UNIVERSITI TEKNIKAL MALAYSIA MELAKA

SILICON DIE CHIPPING IMPROVEMENT THROUGH FULL SANDWICH DOUBLE-SIDED WAFER MOUNTING TECHNIQUE

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A thesis submitted
in fulfillment of the requirements for the degree of
Doctor of Philosophy

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2025

DECLARATION

I declare that this thesis entitled “Silicon Die Chipping Improvement Through Full Sandwich Double-Sided Wafer Mounting Technique“ is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : Mohd Syahrin Amri Bin Mohd Noh

Date : 17 / 10 / 2025

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Doctor of Philosophy.

Signature : .....

Supervisor Name : Prof. Ir. Ts. Dr. Ghazali bin Omar

Date : 17 / 10 / 2025

DEDICATION

"In The Name of Allah, The Most Gracious, The Most Merciful”

This thesis is dedicated to God Almighty, my originator, my source of inspiration, wisdom, knowledge, and comprehension, and my pillar of fortitude. To my wife, Halimah binti Sulaiman, who has been an unwavering source of encouragement and support. I am extremely grateful for your presence in my daily life. To my children, Nurul Fatihah, Muhammad Syahmi, Nurul Faqihah, and Nurul Firzanah, who have been significantly affected by this endeavour. This work is also dedicated to my parent, Mohd Noh Bin Abd Razak and Rohana Binti Chik, who have always loved me unconditionally and whose exemplary behaviour has inspired me to work assiduously towards my goals. I am extremely grateful. There is no way to quantify my love for each of you.

ABSTRACT

This study investigates the development and evaluation of new wafer mounting techniques designed to enhance wafer holding capability, with the primary objective of minimizing chipping and improving the flexural strength of silicon dies by reducing vibration during the wafer dicing process. The conventional single-sided wafer mounting approach was found to be inadequate, particularly in stabilizing non-polished wafers with backgrinding marks, which resulted in insufficient tape adhesion, increased vibration, and compromised mechanical stability during dicing. Chipping was identified as the most critical defect, accounting for 15% of failures within the 23% defect rate related to wafer dicing processes. To address these limitations, double-sided semi-sandwich and full-sandwich wafer mounting configurations were developed and evaluated using UV Tape A, UV Tape B, and non-UV tape. A key focus of the study was the optimisation of UV curing parameters, particularly curing speed, to enable the automatic removal of surface UV mounting tape after dicing, ensuring a seamless transition to subsequent processing steps. Experimental findings showed that UV tape with an adhesive strength of 30 mN/25 mm achieved complete detachment when cured at an optimized speed of 10 mm/s.To assess the impact of this optimization, a comprehensive comparative analysis was performed between the conventional single-sided wafer mounting technique and the proposed double-sided configurations, namely the semi sandwich and full sandwich wafer mounting techniques. Comparative analysis revealed that the full sandwich configuration significantly outperformed the conventional single-sided method, achieving an 84% reduction in topside chipping, a 40% enhancement in die flexural strength, and a 26% reduction in vibration amplitude during dicing. These results validate the double-sided full sandwich wafer mounting technique as a novel and practical solution for improving wafer dicing performance in semiconductor manufacturing applications.

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PENINGKATAN ACUAN SERPIHAN SILIKON MELALUI TEKNIK PELEKATAN WAFER TERAPIT SISI BERKEMBAR PENUH

ABSTRAK

Kajian ini menyiasat pembangunan dan penilaian terhadap teknik pemasangan wafer baharu yang direka bentuk untuk meningkatkan keupayaan pegangan wafer, dengan objektif utama untuk meminimumkan kecacatan serpihan dan meningkatkan kekuatan lenturan acuan silikon melalui pengurangan getaran semasa proses pemotongan wafer. Kaedah pemasangan wafer satu sisi yang konvensional didapati tidak mencukupi, khususnya dalam menstabilkan wafer yang tidak digilap dan mempunyai kesan pencanaian belakang , yang mengakibatkan lekatan pita yang tidak memadai, peningkatan getaran, serta kestabilan mekanikal yang terganggu semasa proses pemotongan. Serpihan dikenal pasti sebagai kecacatan paling kritikal, yang menyumbang sebanyak 15% daripada jumlah kadar kecacatan 23% berkaitan dengan proses pemotongan wafer. Bagi menangani kekangan ini, konfigurasi teknik pelekatan wafer terapit sisi berkembar separuh dan penuh telah dibangunkan dan dinilai menggunakan Pita UV A, Pita UV B, serta pita bukan UV. Tumpuan utama kajian ini adalah pengoptimuman parameter penyinaran UV, terutamanya kelajuan penyinaran, untuk membolehkan penanggalan automatik pita pelekat UV bahagian permukaan selepas pemotongan, bagi memastikan kelancaran peralihan ke langkah pemprosesan seterusnya. Dapatan eksperimen menunjukkan bahawa pita UV dengan kekuatan lekatan 30 mN/25 mm berjaya ditanggalkan sepenuhnya apabila disinar pada kelajuan optimum 10 mm/s. Untuk menilai kesan pengoptimuman ini, satu analisis perbandingan menyeluruh telah dijalankan antara teknik pelekatan wafer satu sisi konvensional dan konfigurasi pelekatan wafer terapit sisi berkembar yang dicadangkan, iaitu teknik separuh dan penuh. Hasil analisis menunjukkan bahawa konfigurasi penuh sandwich menunjukkan prestasi jauh lebih baik berbanding kaedah sebelah tunggal konvensional, dengan pengurangan sebanyak 84% dalam serpihan permukaan atas, peningkatan 40% dalam kekuatan lenturan die, dan pengurangan 26% dalam amplitud getaran semasa proses pemotongan. Keputusan ini mengesahkan bahawa teknik pelekatan wafer terapit sisi penuh merupakan pendekatan baharu yang praktikal dan berkesan dalam meningkatkan prestasi pemotongan wafer dalam aplikasi pembuatan semikonduktor.

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ABS	-	Anti-lock braking systems
AOI	-	Automated optical inspection
BE	-	Back End
BGA	-	Ball Grid Array
CZ	-	Czochralski
DAG	-	Dicing After Grinding
DAF	-	Die Attach Film
DDAF	-	Dicing Die Attach Film
DGB	-	Dicing Before Grinding
EOL	-	End of line
FE	-	Front End
FOL	-	Front of line
FVI	-	Final visual inspection
IC	-	Integrated Circuits
PMC	-	Post Mold Cure
PSA	-	Pressure-sensitive adhesive
RPM	-	Rotation per minute
Sdn Bhd	-	A private limited company
SEM	-	Scanning electron microscope
Si	-	Silicon
SiC	-	Silicon Carbide

UPH - Unit Per Hour

UTeM - Universiti Teknikal Malaysia Melaka

UV - Ultra Violet

LIST OF SYMBOLS

$\sigma_{3\ point}$	-	3-points bending test
α	-	significant test probability
Ra	-	arithmetical mean roughness value

LIST OF PUBLICATIONS

Journal Articles

Mohd Syahrin Amri, Ghazali Omar, Mohd Syafiq Mispan, Fuaida Harun, Zaleha Mustafa, 2024. Semiconductor Chipping Improvement via a Full Sandwich Wafer Mounting Technique. *Majlesi Journal of Electrical Engineering Vol. 18, No. 1, March 2024 Semiconductor*, 10(2), pp. 743-758. (Scopus)

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AWARDS AND SCHOLARSHIPS

Awards:

2023

1) ON Semi special award – Novel full sandwich wafer mounting technique for chipping and flexural strength improvement, Innovation Showcase 2023, UTeM - 26 October 2023.

2) 3rd prize award – Novel full sandwich wafer mounting technique for chipping and flexural strength improvement, Innovation Showcase 2023, UTeM - 26 October 2023.