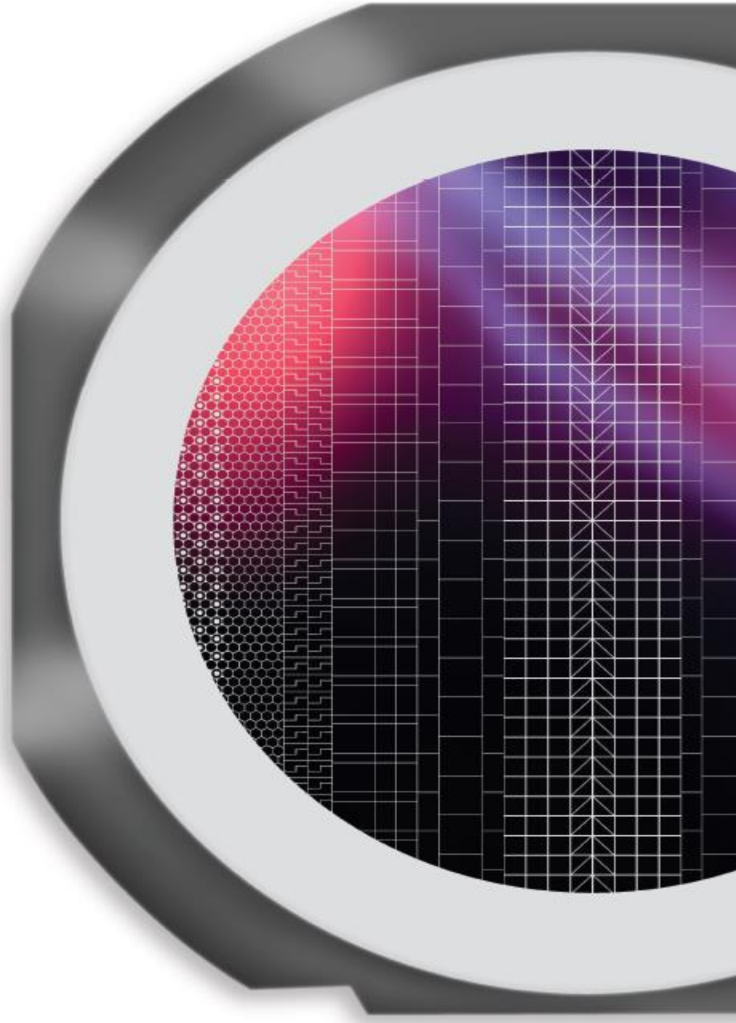
Plasma Dicing Solutions for Power Devices

June 24, 2021



Christopher Johnston

Plasma Dicing Group Manager

Product Manager

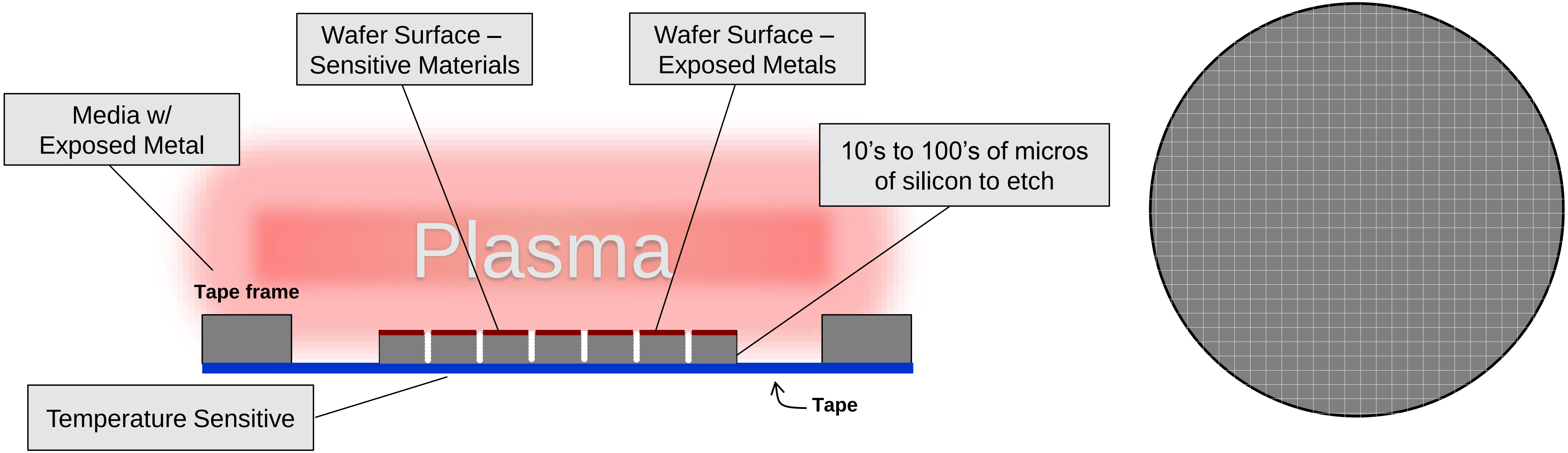
Science and Technology of Materials, Interfaces, and Processing

Outline

- Plasma Dicing Overview
- Technology Benefits and Limitations
- Opportunities and Challenges for Power Devices
- Device Improvements – Yield & Cost
- Plasma Dicing Process Integration
- Summary

Plasma Dicing Overview

Plasma dicing is an emerging technology that uses a dry-etching process to chemically singulate the entire wafer at once without constraints for narrow street widths, small die sizes or odd die shapes.
Etching a “finished“ wafer requires a gentle, low temperature, highly-selective etching solution.



Plasma Dicing Benefits

Higher Die Strength

- Highly selective chemical process
- No chipping or micro-cracking
- No mechanical or thermal stress

Fast Throughput

- Thinner wafers = faster dicing speed. 50µm thick wafer < 3 min

More Die per Wafer

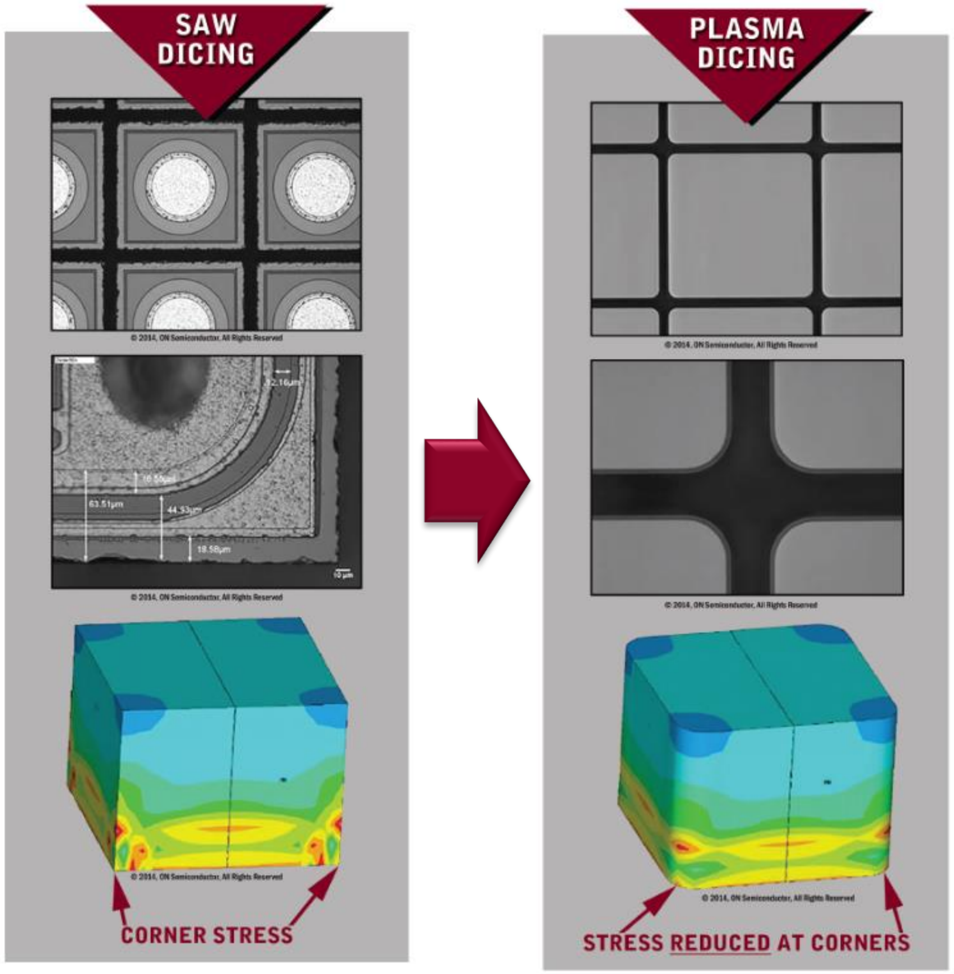
- Ultra narrow streets (~ < 5µm)
- Less wafer starts, more capacity

Dice any shape

- Freedom to dice any shape
- Rethink/relocate test/alignment areas

Dicing Precision

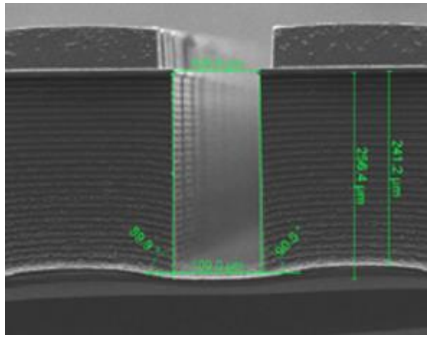
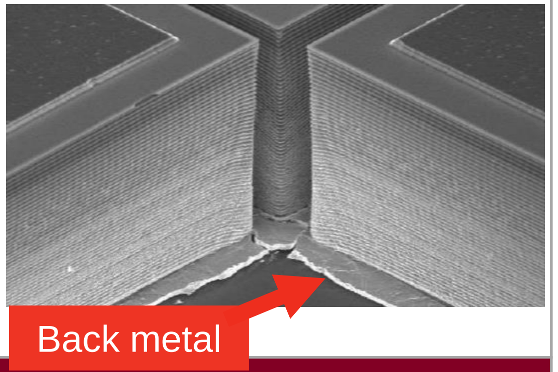
- Every die is the exactly same size
- Die size variation determined by the mask



ON Semiconductor Patent

Plasma Dicing Limitations

Plasma dicing is highly selective to silicon. The fluorinated processing gases used react very effectively to etch all exposed silicon material. The dry etching process is very gentle and low temperature. Such process is not capable to removing metals.

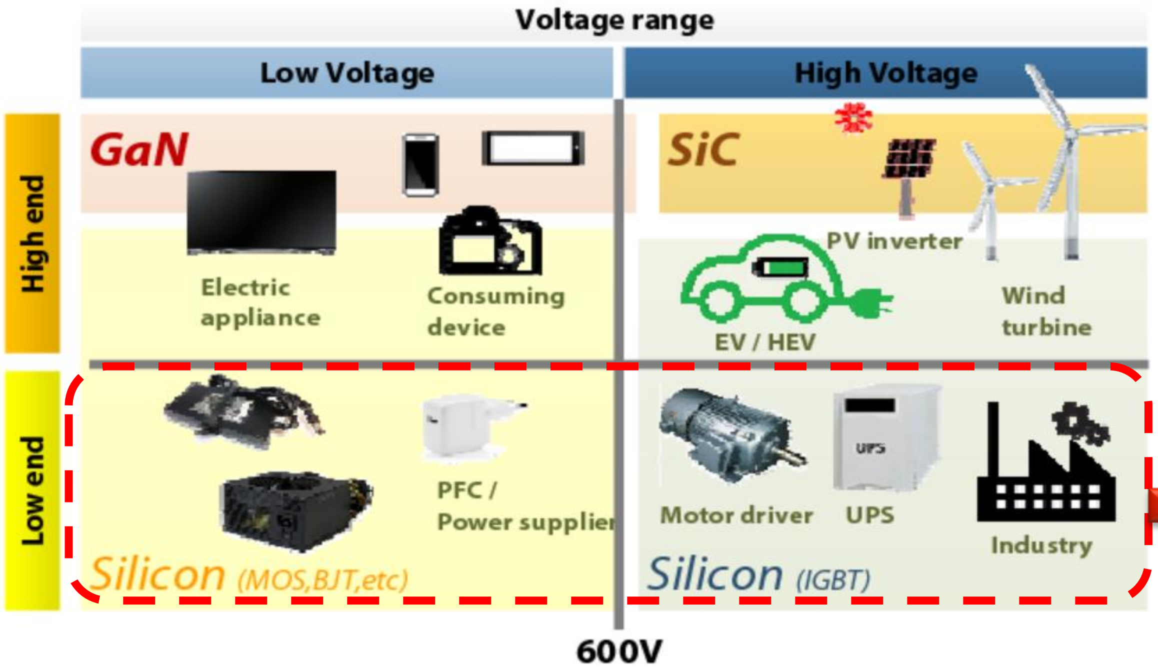
Silicon Device after Plasma Dicing	Power Device after Plasma Dicing
Silicon → 	Silicon / Backside Metallization → 
Full singulation achieved	Singulation not achieved

Power devices have a metalized wafer-backside. The backside metallization is used for electrical conductivity of the device. These metal materials cannot be removed insitu the plasma dicing process and require a separate solution to achieve full singulation of the device.

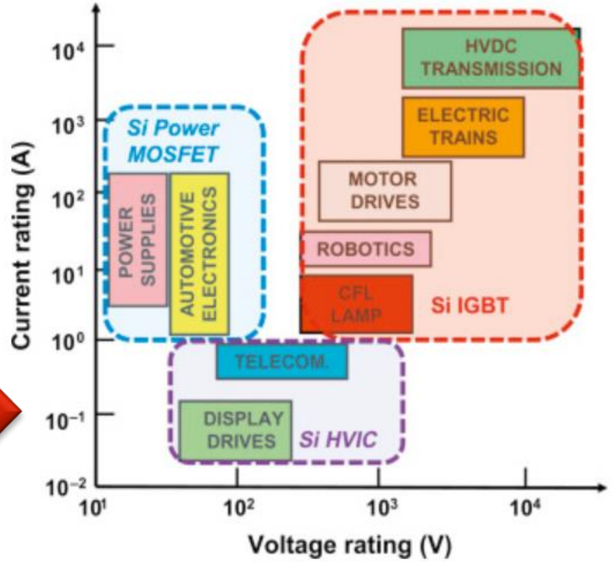
Opportunities and Challenges for Power Devices

Power devices serve a wide range of applications and are made of various materials.

Song, Sungyoung et al. "Performance assessment of commercial gallium nitride-on-silicon discrete power devices with figure of merit." *IECON 2016 - 42nd Annual Conference of the IEEE Industrial Electronics Society* (2016): 1143-1148.



Silicon is suitable for broad rage, high voltage DC power transmission applications

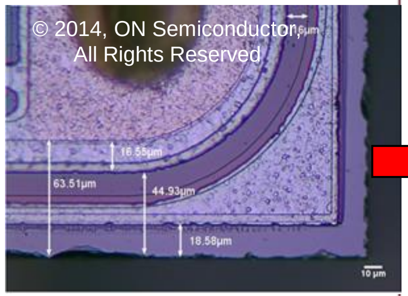


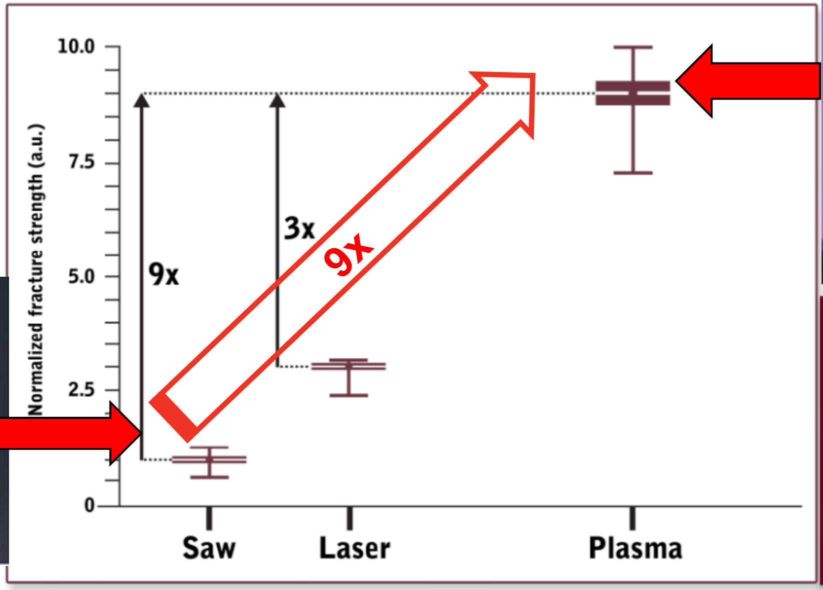
Source: www.sciencedirect.com/topics/materials-science/power-device

Most power devices are very small, thin and have very competitive price points.
Silicon power devices can immediately benefit from plasma dicing processes for higher quality, improved yields and lower costs.

Higher Dicing Quality - Die Strength Improvement

No chipping, no lateral damage, no cracking





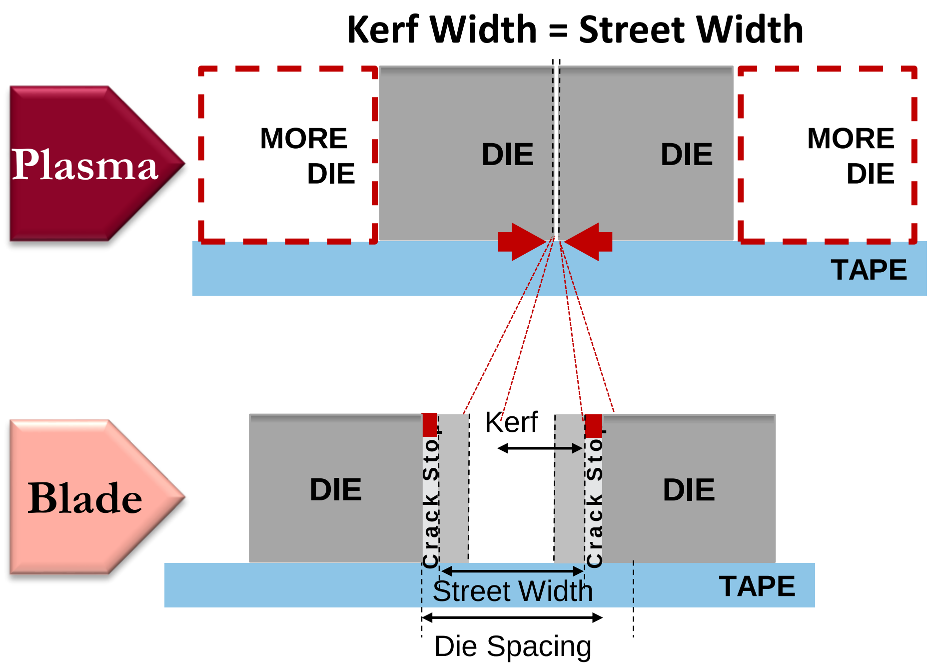
Superior Dicing Quality

1 mm^2 x 120um thick die

In general, all applications that employ plasma dicing will benefit from higher die strength.
Key variables for die strength are sidewall quality, backside quality (particularly for thinner die), reduction of weak areas such as 90˚ corners.

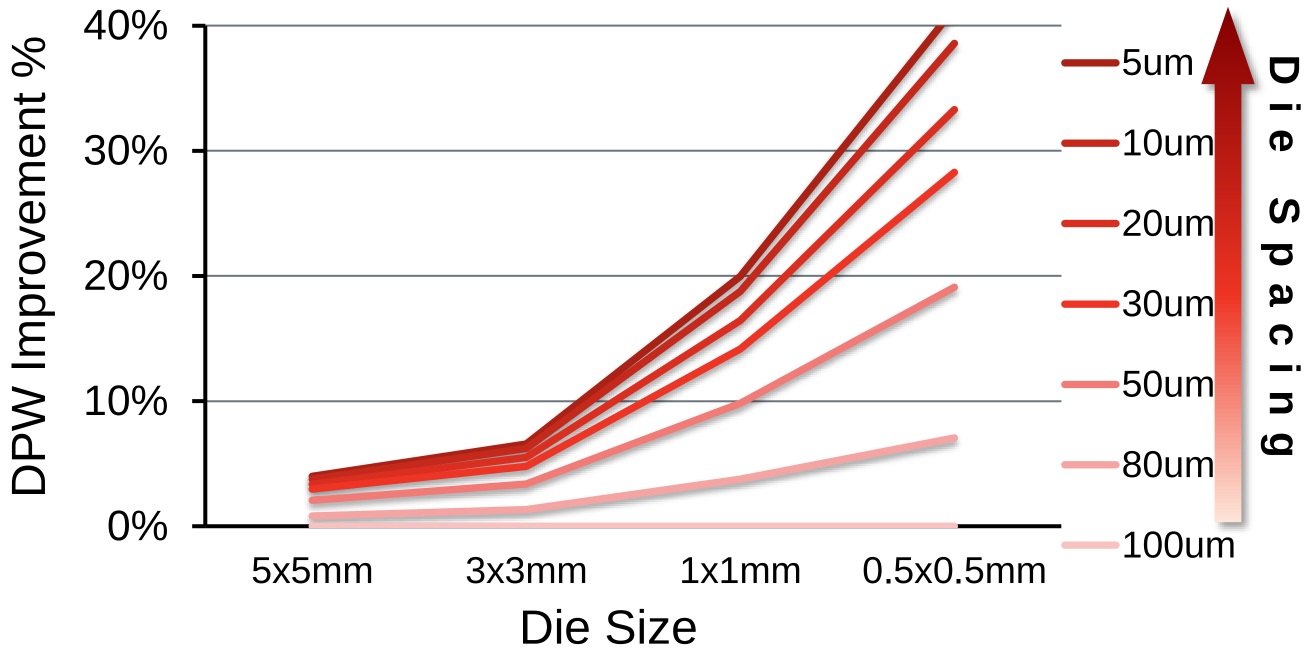
More Die Per Wafer – Die cost reduction

Die Spacing Requirements



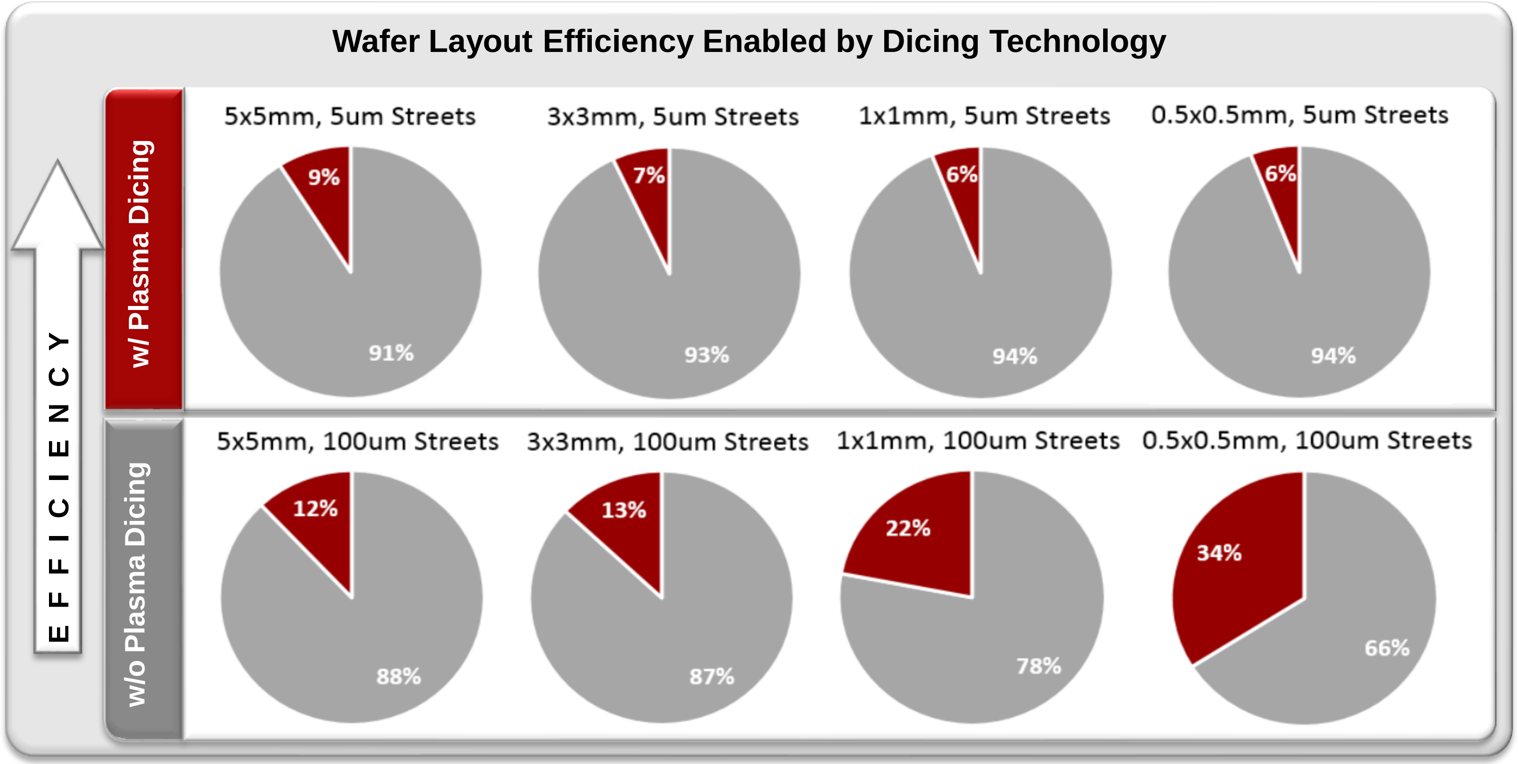
Plasma dicing enables very narrow die spacing, maximizing the die per wafer.

Die per wafer Improvement by Die Spacing



The wafer yield improvements can be very significant for most die sizes

Device Improvements – Yield & Cost

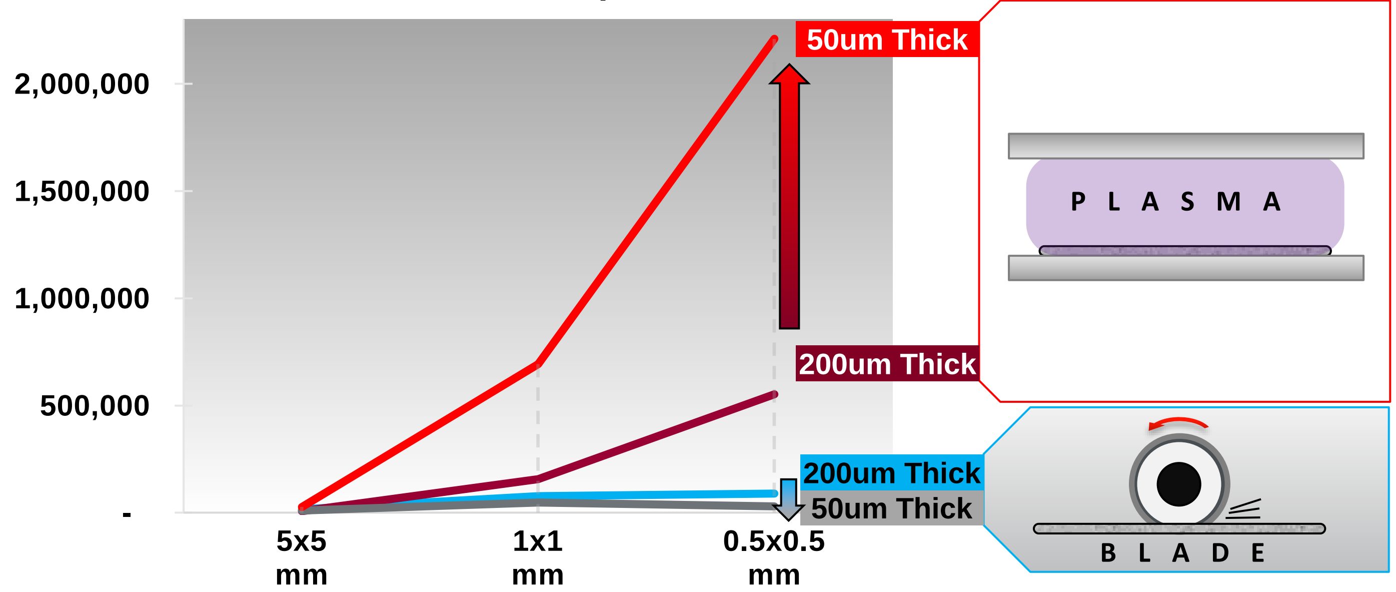


Plasms Dicing enables
Narrower die spacing = more die / wafer

- Today, most small devices waste large areas of wafer real-estate.
- Some small devices are commodities in very competitive markets.
- Plasma dicing can enable manufacturers maximize wafer yields and reduce costs

Device Improvements – Yield & Cost

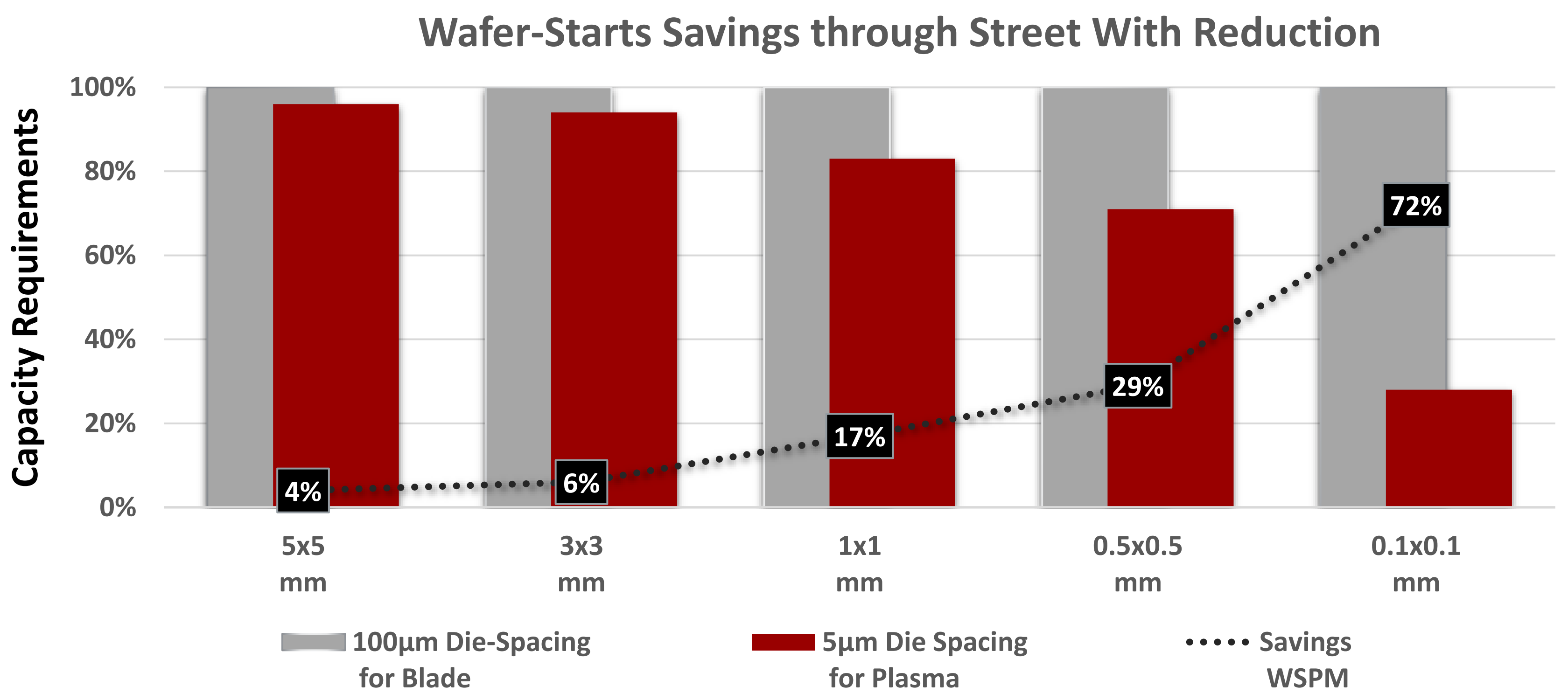
Die Per Hour Comparison



Dicing Process	Die Thickness	Die Size	UPH
Plasma	↓	↑	↑
Plasma	↓	↓	↑
Blade	↓	↑	↑
Blade	↓	↓	↓

- Plasma dicing throughputs are less sensitive to die size.
- As device thicknesses trend down, the throughputs for plasma dicing increase.
- Higher (die per hour) throughputs combined with higher die per wafer yields can have a significant economical impact for device manufacturers

Device Improvements – Yield & Cost

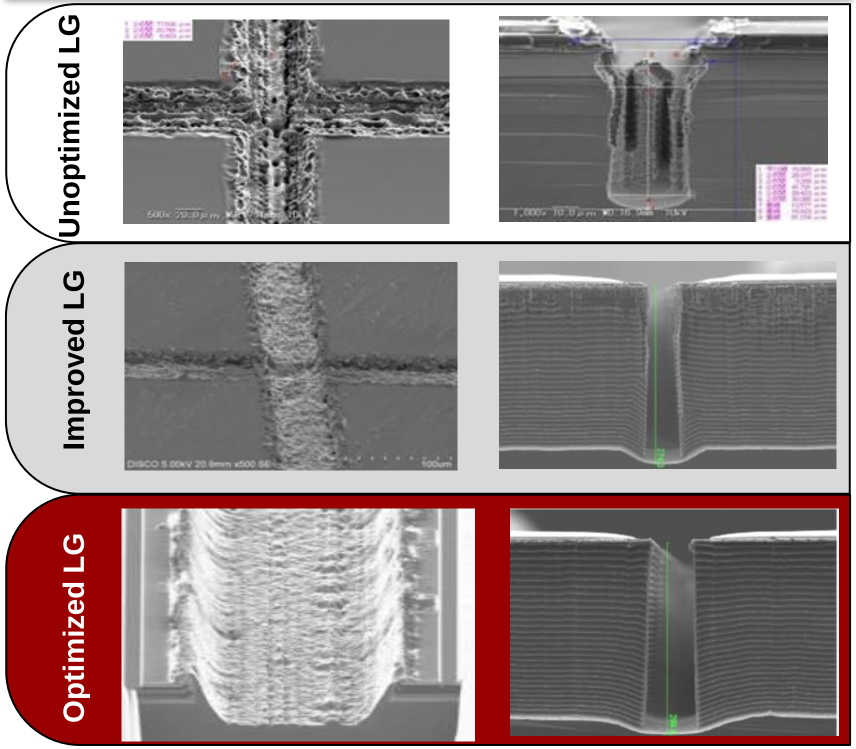


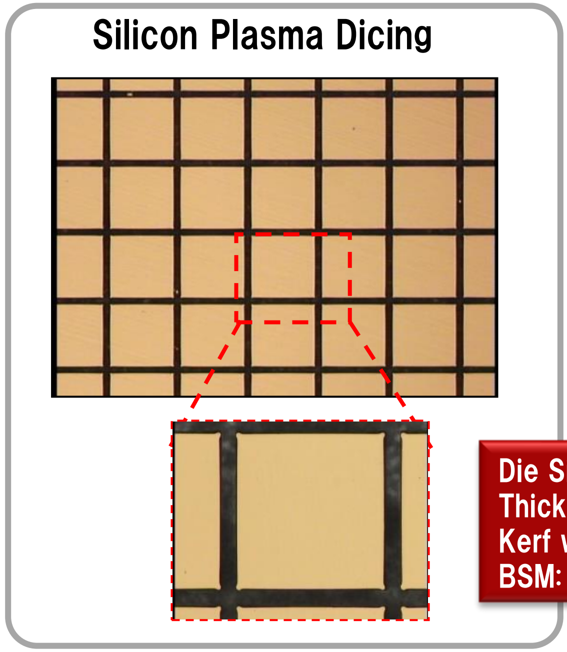
- Higher die-production output requires fewer wafers, which is a significant increase in factory capacity.
- Such new capacity can be used to support more customers/products and generate more business or save factory space, labor, facilities, utilities and reduce carbon footprint.

Plasma Dicing Process Integration

Power devices have 2 very different layers to remove for full singulation. Removal of the metal layer via Laser Grooving (LG) provides effective, flexible and compatible solution for plasma dicing integration.

Evolution of Laser Grooving for Plasma Dicing Integration

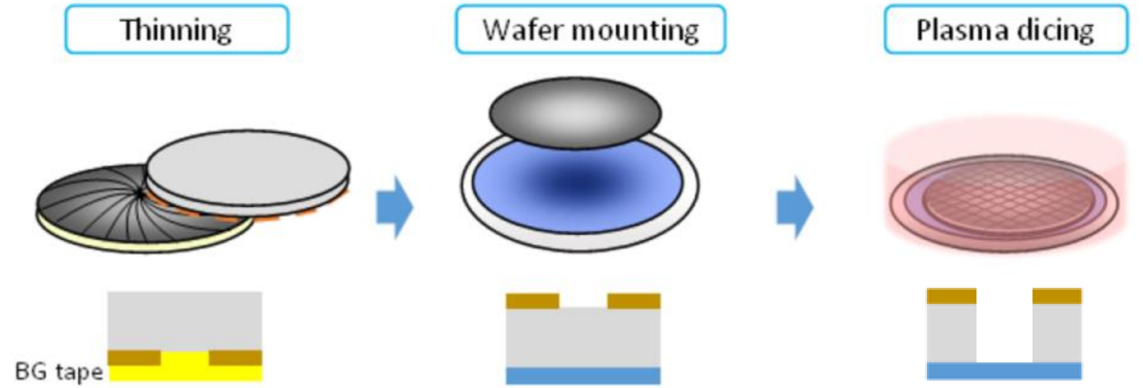


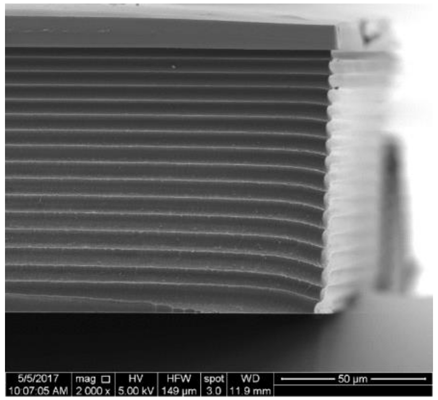


Die Size: 400um^2
Thickness: 200um
Kerf width:15um
BSM: Ti/Ni/Au

Plasma Dicing Process Integration

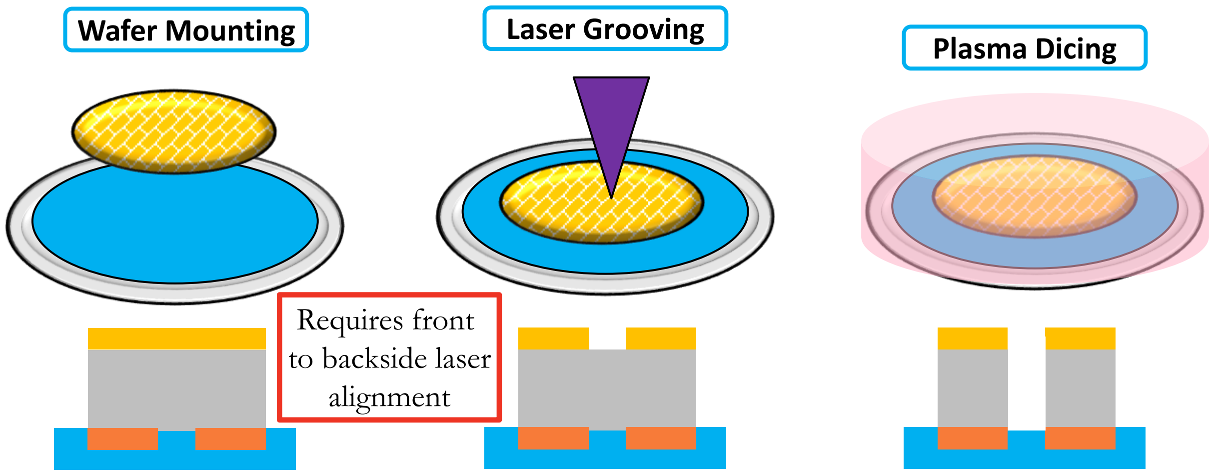
Standard Plasma Dicing Process

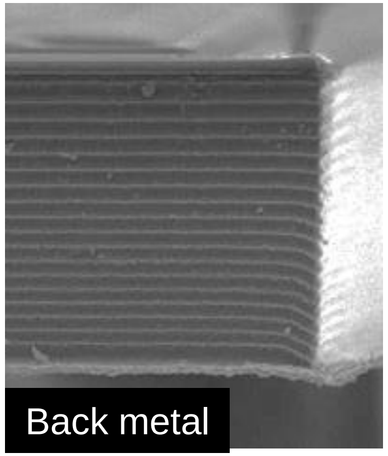




DISCO

Plasma Dicing Process integration for devices back metal





DISCO

Plasma-Therm

Summary

Plasma dicing is very effective for silicon applications. For full singulation of complex material stacks such as metals, process integration requires collaboration and development of a complimentary solutions. For power devices, a low-heat and smooth laser grooving solution.

Plasma Dicing is an emerging technology that enables manufacturers to:

- Solve dicing quality yield related issues
- Reduce wafer real-estate waste, maximize die per wafer output
- Reduce device costs
- Reduce the number of wafers required for the same die output
- Increase factory capacity, reduce CapEx and carbon footprint