Table dress stone dimensions [mm]	
4.3	Hand dress stone specification	
4.4	Hand dress stone dimensions [mm]	
4.5	Start dress procedure (initial dress)	
4.6	In-process table dress procedure	
4.7	In-process hand dress procedure	
4.9	Preventive dress procedure	
5	**Operating**	
5.1	Revolutions [rpm]	
5.2	Blade start-up process	
5.3	Production feed rate [mm/min]	
5.4	Retensioning [µm]	