Die Prep Considerations for IC Device Applications

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Die Prep

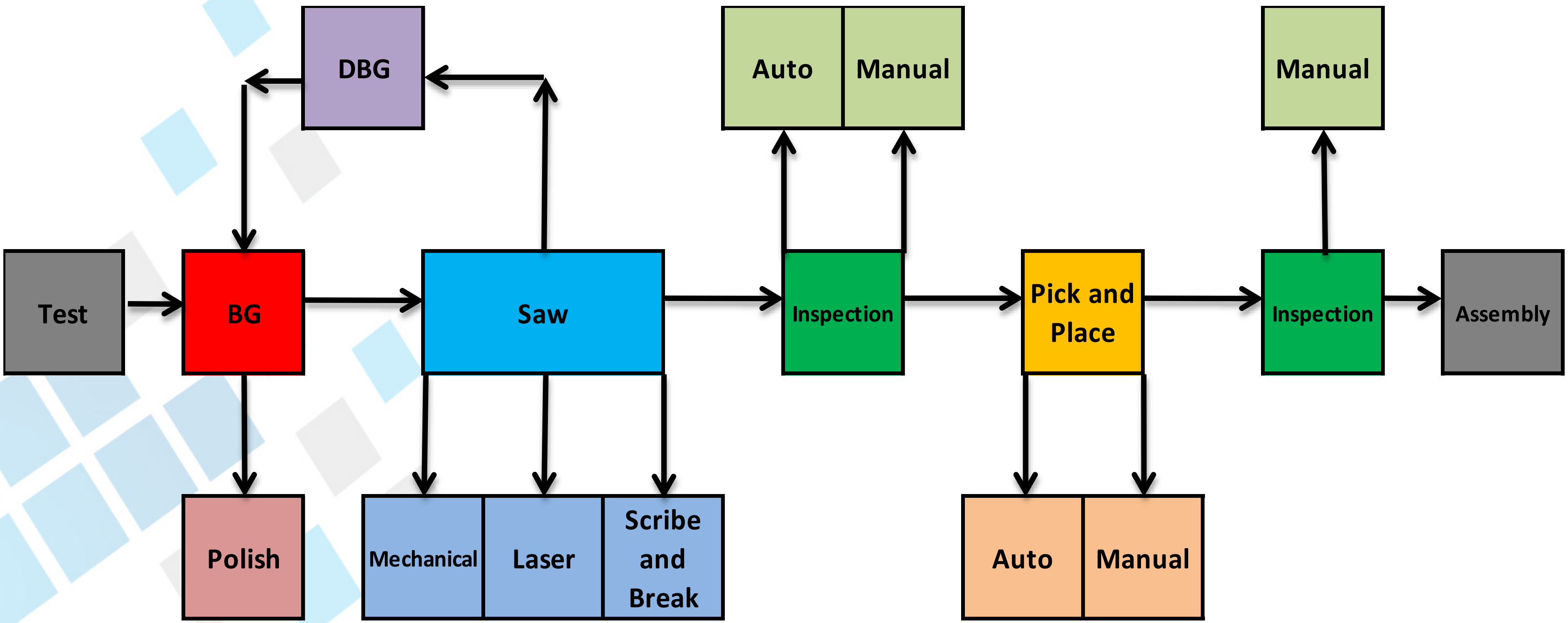
While quality, functional parts are the end goal for all semiconductor companies, getting from the fab to the assembly line is often an undervalued aspect of the IC supply chain.

Wafer design and characteristics are critical for not only the final product, but also for optimizing an efficient and cost-effective production stream. Utilizing specific process methods can improve die quality and reduce unexpected downstream hiccups.

In this presentation we will explore the various means of die preparation and what you should look for when designing your wafers to enhance the probability of success during die prep.

Die Prep

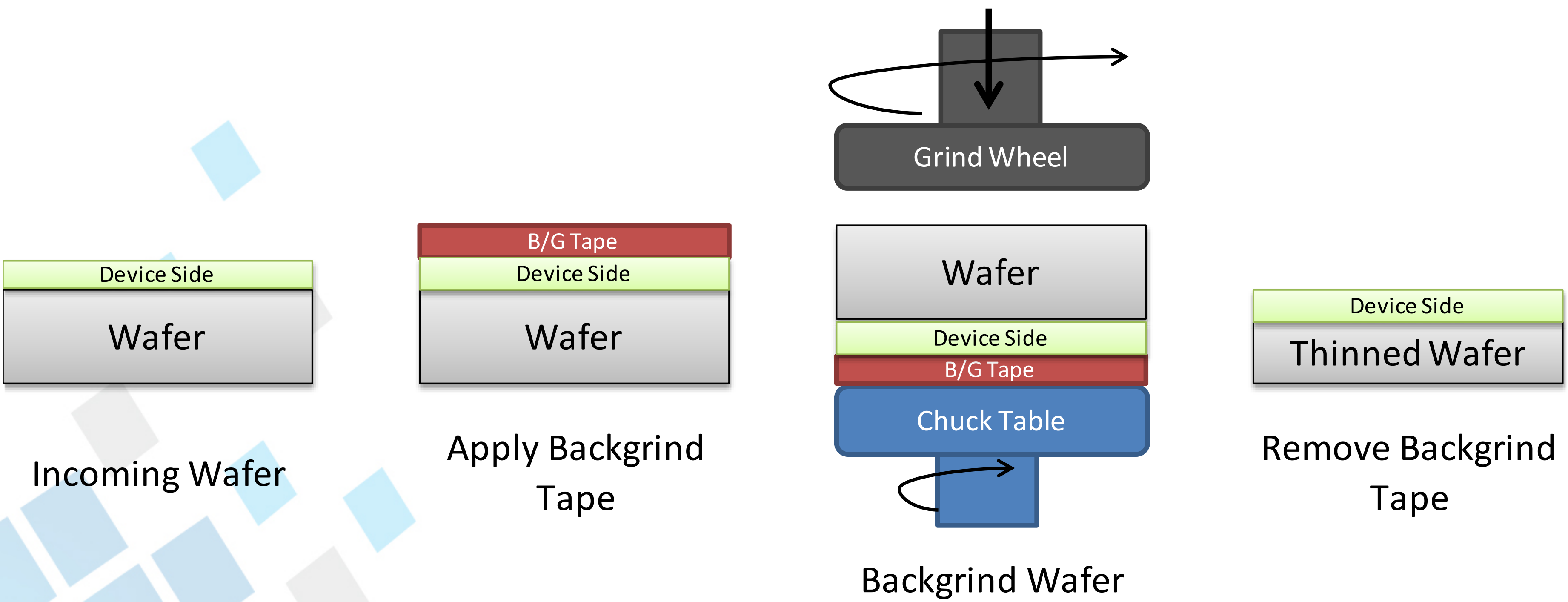
- Die prep encompasses all processes that take an IC from a wafer after test and into die form prior to assembly



Wafer Thinning

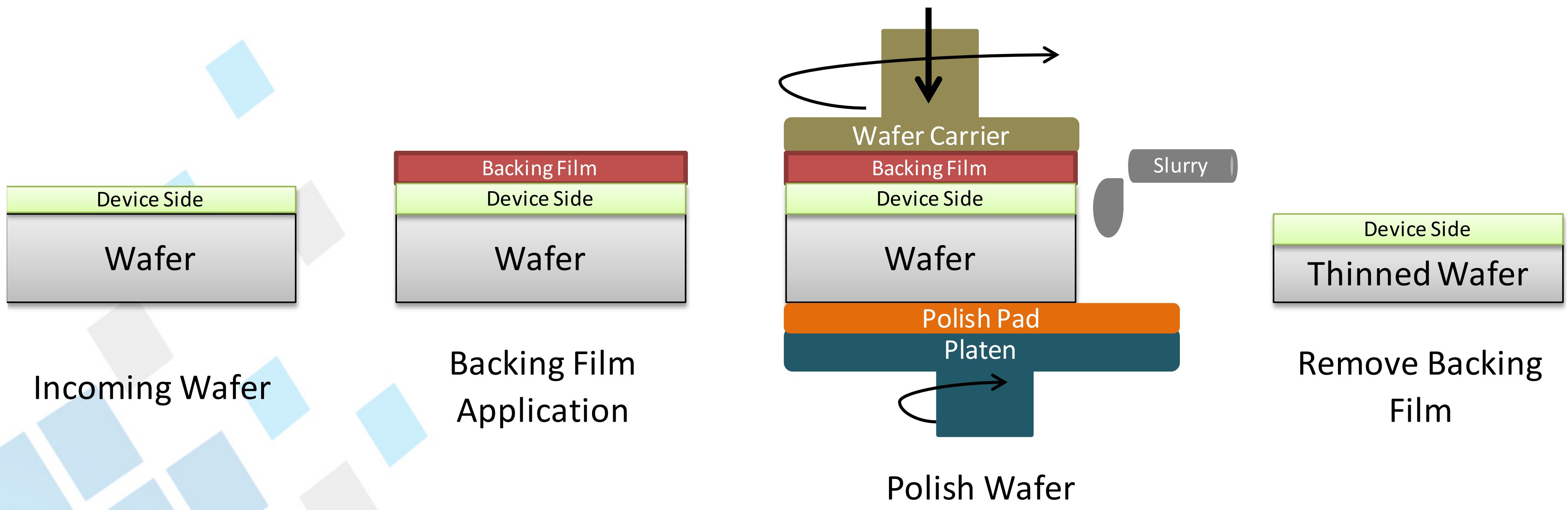
- Wafer thinning is the process of removing material from the backside of a wafer to a desired final target thickness
- The most common methods of wafer thinning are mechanical grind, wet etch, and chemical-mechanical planarization (CMP)
- A protective film is typically applied on the device side of the wafer to secure the die during thinning
- Die strength and smoothness can be increased based on grit/slurry selection, while also decreasing warpage and subsurface damage

Wafer Thinning



Mechanical Grinding

Wafer Thinning



CMP

Wafer Thinning

Mechanical Grind	CMP

Benefits

Mechanical Grind

- Lower cost
- Clean process
- Faster throughput

CMP

- Lower roughness
- Tighter TTV
- More forgiving when processing hard and exotic materials

Challenges

Mechanical Grind

- Higher roughness
- Ultra-thin wafer handling

CMP

- Dirty process
- Consumable disposal
- Cost of ownership

Wafer Singulation

- Singulation is the process of isolating individual IC’s from a wafer
- The most common methods of wafer singulation are mechanical dicing, laser dicing, scribe and break, and dice before grind (DBG)
- Wafers are typically mounted to tape and frame when singulated
- Material type, wafer thickness, and street width are the most critical factors in wafer singulation when determining the optimal process method

Mechanical Dicing

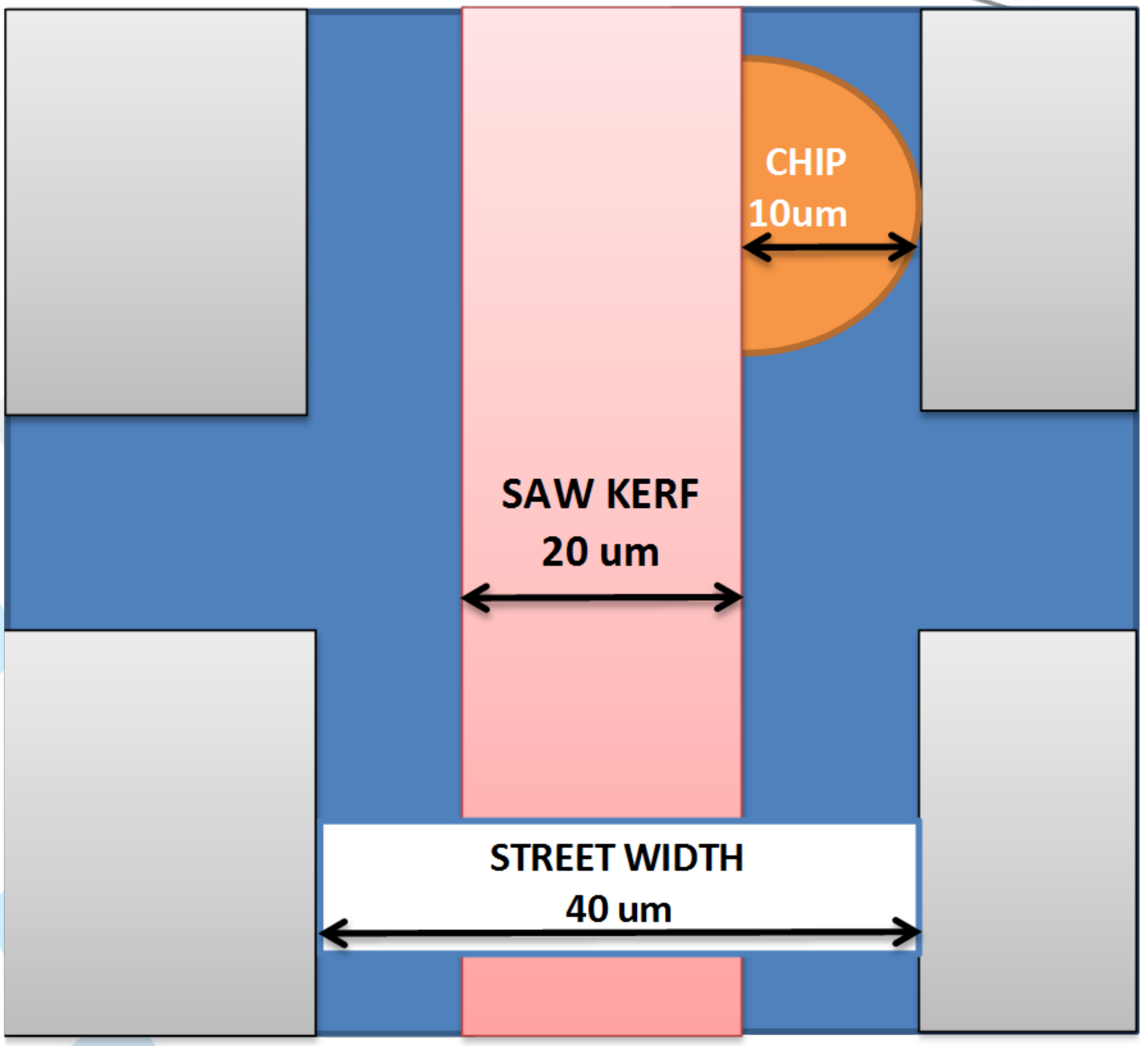
- Mechanical blade dicing is the traditional method of singulating die utilizing (typically) a diamond embedded blade to remove material while process water cools the blade and workpiece

- While more robust and flexible than other methods, mechanical dicing does produce a large kerf and chipping is inherent with the process

- Consumable costs are prevalent due to blade wear and replacement

- Mechanical dicing is limited by street width

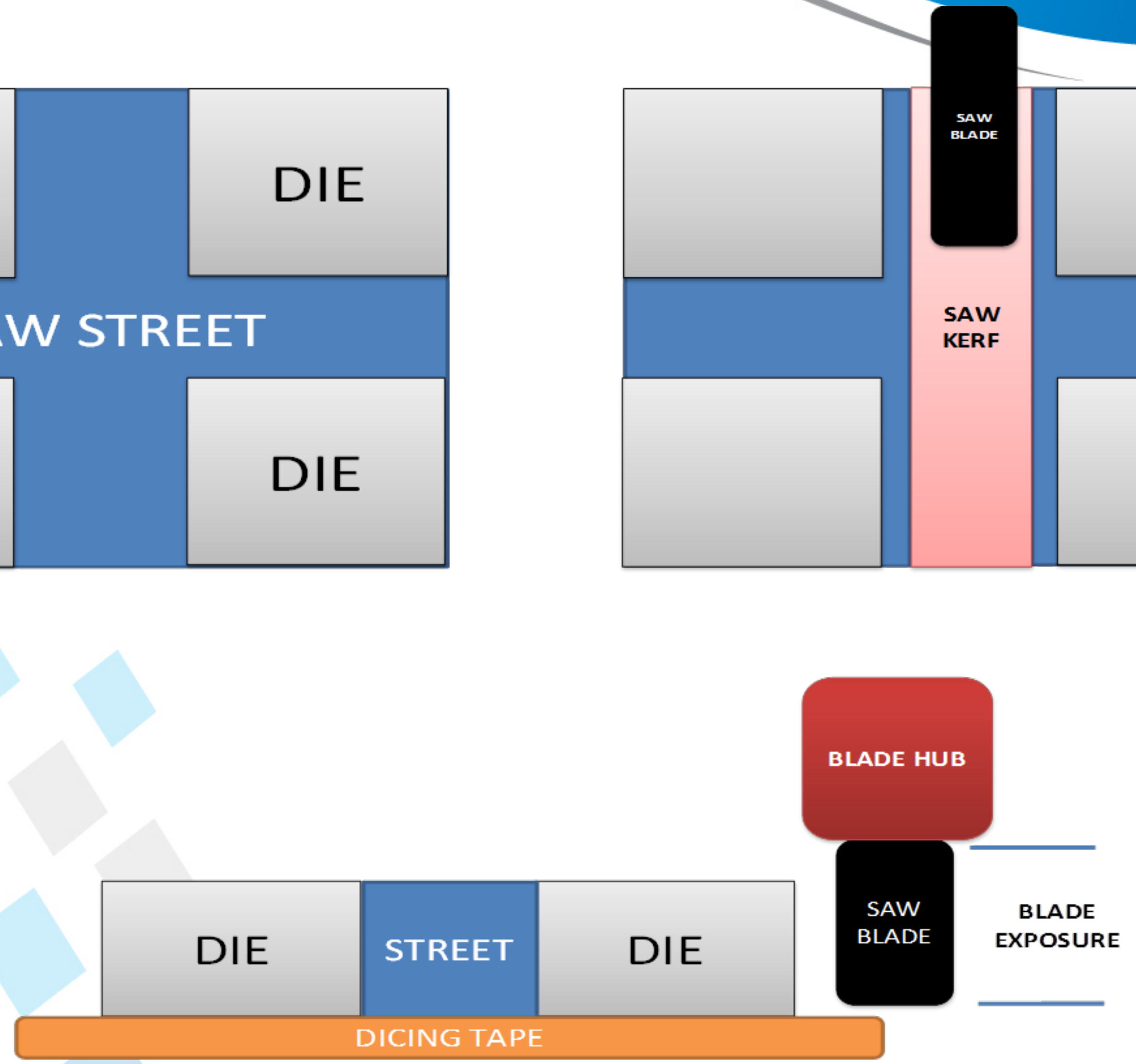
Mechanical Dicing



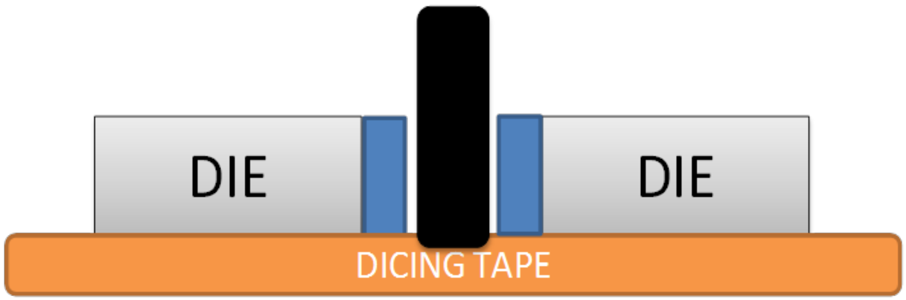
Mechanical Dicing

- Street width governs the blade/kerf width
- Total thickness (including bumps) determines blade exposure
- Blade exposure is restricted by blade width
- The narrower the blade the smaller the exposure
- Therefore, for wafers with narrow streets thinning is required

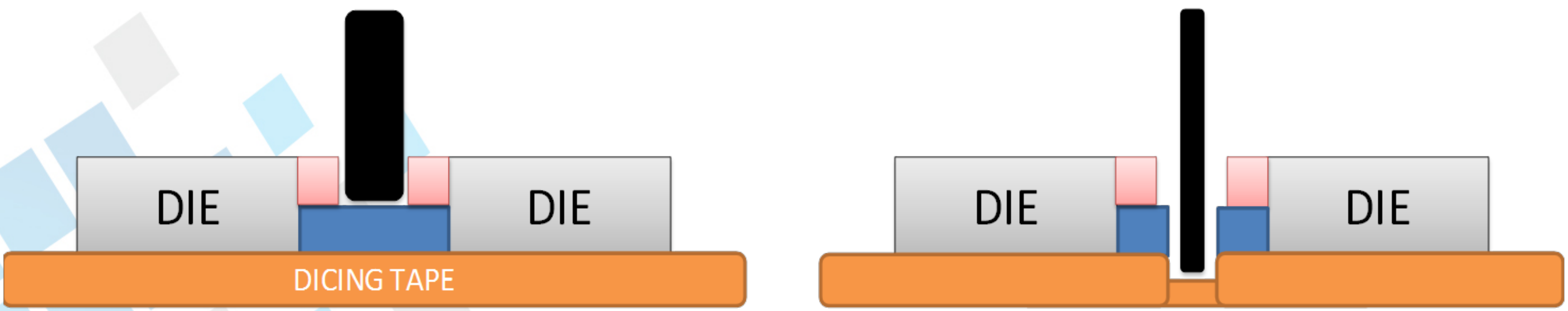
Mechanical Dicing



Mechanical Dicing



SINGLE PASS



STEP CUT

Mechanical Dicing

Single Pass	Step Cut

Benefits

Single Pass

- Faster throughput
- Ultra-thin wafer dicing
- Narrow streets

Step Cut

- Improved topside and backside quality
- Thick wafers

Challenges

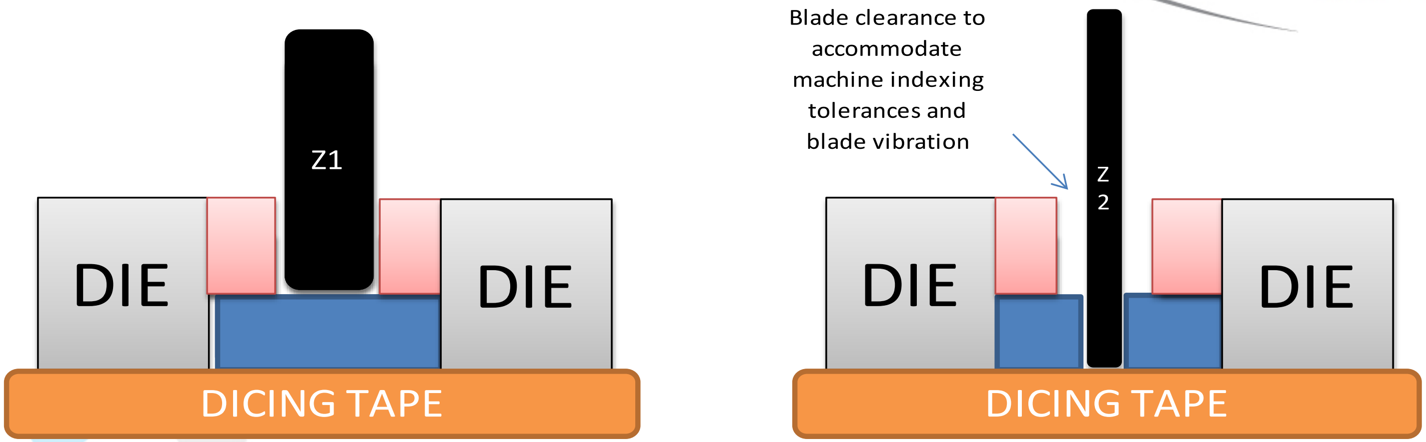
Single Pass

- Street width to thickness ratio
- Cut quality

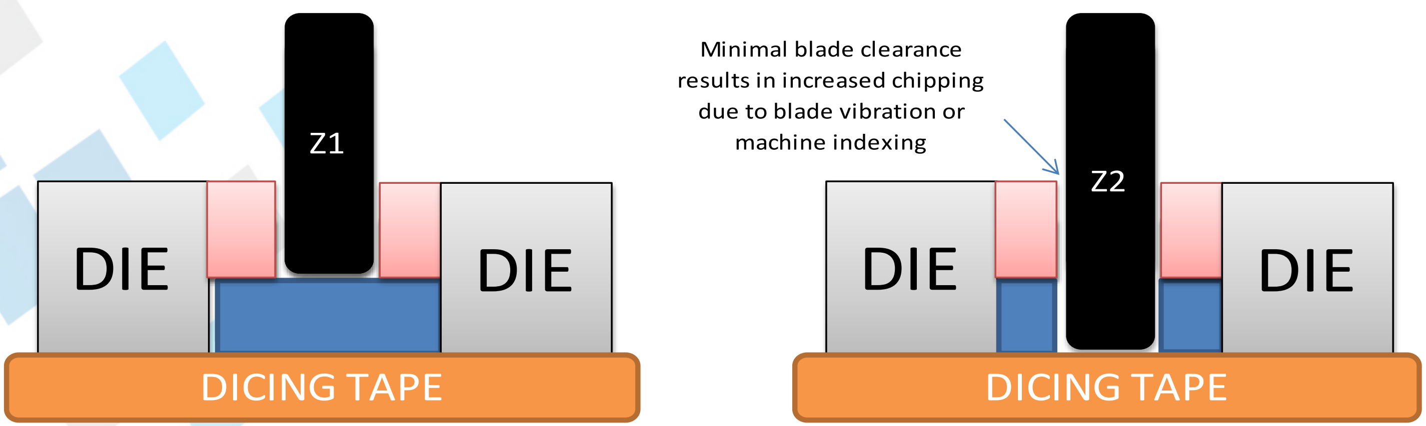
Step Cut

- Slower throughput
- Increased inventory and consumables

Mechanical Dicing

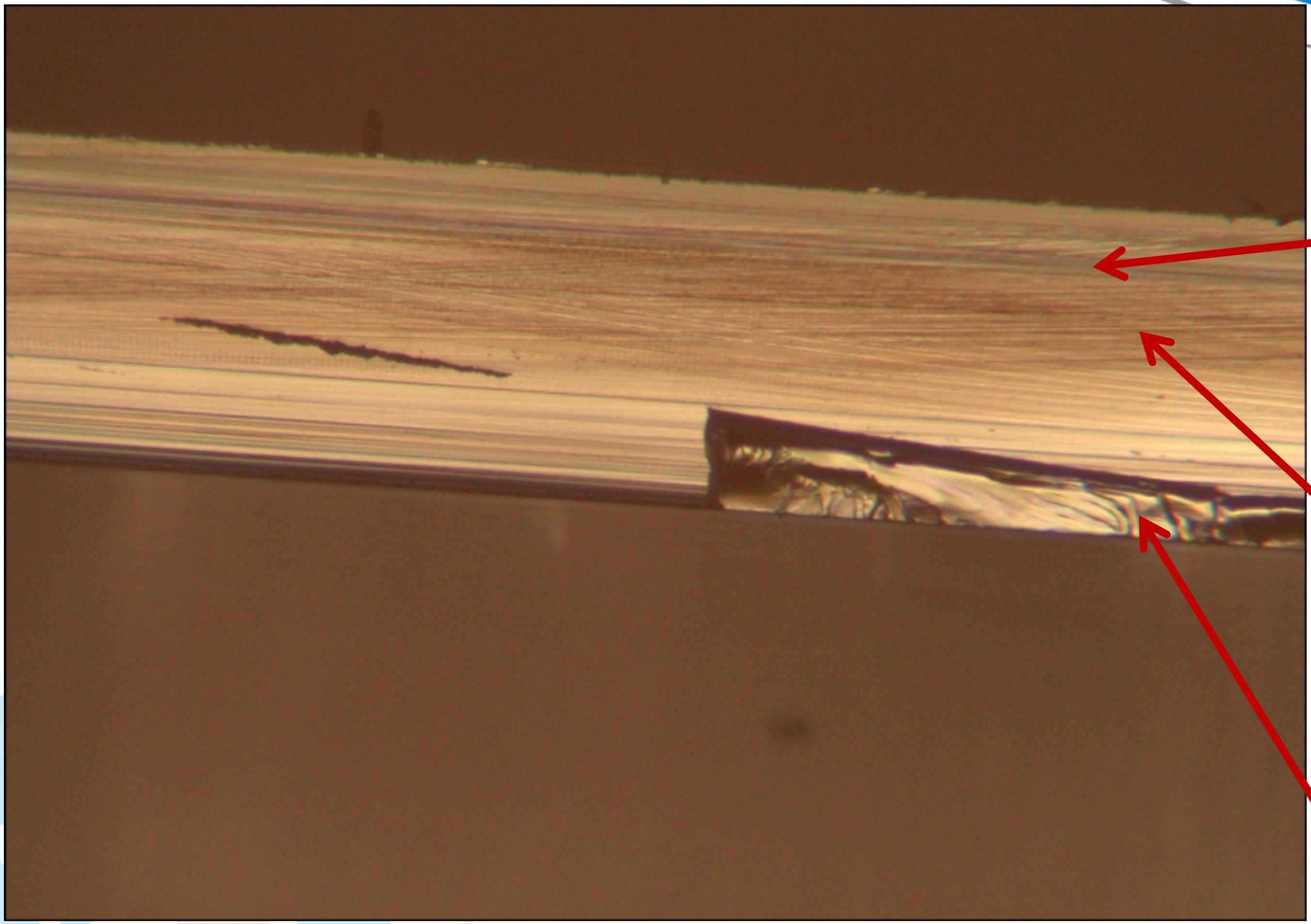


Step Cut - Wider Z1 Blade



Step Cut - Same Blade Width

Mechanical Dicing



Cut line difficult to distinguish due to same blade width on Z1 and Z2

Dark discoloration and burn mark from blade rubbing and glazing. Blade marks against blade rotation

Backside chipping created from blade vibration and minimal clearance

Step Cut Defects – Same Blade Width

Mechanical Dicing

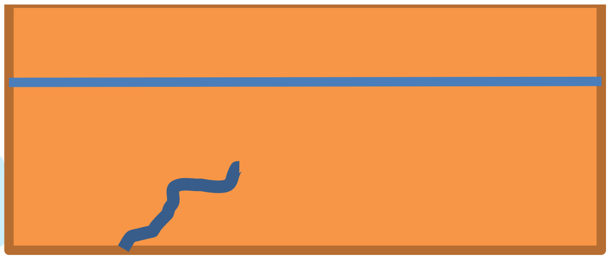
Definitive cut line

No sign of blade rubbing or burning

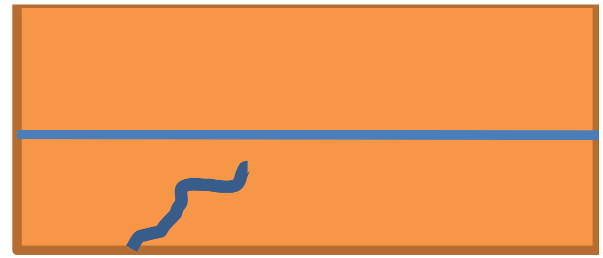
Clean blade marks going with blade rotation

Step Cut – Differing Blade Widths

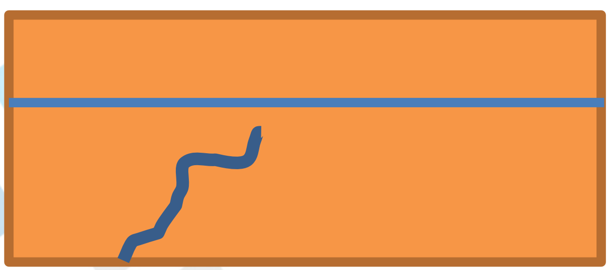
Mechanical Dicing



Location of sidewall
crack subjective,
potentially rejected



Sidewall "guard ring" clearly
identifies crack as acceptable
per 50% sidewall spec



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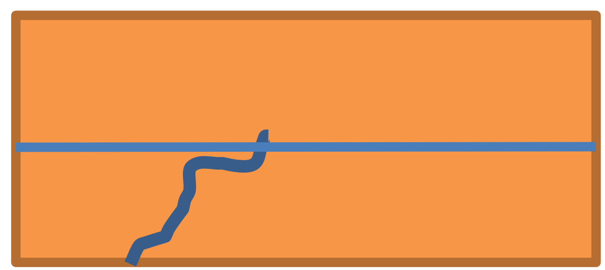

Sidewall "guard ring" clearly
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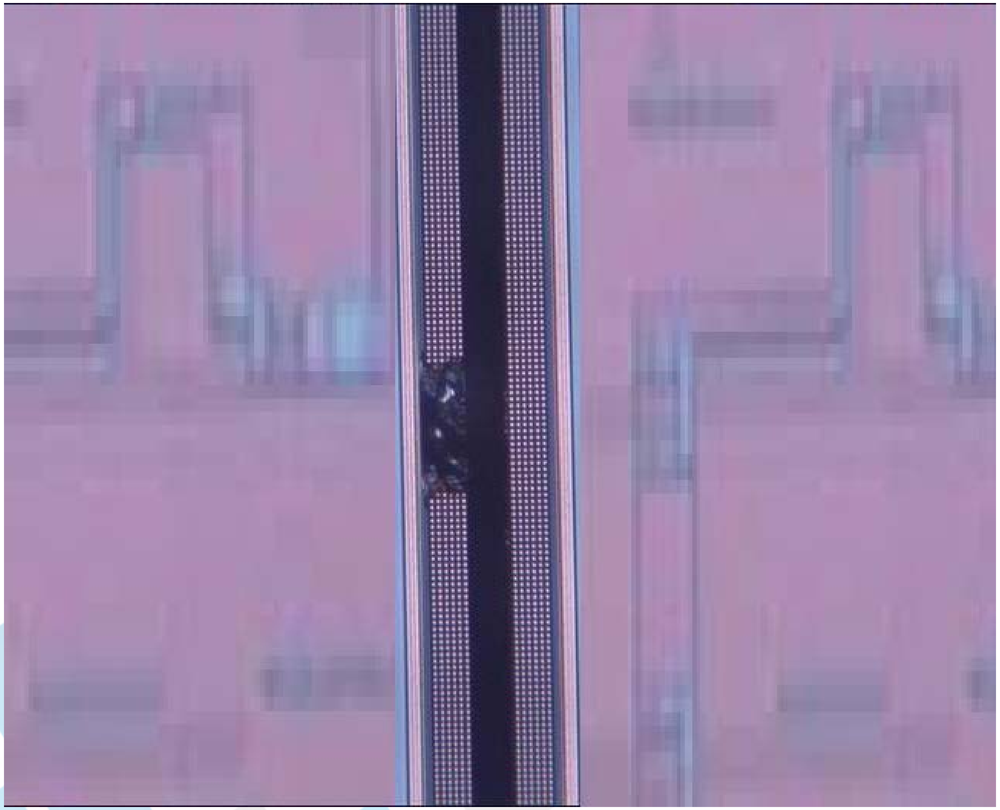
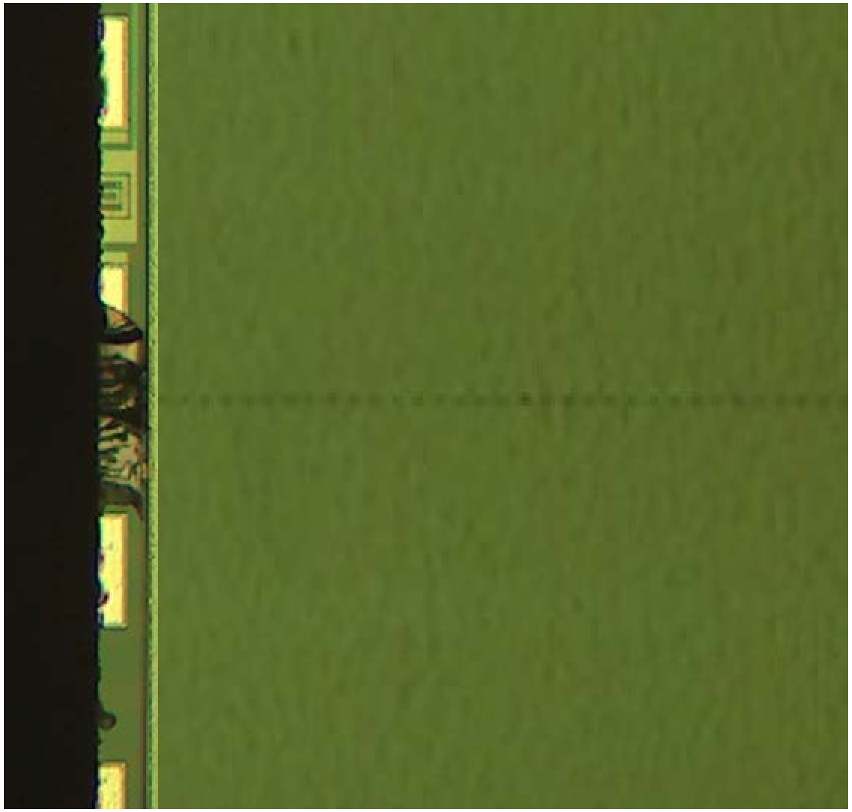
Mechanical Dicing



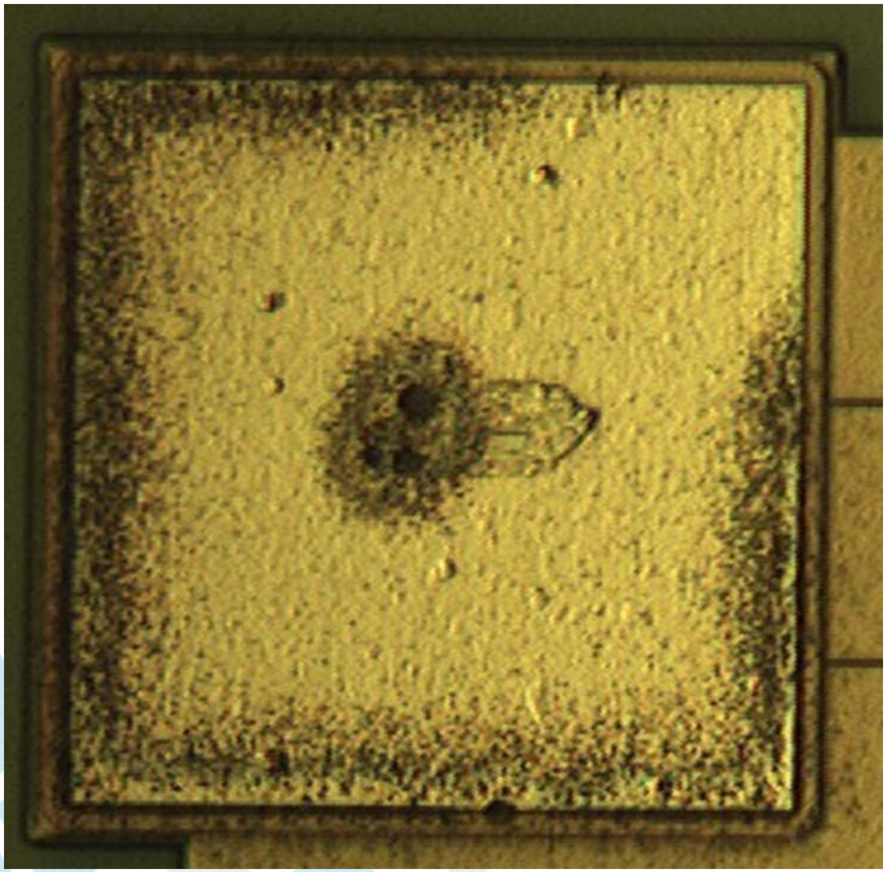


Dicing Blowouts Caused By Metal or Test Structures in Saw Street

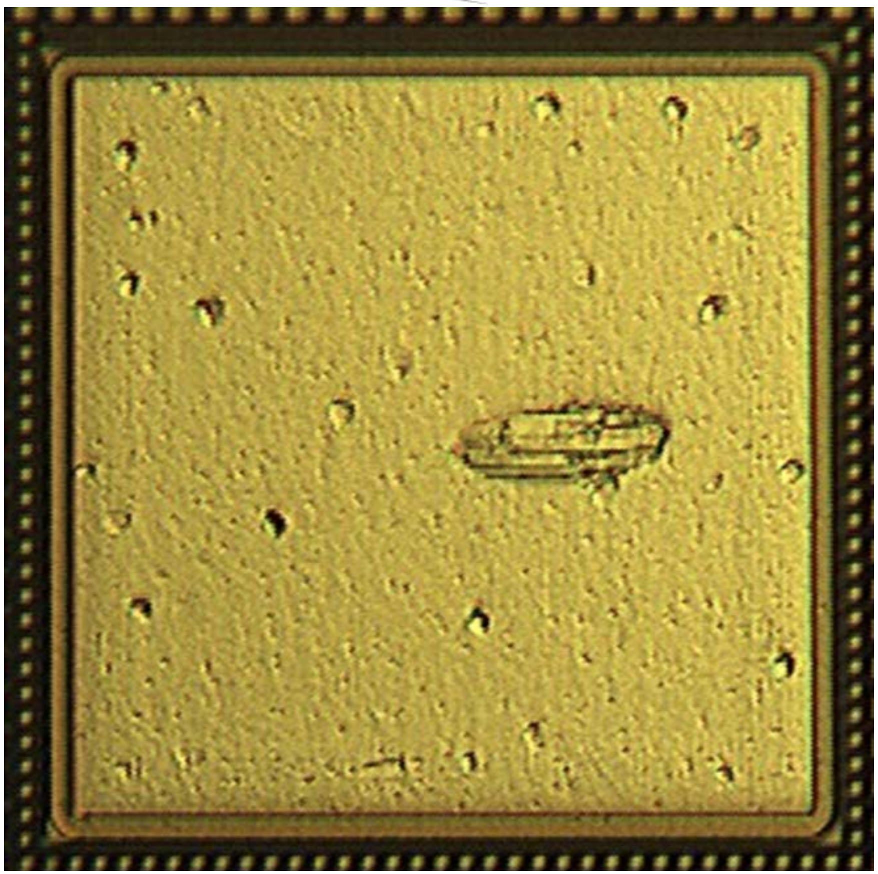
Mechanical Dicing

- For mechanical dicing, the process water is critical to maintaining overall die quality
- Saw process water temperature must be maintained at or below room temperature, preferably chilled, to help ensure planarity of the dicing chuck table and to reduce wobble in the dicing blade
- Process water resistivity kept below 2.0 mega ohms minimizes the potential for galvanic corrosion in copper bond pads
- Surfactant injected into water assists cleanliness by suspending dicing particles on the wafer surface, making the debris easier to wash off
- Additionally, some surfactants provide the added benefit of containing corrosion inhibitors.
- CORWIL employs all of the above methods, in addition to real-time process monitors, to provide superior dicing quality

Mechanical Dicing



Galvanic Corrosion – No surfactant, resistivity > 2 Mohm



Clean Pad – With surfactant and resistivity < 2 Mohm

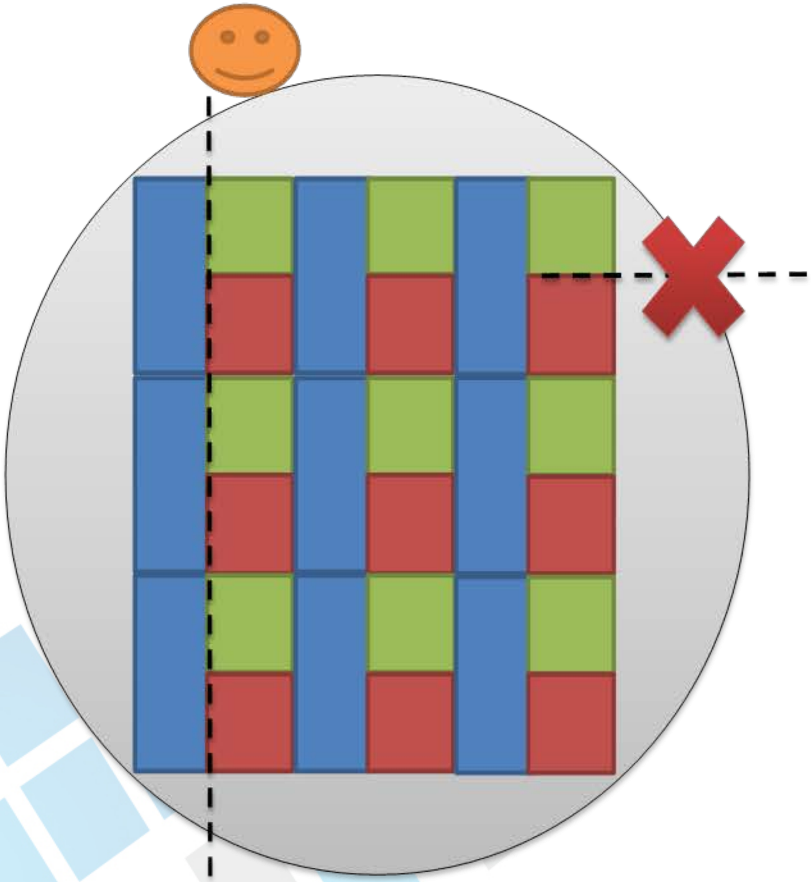
MPW Dicing

- Multi-project wafers require the indexing to be consistent across all die in a reticle in order to singulate without sacrificing die

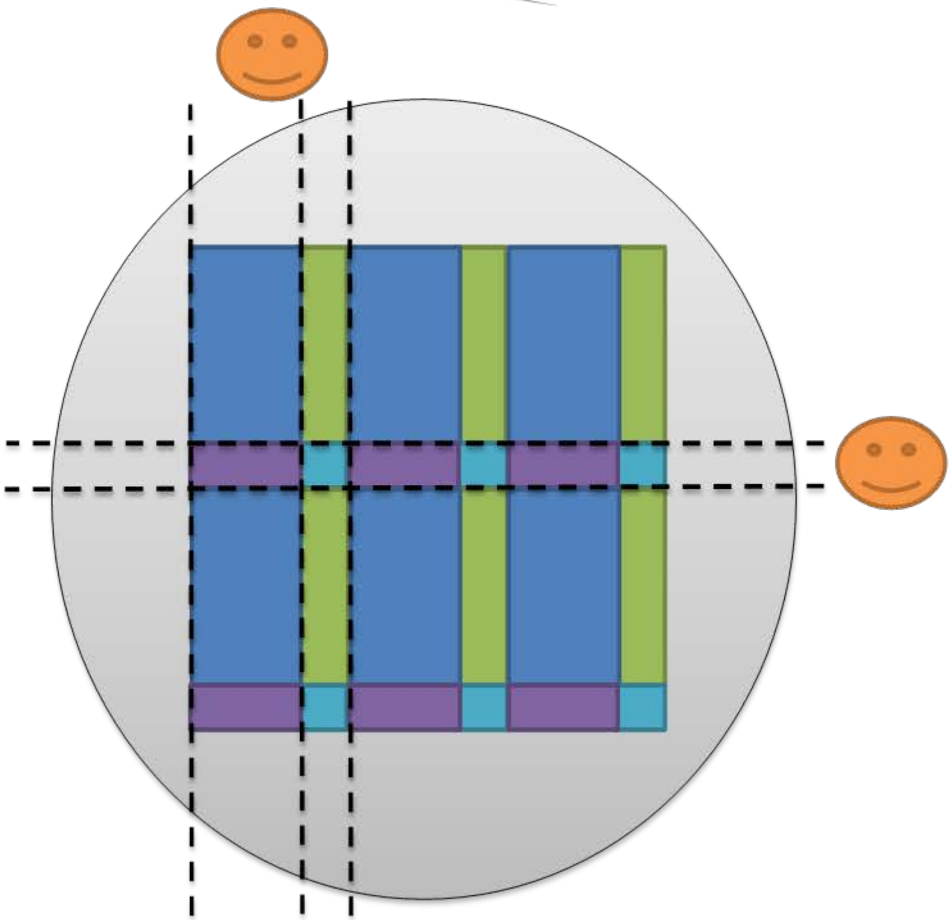
- Inconsistent indexing between die in a reticle would require die to be sacrificed, or cut through, in order to salvage the target die

- If all die in an inconsistent reticle are required to be saved, then remounting is necessary

MPW Dicing



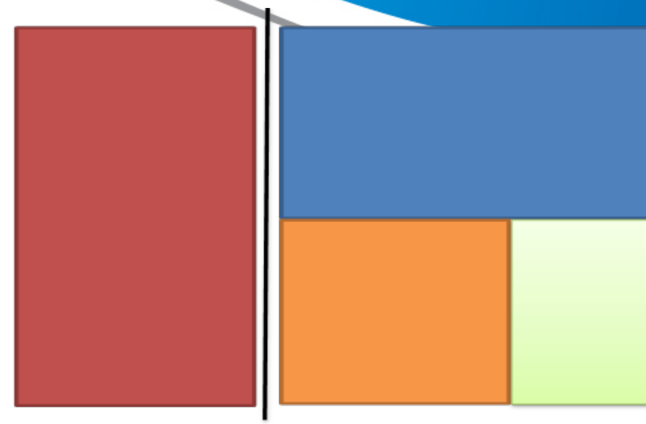
REMOUNT REQUIRED



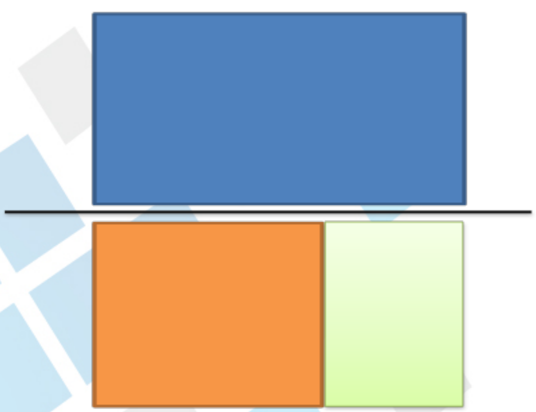
MULTI-INDEXING (NO REMOUNT REQUIRED)

MPW Dicing

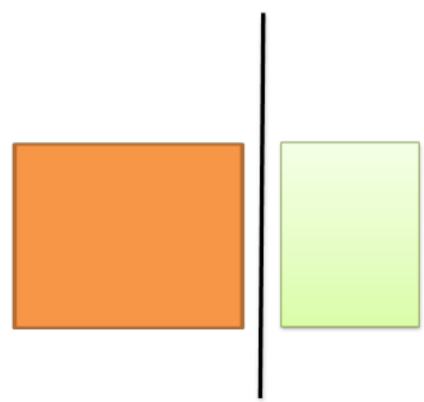
RETICLE LAYOUT



(1) MOUNT RETICLE (2) PERFORM CUT TO ISOLATE LARGE RED DIE



(3) REMOVE RED DIE FROM DICING TAPE. (4) REMOVE RETICLE. (5) REMOUNT RETICLE. (6) PERFORM CUT TO ISOLATE BLUE DIE



(7) REMOVE BLUE DIE. (8) REMOVE RETICLE. (9) REMOUNT RETICLE. (10) PERFORM CUT TO ISOLATE ORANGE DIE.

(11) REMOVE ORANGE DIE. (12) PLATE DESIRED YELLOW DIE

Dice Before Grind

- Dice Before Grind (DBG) is a process in which the wafers are trenched prior to backgrind and then thinned to singulate the die

- The DBG process utilizes the same consumables and equipment as mechanical thinning and dicing with the only change being the order in which they are performed

- DBG minimizes backside chipping

- Wafers must be thinned to utilize DBG and the process is limited by the wafer thickness and die size

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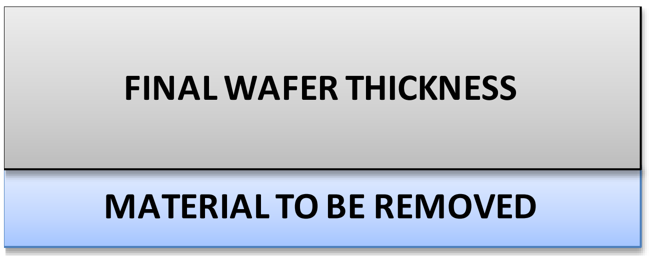
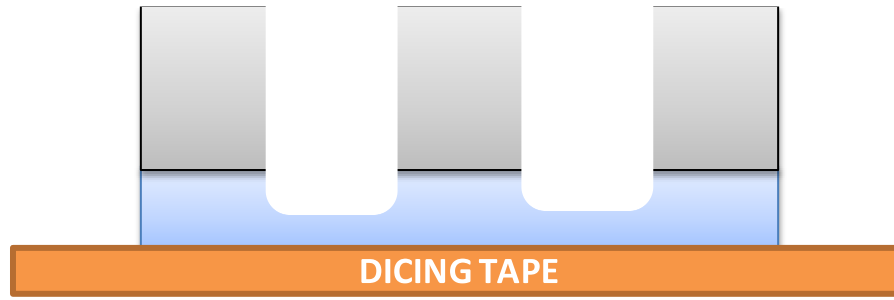
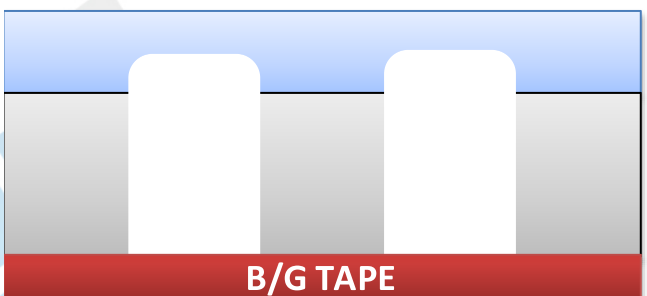
Dice Before Grind





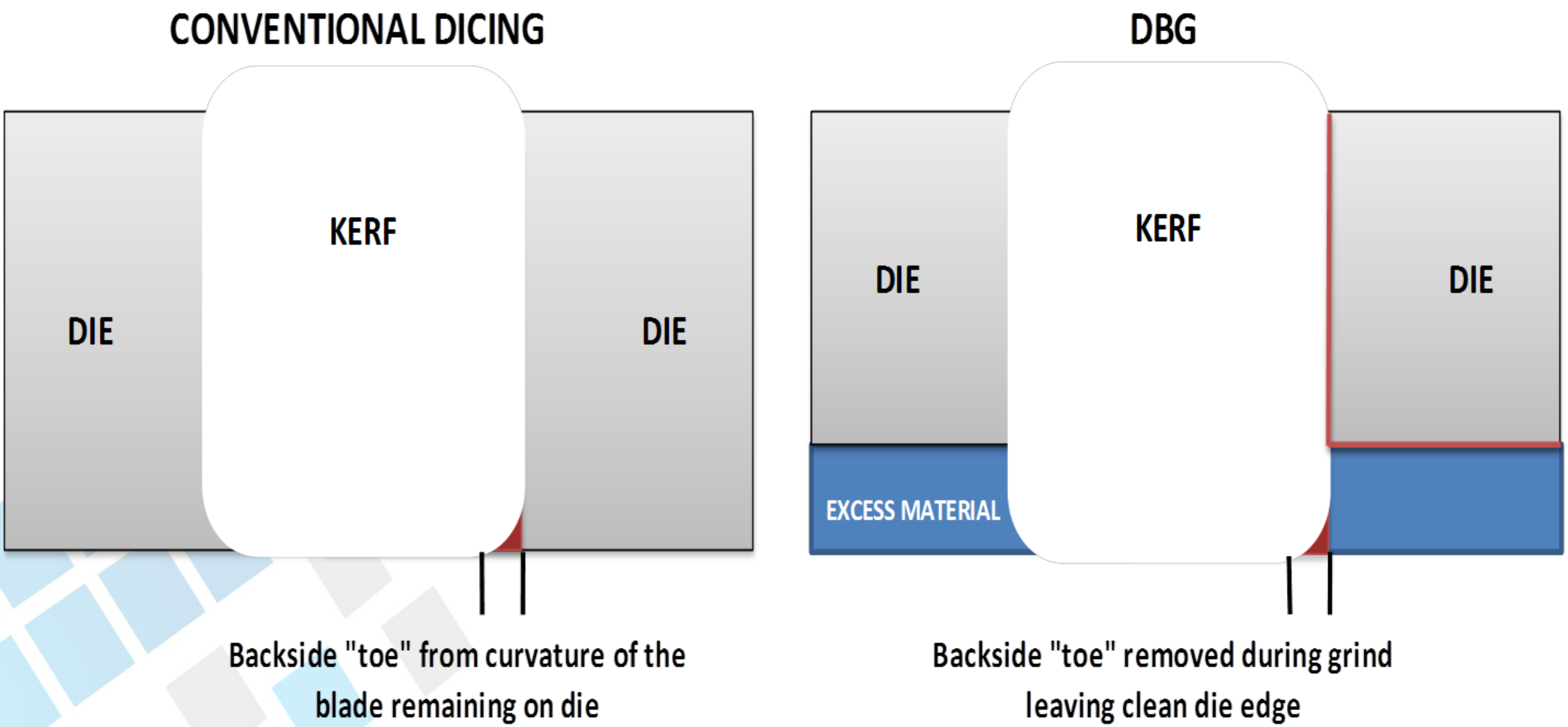
Trench beyond final target thickness



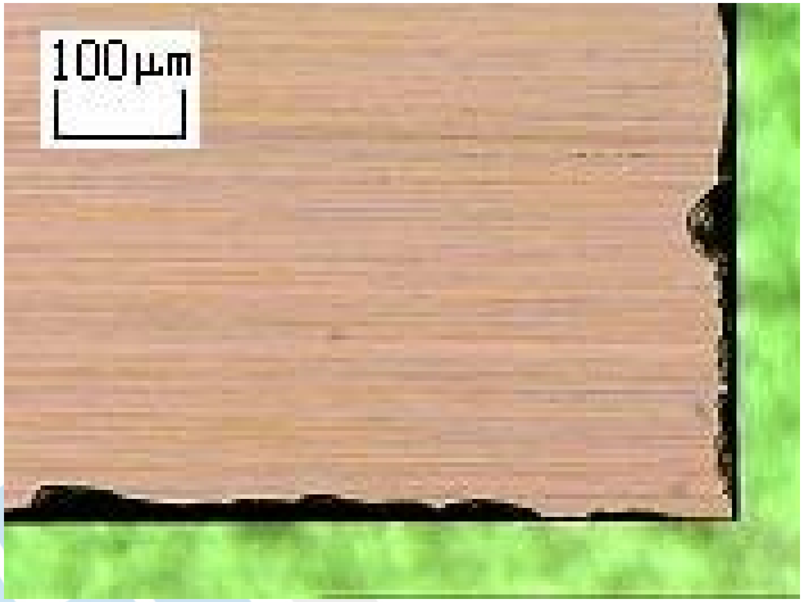
Thin wafer to target

Mounted singulated die to dicing tape and frame and remove B/G tape

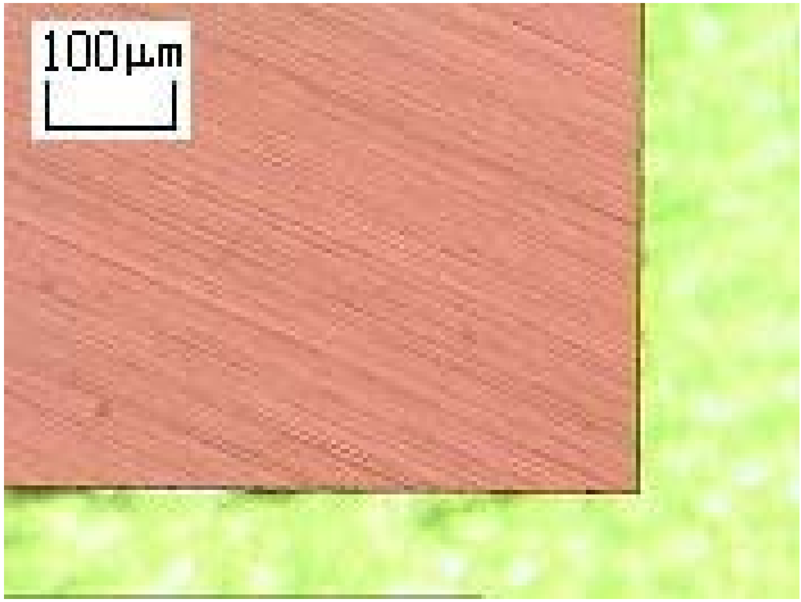
Dice Before Grind



Dice Before Grind



Single Pass



DBG

Scribe and Break

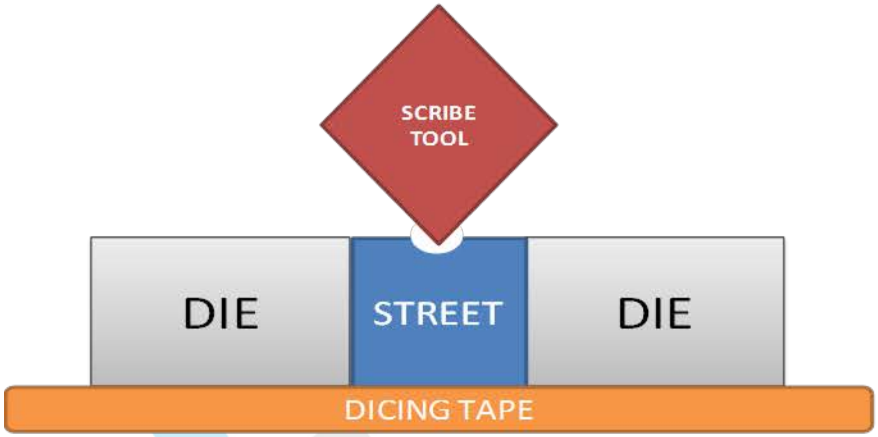
- Scribe and Break is the process of depressing material into the saw street to create stress in the wafer and then fracturing the wafer along that stress line

- SnB is a completely dry process involving no liquids or chemicals and there is no material loss during the process

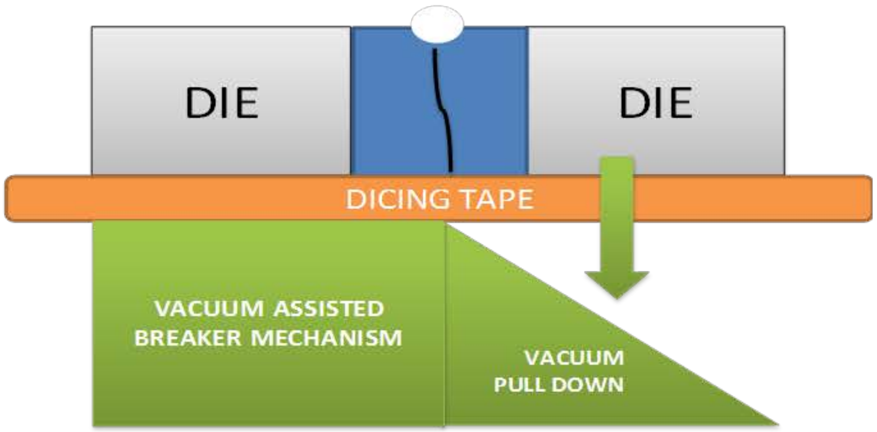
- SnB is ideal for ultra-thin silicon, hard materials (glass), and fragile material (GaAs, InP)

- Wafer thickness, die size, and crystalline orientation are limiters for the SnB process

Scribe and Break



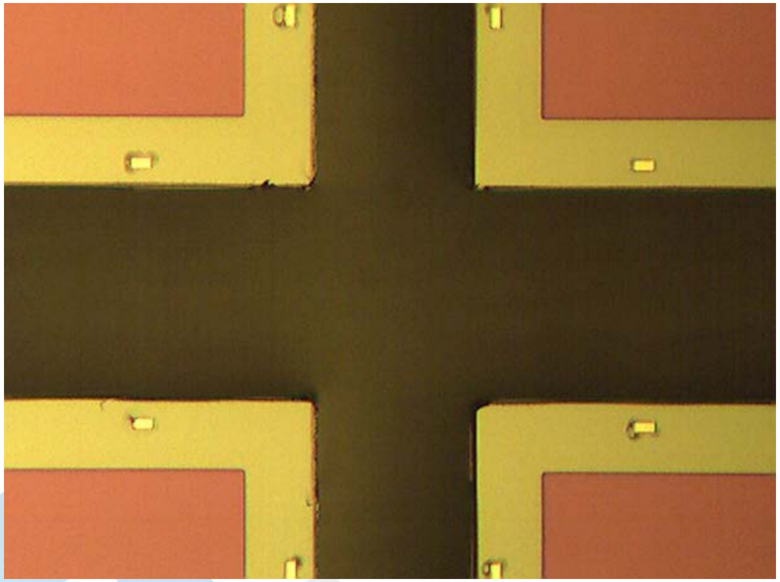
SCRIBE WAFER ON DICING TAPE AND FILM FRAME



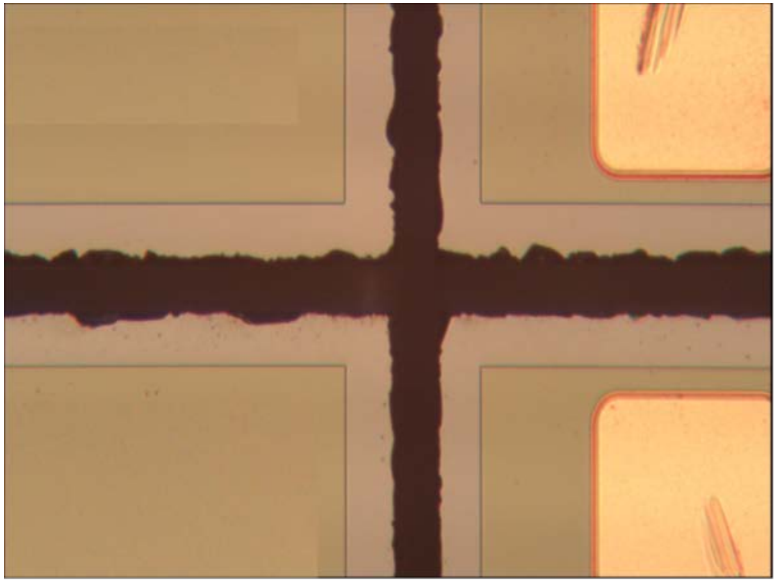
DIE BREAK PERFORMED BY "BENDING" WAFER WITH STRESS LINE CENTERED ON THE BREAKER BAR EDGE

TRANSFER TO STRETCH RING FOR INCREASED DIE SEPARATION

Scribe and Break



GaAs Scribe and Break

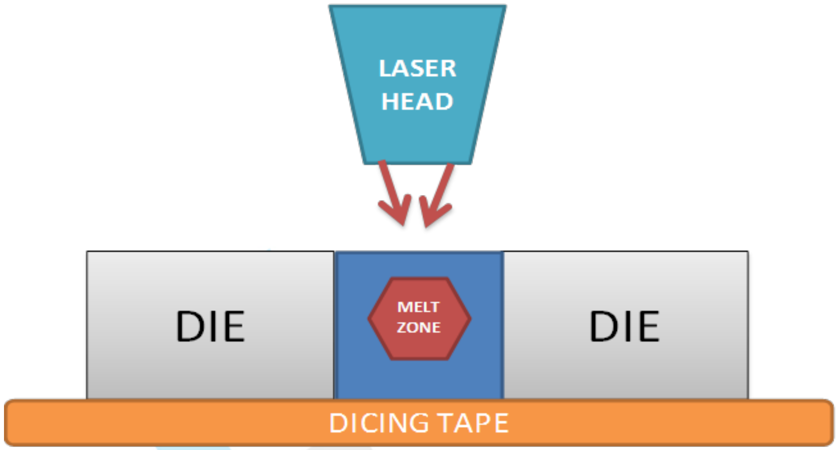


GaAs Mechanical Dicing

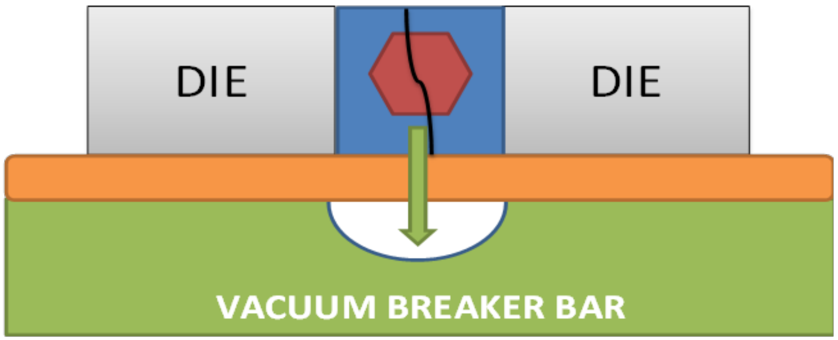
Stealth Dicing

- Stealth Dicing is essentially a scribe and break process where the scriber is a laser instead of a diamond
- The laser generates a melt zone in the middle of the saw street creating a stress line in the wafer. The stress line is then broken and the die are separated
- Stealth dicing is ideal for wafers that have extremely narrow streets or non-contact products such as MEMS devices
- The heat generated from the laser can have adverse effects on die performance

Stealth Dicing



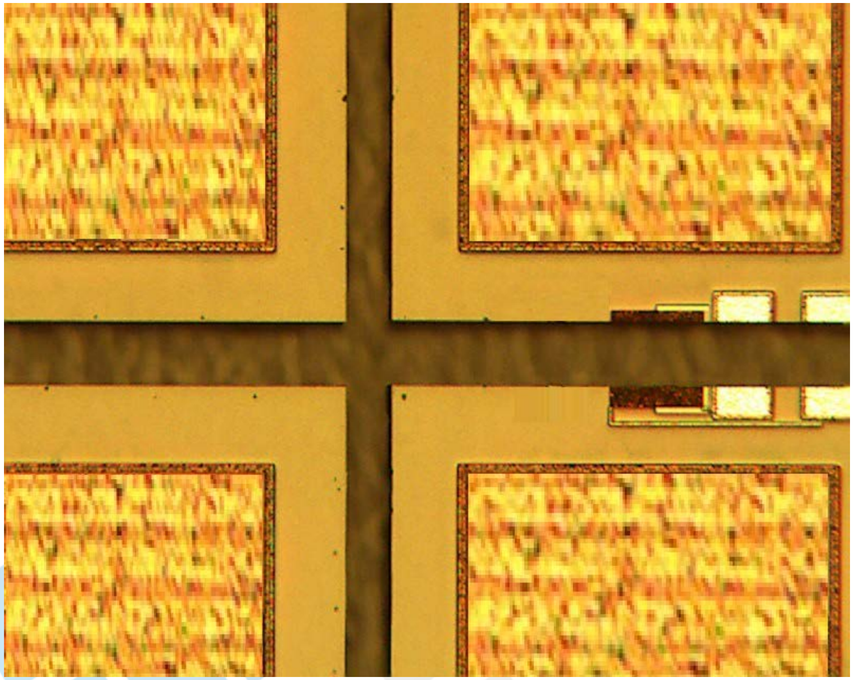
LASER SCRIBE GENERATING MELT ZONE IN MIDDLE OF THE STREET

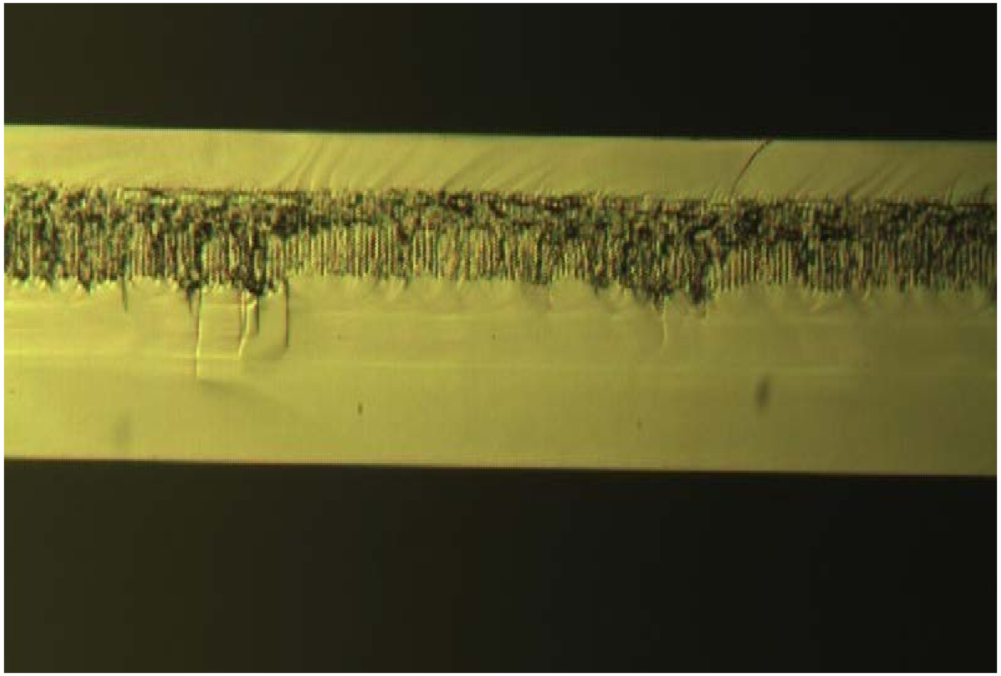


BREAKER BAR PULLS VACUUM ON THE STREET CAUSING THE MELT ZONE AND STREET TO FRACTURE

THE DICING TAPE IS STRETCHED ONTO A FILM FRAME TO PROVIDE INCREASED DIE SEPARATION

Stealth Dicing



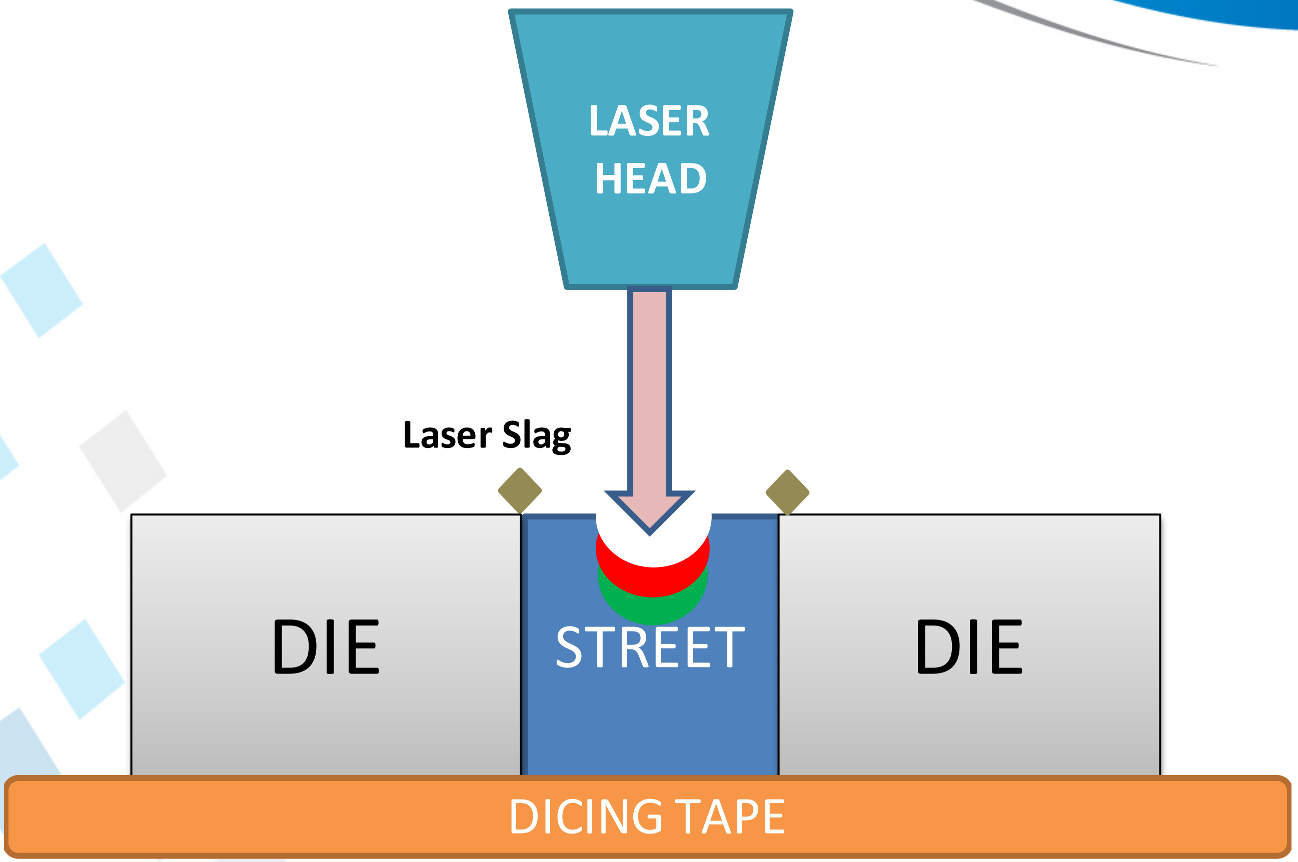


Stealth Dicing Topside and Melt Zone

Laser Ablation

- Laser ablation dicing is the process of removing material in the wafer street with a laser to singulate the die
- Laser ablation is ideal for thin wafers with narrow streets
- However, laser ablation generates molten debris, or slag, that can get on the die surface and is difficult to remove
- Protective coatings can be applied to the wafer surface to shield the die from the slag
- Cost of ownership is prohibitive

Laser Ablation



LASER DICE WAFER ON TAPE AND FILM FRAME

Laser Ablation

Residue from protective film and slag after cleaning

Low-K Singulation

- Laser grooving followed by mechanical dicing is a common method for processing Low-K wafers, however, this requires substantial resources

- Mechanical dicing alone can be used for singulating Low-K wafers by utilizing a step cut with a shallow first pass to trench through the dielectric layer. This has proven to be successful for 28nm technology and greater and is more cost effective compared to laser grooving

- Stealth dicing is another method that is becoming more popular for Low-K processing. The stealth process provides a clean cut to help minimize chipping and delamination

Wafer Singulation

Mechanical	SnB	Stealth	Ablation
Benefits			
• Flexibility	• Specialty matl's	• Narrow streets	• Narrow streets
• Cost effective	• Narrow streets	• High throughput	• High throughput
• Robust process	• Dry process	• Dry process	• Specialty matl's
Challenges			
• Narrow streets	• Thickness	• Thickness	• Cleanliness
• Chipping	• Limited flexibility	• Cost of ownership	• Cost of ownership
• Wet process	• Die size	• Power effects	• Power effects

Pick and Place

- Pick and place is the process of removing the singulated die from the tape and placing it into an output medium
- The most common mediums are waffle packs, gel packs, tape and reel, and tape and frame (known good wafers)
- Picking can be done manually, using tweezers or vacuum wands, or on automated equipment
- Edge pick tools can be utilized for die with sensitive and non-contact surfaces

Inspection

- Inspection identifies all fab and process related defects on the wafer or in die form
- Inspection is performed either manually or using automated equipment
- Visual inspections can occur at any point during the die prep flow, but are typically done after singulation and pick
- Multiple inspections can be used to identify and track process induced defects

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THANK YOU!

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