

Sample of Level 3 Editing

Target Tutor included, Content Ideas included

The Effect of Uncut Chip Thickness on Edge Chipping and Grinding Ratio in Groove Grinding of Single Crystal Silicon

1. Introduction

~~With the growing of~~ AsDue to the growth of the semiconductor and optics industries ~~have grown~~, demand ~~has increased~~ for enhanced ~~ing~~ manufacturing quality and reduced ~~ing~~ machining costs ~~is increasing~~. Most mechanical machining of ~~the~~ semiconductor materials and optic glass requires the use of a diamond-impregnated wheel for grinding ~~with diamond-impregnated wheel~~. Groove grinding is extensively used for separating small sized components ~~or~~ and for cutting grooves. ~~Edge chipping is a major issue~~ During the precision groove grinding of brittle materials, ~~the serious edge chipping is a major issue~~ due to the brittleness of the workpiece. In addition, the grinding wheel ~~additionally often~~ comprises ~~up to~~ majority of the manufacturing cost, ~~because due to the~~ large utilization of the diamond wheel during manufacture, and its high unit price. For these reasons, an improved ~~better~~ understanding of ~~what happens during~~ the groove grinding process should provide a technologicaly basise for engineers

Comment [M1]: IDEA: Your readers may find it interesting to read more regarding the increasing need for the machining process, so it may be helpful to include references.

Comment [M2]: IDEA: It would improve your article to elaborate on the uses of this process and the industries, in order to demonstrate its relevance.

Comment [M3]: IDEA: It may be useful to identify the more commonly used materials, to highlight the need for this research. (i.e. your research focuses on single crystal silicon, but if you highlight other materials that are also commonly used, it will serve to demonstrate how large an issue edge chipping is).

Comment [M4]: IDEA: Cite a reference for this statement.

Comment [M5]: CHECK: "large utilization" refers solely to the fact that the diamond wheel is used greatly during the manufacturing process. Is this your intention? Or were you intending to imply the large running costs of the wheel, due to power consumption, or other factors? (Utilization does not necessarily imply costs, particularly if power costs are small, so it may be helpful to elaborate on this point).

Comment [M6]: TUTOR - phrase choice:
Incorrect: "...understanding what happens during..."
Correct: "...understanding of the groove grinding process..."
Reason: "what happens during" would not generally not be used in academic English. By restructuring the phrase slightly, to use the word "process," improves the presentation.

to enhance the process efficiency ~~enhancement~~ and ~~point way for the~~ guide equipment manufacturers ~~to in future~~-improvement their products.

Efficient production ~~ity~~ is achieved in the groove grinding of brittle materials ~~requires—through the~~ selection ~~ing~~ of suitable grinding conditions, and by consideration ~~ing~~ of material properties, in order to maximize the wheel life while ~~controlling~~ edge chipping. The fundamental grinding parameter ~~for—in a grinding~~

process is the ~~cutting geometry~~; ~~which is also called~~ ~~in particular, it is the~~ uncut chip thickness ~~or—(also known as~~ the grit depth of cut) [1, 2]. In general, the uncut chip

thickness is well known to play an important role relative to the surface finish and ~~to the~~ wheel life. ~~For the—In regards to the~~ surface finish, controlling the uncut chip thickness

~~by varying~~ through the modification of grit size, grit density, wheel dimension, cutting speed, feed speed, and/or wheel depth of cut can improve the surface roughness [1-7].

In past studies ~~on—of~~ surface finish, ~~some—~~researchers have undertaken ~~to—~~experiments to investigate ~~experimentally—what happen during~~ the effects of ~~changing—altering~~ the uncut

chip thickness. The surface roughness ~~is indicated in experimental investigations—~~ can be improved ~~effectively—with—~~by decreasing the feed rate, abrasive grit size and/or

increasing cutting speed, as reported by ~~some authors~~ [1-4]. For very hard materials; ~~such as~~ silicon nitride [5], ~~silicon carbide~~ [6] and granite [7], the roughness of the

grinding surface also decreases ~~with decreasing~~ as the uncut chip thickness decreases.

Comment [M7]: CHECK: "controlling" or "minimizing?"

Comment [M8]: CHECK: Normally I've only seen 'cutting geometry' used to refer to a group of cutting tool parameters. I have changed the sentence to reflect this, however, feel free to alter it if you feel that your usage is correct.

Comment [M9]: CHECK: Depending on the journal to which you are submitting, it may be unnecessary to use "by some authors [1-4]." Instead you may be able to simply use "by [1-4]."

Comment [M10]: CHECK: Do you mean "silicon carbon" or "silicon carbide?"

~~Besides characterizing for surface finish~~ In addition to its' effect upon the surface finish, the uncut chip thickness can be a factor ~~to characterize~~ in determining the wheel wear for a cutting process. For instance, it has been experimentally shown that ~~the behavior in~~ during the sawing of granite, there is evidence that suggests a transition in the predominant diamond wear mechanism, ~~from~~ attrition at a smaller uncut chip thickness to fracture at a larger uncut chip thickness [7].

Comment [M11]: IDEA: Consider stating how much of a factor it is. Is it the critical factor? Or only a minor factor?

Comment [M12]: TUTOR – word choice:
Incorrect: "...to characterize the wheel wear..."
Correct: "...determining the wheel wear..."
Reason: "characterize" indicates that the uncut chip thickness is a symptom of wheel wear while "determining" is used to indicate that the uncut chip thickness is a factor in the degree of wheel wear.

In addition to the uncut chip thickness, the material properties of the workpiece may also be a crucial factor. ~~The material removal process~~ During the grinding of a brittle material, the material removal process results in brittle fracture and leads to ~~the an~~ undesirable ~~worsens~~ decrease of surface roughness. This occurs, to a greater degree ~~more ease~~ than would occur in conventional metal cutting. ~~But-However,~~ if the cutting parameters ~~were~~ are chosen adequately, ~~the~~ brittle materials can deform ~~plastic~~ plastically, without brittle fracture, at room temperature under conditions of large hydrostatic compressive stress [8, 9]. Research in ~~S~~scribing [10-12], turning [13], vibration cutting [14], and grinding [15-17] ~~also have~~ also observed ductile chip ~~respectively~~ formation. In order to ensure ~~get a~~ ductile-to-brittle transition~~al~~ depth during ~~the~~ cutting of brittle materials, analyzing of fracture mechanics [15, 18] ~~or~~ and

Comment [M13]: CHECK: Does "worsens" mean reduces surface roughness or increases it? This is a little ambiguous here.

Comment [M14]: IDEA: Include a reference to demonstrate that this statement is accurate.

Comment [M15]: CHECK: "Plastic" is a noun or adjective. Do you intend to say that the brittle materials can deform another plastic material? Or that they themselves deform plastically? Or do you mean in a ductile manner? I have assumed your intention was that the brittle material deforms in a plastic manner.

Comment [M16]: IDEA: It may be useful to discuss how this research relates to your focus on grinding.

dislocation theory [19] further can aid in estimating the transitional depth, that is called known as the critical depth of cut (CDC). The CDC can be formulated as a function of the geometry of the tool and the material properties of the workpiece [18]. The CDC model for a grinding process on-used for various hard and brittle materials has been presented [15].

Comment [M17]: CHECK: It would be clearer here to state either "The CDC model... has been presented in [15]." Or alternatively, to state "The CDC model... has been presented by Bifano, Dow and Scattergood [15]."

~~A logical methodology for optimization of the grinding parameters, in order and to reduce total manufacturing cost in groove grinding of brittle materials (given for consideration the for wheel life and groove edge chipping) in groove grinding of brittle materials is still lacking. Although several grinding studies have been reported,~~

Comment [M18]: CHECK: Please ensure that this retains your desired meaning.

a logical methodology for the optimization of the grinding parameters, in order to reduce total manufacturing cost in groove grinding of brittle materials (given consideration for wheel life and groove edge chipping), is still lacking. An experimental

Comment [M19]: CHECK: Please clarify what they have reported. Have they reported possible sub-optimum methodologies, the necessity for a study into optimization of parameters, or the effects of parameter optimization? (Or some mix). Or are you referring to those studies already cited in your paper? (If this last is the case, then it is unnecessary to include "although several grinding studies have reported.")

investigation of edge chipping and performance in the grinding of a single crystal silicon (SCS) wafer over a range of uncut chip thickness (5 nm – 32 nm) has been undertaken in this study, over a range of uncut chip thickness (5 nm – 32 nm) in this process of a commercial single crystal silicon (SCS) wafer is then attempted in this study. The results show that the edge chipping and wheel performance for in a groove

Comment [M20]: CHECK: Please ensure that this retains your desired meaning.

grinding process can be characterized by a newly defined value, i.e. the cutting depth ratio (CDR). This dimensionless parameter can be used for to explaining the effect of

Comment [M21]: IDEA: If you are going to state what they have reported, please include some citations to ensure interested readers can pursue these avenues of thought.

Comment [M22]: CHECK: Are you referring to wear resistance or another measure of performance?

uncut chip thickness on ~~the~~ edge chipping and ~~the~~ grinding ratio ~~in~~during groove grinding of SCS. Evidence ~~derived~~ ~~form~~ ~~from~~ both of these approaches ~~can~~ provides important insights into the groove and cutoff grinding mechanism for ceramics.

Comment [M23]:

TUTOR: - word choice:

Incorrect: "form" is a noun used for a number of things, such as appearance.

Correct: "from" is a preposition used to indicate a starting point.

This occurs a few times during this article, I felt it worth pointing out.

2. Processing Modeling

The block diagram ~~in~~for a groove grinding system ~~can~~ be is illustrated ~~in~~as Fig. 1.

~~Many~~ A variety of input parameters directly ~~affect~~ affects the grinding mechanisms and their influence on the resulting edge chipping and wheel ~~performance~~. ~~This study~~

Comment [M24]: CHECK: As before, please specify what performance refers to.

~~reduces~~ these input parameters to two characteristic parameters, the uncut chip thickness and the ~~critical depth of cut (CDC)~~. ~~Assuming that the~~ thermal effect in the fracture

removal process ~~more~~ ~~small~~ is of negligible magnitude in comparison to the ~~than~~ cutting force effect [20]. ~~this study therefore groups and reduces these input parameters into~~

~~two characteristic parameters, uncut chip thickness and CDC.~~ The following section

defines the uncut chip thickness and the CDC. ~~Introducing uncut chip thickness, CDC,~~

~~and how to define new characteristic parameter are described detailed on the following section.~~

Comment [M25]: IDEA: In some instances, such as those in which you are highlighting the aims of the study, it may help to use the full term (i.e. critical depth of cut), rather than the acronym (CDC), in order to reinforce the meaning of the acronym to the reader. (Although this is not strictly necessary).

Comment [M26]: IDEA: What is the thermal effect? Will your readers understand this term? It could potentially help to explain this term and why your are neglecting it.

2.1 Uncut chip thickness

The uncut chip thickness ~~of~~ in grinding processes can be formulated as a function of the grinding conditions and the geometry of the wheel. The essential ~~parameter~~ variables includes the cutting speed, feed rate, depth of cut, contact length of cutting,

abrasive grit size, and active grit density, as shown in Fig. 2. The average uncut chip thickness is given by the following equation. [1]

$$\bar{t} = \left[\left(\frac{v}{VCr} \right) \left(\frac{d}{l} \right) \right]^{0.5} \quad (2)$$

Comment [M27]: CHECK: Equations 1 and 2 are out of order.

where C is active grit density (grits/mm²); V is cutting speed (m/sec); v is feed rate (mm/sec); d is cutting depth (μm); l is contact length of cutting (μm) and r is the ratio of the mean scratch width to the mean scratch depth (10 - 20) [1].

Comment [M28]: IDEA: would readers know the terms scratch width and scratch depth? It may help to elaborate on these terms.

2.2 Critical depth of cut

The ductile to brittle deformation transition has been shown to occur during the indentation and in the cutting process of brittle materials, as reported by some researchers [8-17]. This transitional depth is called known as the critical depth of cut. An analytical model has been presented to predict the theoretical critical depth of indentation [18]; this model was later modified to estimate the CDC in the grinding of a brittle material, and is given by [15]

$$d_c = \alpha \frac{E}{H} \left(\frac{K_c}{H} \right)^2 \quad (1)$$

Comment [M29]: CHECK: As per previous comments.

Comment [M30]: CHECK: Is this reference to "this model was later modified to estimate the CDC in the grinding of a brittle material" or for the following equation? If the former, insert the reference at the end of "the grinding of a brittle material", or if the latter, then insert it at the end of the sentence (after the equation, just before the first period).

where E , H and K_c are the Young's modulus, hardness and fracture toughness respectively. α is the grinding tool factor representing the combined effect of the tool geometry and the cutting conditions.

Comment [WL31]: CHECK: Should this be here or is it an error?

2.3 Cutting depth ratio

The removal mechanism in the cutting of brittle materials is deeply affected by the CDC of the work material and the uncut chip thickness. For this reason, the following investigation is further then combining combines the CDC model of the work materials with the average uncut chip thickness; in order to discuss the groove edge chipping and the life-of wheel lifespan. The cutting process is then characterized by a newly defined value, the cutting depth ratio (CDR), or γ_c . The CDR is defined as the ratio as of the maximum uncut chip thickness and to the CDC. As the depth of the cut is very far smaller than the diameter of the wheel, the maximum uncut chip thickness is notably around twice the average uncut chip thickness [1]. The CDR can be written as

$$\gamma_c = \frac{t_{\max}}{d_c} \square \frac{2\bar{t}}{d_c}$$

(3)

where t_{\max} is the maximum uncut chip thickness, d_c is the cutting depth, and \bar{t} is the average uncut chip thickness.

Comment [M32]: CHECK: Please ensure that this sentence retains your original intended meaning, as the original sentence was difficult understand.

Comment [M33]: CHECK: Was this your intention?

Comment [Ozy34]: TUTOR – grammar:
Incorrect: very far smaller
Correct: far smaller
Reason: ‘very far’ can be used in ‘very far away’, ‘very far from here’. That is, ‘very far’ acts like one word meaning a long distance. To say ‘very far smaller’ is thus strange.

Comment [WL35]: CHECK:
You may be missing a symbol in this equation from a lack of characters.

Comment [WL36]: CHECK:
Again, is this symbol meant to be here?

3. Experimentation

3.1 Set up and cutting parameters

The experiments were ~~carried out on~~ undertaken using a grinding machine tool ~~using~~ incorporating a diamond-grinding wheel. A commercial single crystal silicon wafer was used as the work material. Fig. 3 shows the schematic illustration of the groove grinding experiment, where d is the depth of cut and the wheel width ~~is~~ was 43 μm . The diameter of the wheel ~~is~~ was 55.56 mm. Fig. 4 shows the distribution of the participating grits for the wheel. Subsequently, using the abrasive grit size (#2000), diameter of wheel, and the distribution of the participating grits, ~~then could estimate~~ active grit density ~~could be~~ was estimated, ~~which is to~~ be 23885 grits/ mm^2 . Table 1 summarizes the experimental conditions used for studying the edge chipping and the performance. The experimental parameters were the depth of cut, feed rate and cutting speed. The cutting length of every experiment ~~is~~ was 120 m. At the restricted range of experimental parameters, the ~~variable~~ average uncut chip thickness lies between 5.5 nm to 32 nm, as listed in Table 2.

Comment [M37]: CHECK: Please check this term. To a non-technical reader this would appear that the wheel was designed to grind diamond. The use of this term is fine if it is a commonly known technical term, otherwise, it may be clearer to state something along the lines of "a diamond-grit grinding wheel."

Comment [M38]: IDEA: Your readers may be interested to know where the SCS wafer that you have used would be commonly used in manufacturing. Also consider providing the manufacturer of the wafer.

Comment [WL39]: TUTOR:
Incorrect: "...could be estimated..."
Correct: "...was estimated..."
Reason: The use of "could be" suggests that it is not necessary to have that value. If however, the value is critical, you should use "was estimated".

Comment [M40]: CHECK: 120 meters seems very large given measurements for other variables. Is this correct?

Comment [M41]: CHECK: What do you mean by restricted range? Will your readers understand this terminology? Perhaps include a sentence to explain this term.

As ~~S~~shown in Fig. 5, ~~the method of~~ digital imaging was used to quantify ~~detect the~~ magnitude of groove edge chipping. A CCD camera was used to catch edge chipping images off-line. ~~Each~~~~very~~ experiment took ~~a~~ ~~minimum of 50 pictures~~ ~~least~~. ~~The~~ ~~P~~pixel array ~~is~~ ~~was~~ 640X480-, the size of each image ~~is~~ ~~was~~ 300X225 μm ~~per picture~~, and the mode of image acquisition card ~~i~~ ~~was~~ IMAQ PCI-1408. As stated ~~above~~ ~~previously~~, the resolution of ~~the~~ images ~~was~~ ~~is~~ 300/640 μm .

Comment [M42]: CHECK: It may help to clarify to your readers what off-line is referring to (a simple explanation in brackets would suffice).

Comment [Ozy43]:

TUTOR – word choice:

Incorrect: every experiment

Correct: each experiment

Reason: 'Every' means 'not just this one or that one, but all of them'. The emphasis is on 'all of the'.

'Each' means 'the first, second, third and fourth one etc'. The emphasis is on 'the same applies to each experiment'

Example: I think there is some error in the result. Every (*all of the*) experiment has some measurement error.

Example: How much time will we need? Well, each (*the 1st, 2nd, 3rd etc*) experiment takes 10 min, so we need 2 hours in total.

TUTOR - phrase choice:

Incorrect: "...understanding what happens during..."

Correct: "...understanding of the groove grinding process..."

Reason: "what happens during" would not generally not be used in academic English. By restructuring the phrase slightly, to use the word "process," improves the presentation of the article, without losing the meaning.