INTEGRA TECHNOLOGIES

Integra Silicon Valley Die Prep Overview

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INTEGRA TECHNOLOGIES

Die Prep

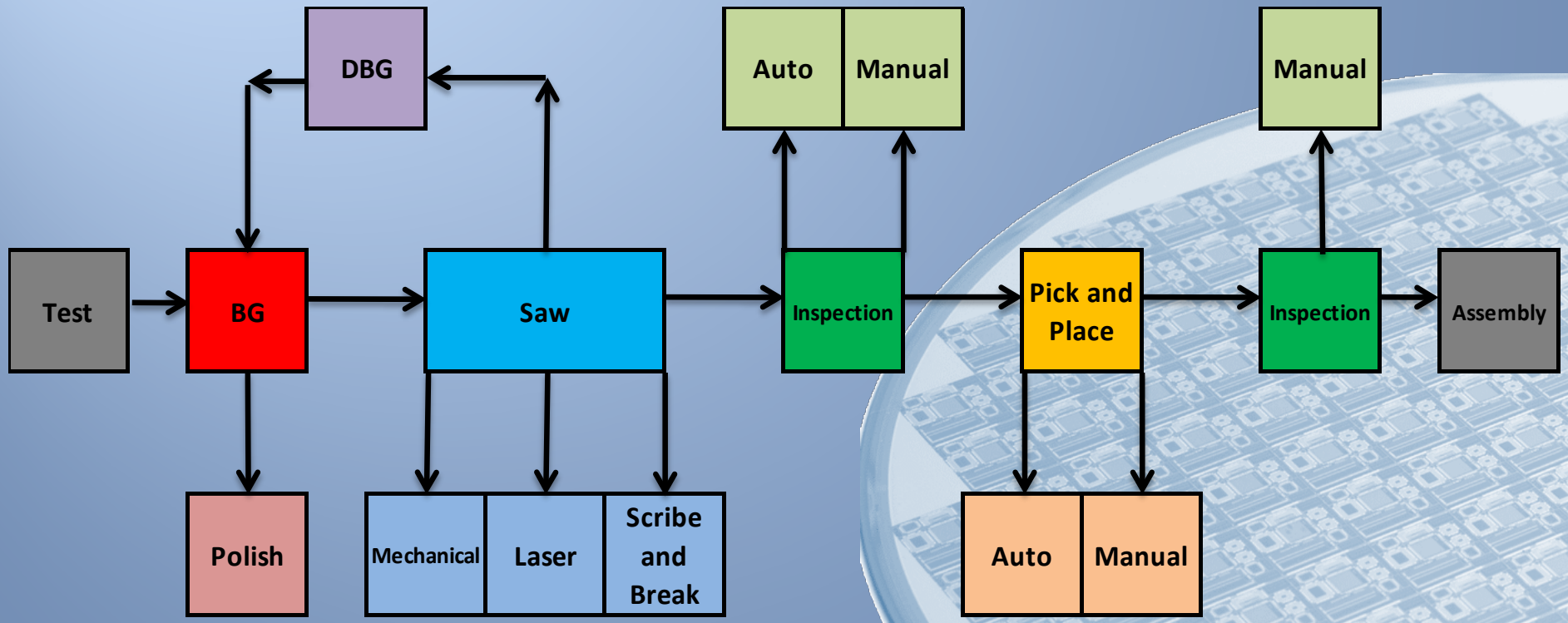
While quality, functional parts are the end goal for all semiconductor companies, **getting from the fab to the assembly line** is often an undervalued aspect of the IC supply chain.

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 to look for when designing 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
  - Primary die prep processes are: Backgrind, Saw, Pick, and Inspection



INTEGRA TECHNOLOGIES

Wafer Thinning

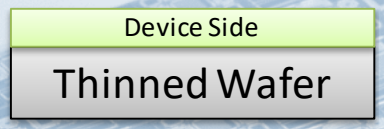
- **Wafer thinning, or backgrind**, is the process of removing material from the backside of a wafer **to a desired final target thickness**
- The most common methods of wafer thinning are mechanical grind, wet etch, and chemical-mechanical planarization (CMP)
- A protective film is typically applied 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

Incoming Wafer

Apply Backgrind Tape

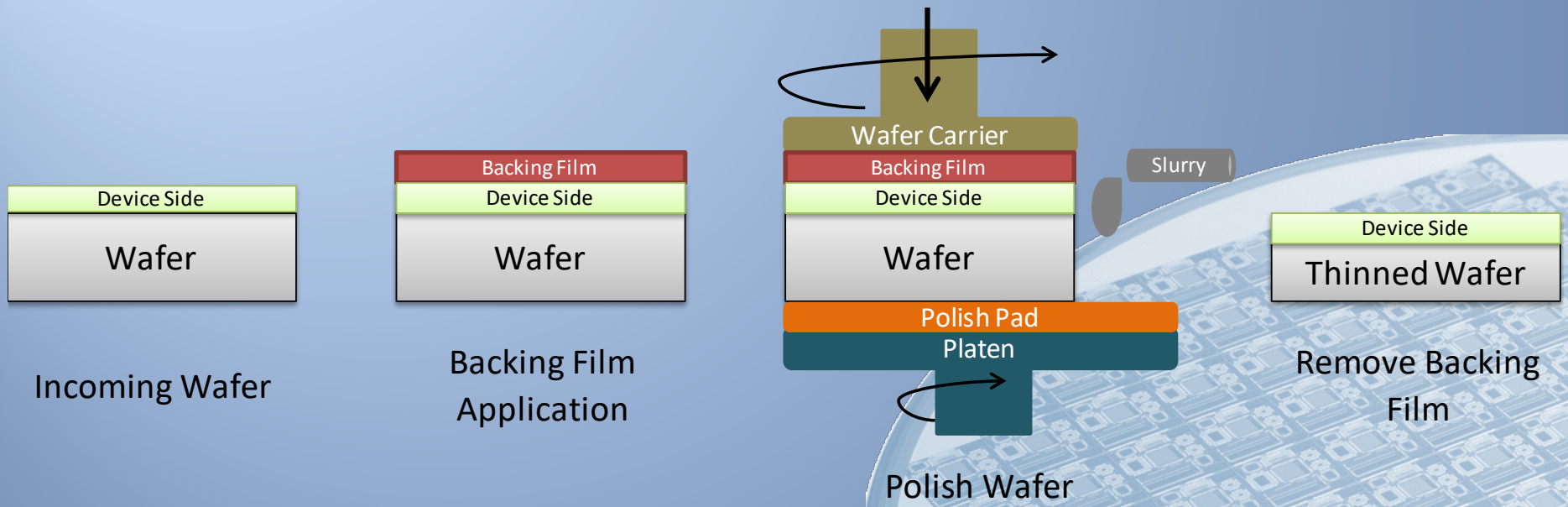
Backgrind Wafer



Remove Backgrind Tape

Mechanical Grinding (Integra SV Standard Process)

Wafer Thinning



CMP

Wafer Thinning

Mechanical Grind	CMP
Benefits	
• Lower cost	• Lower roughness
• Clean process	• Tighter TTV
• Faster throughput	• More forgiving when processing hard and exotic materials
Challenges	
• Higher roughness	• Dirty process
• Ultra-thin wafer handling	• Consumable disposal
	• Cost of ownership

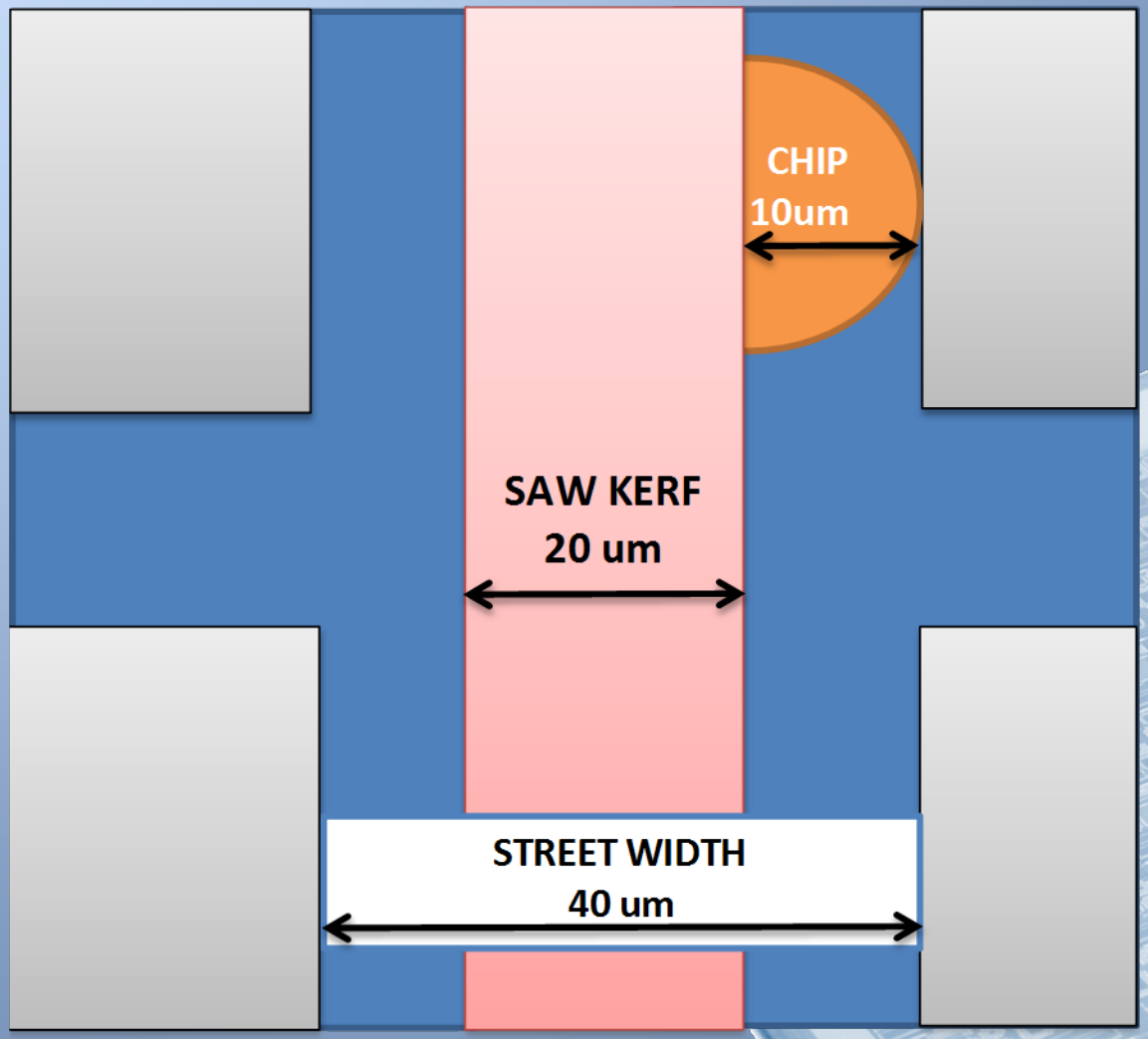
Wafer Singulation

- **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
  - Singulation tapes can consist of UV release, low-tack Blue Tape, Die Attach Film (DAF), and backside lamination tape for laser marking
- 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
  - The standard process for Integra SV is mechanical dicing
- 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

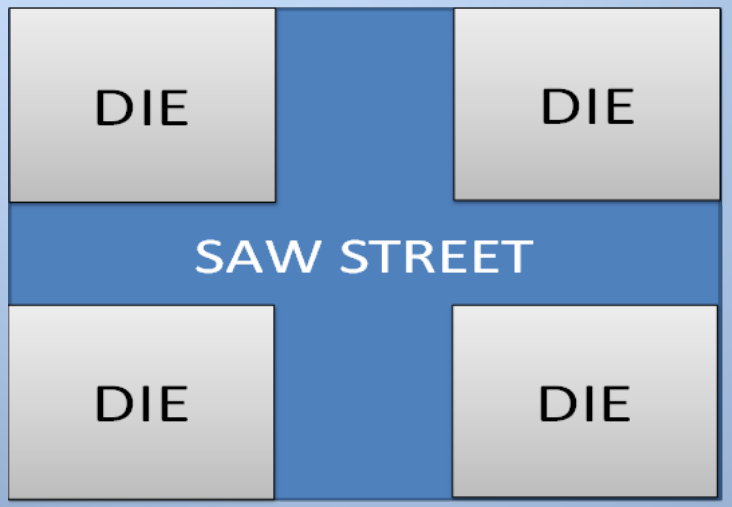
Mechanical Dicing

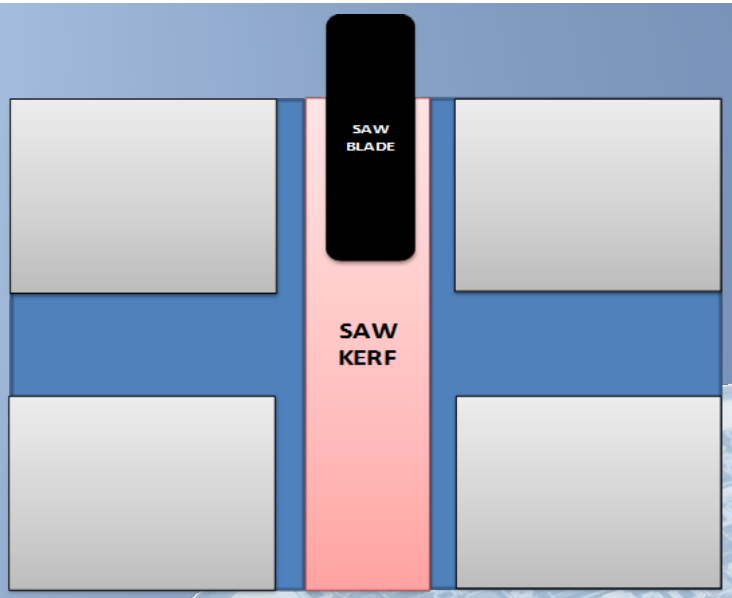


Mechanical Dicing

- 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

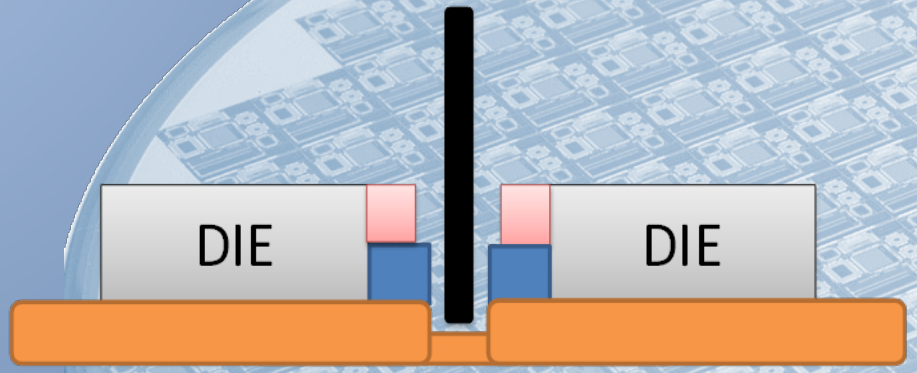
Mechanical Dicing





Mechanical Dicing

SINGLE PASS

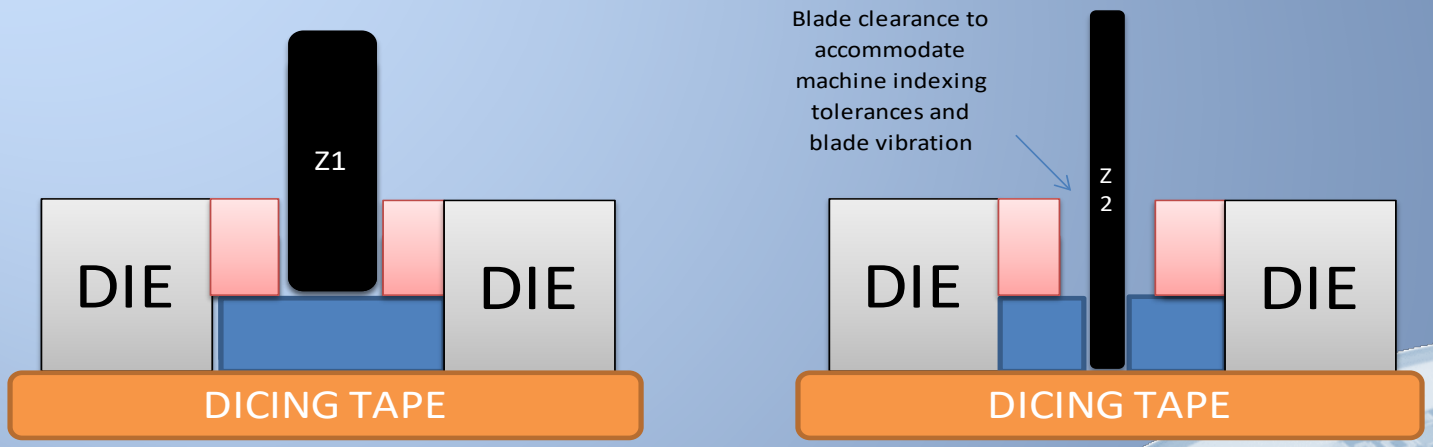


STEP CUT

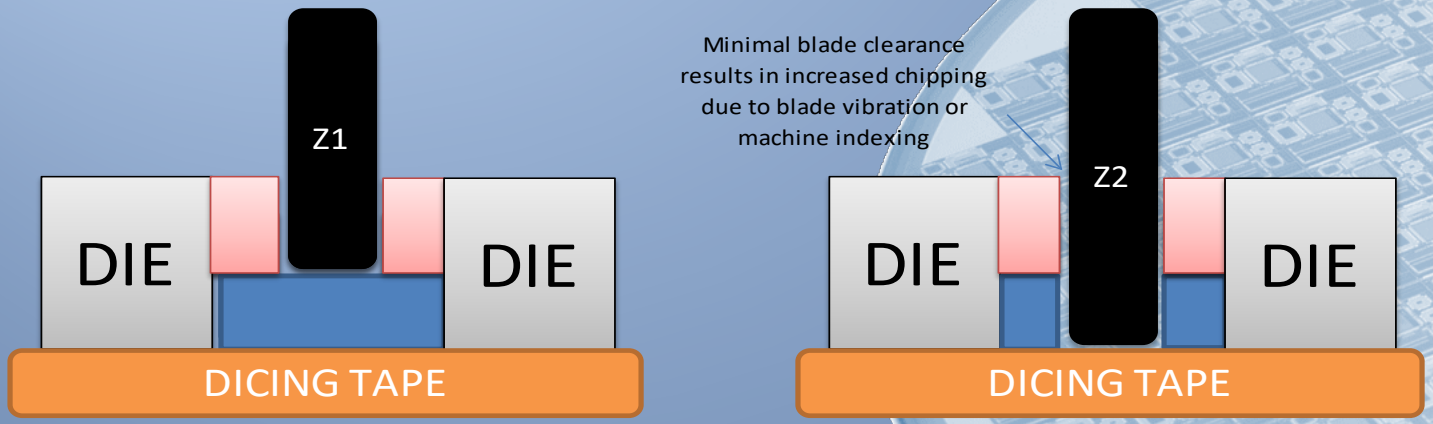
Mechanical Dicing

Single Pass	Step Cut
Benefits	
• Faster throughput • Ultra-thin wafer dicing • Narrow streets	• Improved topside and backside quality • Thick wafers
Challenges	
• Street width to thickness ratio • Cut quality	• 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

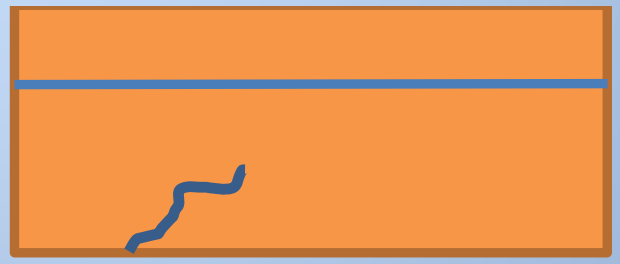
Definitive cut line

No sign of blade rubbing or burning

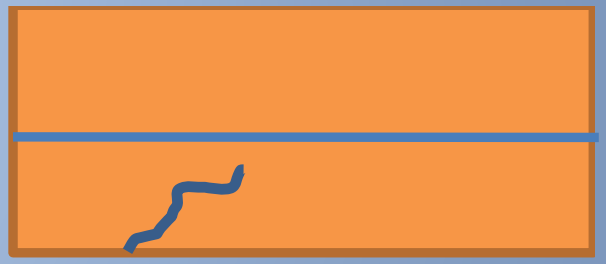
Clean blade marks going with blade rotation

Step Cut – Differing Blade Widths

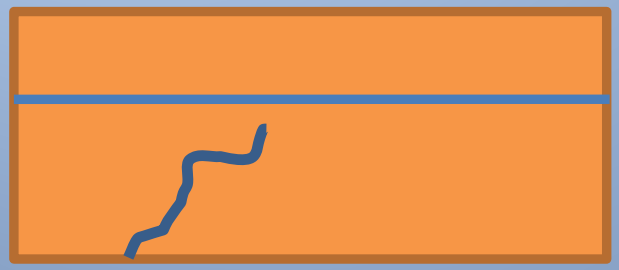
Mechanical Dicing



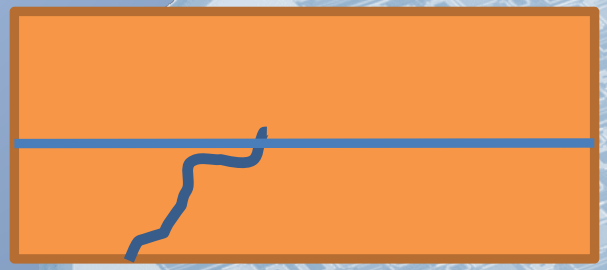
Location of sidewall crack subjective, potentially rejected



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

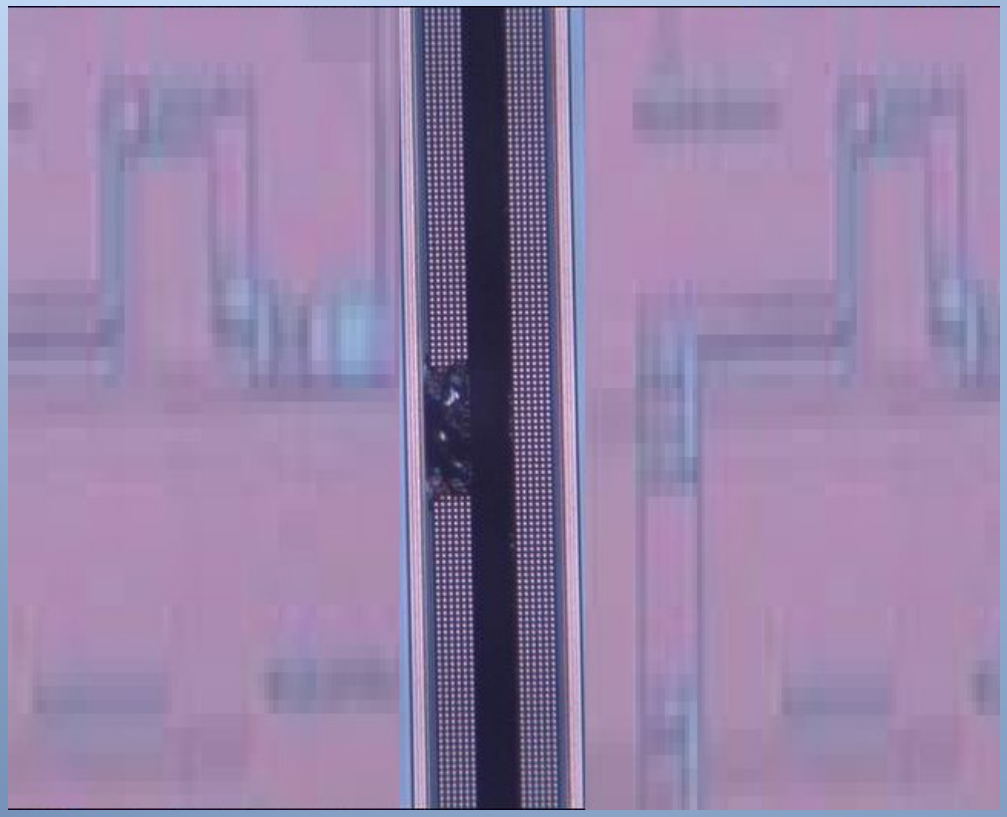


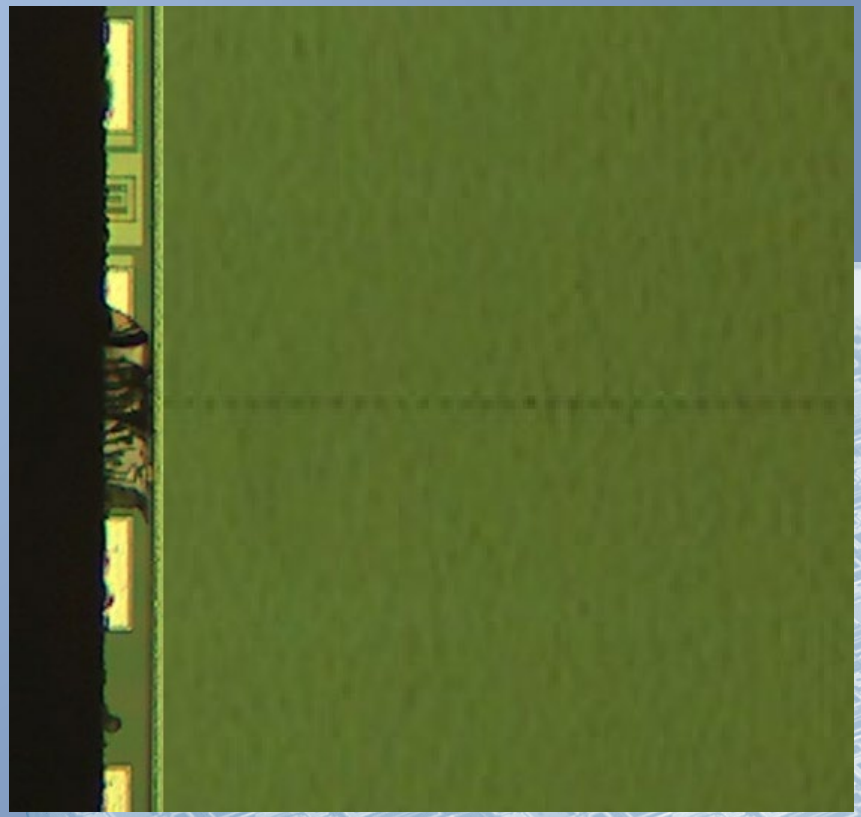
Location of sidewall crack subjective, potentially accepted



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

Mechanical Dicing



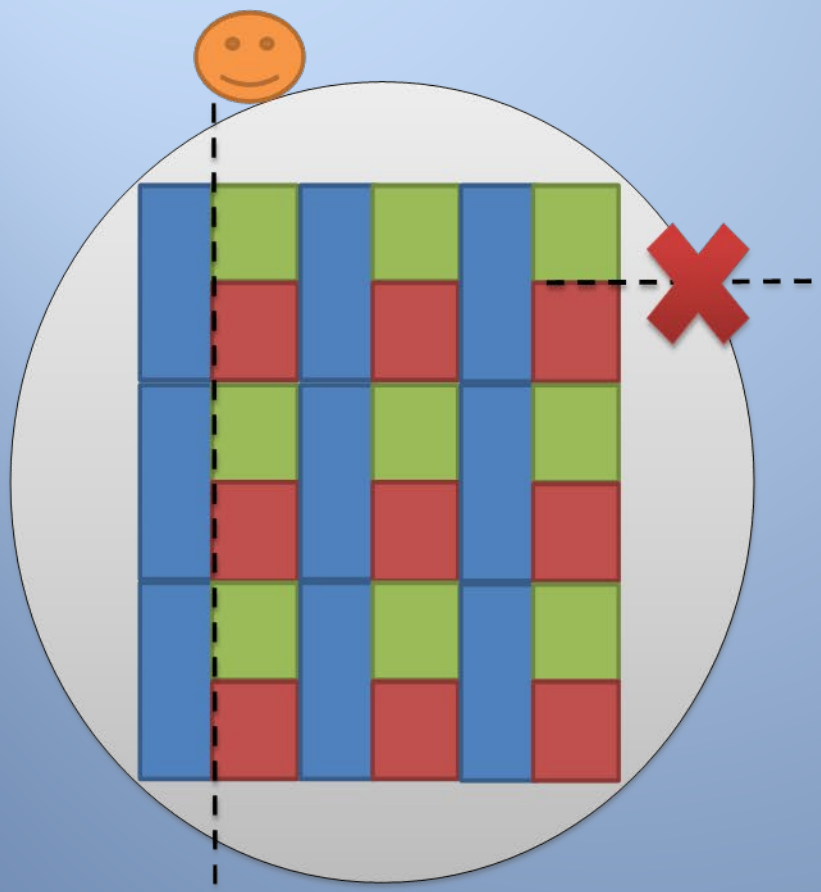


Dicing Blowouts Caused By Metal or Test Structures in Saw Street

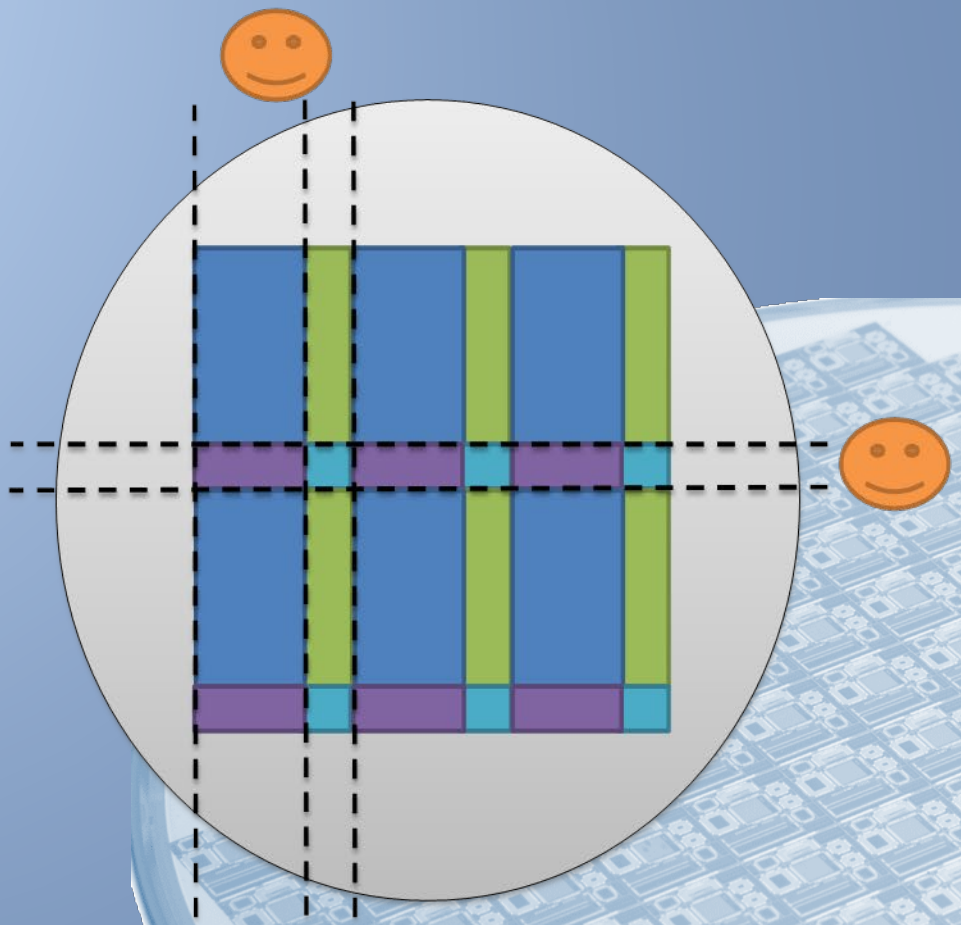
MPW Dicing

- 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 needed to be saved, then remounting is required**
  - *Note: The laser process is capable of singulating inconsistent reticles without remounts, but there are limitations in terms of die size and layout*

MPW Dicing



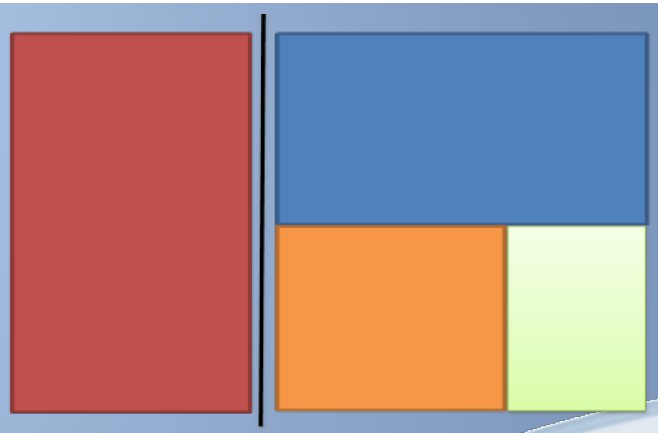
REMOUNT REQUIRED



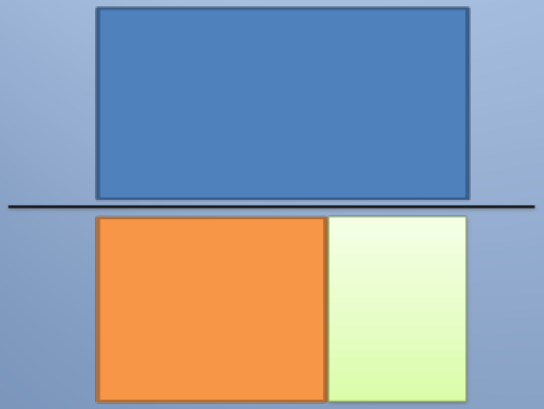
MULTI-INDEXING (NO REMOUNT REQUIRED)

MPW Dicing

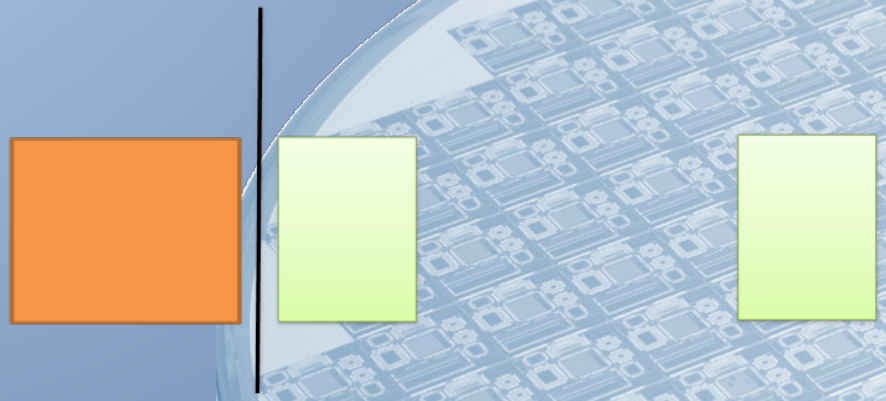
RETICLE LAYOUT



(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



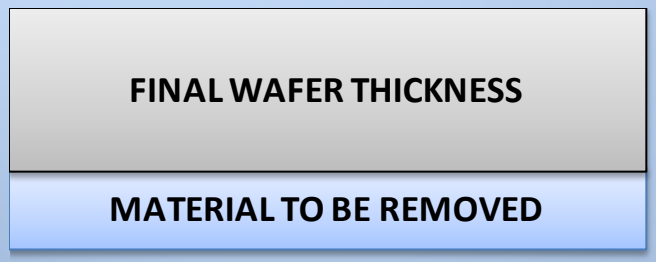
(7) REMOVE BLUE DIE. (8) REMOVE RETICLE. (9) REMOUNT RETICLE. (10) PERFORM CUT TO ISOLATE ORANGE DIE.

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

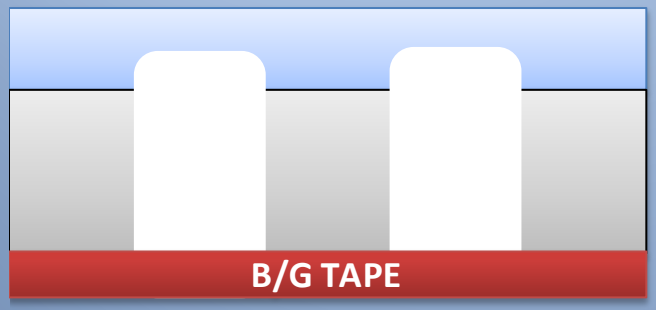
Dice Before Grind

- 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

Dice Before Grind



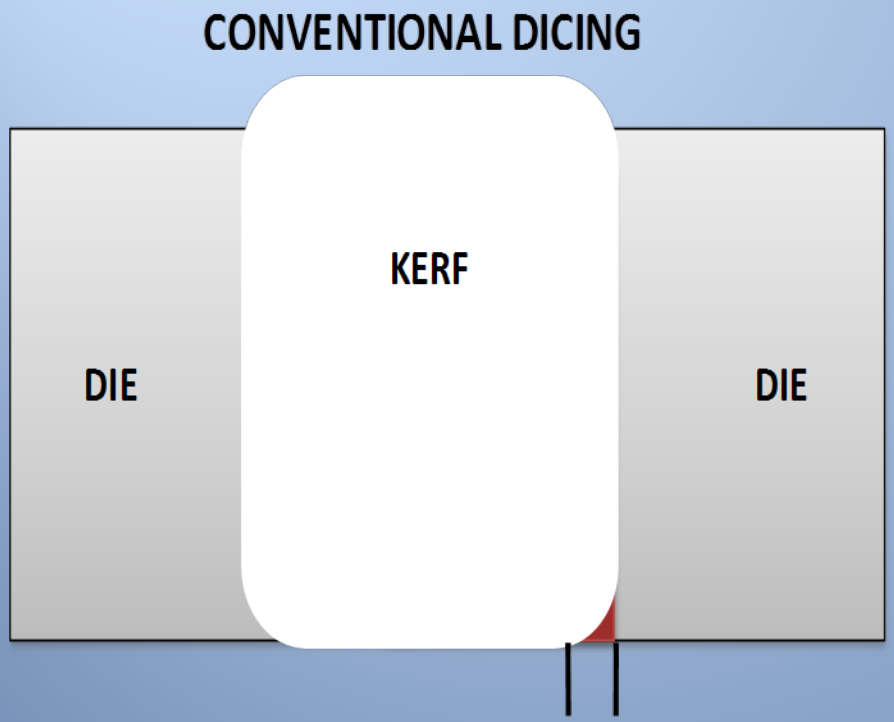
Trench beyond final target thickness



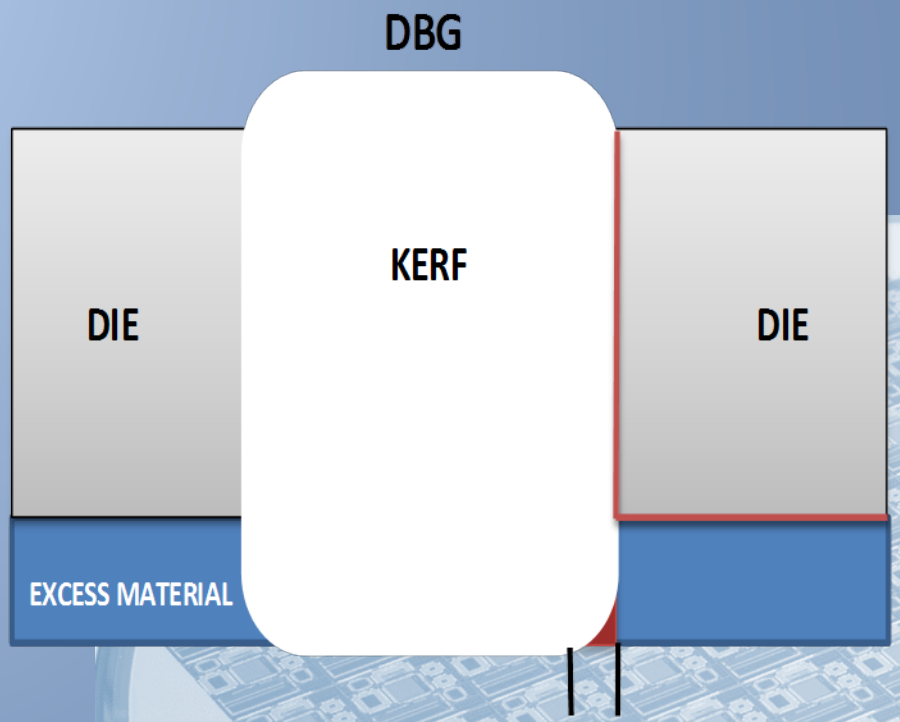
Thin wafer to target

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

Dice Before Grind

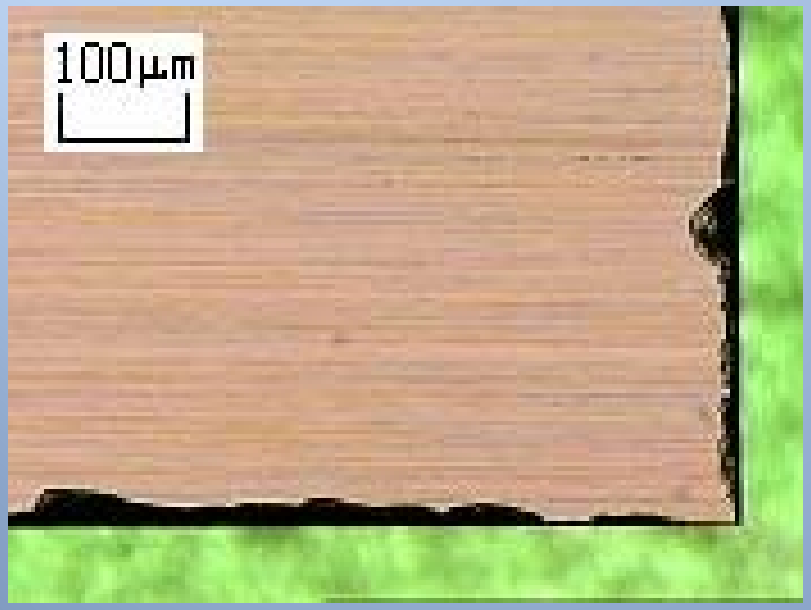


Backside "toe" from curvature of the blade remaining on die

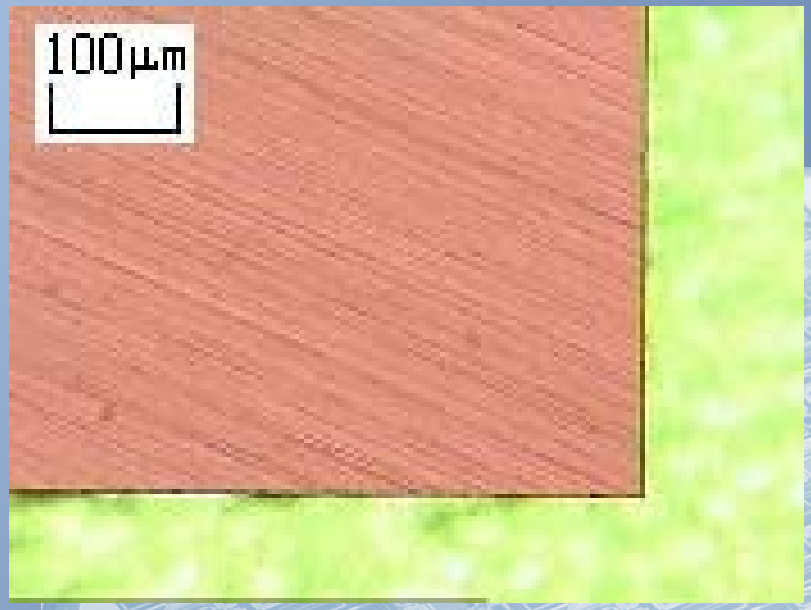


Backside "toe" removed during grind leaving clean die edge

Dice Before Grind



Single Pass

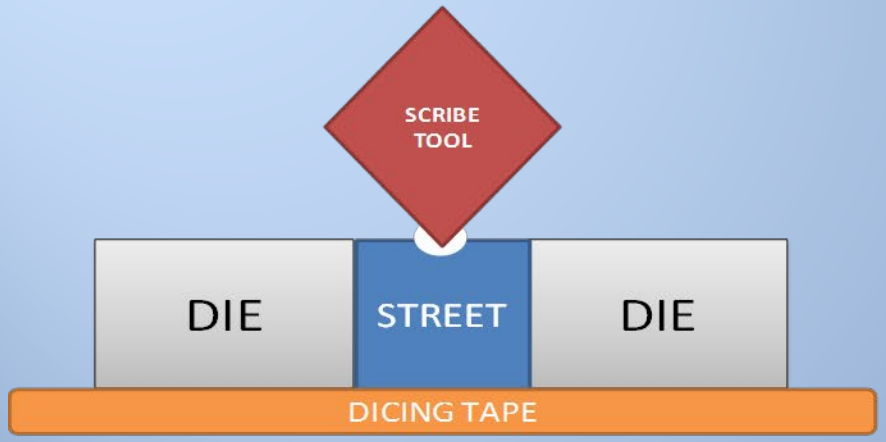


DBG

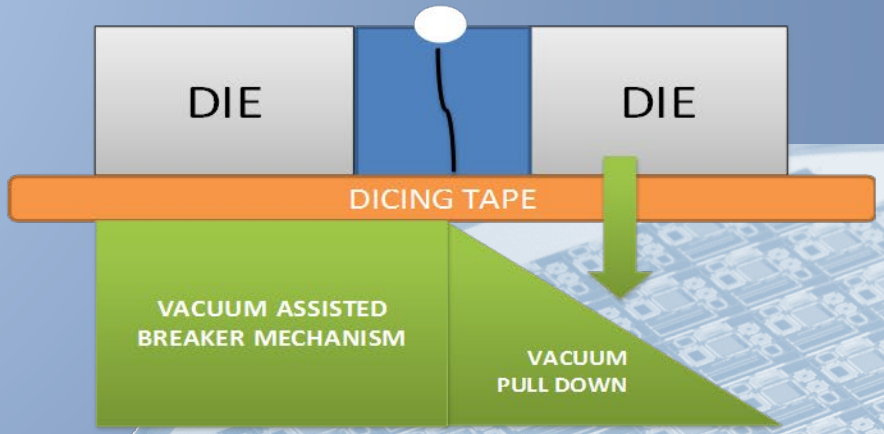
Scribe and Break

- 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
  - Integra SV does provide scribe and break services
- 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



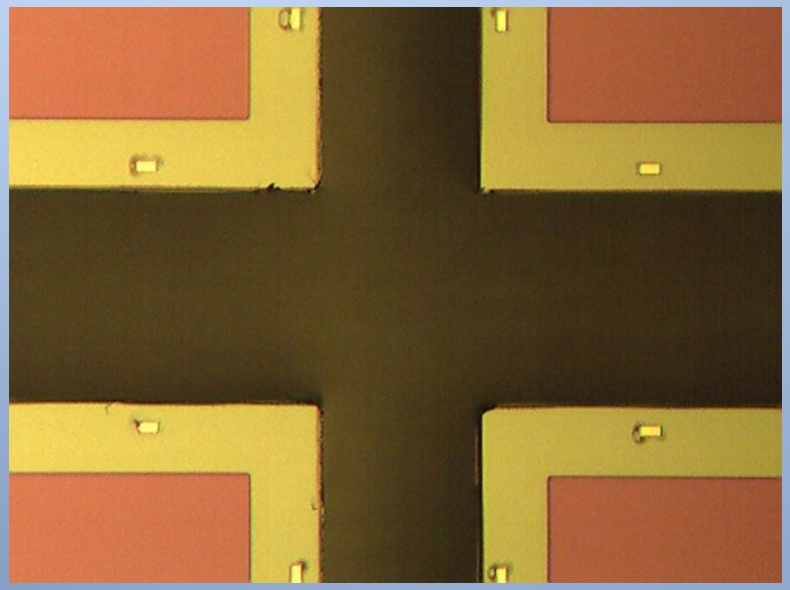
SCRIBE WAFER ON DICING TAPE AND FILM FRAME



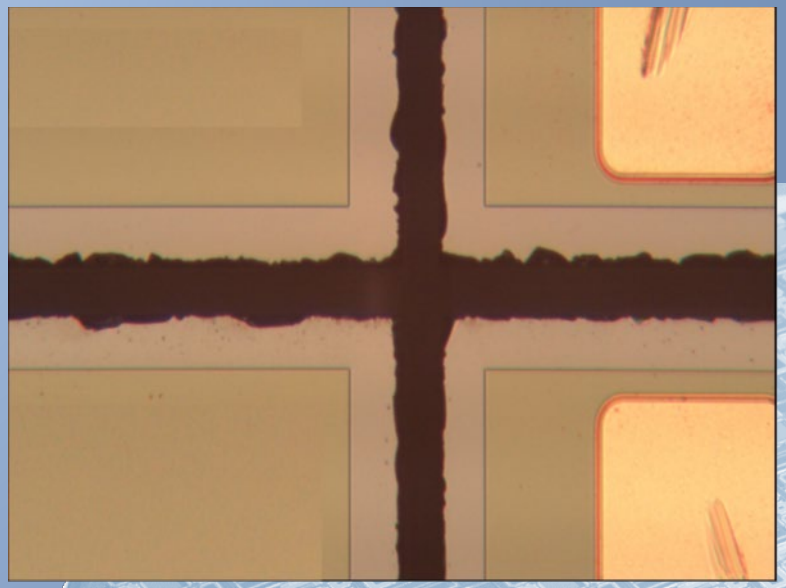
DIE BREAK PERFORMED BY "BENDING" WAFER WITH STRESS LINE CENTERED ON THE BREAKER BAR EDGE

TRANSFER TO STRETCH RING FOR INCREASED DIE SEPARATION

Scribe and Break



GaAs Scribe and Break

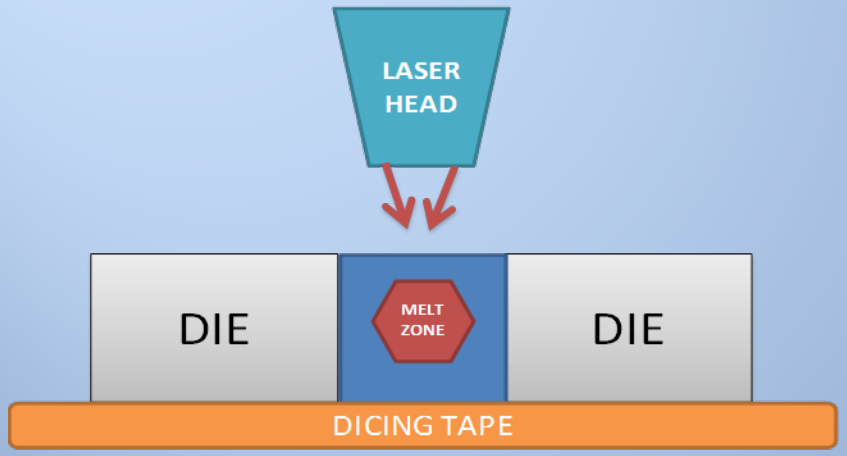


GaAs Mechanical Dicing

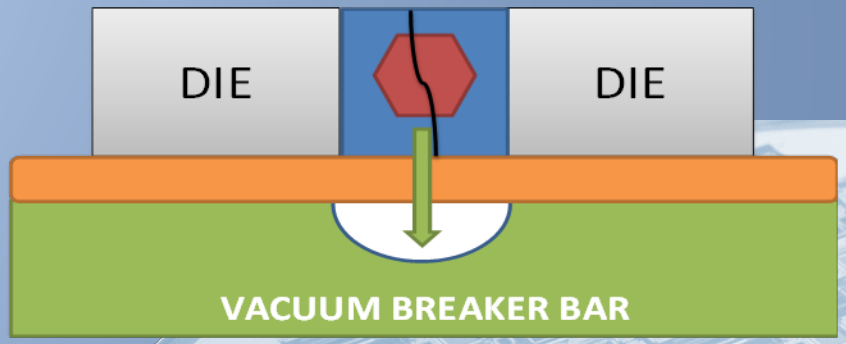
Stealth Dicing

- Stealth Dicing is essentially a scribe and break process where the scriber is a laser instead of a diamond
  - Integra SV previously provided stealth services internally, but currently subcontracts stealth dicing
- The laser generates a heat affected 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



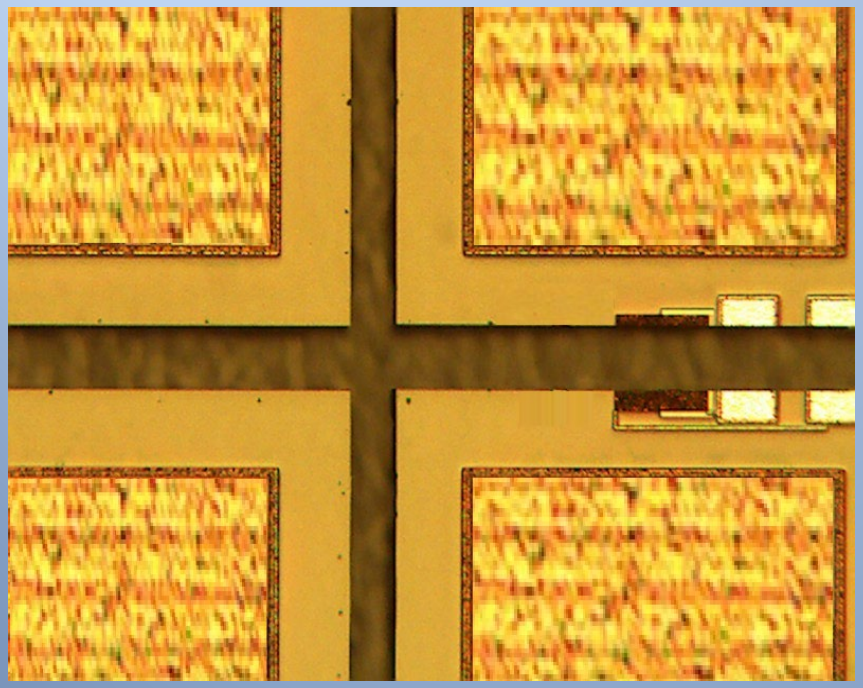
LASER SCRIBE GENERATING MELT ZONE IN MIDDLE OF THE STREET

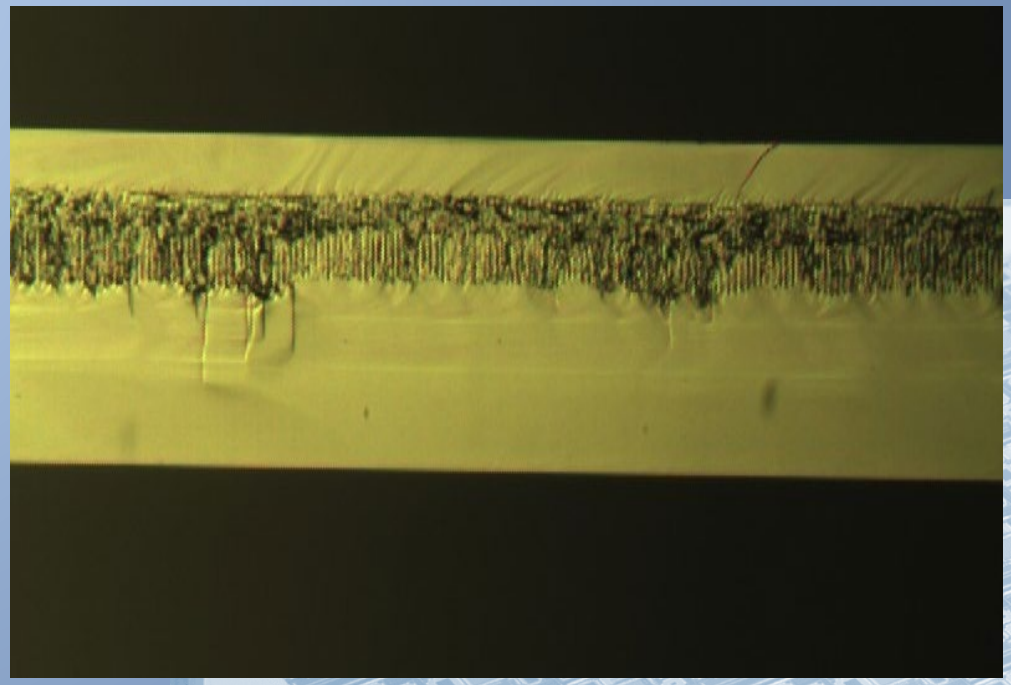


BREAKER BAR PULLS VACUUM ON THE STREET CAUSING THE MELT ZONE AND STREET TO FRACTURE

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

Stealth Dicing



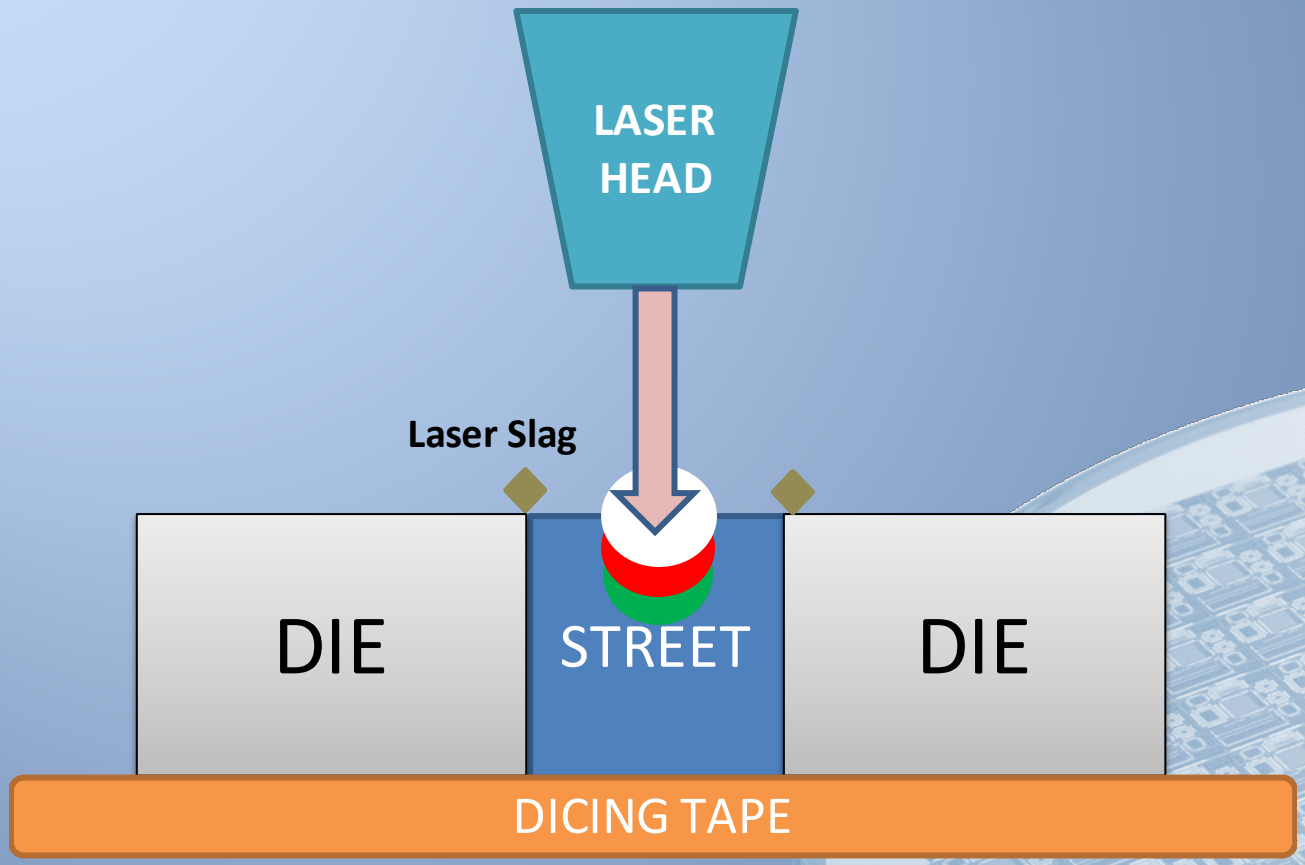


Stealth Dicing Topside and Melt Zone on Sidewall

Laser Ablation

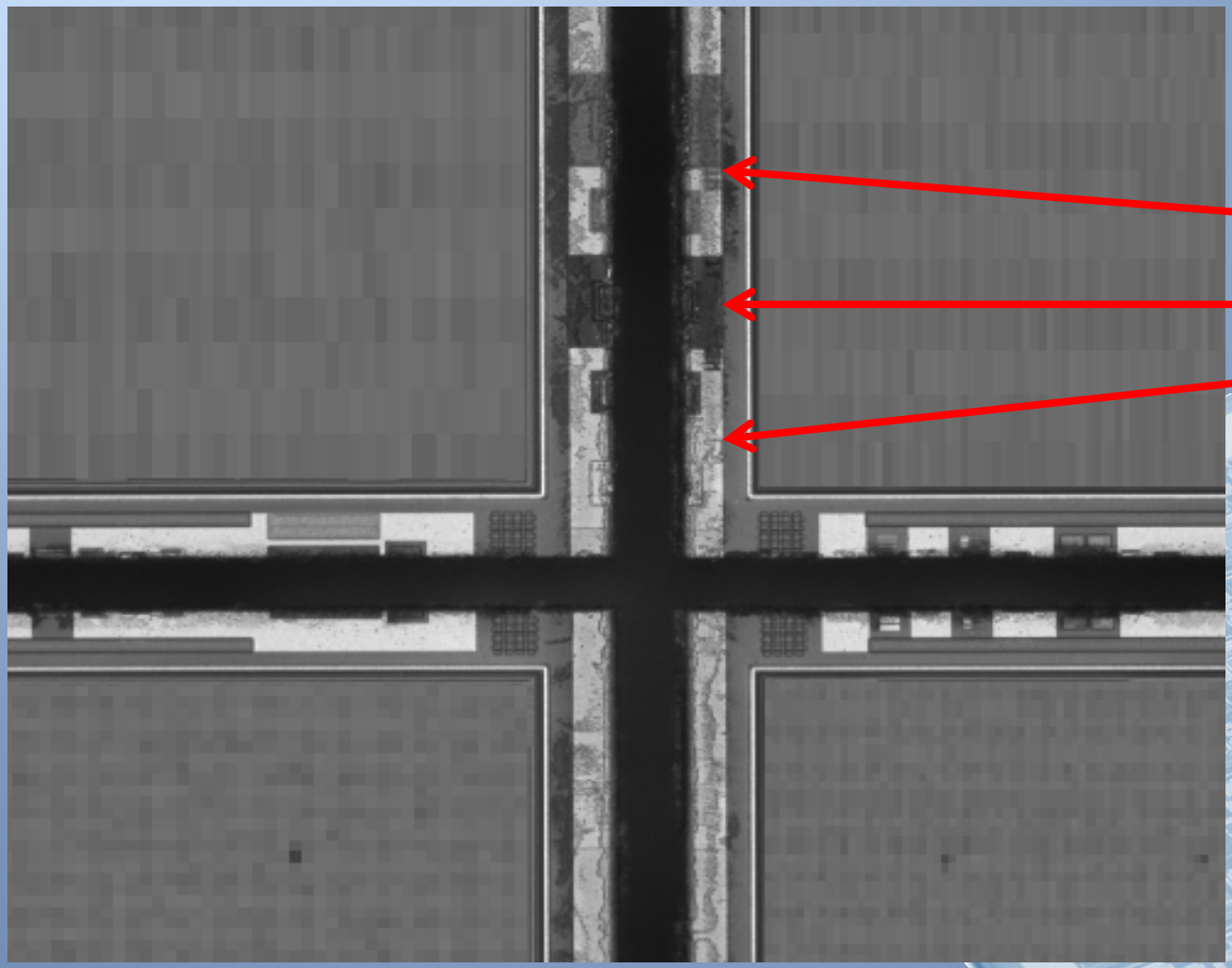
- Laser ablation dicing is the process of removing material in the wafer street with a laser to singulate the die
  - Integra SV does not perform laser ablation
- Laser ablation is ideal for thin wafers with narrow streets
- However, laser ablation generates molten debris, or slag, that can get on the 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
  - Integra SV currently does not perform laser grooving

- 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. Integra SV has been successful using mechanical dicing for 14nm technology and greater in production

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

Wafer Singulation

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

Pick and Place

- Pick and place is the process of removing the singulated die from tape and placing it into an output medium
- The most common mediums are waffle packs, Gel Paks, 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 like MEMS and imager die
- Electronic maps, ink dot recognition, and blind builds (pick all) are methods of identifying the appropriate die to be picked
- Die tracking can trace the exact position from where a die was picked and its corresponding location in the output medium

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
- Post-pick automated inspection in waffle packs is a challenge due to the movement of die within the waffle cavity pocket

Inspection

- There major Die Inspection Standards are:
  - Military 883:Visual inspection criteria for inspecting microcircuit die comply with MIL-STD-883, Method 2010 Cond A (Space) & Cond B (Military).
  - Commercial: Visual inspection criteria for inspecting microcircuit die is based on Industry & Military Standards (generally acceptable for commercial use). Spec # MAS-2010
  - European standards (Requirements same or similar to Mil-Std 883).
  - Custom/Customer Specific

INTEGRA TECHNOLOGIES

Inspection

MILITARY

- A high-power microscope with illumination and magnification of 75X to 150X for Class B (Integra uses 50X to 100X) and 100X to 200X for Class S. Refer to MIL-STD-883, Method 2010.
- When using Low power (usually for sidewall and backside inspection), use Binocular low power microscope with illumination and magnification of minimum 30X. Refer to MIL-STD-883, Method 2010.
- CDA (Clean Dry Air). Pressure is not to exceed 20 psig.
- Anti-static finger cots or gloves.
- Vacuum wand with rubber tip.
- Tweezers.
- ESD Wrist strap with 1 Mega-Ohm, 1/4-Watt resistor.
- Grounded workstation with laminar flow hood.
- Conductive rubber bands and lint-free filter paper.
- Tyvek paper over the plated die after inspection.

COMMERCIAL

- A high-power microscope with a magnification range of 40X to 150X. (Integra uses 50X)
- Vacuum wand with rubber tip.
- Anti-static finger cots or gloves.
- Wrist strap with 1 Mega-Ohm, 1/4-Watt resistor.
- Tweezers (conductive plastic).
- ESD Wrist strap with 1meg ohm 1/4-Watt resistor.
- Grounded workstation with laminar flow hood.
- Conductive rubber bands and lint-free filter paper.
- Tyvek paper over the plated die after inspection.