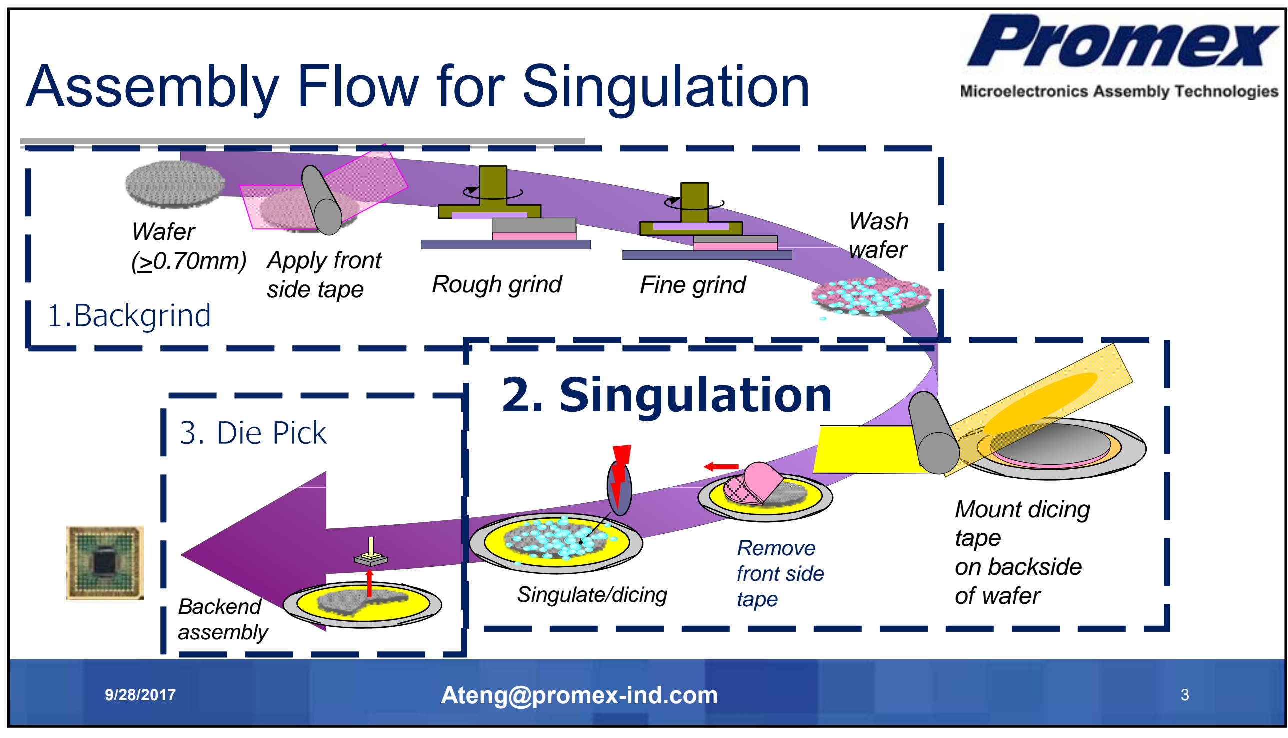
Comparison of Singulation Techniques

Electronic Packaging Society, Silicon Valley Chapter
Sept. 28, 2017

ANNETTE TENG

Sept 28, 2017 1


Assembly Flow for Singulation
Promex
Microelectronics Assembly Technologies
Wafer
(≥0.70mm)
Apply front
side tape
Rough grind
Fine grind
Wash
wafer
1.Backgrind
2. Singulation
3. Die Pick
Mount dicing
tape
on backside
of wafer
Remove
front side
tape
Singulate/dicing
Backend
assembly
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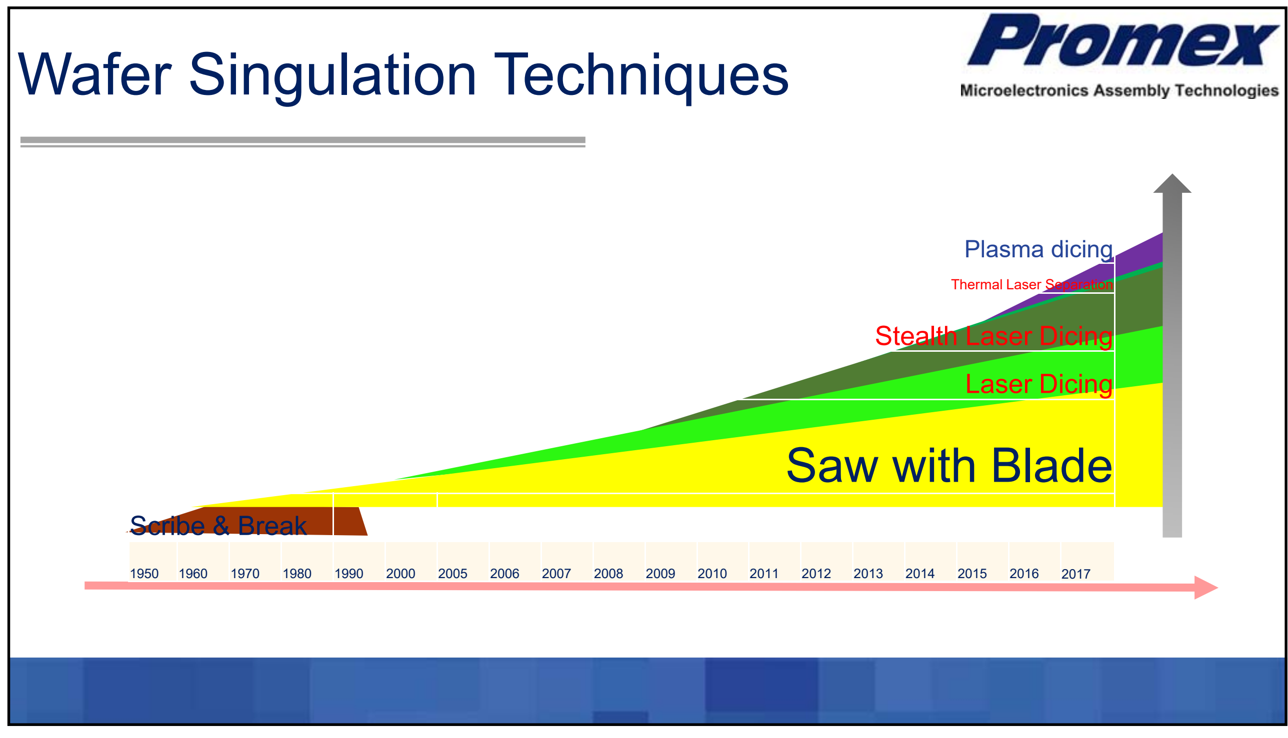
Wafer Singulation Techniques
Promex
Microelectronics Assembly Technologies
Plasma dicing
Thermal Laser Separation
Stealth Laser Dicing
Laser Dicing
Saw with Blade
Scribe & Break
1950
1960
1970
1980
1990
2000
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

- **SAW**
- LASER
  - Ablation
  - Stealth
  - TLS
- Plasma

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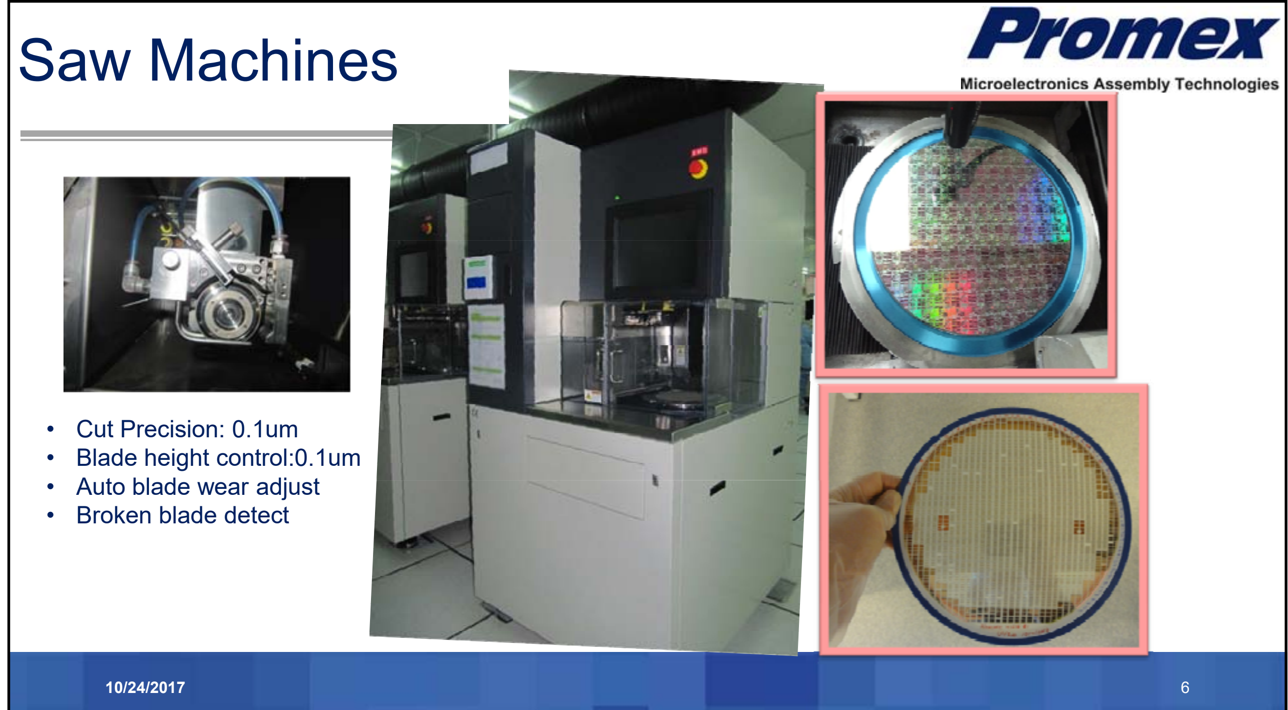

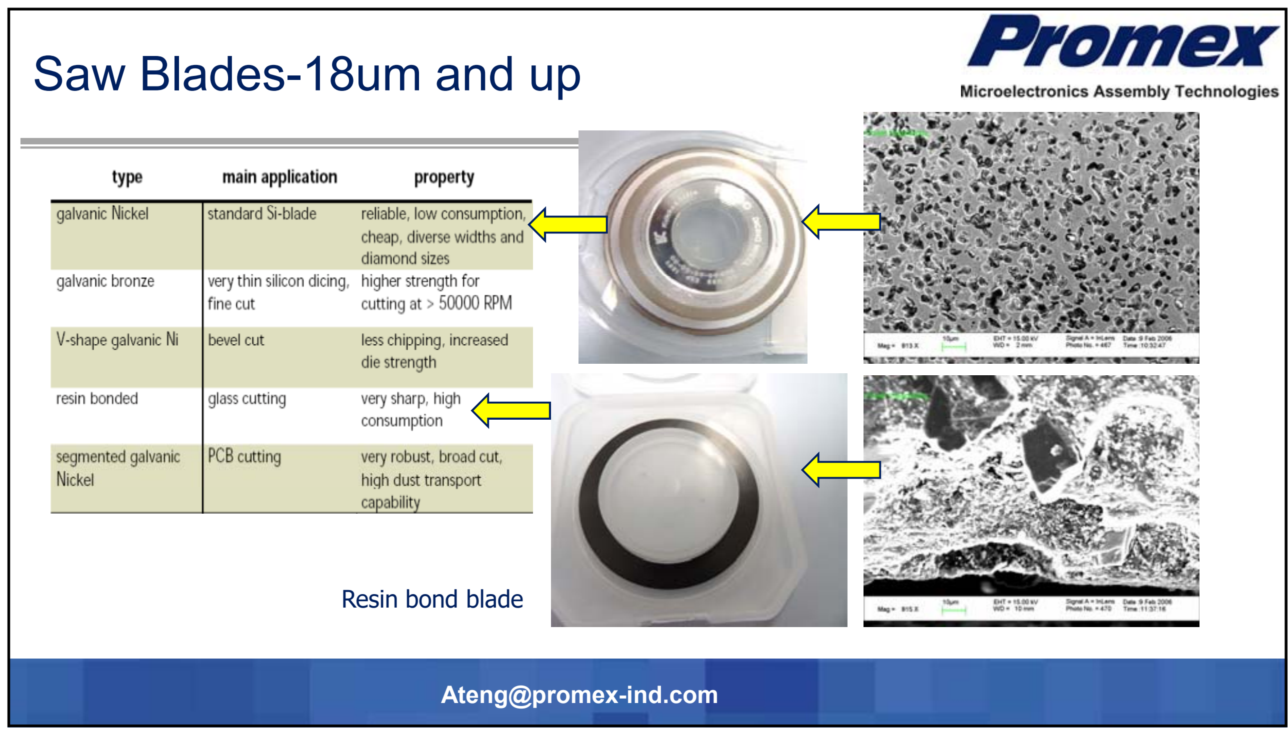
Saw Blades-18um and up
Promex
Microelectronics Assembly Technologies
type | main application | property
galvanic Nickel | standard Si-blade | reliable, low consumption, cheap, diverse widths and diamond sizes
galvanic bronze | very thin silicon dicing, fine cut | higher strength for cutting at > 50000 RPM
V-shape galvanic Ni | bevel cut | less chipping, increased die strength
resin bonded | glass cutting | very sharp, high consumption
segmented galvanic Nickel | PCB cutting | very robust, broad cut, high dust transport capability
Resin bond blade
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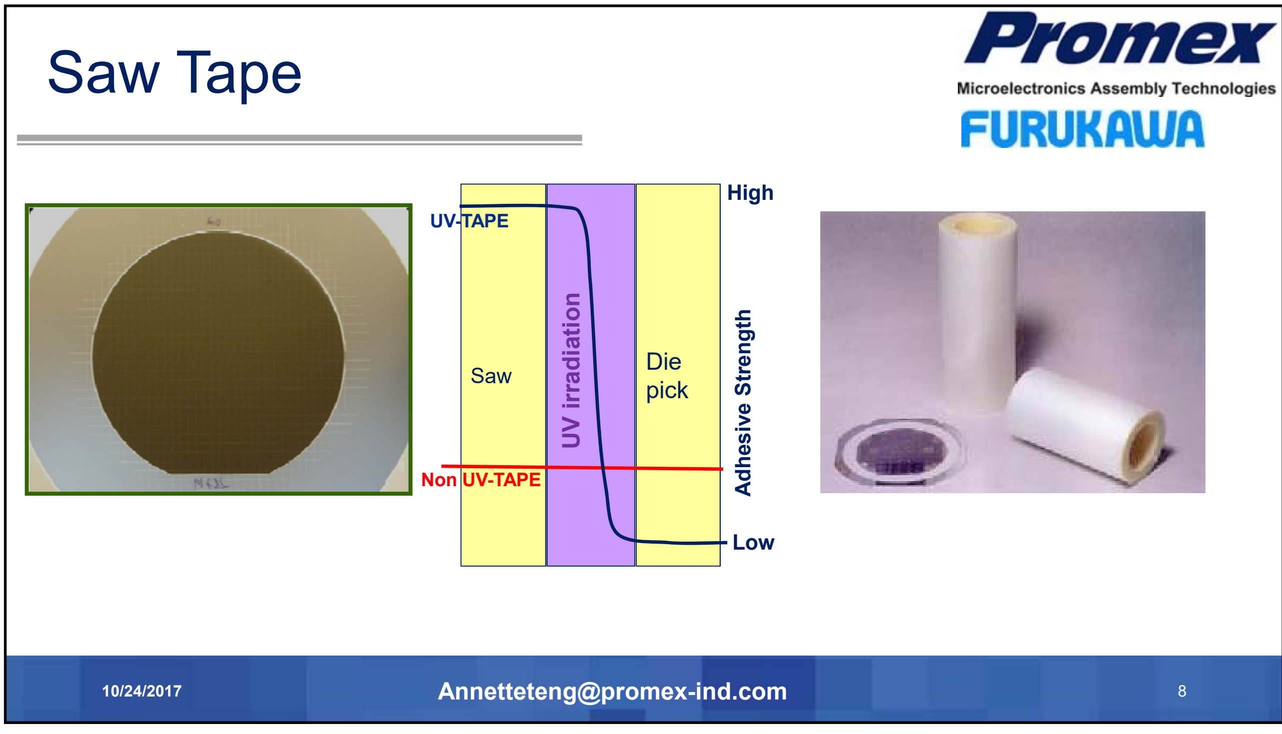
Saw Tape
Promex
Microelectronics Assembly Technologies
FURUKAWA
High
UV-TAPE
Saw
UV irradiation
Die pick
Adhesive Strength
Non UV-TAPE
Low
10/24/2017
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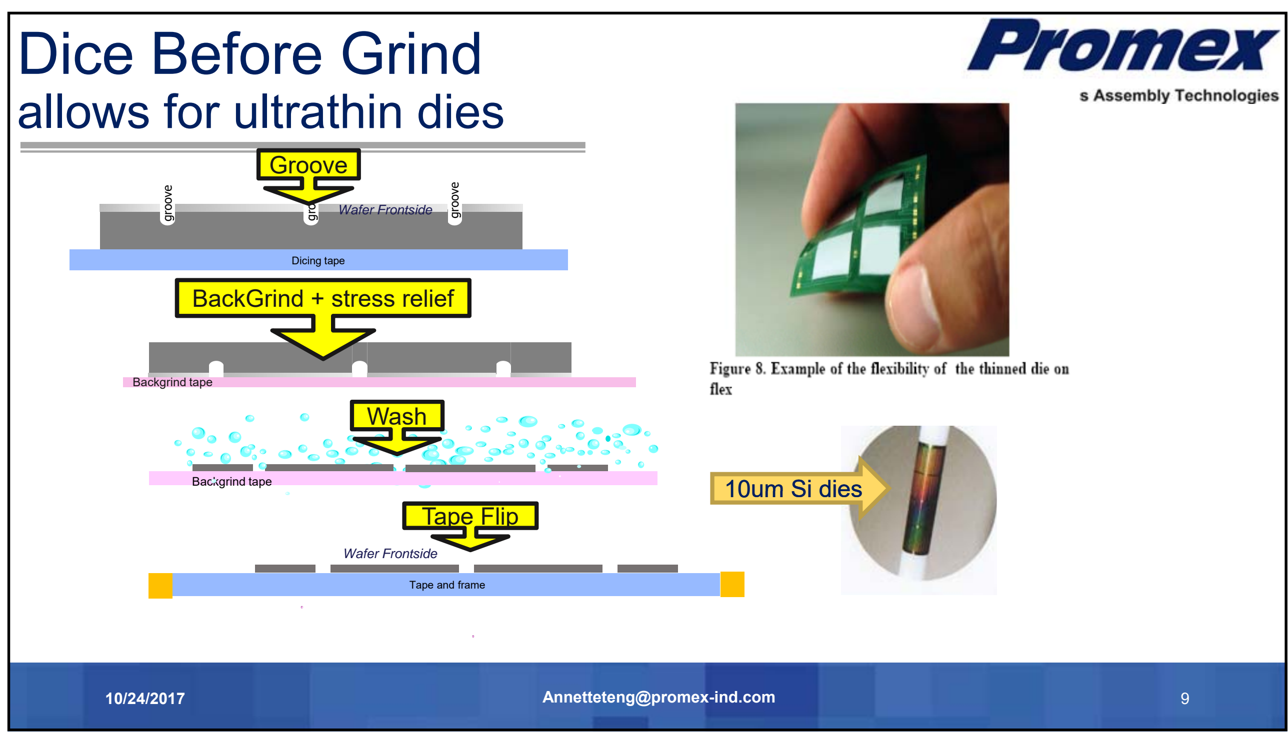
Dice Before Grind
allows for ultrathin dies
Promex
s Assembly Technologies
Groove
groove
groove
Wafer Frontside
Dicing tape
BackGrind + stress relief
Backgrind tape
Wash
Backgrind tape
Tape Flip
Wafer Frontside
Tape and frame
Figure 8. Example of the flexibility of the thinned die on flex
10um Si dies
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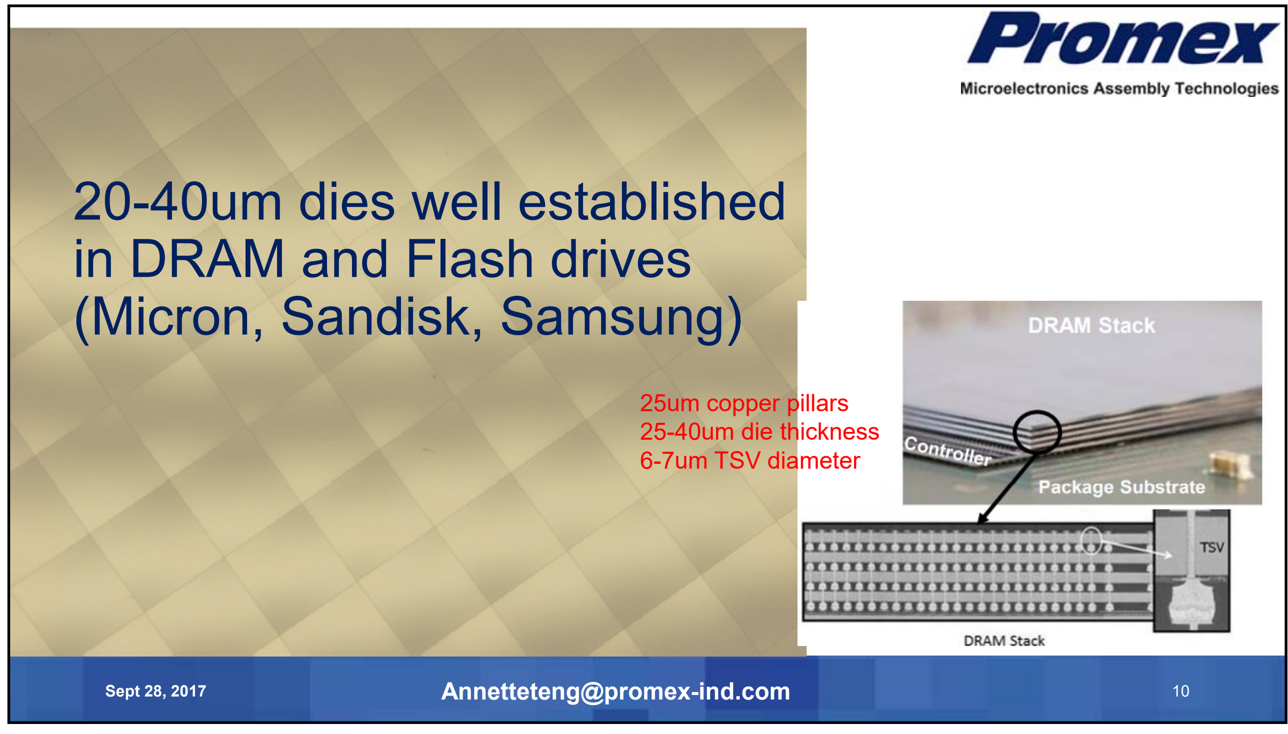
Promex
Microelectronics Assembly Technologies
20-40um dies well established in DRAM and Flash drives (Micron, Sandisk, Samsung)
25um copper pillars
25-40um die thickness
6-7um TSV diameter
DRAM Stack
Controller
Package Substrate
TSV
DRAM Stack
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VERSATILITY of SAW
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Microelectronics Assembly Technologies
DAF
Profile cuts
Multilayer material
Metallized wafer
Making needles
Metallized street
Multilayer materials
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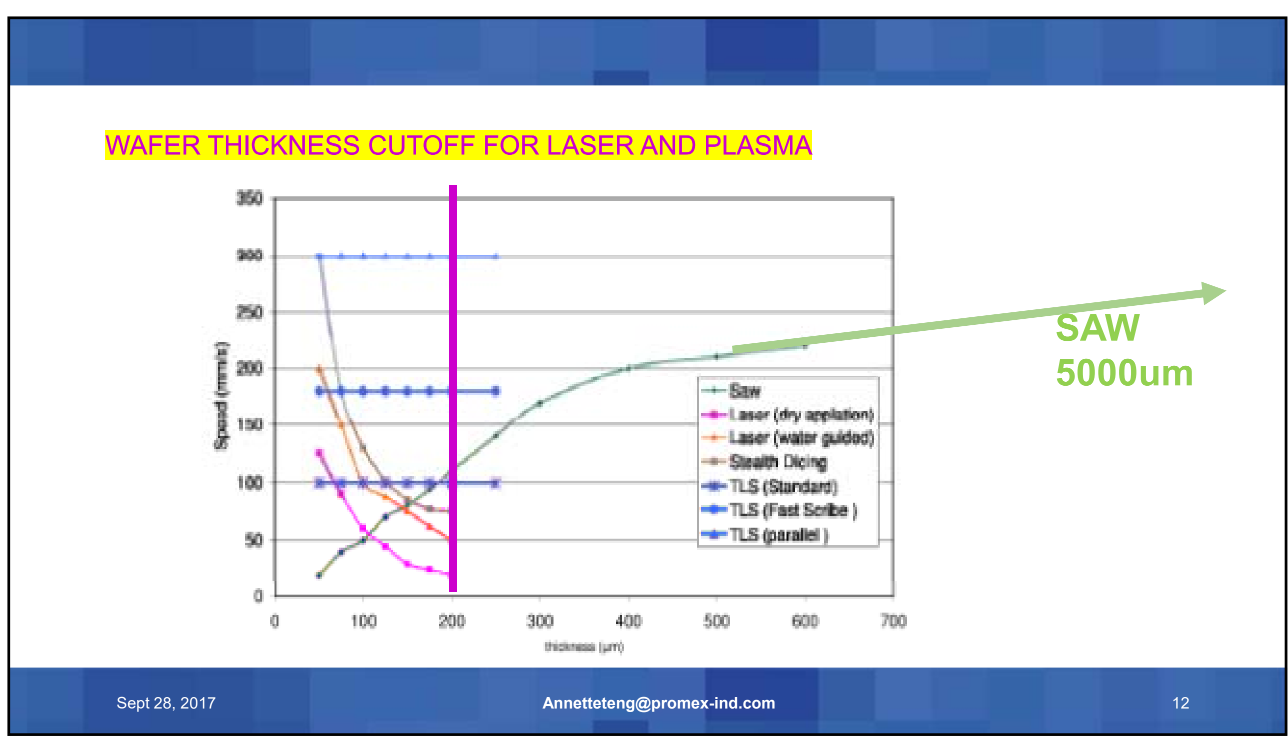
WAFER THICKNESS CUTOFF FOR LASER AND PLASMA
Speed (mm/s)
thickness (µm)
Saw
Laser (dry ablation)
Laser (water guided)
Stealth Dicing
TLS (Standard)
TLS (Fast Scribe)
TLS (parallel)
SAW
5000um
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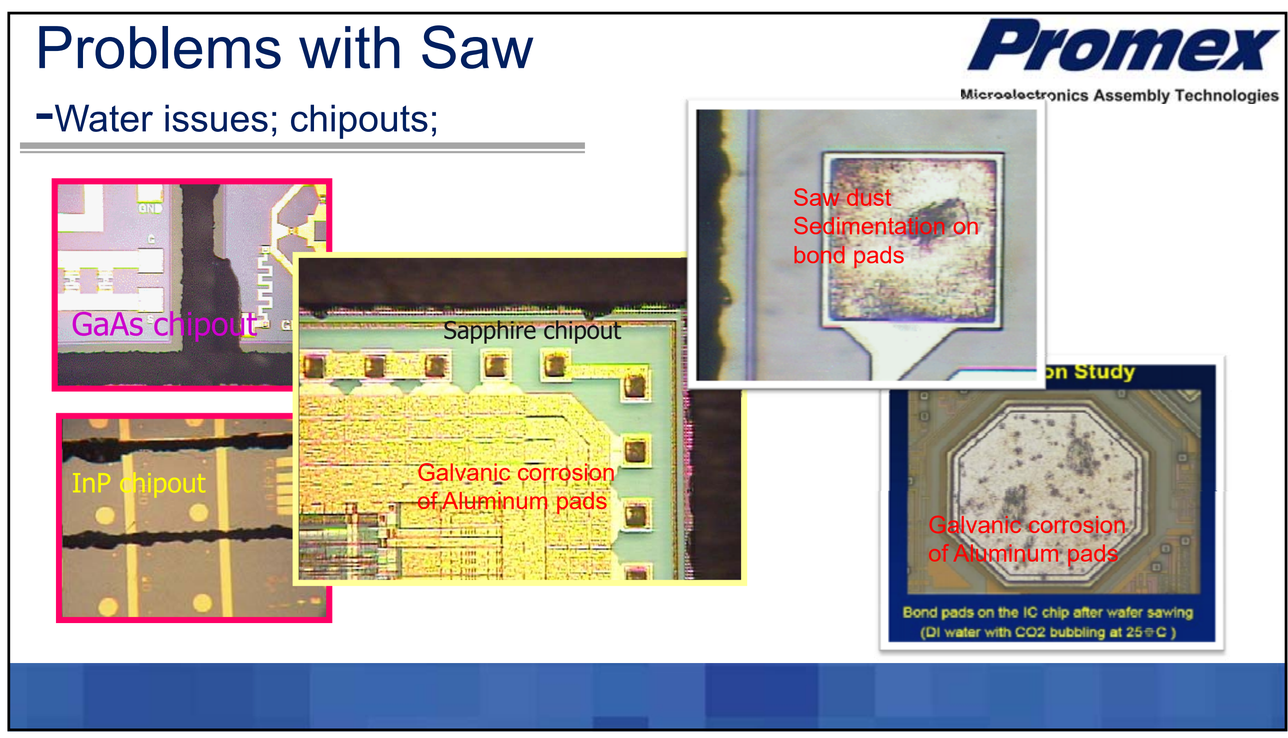
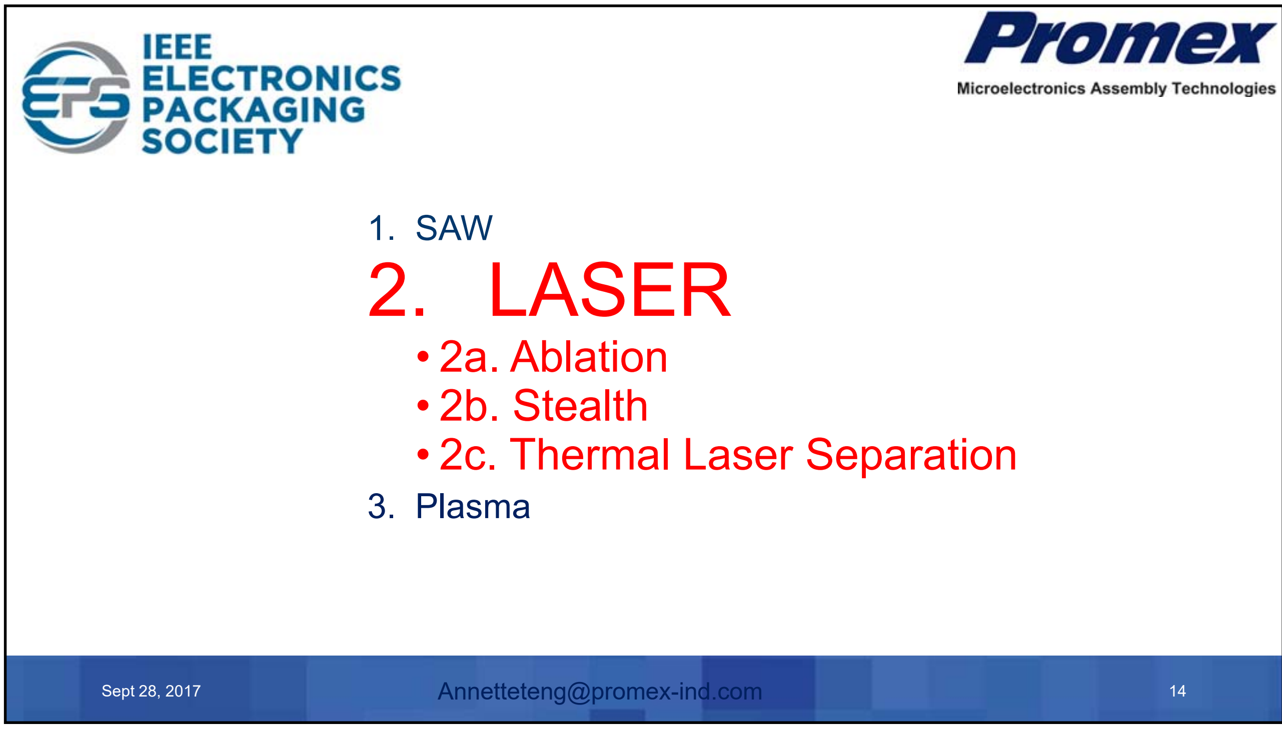

Problems with Saw
-Water issues; chipouts;
Promex
Microelectronics Assembly Technologies
GaAs chipout
InP chipout
Sapphire chipout
Galvanic corrosion of Aluminum pads
Saw dust Sedimentation on bond pads
Galvanic corrosion of Aluminum pads
Bond pads on the IC chip after wafer sawing
(DI water with CO2 bubbling at 25°C)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Promex
Microelectronics Assembly Technologies
1. SAW
2. LASER
• 2a. Ablation
• 2b. Stealth
• 2c. Thermal Laser Separation
3. Plasma
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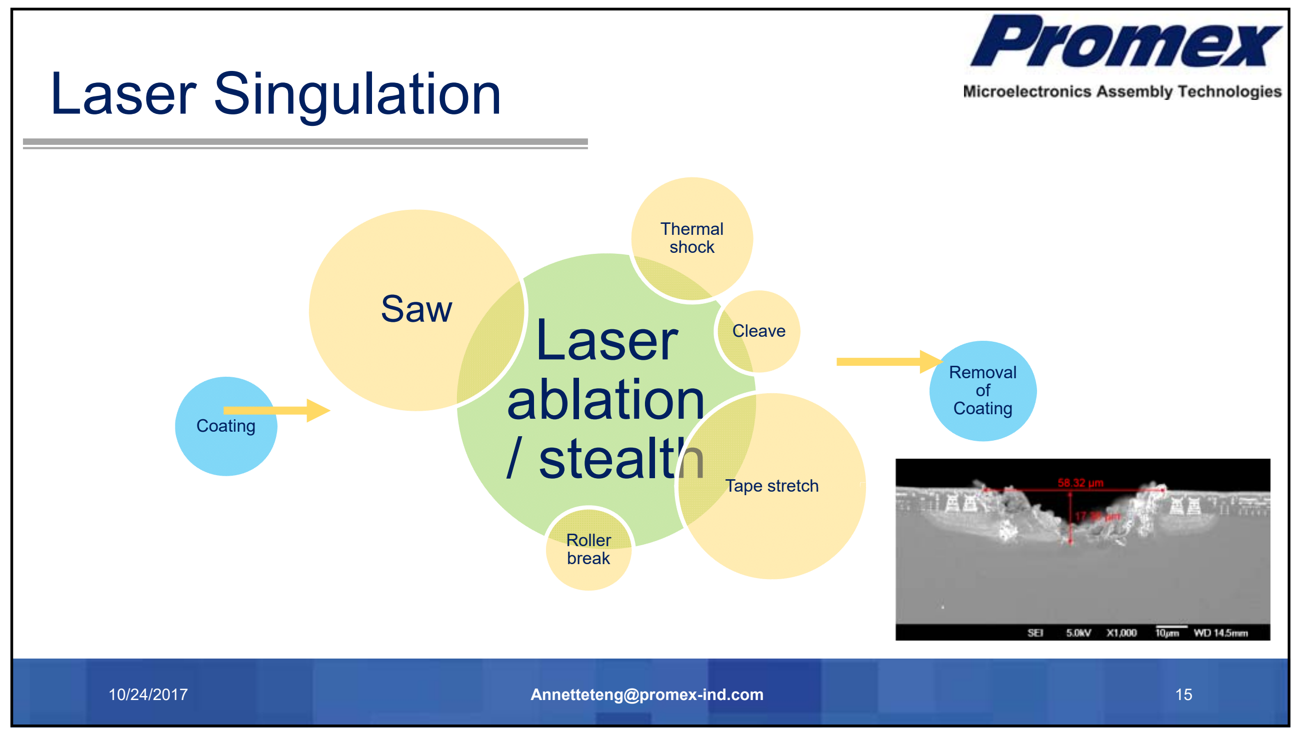
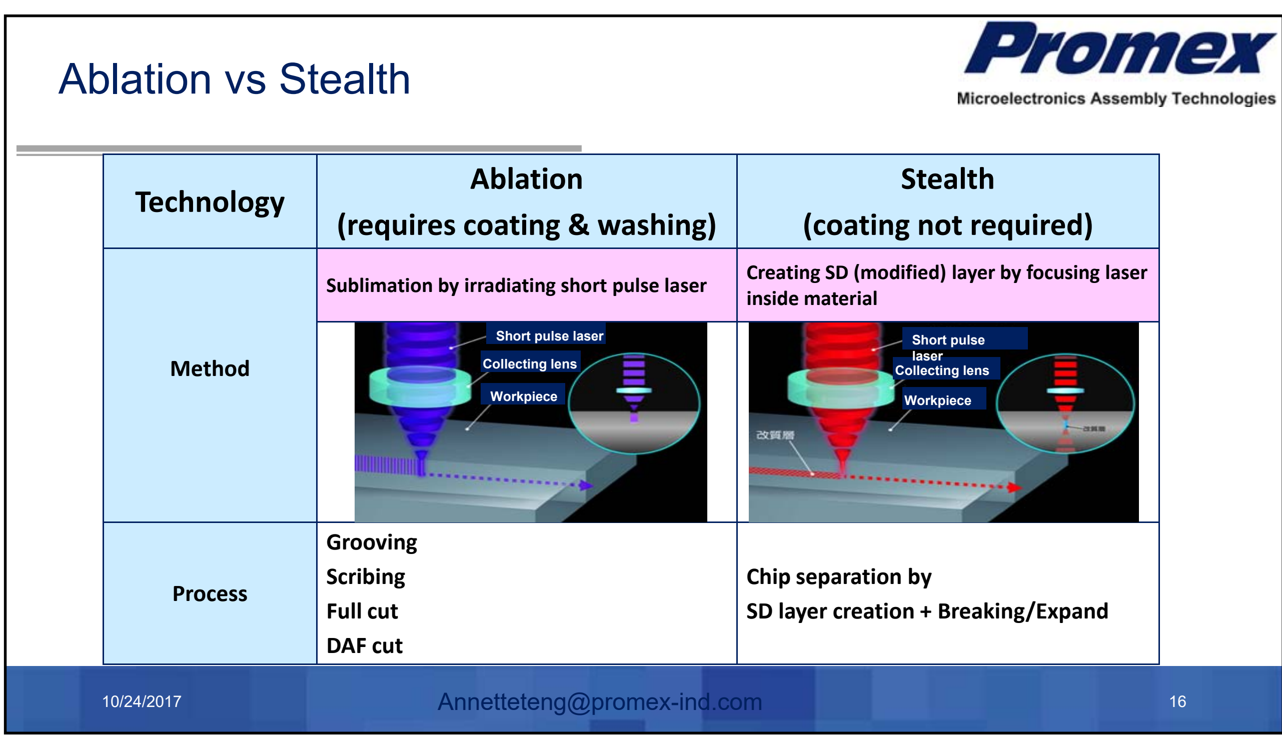
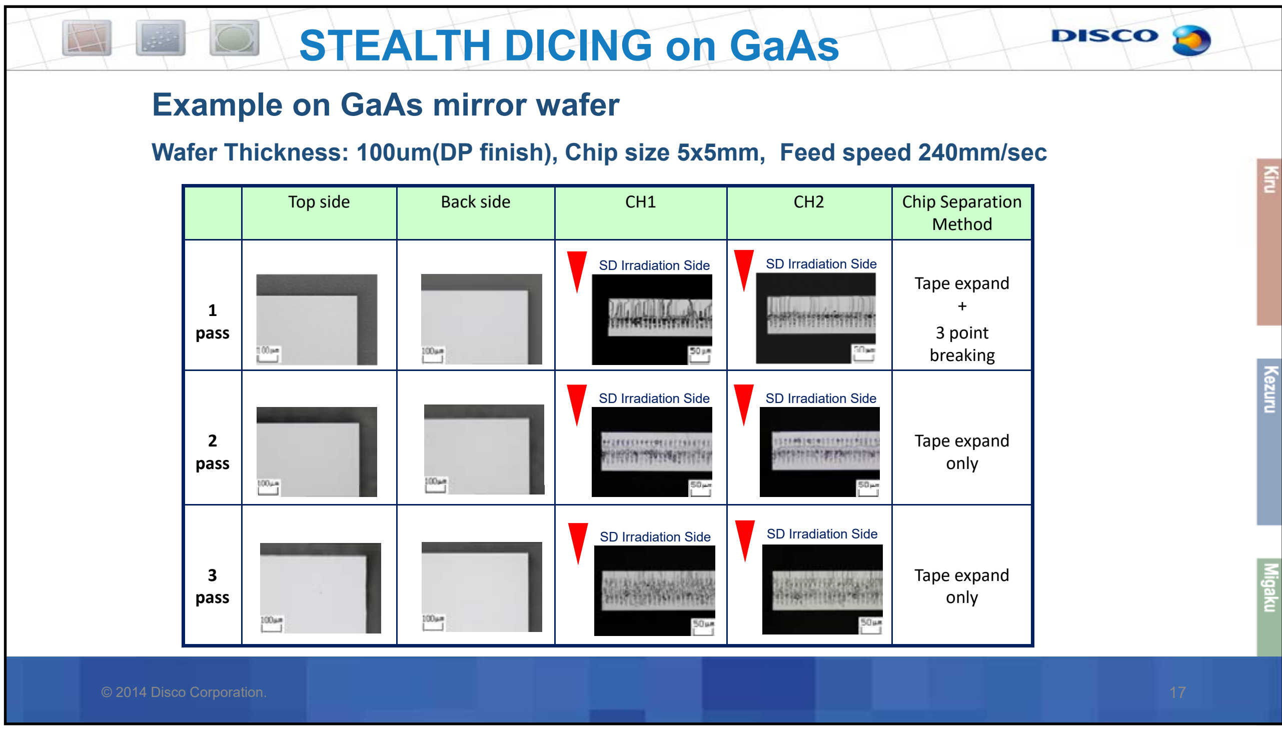




Technology	Ablation (requires coating & washing)	Stealth (coating not required)
Method	Sublimation by irradiating short pulse laser	Creating SD (modified) layer by focusing laser inside material
Process	Grooving Scribing Full cut DAF cut	Chip separation by SD layer creation + Breaking/Expand


STEALTH DICING on GaAs
DISCO
Example on GaAs mirror wafer
Wafer Thickness: 100um(DP finish), Chip size 5x5mm, Feed speed 240mm/sec
Top side
Back side
CH1
CH2
Chip Separation Method
1 pass
2 pass
3 pass
SD Irradiation Side
Tape expand + 3 point breaking
Tape expand only
Tape expand only
Kiru
Kezuru
Migaku
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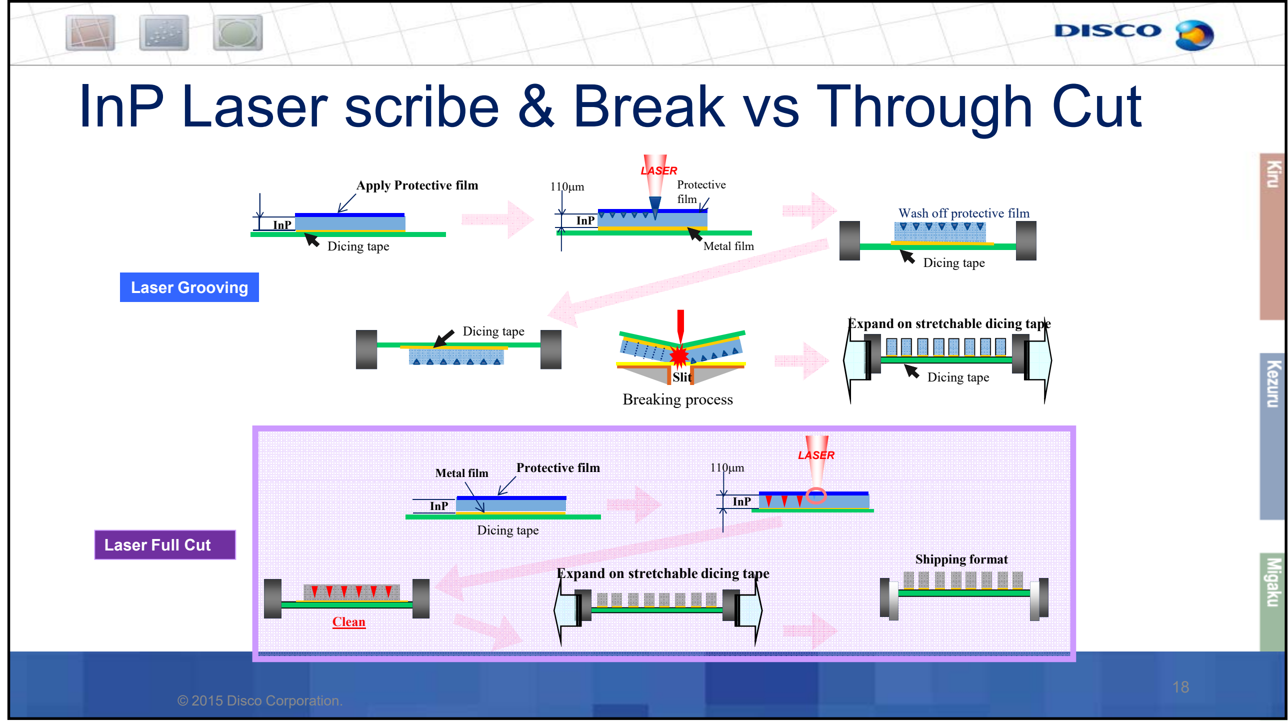
DISCO
InP Laser scribe & Break vs Through Cut
Laser Grooving
Apply Protective film
InP
Dicing tape
110µm
LASER
Protective film
Metal film
Wash off protective film
Dicing tape
Breaking process
Slit
Expand on stretchable dicing tape
Laser Full Cut
Metal film
Protective film
Clean
Shipping format
Kiru
Kezuru
Migaku
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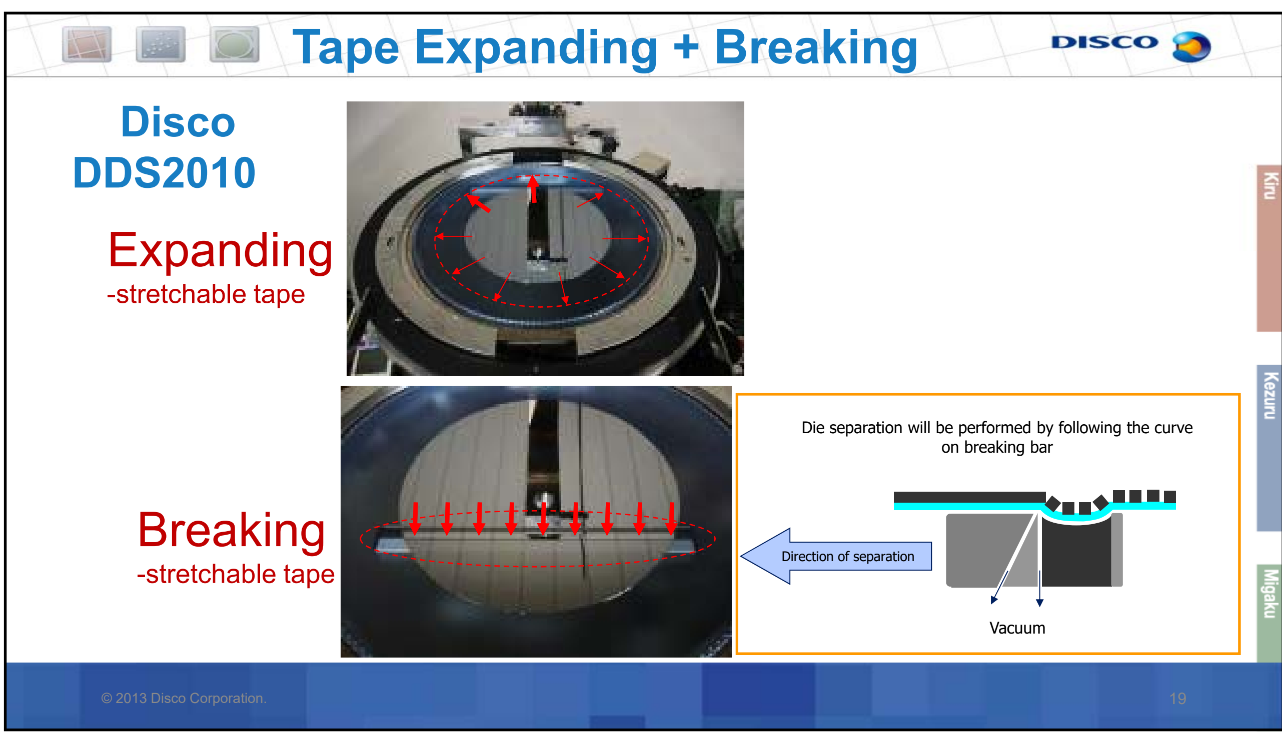
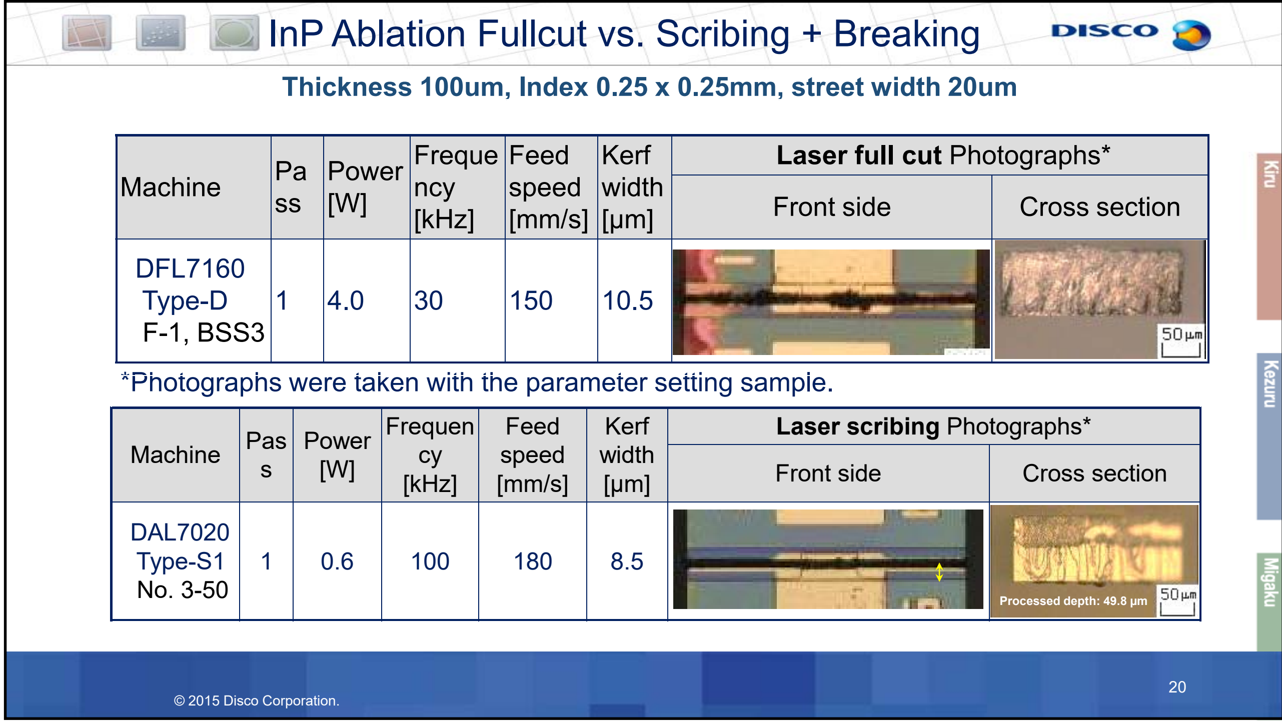
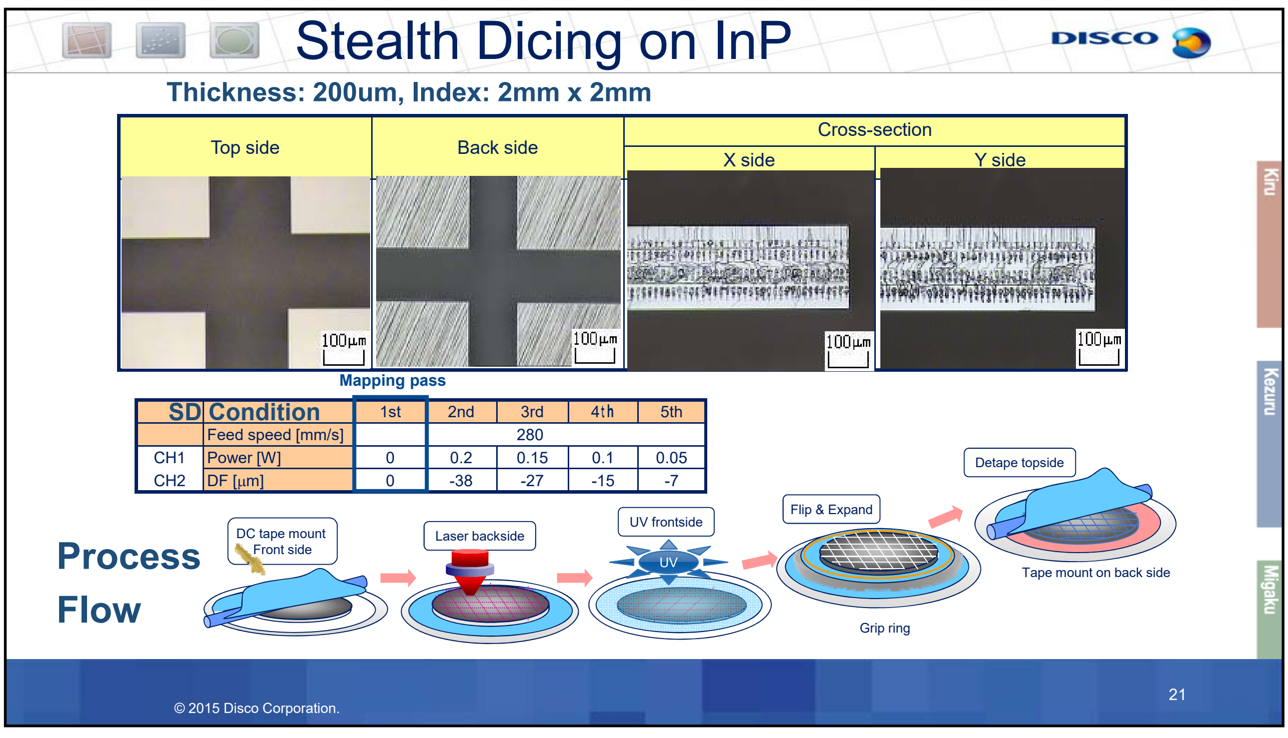




Machine	Pass	Power [W]	Frequency [kHz]	Feed speed [mm/s]	Kerf width [µm]	**Laser full cut** Photographs*	
						Front side	Cross section
DFL7160 Type-D F-1, BSS3	1	4.0	30	150	10.5		50µm

*Photographs were taken with the parameter setting sample.

Machine	Pass	Power [W]	Frequency [kHz]	Feed speed [mm/s]	Kerf width [µm]	**Laser scribing** Photographs*	
						Front side	Cross section
DAL7020 Type-S1 No. 3-50	1	0.6	100	180	8.5		Processed depth: 49.8 µm 50µm


Stealth Dicing on InP
DISCO
Thickness: 200um, Index: 2mm x 2mm
Top side
Back side
Cross-section
X side
Y side
100μm
Mapping pass
SD Condition
1st
2nd
3rd
4th
5th
Feed speed [mm/s]
280
CH1 Power [W]
0
0.2
0.15
0.1
0.05
CH2 DF [μm]
0
-38
-27
-15
-7
Process Flow
DC tape mount Front side
Laser backside
UV frontside
UV
Flip & Expand
Grip ring
Detape topside
Tape mount on back side
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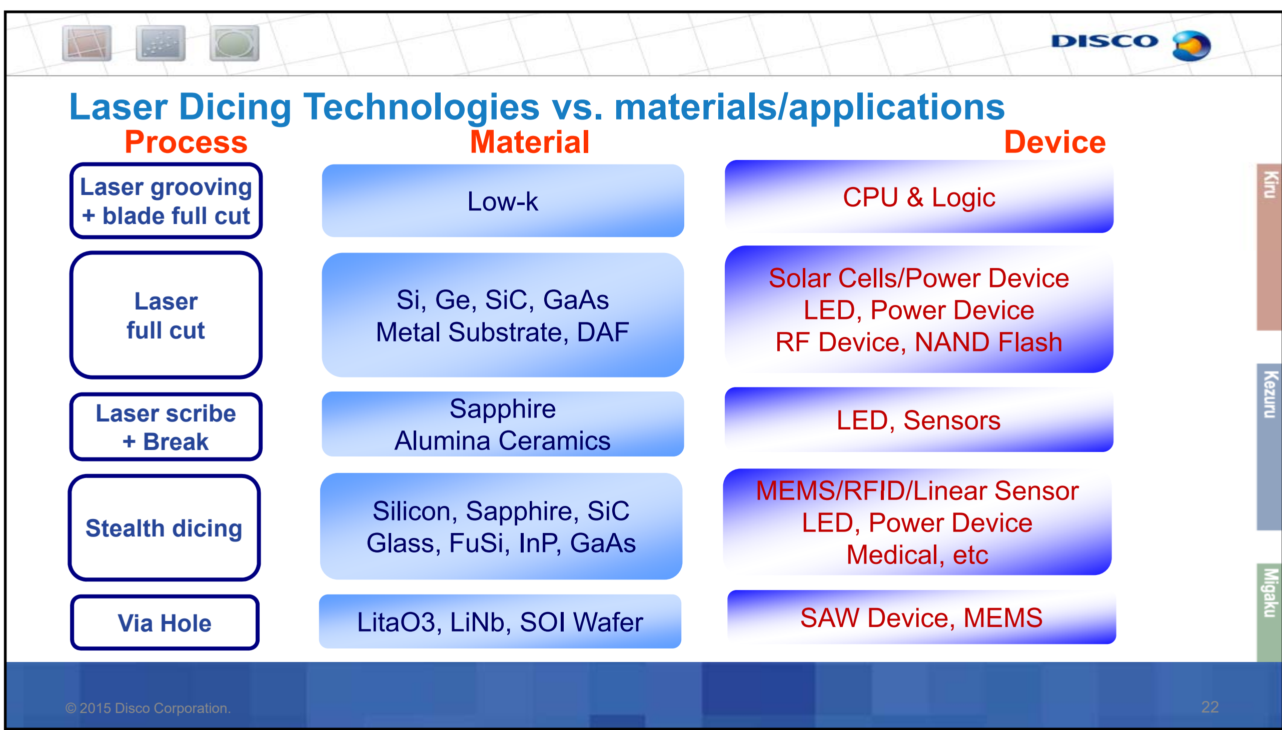
DISCO
Laser Dicing Technologies vs. materials/applications
Process
Material
Device
Laser grooving + blade full cut
Low-k
CPU & Logic
Laser full cut
Si, Ge, SiC, GaAs Metal Substrate, DAF
Solar Cells/Power Device LED, Power Device RF Device, NAND Flash
Laser scribe + Break
Sapphire Alumina Ceramics
LED, Sensors
Stealth dicing
Silicon, Sapphire, SiC Glass, FuSi, InP, GaAs
MEMS/RFID/Linear Sensor LED, Power Device Medical, etc
Via Hole
LitaO3, LiNb, SOI Wafer
SAW Device, MEMS
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Disco Laser Systems (Head + Optics)

DISCO

Wafer Type	Ablation Laser	Stealth Dicing
Low-K Grooving	Type-F + Standard Optics Type-FX + BSS6 Optics	SDE01 / SDE03 SDE03R / SDE05/ SDE06
Si Full cut	Type-D + BSS3 Type-M BSS5 (Ultra thin)	
GaAs / InP Full cut	Type-G + BSS3G Type-D + BSS3	SDE21
Ge	Type-K + BSS4	SDE03
Sapphire Full cut	Type-F + Sapphire Optics	SDE31
SiC Full cut	Type-D + BSS3	SDE41
DAF Cut	Type-A + DAF Optics	(Use DDS2300)
Glass / LT LN / GaN	Under R&D (see below)	SDE33/ SDE12
Others	Feasibility for most of Laser process available in Japan. Such as VIA, glass dicing, curved shape dicing, LLO etc.	Some SD engine are under R&D phase. To be released

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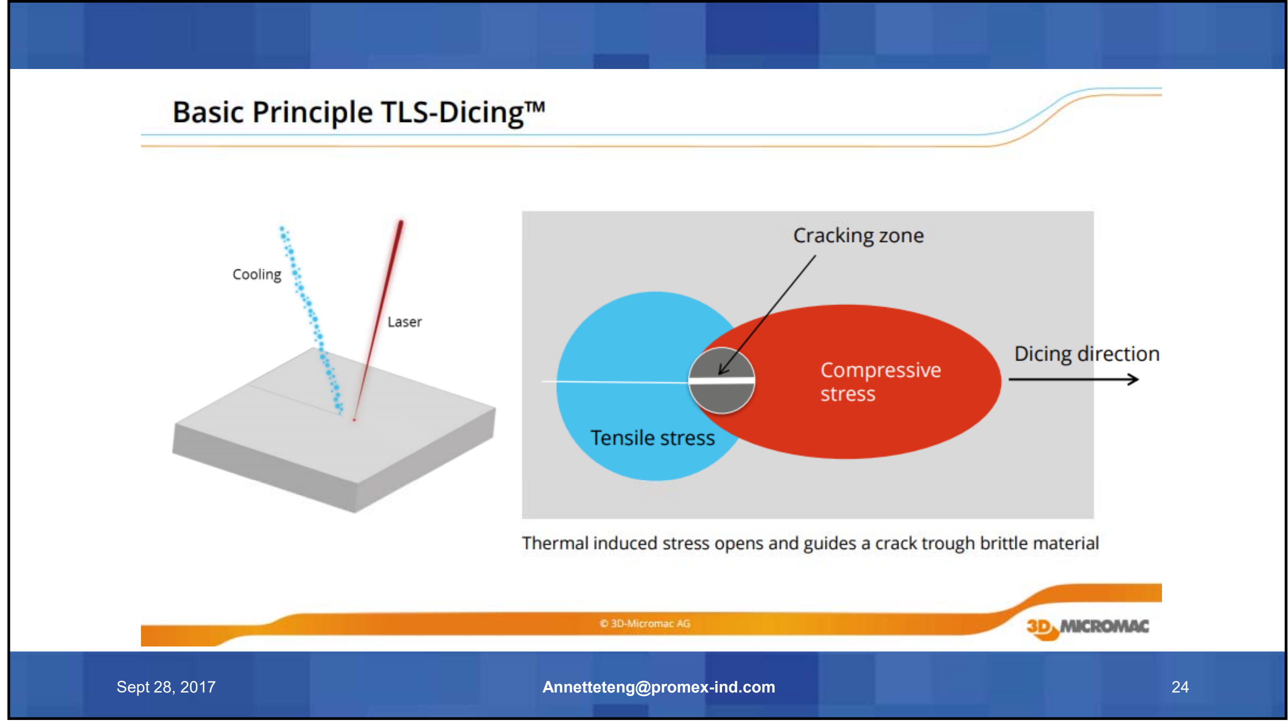

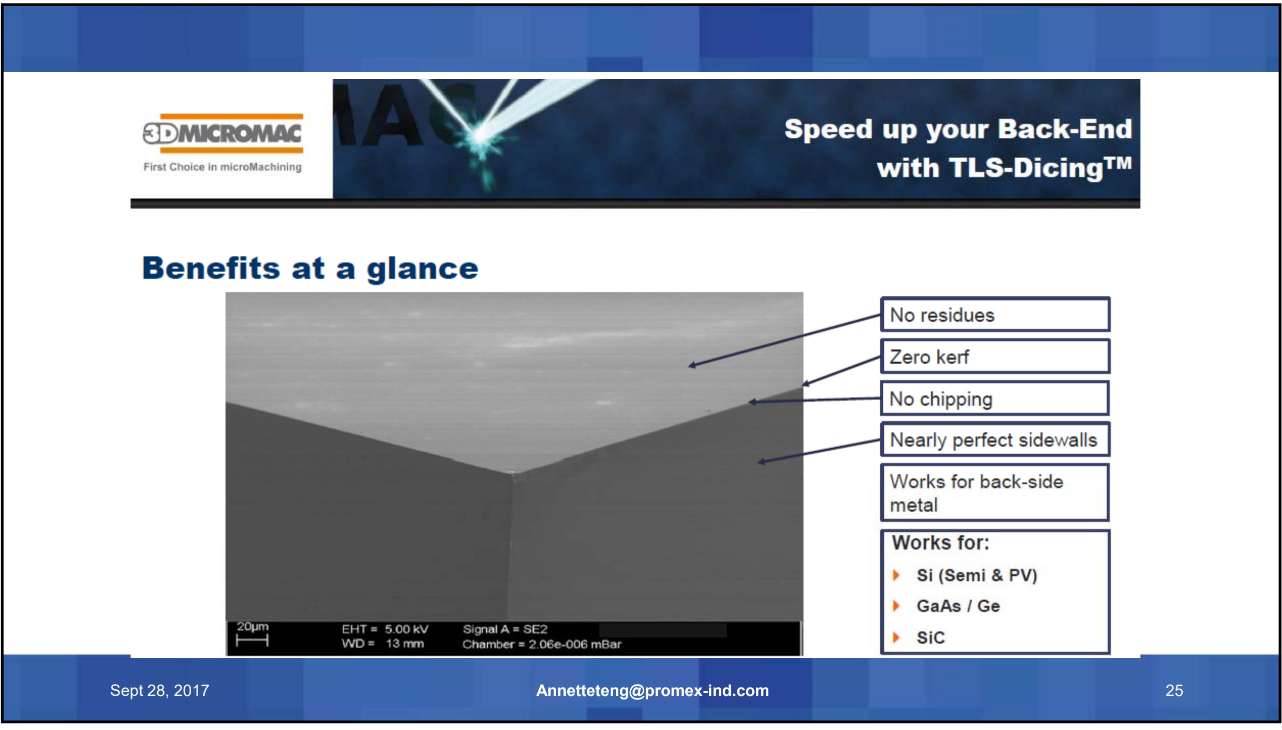
3D MICROMAC
First Choice in microMachining
Speed up your Back-End with TLS-Dicing™
Benefits at a glance
No residues
Zero kerf
No chipping
Nearly perfect sidewalls
Works for back-side metal
Works for:
Si (Semi & PV)
GaAs / Ge
SiC
20µm
EHT = 5.00 kV
WD = 13 mm
Signal A = SE2
Chamber = 2.06e-006 mBar
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TLS-Dicing™ – Bending Strength
Resizing of Si (ø 300 to 200 mm, Si 775 µm), Courtesy of Fraunhofer Gesellschaft
Spiral of Si (ca. 400 µm thick) after TLS-cleave and I-Scribe
© 3D-Micromac AG
3D MICROMAC
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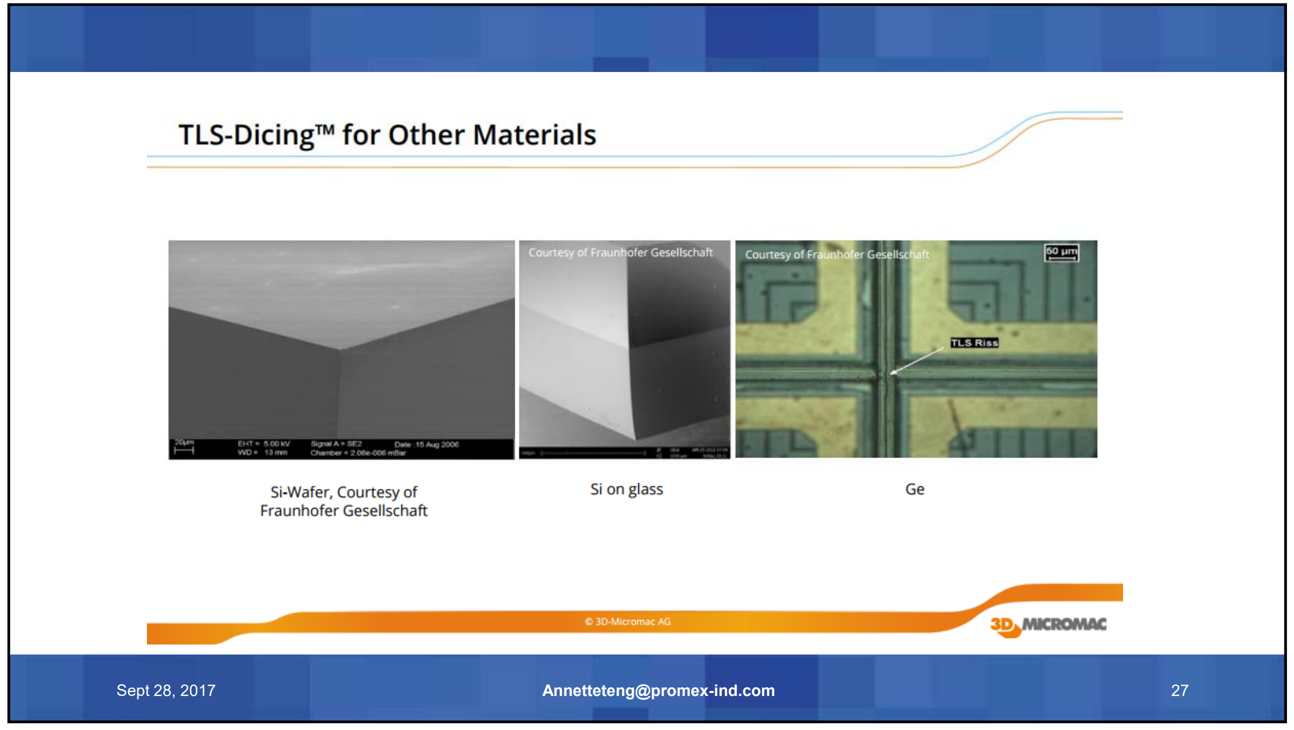
TLS-Dicing™ for Other Materials
Courtesy of Fraunhofer Gesellschaft
Courtesy of Fraunhofer Gesellschaft
50 µm
TLS Riss
Si-Wafer, Courtesy of Fraunhofer Gesellschaft
Si on glass
Ge
© 3D-Micromac AG
3D MICROMAC
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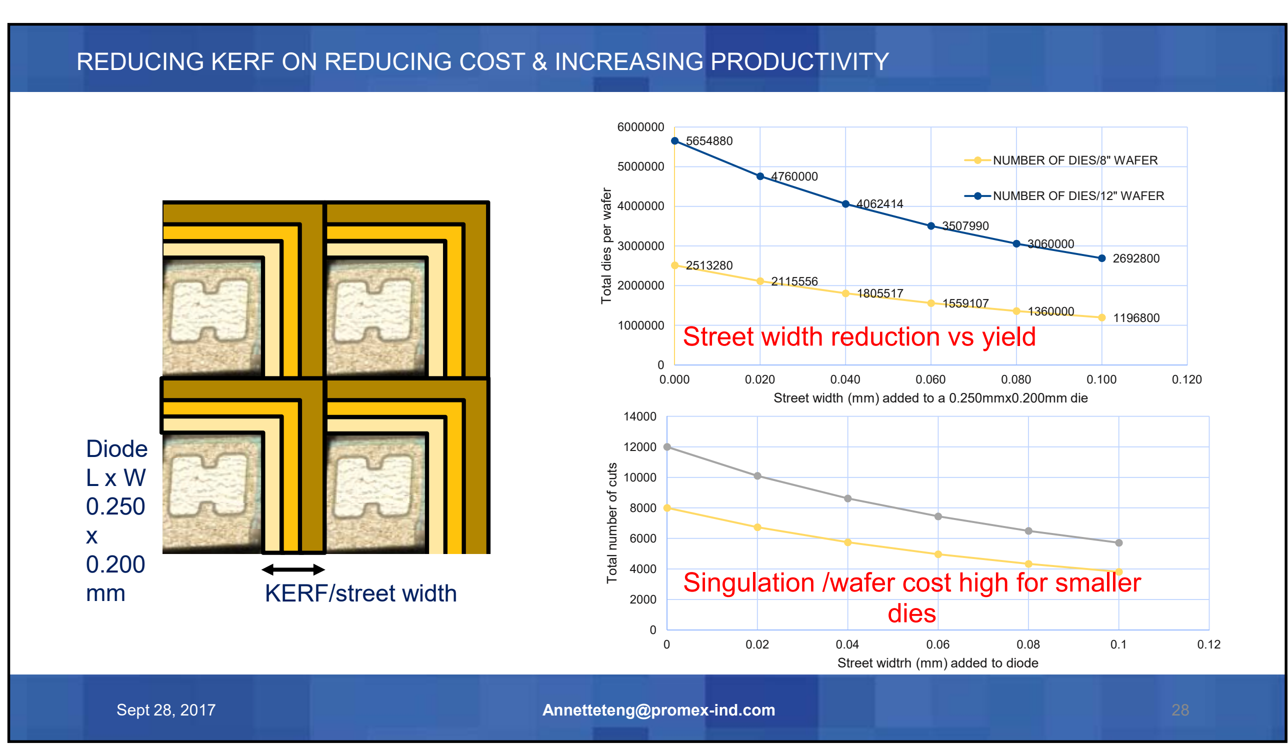
REDUCING KERF ON REDUCING COST & INCREASING PRODUCTIVITY
Diode L x W 0.250 x 0.200 mm
KERF/street width
NUMBER OF DIES/8" WAFER
NUMBER OF DIES/12" WAFER
Total dies per wafer
5654880
4760000
4062414
3507990
3060000
2692800
2513280
2115556
1805517
1559107
1360000
1196800
Street width reduction vs yield
Street width (mm) added to a 0.250mmx0.200mm die
Total number of cuts
Singulation /wafer cost high for smaller dies
Street widtrh (mm) added to diode
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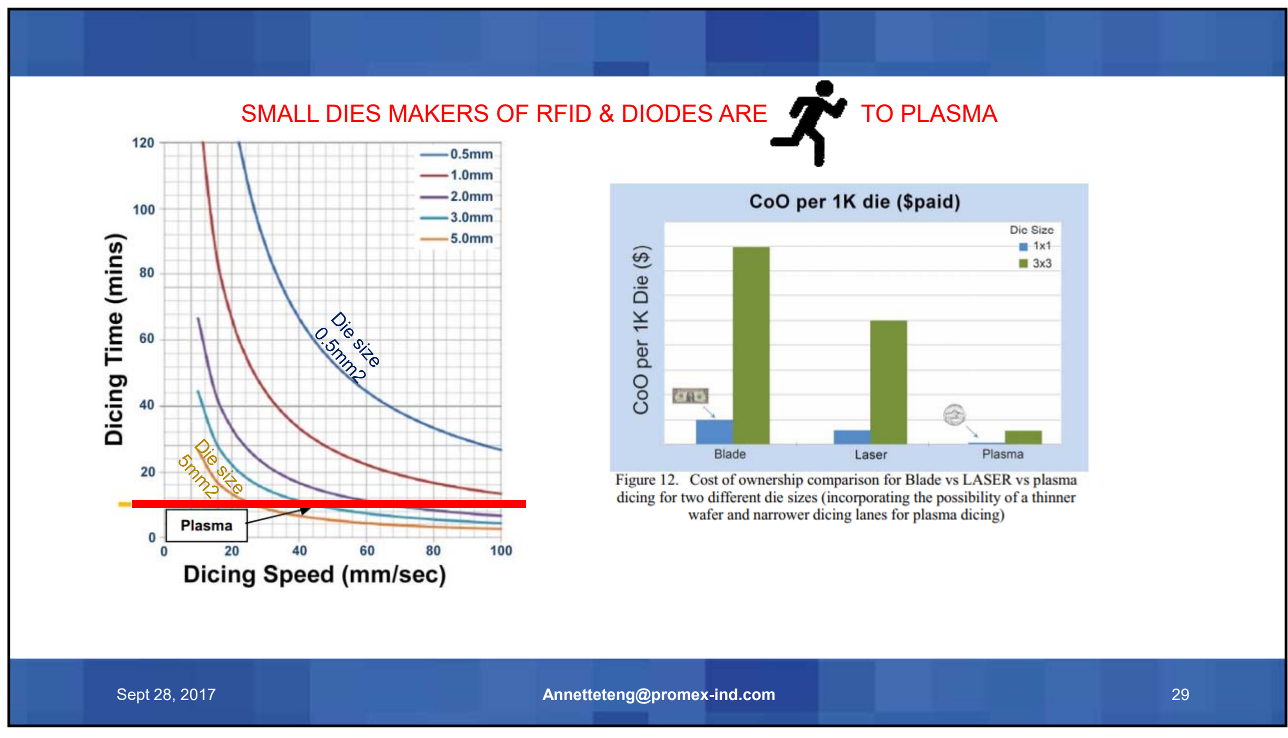
SMALL DIES MAKERS OF RFID & DIODES ARE TO PLASMA
Dicing Time (mins)
Dicing Speed (mm/sec)
0.5mm
1.0mm
2.0mm
3.0mm
5.0mm
Die size 0.5mm2
Die size 5mm2
Plasma
CoO per 1K die ($paid)
CoO per 1K Die ($)
Die Size
1x1
3x3
Blade
Laser
Plasma
Figure 12. Cost of ownership comparison for Blade vs LASER vs plasma dicing for two different die sizes (incorporating the possibility of a thinner wafer and narrower dicing lanes for plasma dicing)
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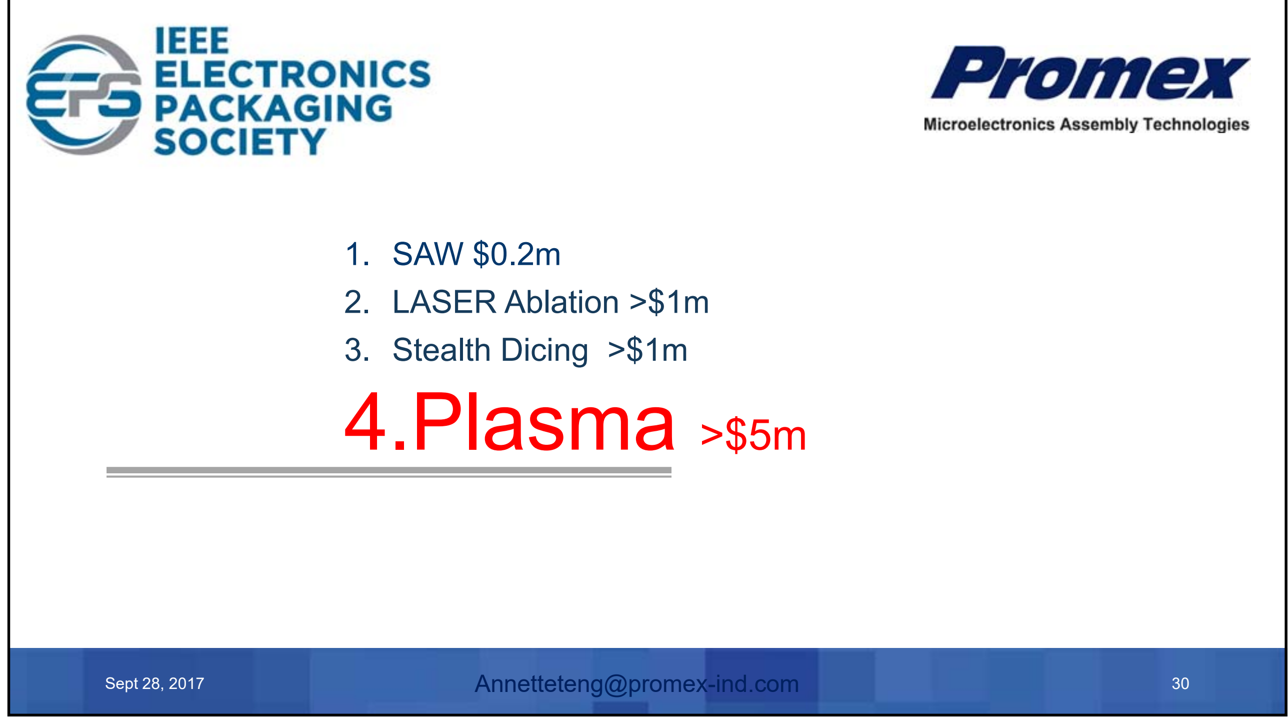
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Microelectronics Assembly Technologies
1. SAW $0.2m
2. LASER Ablation >$1m
3. Stealth Dicing >$1m
4.Plasma >$5m
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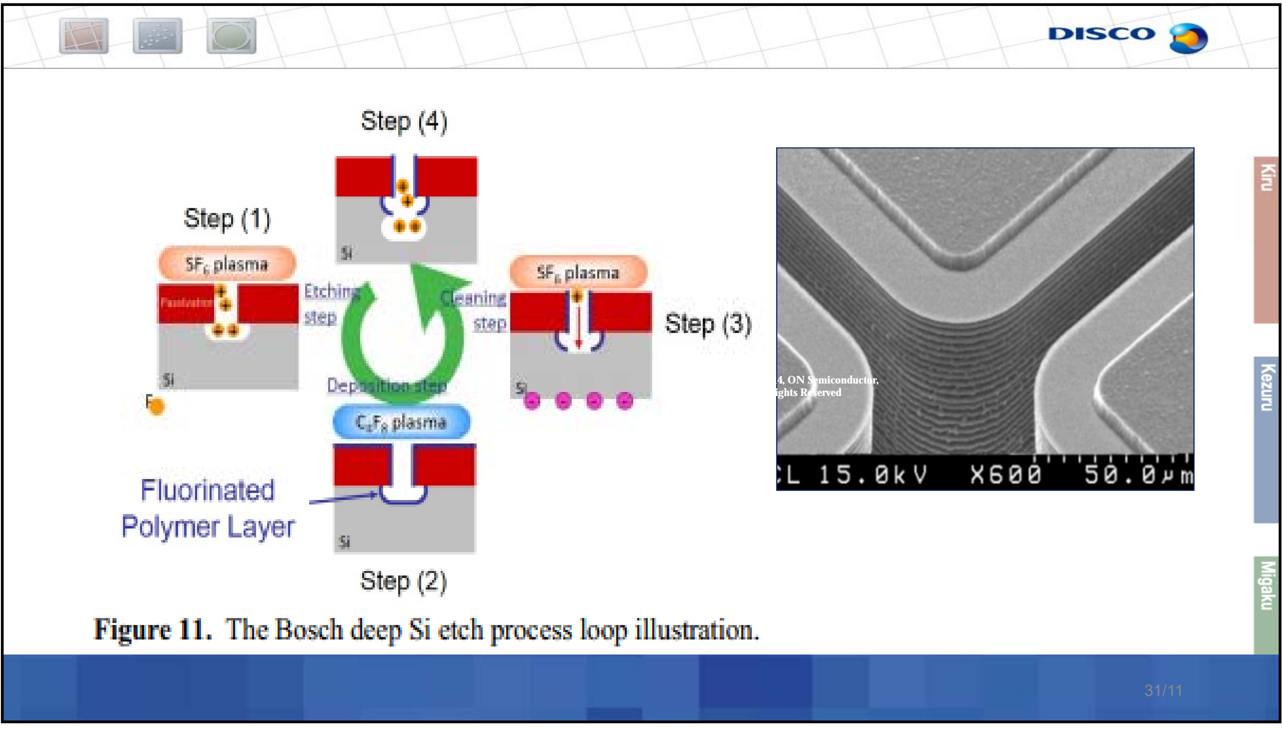


Figure 11. The Bosch deep Si etch process loop illustration.

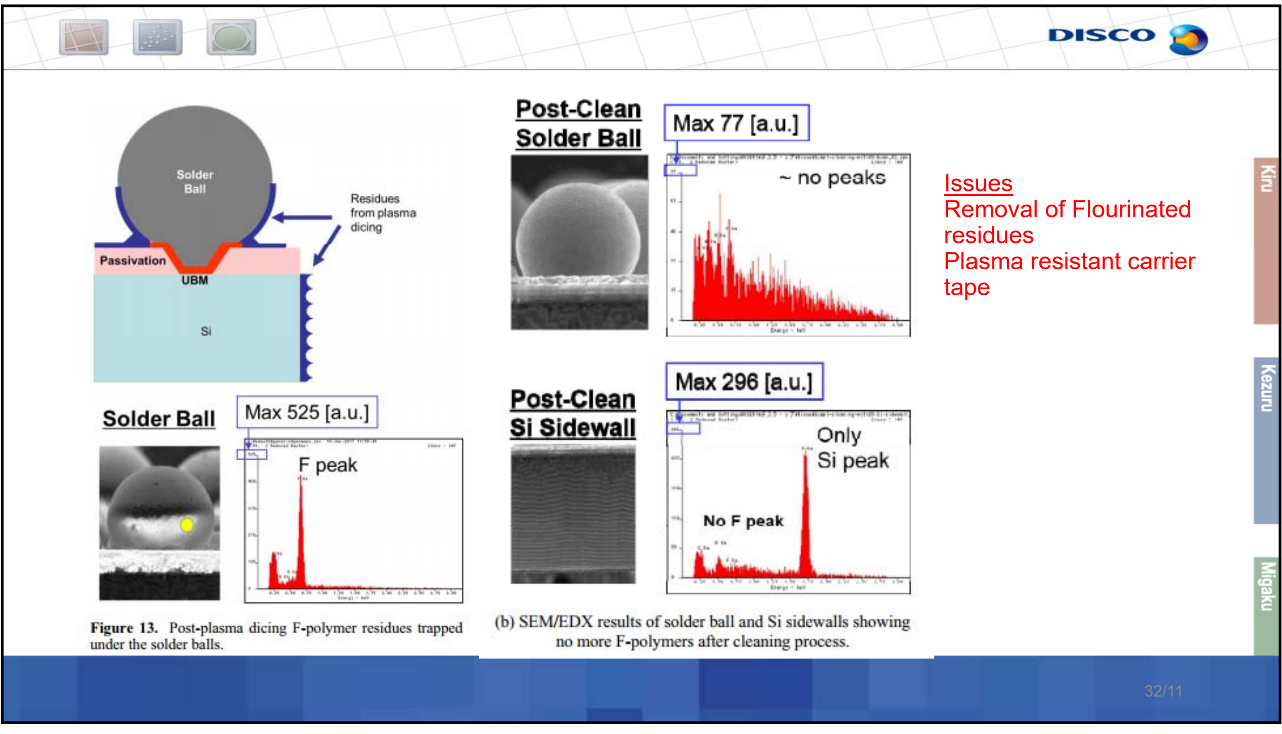
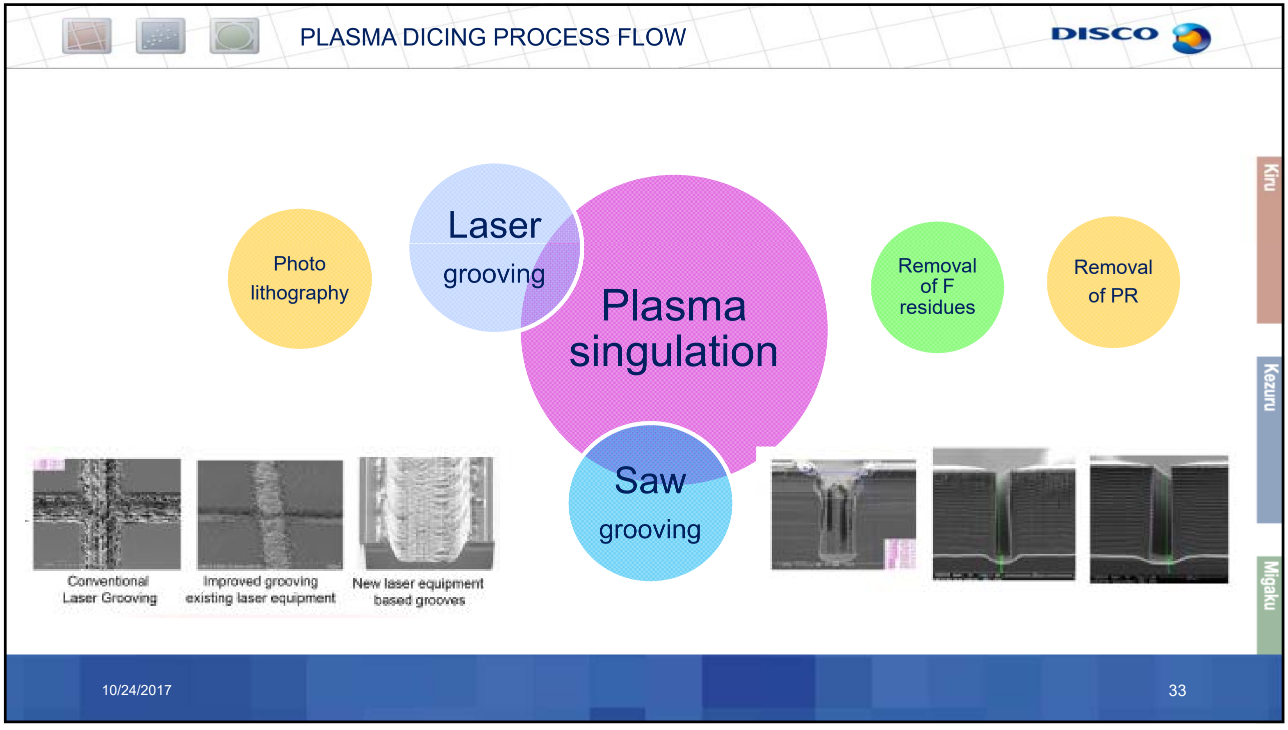


Figure 13. Post-plasma dicing F-polymer residues trapped under the solder balls.

(b) SEM/EDX results of solder ball and Si sidewalls showing no more F-polymers after cleaning process.


PLASMA DICING PROCESS FLOW
DISCO
Photo lithography
Laser grooving
Plasma singulation
Removal of F residues
Removal of PR
Saw grooving
Conventional Laser Grooving
Improved grooving existing laser equipment
New laser equipment based grooves
Kiru
Kezuru
Migaku
10/24/2017
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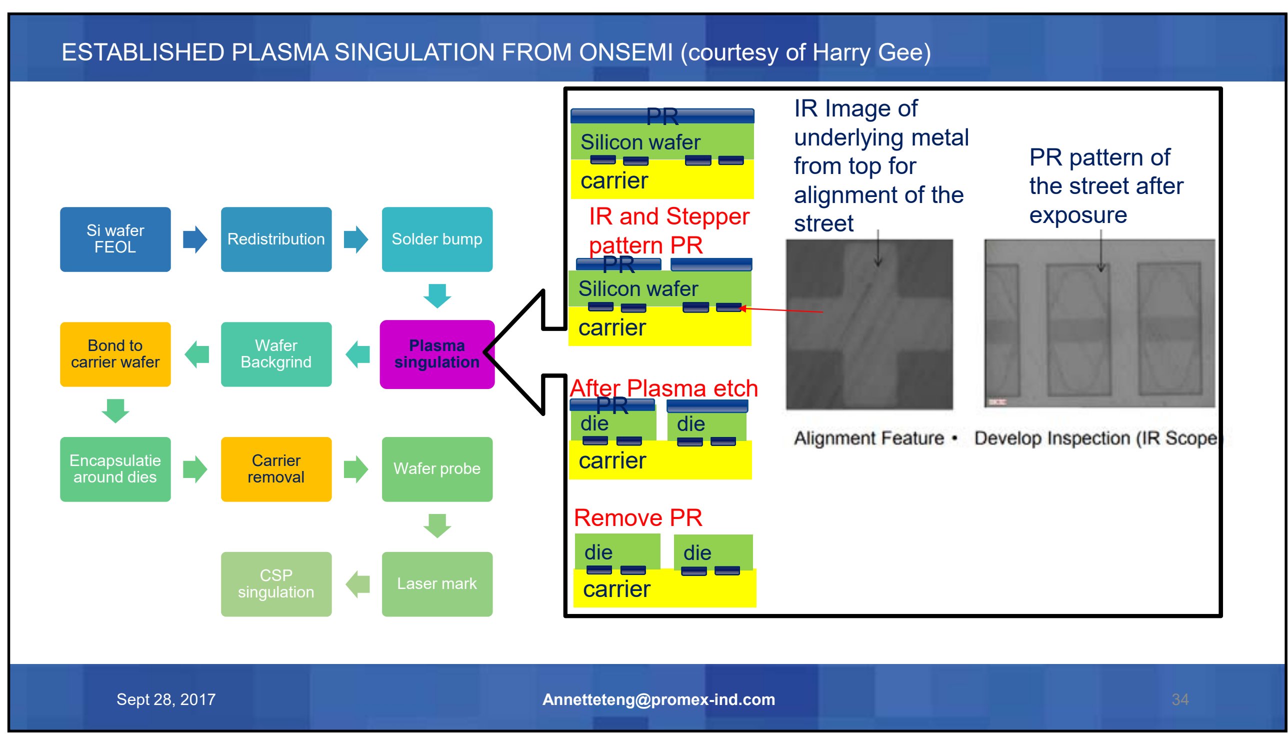
ESTABLISHED PLASMA SINGULATION FROM ONSEMI (courtesy of Harry Gee)
Si wafer FEOL
Redistribution
Solder bump
Plasma singulation
Wafer Backgrind
Bond to carrier wafer
Encapsulatie around dies
Carrier removal
Wafer probe
Laser mark
CSP singulation
PR
Silicon wafer
carrier
IR and Stepper pattern PR
PR
Silicon wafer
carrier
After Plasma etch
PR
die
die
carrier
Remove PR
die
die
carrier
IR Image of underlying metal from top for alignment of the street
PR pattern of the street after exposure
Alignment Feature
Develop Inspection (IR Scope
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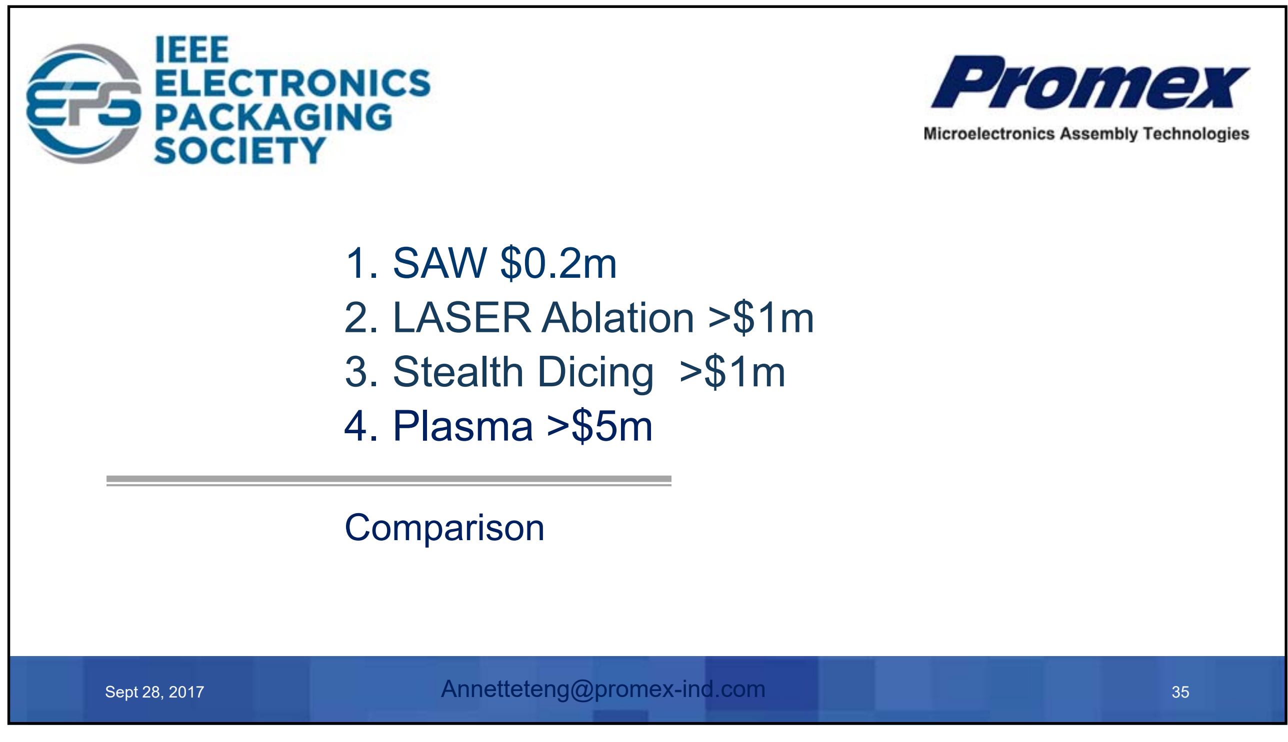
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Promex
Microelectronics Assembly Technologies
1. SAW $0.2m
2. LASER Ablation >$1m
3. Stealth Dicing >$1m
4. Plasma >$5m
Comparison
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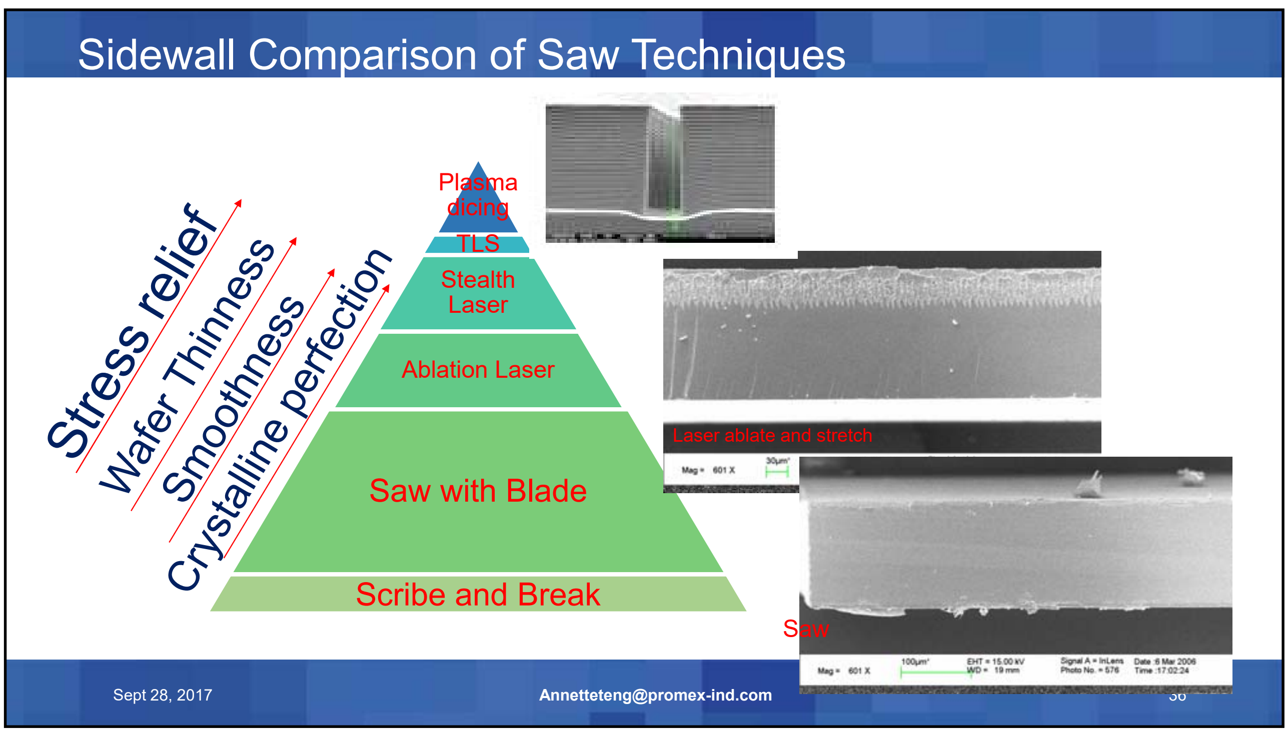
Sidewall Comparison of Saw Techniques
Stress relief
Wafer Thinness
Smoothness
Crystalline perfection
Plasma dicing
TLS
Stealth Laser
Ablation Laser
Saw with Blade
Scribe and Break
Laser ablate and stretch
Saw
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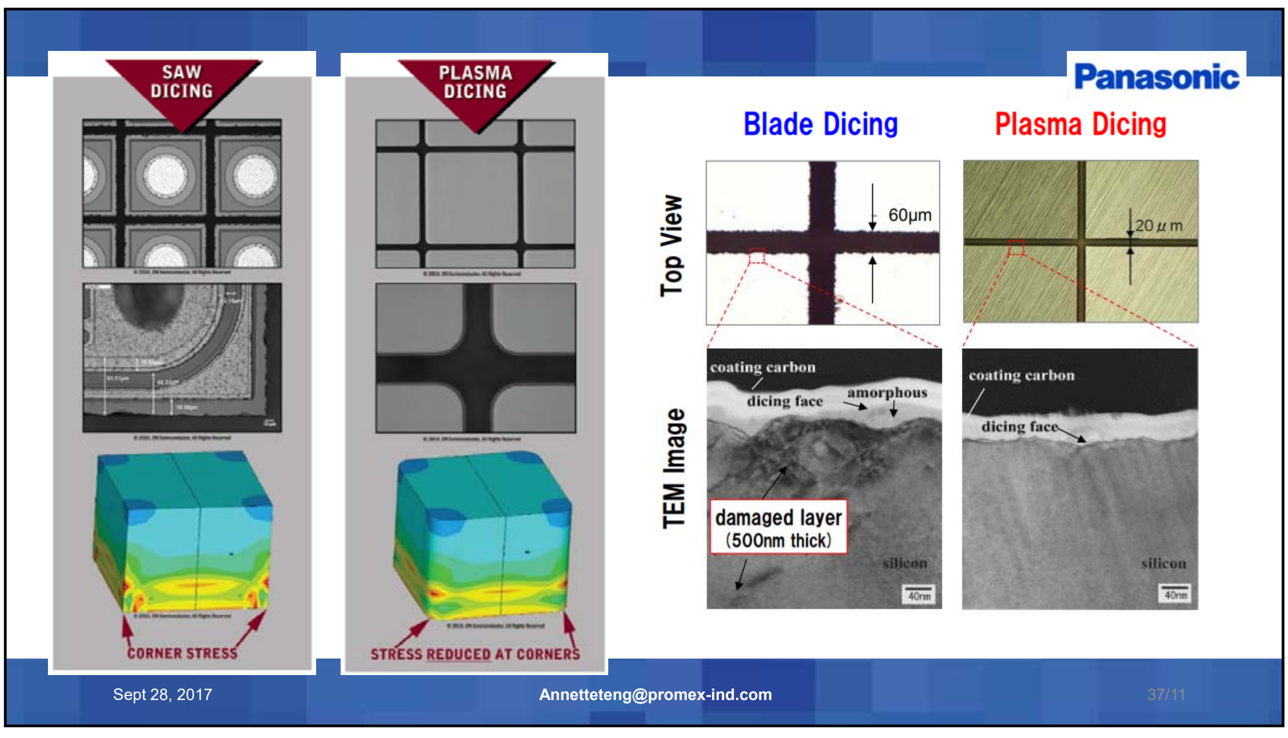
SAW DICING
PLASMA DICING
CORNER STRESS
STRESS REDUCED AT CORNERS
Panasonic
Blade Dicing
Plasma Dicing
Top View
TEM Image
60µm
20µm
coating carbon
dicing face
amorphous
damaged layer
(500nm thick)
silicon
coating carbon
dicing face
silicon
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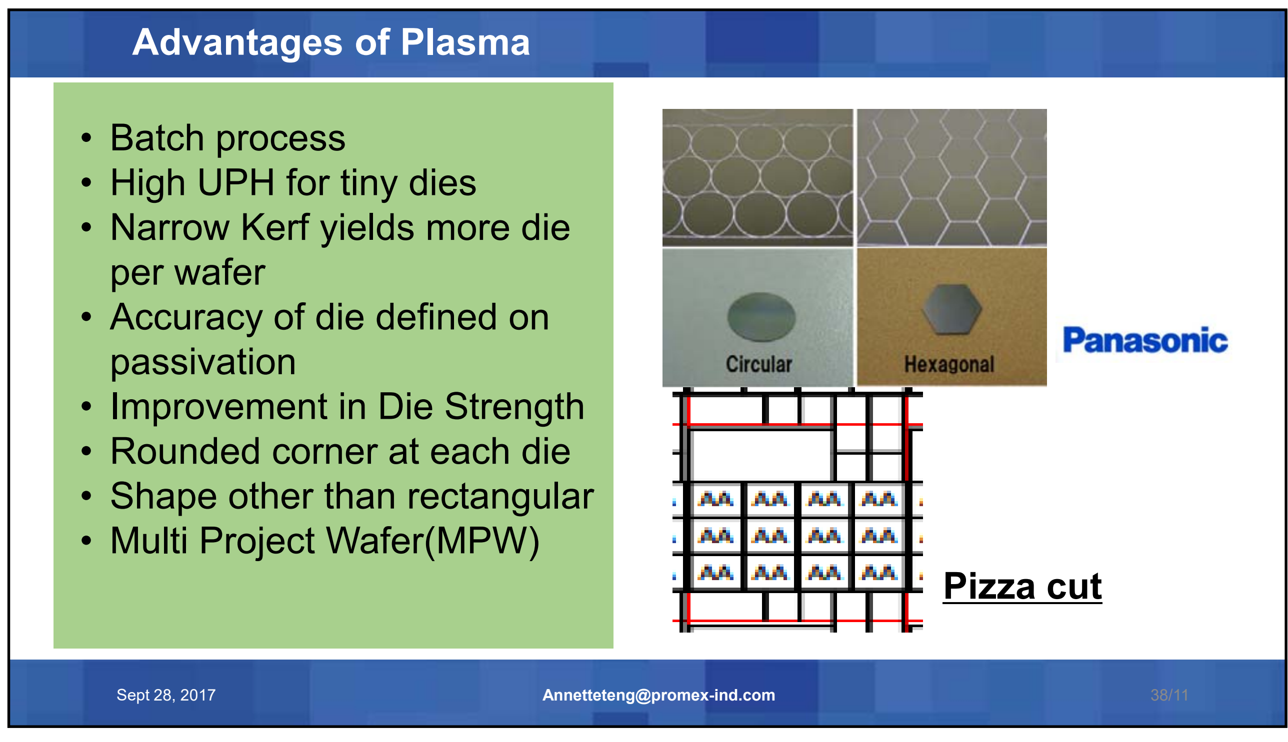
Advantages of Plasma
• Batch process
• High UPH for tiny dies
• Narrow Kerf yields more die per wafer
• Accuracy of die defined on passivation
• Improvement in Die Strength
• Rounded corner at each die
• Shape other than rectangular
• Multi Project Wafer(MPW)
Circular
Hexagonal
Panasonic
Pizza cut
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38/11

Promex
Microelectronics Assembly Technologies
IEEE ELECTRONICS PACKAGING SOCIETY
Foundry equipment suppliers to assembly.
Foundry Plasma Dicing Suppliers includes
PlasmaTherm has partnered with
Disco
Panasonic
SPTS
APX300
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Microelectronics Assembly Technologies
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Takeaway from this talk….
Wafer design engineers must work with singulation engineers
Thank you
Acknowledgement:
Disco Hi-Tec America, Inc.
www.discousa.com
damianp@discousa.com & Jordan_k@discousa.com
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