More Die, Stronger Die. Smaller, Thinner Packages Drives Die Singulation by Plasma Etch

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The case for plasma dicing
- Si DRIE
  - Bosch Process
- DRIE Benefits Summary
- Integration
  - Patterning
  - Metals
  - Process control & notching
- Die Strength
- Summary
The Case for Plasma Dicing

For small die
- Trend to the very small
  - RFID
  - PMIC
  - MEMS
  - <0.25x0.25mm
  - >100,000 die per wafer
- Dice lane for saw - ~80um
- Dice lane for plasma - <20um
  - Can be up to 80% more die per wafer
- Parallel vs serial dicing
  - Plasma parallel… wfr per hr
  - Saw serial … hrs per wfr

For thin die
- Trend to the very thin
  - 3D stacking, low z height
  - IGBT devices
  - <<50 um
- Saws damage die
  - Chipping & cracking
  - Reduce die strength
- By plasma
  - No chipping
  - Shape die for stress management
  - Stronger die
The Case for Plasma Dicing

- OSATS do 5 side inspection on sawn die. Every one
  - By direction of their customers
  - To look for cracking/chipping on sides and back of die
  - Big investment in inspection tools, and time
- Collecting data, but expect to delete this step with plasma
  - No cracking or chipping with plasma dicing
Si DRIE for Plasma Dicing

The “Bosch” Process

- Repeating loops
  - Polymer dep
  - Polymer removal
  - Isotropic Si etch
- Chemical, non damaging

Fundamental to the Si dicing etch:

- Providing a compatible etch structure; dealing with metal, dielectrics
- Definition of the Si to be etched
- Majority of challenges relate to test structures

“Scallops” – generated by isotropic Si etch
Dicing Schemes

DBG – Dice Before Grind

- ‘Standard’ equipment
- Partial DRIE from device side
- Invert wafer & frame mount
- Singulate during B/S grinding

DAG – Dice After Grind (On Carrier)

- ‘Standard’ equipment
- Temporarily bond to wafer sized carrier
- Singulate during DRIE
- Remount die onto tape/frame for pick & place

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Mosaic fxP – for DAG

- Mosaic platform
  - EFEM compatible with tape frames
  - Frame and/or wafer alignment
  - Simultaneous wafer/frame running

- Rapier-200S
  - Sized for 200mm wafer on tape frames
  - Modified handling & ESC
  - Same processes as standard Rapier

- Rapier-300S
  - Sized for 300mm wafer on tape frames
  - Modified handling & ESC
  - Same processes as standard Rapier
Benefits of DRIE for Dicing

- Throughput
  - Parallel process
  - Largely independent of die size
  - Cluster approach for higher output/floor area

- Non-damaging
  - Bosch etch creates clean scallops
  - No vibration, debris, water
  - Increased die strength
  - Yield improvement

- Die Density
  - Narrower dicing lanes
  - Die shape/location can be varied
Mosaic Plasma Dicing Examples
Die Sizes from <1mm² to >10mm²

- 20µm x 100µm
- 30µm x 300µm
- 10µm x 100µm
- 50µm x 190µm
- 7µm x 120µm
Preparing for Plasma Dicing

If start with a blank sheet…
• Lane width reduction
• Die shape & tessellation
• Removal of seal rings, etc
• Moving of test structures (TEG)
  • Especially metals
  • On-die or in “die” locations
  • Ensure space around TEG

Process Flow

Adapt main device process flow
Remove non-Si features

Additional etch steps after test structures are used
Options to Define Lanes

**Litho/Self-masking**

- Mask
- Top Dielectrics
- Si, including active layers
- Bondpads?
- Solder?

After clearing non-Si materials

Litho for additional mask layer
- Standard films can be used
- PR, PI, Oxide, etc

Or thicken existing layers as sacrificial mask layers
- Cleared during main steps

**Combine LASER/Blade & Plasma**

- Use LASER or blade to start
  - Eliminate non-Si materials
  - Open lane to Si.
- Complete singulation with DRIE.
Combining Plasma & LASER/Blade

- Lane definition not perfect
  - Edges not as “sharp” as litho
  - DRIE can manage
- If non-Si materials not completely removed
  - OK, if they do not bridge lane
  - Simply etch around them
Metals on Device Side

- Bondpads and solder bumps
  - All are compatible with DRIE PM
  - No apparent risk to chamber condition
- No observable damage to bumps/pads post-etch & clean
Backside Metals

- Having a backside metal is an advantage
  - Can be used with electrostatic clamp to allow wider process window

- How are die separated?
  - Not by etch
  - Unique step to complete singulation from metal

- Multiple backside metal (BSM) separation options available
  - Cleaving
  - Stretching
  - Blade/LASER

After BSM Separation
Metal from lanes retained on original tape

After tape transfer
Notching

- Notching is where etch continues under the die
  - It will reduce die strength
- Dicing to tape is parallel to SOI
  - Risk of notching at interface
  - Due to build up of standing charge
- Notching can be prevented
  - Pulsed bias RF dissipates charge, we have IP
  - Endpointing

With EPD
With Overetch control

Notching <3μm

Without EPD
Without Overetch control

Notching >15μm
Endpointing to Prevent Notching

- Endpoint control of process upon reaching tape
  - Requires EPD able to cope with low OA & high process pressures
  - SPTS developed Claritas to enhance OES detection

- Once at tape, manage process completion
  - Pulsed RF
Die Strength Experiment

- SPTS & DISCO compared die strength behaviour
  - Comparing the patterning methods; Photo, Blade & LASER
  - Notching; With & without EPD/Overetch control

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No.3 Litho + STD

Cross section | Back side
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No.5 Litho + Large

Cross section | Back side
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EPD & Bias Pulsing
No Notch

No EPD/No Bias Pulsing
Large Notch
Plasma dicing gives approx 2x gain in die strength
- Patterning method has minor influence
- The weakest die had the largest notch
- Shows importance of endpoint & pulsed biasing
Compared to Stealth

- OSAT data for plasma
  - 80% stronger than blade
  - 17% stronger than stealth
- Stealth works by creating a damage line inside Si
  - Impact on die strength will increase as die gets thinner
Plasma dicing is rapidly becoming an accepted technique
- For small die, for thin die
- Non-damaging. No residue. Fast

Process & Hardware are set & available

Key issue is integration of plasma etch into this stage
- Patterning
- Metals & Dielectrics in the dicing lane

Variety of options to be considered
- Layout & process flow changes
- Additional or Self masking
- Use of LASER/Blade as patterning medium

Process control through EPD & Notch prevention
- Critical for die strength
Thanks to…

SPTS Samples & Applications Groups
DISCO