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Development of a process data-based strategy for conditioning position-controlled ID cut-off grinding wheels in silicon wafer manufacturing

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Abstract

Manufacturing technologies in the semiconductor industry put high demands on accuracy, especially for the initial steps of wafering. ID grinding has established itself as a cost-effective manufacturing method for the production of wafers with a diameter of up to 150 mm. Methods for improving the quality parameters of the wafer, resulted in the integration of a magnetic position control for the ID grinding wheel to control its axial position. For this, a new conditioning strategy had to be developed in consideration of tool life of the grinding wheel, process automation and wafer quality.

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Keywords: grinding; wafering; silicon; ID cut-off grinding; position control; conditioning; dressing; automation

1. Introduction

Manufacturing technologies in the semiconductor industry have enormous demands on precision and process reliability, which are reflected in high production costs. A special focus has to be given on the first steps of the

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wafering process, since these processes determine the quality parameters and influence subsequent processes economically.

Nomenclature

ADM		Axial dressing method
δ	[µm]	Air gap between magnet and grinding wheel
DAQ		Data Acquisition card
F_m	[N]	Magnetic force
ID		Internal diameter
RSM		Radial sharpening method
TTV	[µm]	Total thickness variation

2. Literature review

Internal diameter (ID) cut-off grinding is an established economical method for the production of silicon wafers up to a diameter of 150 mm [1], whereby a further application of the method is given in the optical and ceramic industries due to the high flexibility and the precise crystal orientation capabilities [2]. The deflection of the grinding wheel during the operation has a negative effect on the quality parameters bow and warp, whereas the tool wear or deficient conditioning of the grinding wheel are responsible for high values of the total thickness variation (TTV) [3].

The application of a position control system for the grinding wheel is one approach for reducing the grinding wheel deflection during the engagement and thus a solution for improving the quality parameters of the wafer. Active control systems of the axial position of the grinding wheel are known with active principles being based on hydrodynamic [4], pneumatic [5] or magnetic effects [6].

However, a decisive precondition for the productive and quality-appropriate application of a grinding wheel is the establishment of an adequate conditioning strategy [7]. In the field of the ID cut-off grinding wheels, there is a need of specific developments in order to ensure the applicability of the position control system on the one hand and to avoid process-induced damage of the wafer due to worn abrasives material on the other hand [8].

New machine solutions for the implementation of dressing units are primarily aimed at being used in an automated manner with low backfitting costs [9]. Beside the machine solutions a quality standardized and productive manufacturing is only possible with a strategy for the application of the dressing and conditioning units by adequate sensors by which an automation of the process for the dressing system will be achieved [10]. The combination of a position control system and a conditioning or rather a dressing strategy adapted for this purpose is the subject of the development since comparable solutions have not been available yet. The requirement placed on this combination refers to improved geometric values maintaining until the end of the grinding wheel tool life. The necessary work for the automation of the conditioning strategy also serves to ensure long tool life of the grinding wheel.

3. Experimental conditions

A modified grinding machine TS-23 from Meyer + Burger AG, Switzerland combined with a force measuring device from Kistler was used for all the experiments. A cutting speed of 20 m/s was set for the grinding process. The feed rate for the cut-off process was adjusted by means of the type of grinding wheel and the cutting number during the run-in period between 40 and 80 mm/min.

The ingot diameter, and thus the diameter of the monocrystalline wafers, was approximately 150 mm with a crystal orientation <1-0-0>. The investigation involved a total of 10265 ground wafers in connection with 17 analyzed grinding wheels. The grinding wheels were of the type S35D from Ernst Winter & Sohn Diamantwerkzeuge GmbH & Co, Norderstedt, Germany and the type D690D1-235 from the company Wendt