



QCW CO2 Laser Drilling for FCBGA Applications

Kyle Baker
MKS Instruments
Beaverton, Oregon
kyle.baker@mksinst.com

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Agenda

- Highest throughput – Up to 70% Faster
- Smallest footprint – 21% Smaller Area
- Lowest weight – 72% Lighter
- Lowest power consumption – Up to 35% less
- Highest application flexibility – AOD Technology
- Lowest cost/panel – High Productivity/Low Utility



Intro	Geode Platform	AODs QCW Laser	AcceleDrill Advanced Coordinated Motion	TPT Results	Summary Questions
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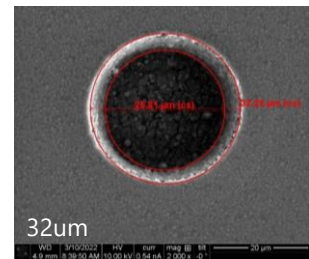
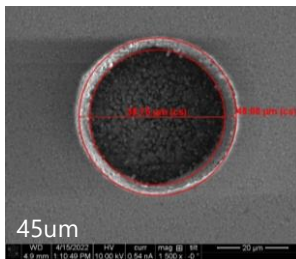
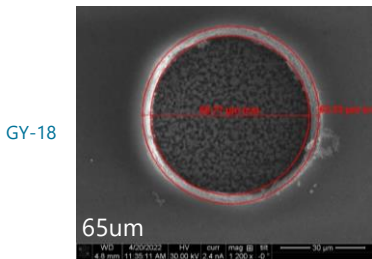
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Introduction

Maximizing HVM throughput and quality on FCBGA package substrate components when laser via drilling on ABF materials has become challenging within current and future OEM specifications (accuracy, quality, throughput, etc)

Current generation laser via drilling systems **are capable, but not productive enough for the increasing throughput and quality needs** of the top substrate suppliers

Principals of a laser via drilling system that can deliver both constant power and high via quality on ~30-65um vias, and how to harness and manipulate the properties of AODs and QCW laser for maximum application efficiency



Geode Platform – Configurations

First Generation Tools

Geode L

HDI – Maximum Applications Flexibility for 60-200um vias

Geode S

HDI/mSAP – Best Industry Throughput for 35-90um vias

Geode VS

FC-CSP/mSAP – High Accuracy and Throughput for 28-75um vias



*Available until 2025

Second Generation Tools

Geode G2/L

HDI – Maximum Applications Flexibility for 60-200um vias

Geode G2/S

HDI/mSAP – Best Industry Throughput for 35-90um vias

Geode G2/VS

FC-CSP/mSAP – High Accuracy and Throughput for 25-75um vias



Geode A

FC-BGA – Fastest Throughput for 30-65um vias in ABF

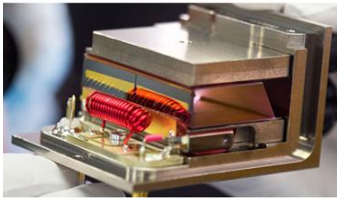
(Under Development)

Advanced FC-BGA – Fastest Throughput for 10-50um vias in ABF

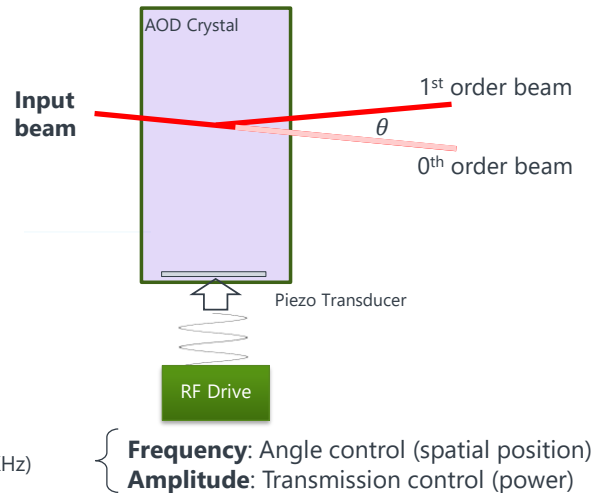


The AOD – The heart of Geode's High Performance

An AOD (**Acousto-optic Deflector**) is a non-moving component that **enables sound waves to modify laser energy for optimum throughput, and controls the laser beam** power and position



- Non-moving optical component
- Controls pulse time power and beam position
- Used together with galvos and stage (3rd Dynamics)
- Deflection in MHz regime (much faster than galvos in KHz)
- ESI (MKS) has decades of experience with AOD's



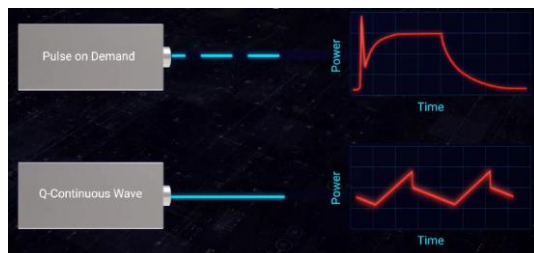
QCW Laser

A quasi-continuous wave laser (QCW) source enables **constant laser power to the work surface**, which **eliminates the wait time needed for pulse availability on traditional CO2 lasers**



Special QCW laser configuration = less move-time restrictions

Fewer restrictions = highest possible throughput



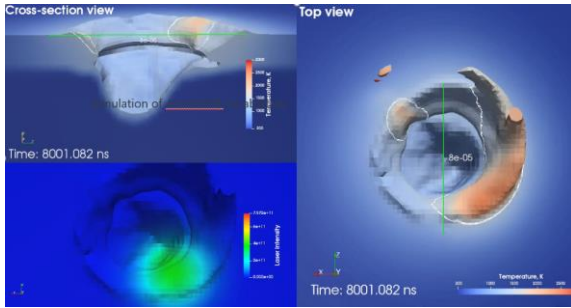
CO2 Laser for Via Drilling	Traditional Pulsed Laser	QCW Laser
Materials	ABF, FR4, BT, RCC	ABF, Non-Cu cladded dielectric
Energy availability	Pulse on demand	Constantly Available
Average Power	>400W	>250W

AcceleDrill™ for Geode



- Uses ESI's expertise in AOD technology to steer the laser beam
- Drill multiple via diameters in single pass
- Improve overhang value for larger vias through better thermal control

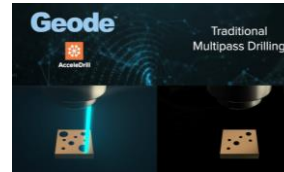
Simulation of AcceleDrill via ablation



1. Drilling begins for initial via diameter until that tooling is complete



2. Geode begins drilling second via diameter without any tooling change

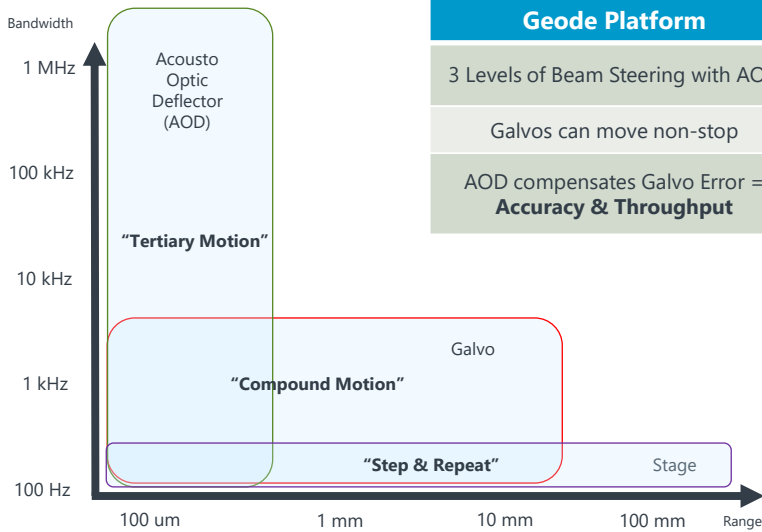


3. Geode completes drilling all vias for second diameter; Competitor begins drilling after tooling change

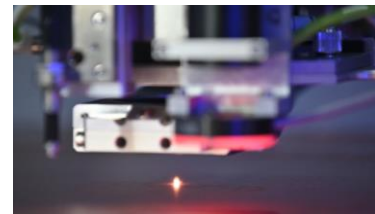


4. Geode already completed full multi-diameter toolpath, while Competitor drilling is still on-going

Advanced Coordinated Motion



Geode Platform	Traditional CO2 laser system
3 Levels of Beam Steering with AOD	Max. 2 Levels of Beam Steering = Less Throughput
Galvos can move non-stop	Galvos settle during stage move
AOD compensates Galvo Error = Accuracy & Throughput	Galvos driven slower to avoid deflection error and accuracy issues



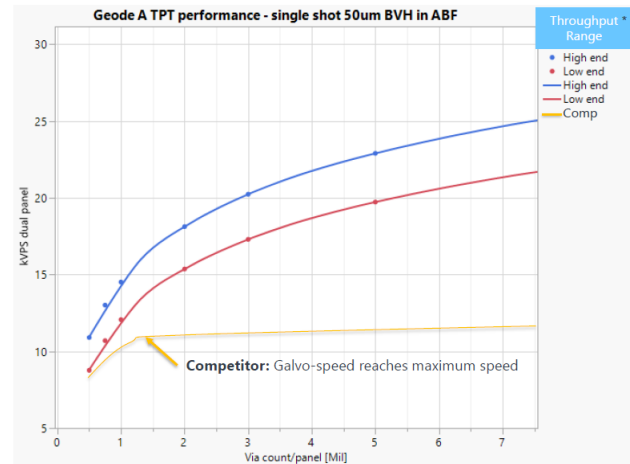
Geode A: Throughput Increases with Via Density

Throughput enablers:

- QCW laser supplies constant energy to work surface
- AODs enable single-pass, multi-diameter drilling
- Advanced coordinated motion enable 3 levels of beam steering @ 1Mhz Bandwidth

Ave. Throughput*	1m vias: 13k vps
	2m vias: 15k vps
	3m vias: 18k vps

*Figures are single-pulse recipes based on Test Toolpath.
Vias <38um typically require 2 pulses.



*Throughput range determined by factors such as via pitch, diameter, aspect ratio, toolpath, etc

Summary

- Companies and manufacturers willing to **explore and test new technologies using an AOD laser via drilling system** will benefit from major increases in process flexibility
- Roadmap objectives of top OEMs **will continue to move towards miniaturization and higher density** and having a **laser via drill capable of the upcoming challenges**, that also meets current requirements, will be a significant consideration for substrate makers and suppliers
- The combination of a **QCW laser, acousto-optic device (AOD) beam-steering and modulation technology will enable a new level of throughput and accuracy for ABF drilling** needed for AI and high-powered computing applications

Thank you for your time and attention!



MARKET LEADER

MKS is a leading global provider of process control solutions for

- Semiconductor
- Electronics & Packaging
- Specialty Industrial

STRATEGIC GROWTH

• Q3 2022 – acquired Atotech

- Leader in specialty chemicals, equipment, software and services for PCBs, semi IC packaging and surface finishing

• Q1 2019 – acquired Electro Scientific Industries (ESI)

- Leader in laser-based manufacturing for the micro-machining industry

• Q2 2016 – acquired Newport Corporation

- Leader in sophisticated laser, light and motion products

INNOVATIVE SOLUTIONS

• Vacuum Processing

- Pressure measurement & control, flow, power, reactive gas analysis, automation

• Laser Solutions

- Precision laser applications
- Laser-based process equipment

• Motion, Photonics & Optics

- Vibration & performance motion control, gratings & optics, laser measurement

• Materials Solutions

- Process and manufacturing technologies for advanced surface modification, electroless and electrolytic plating and surface finishing

KEY FACTS

- Founded: 1961
- HQ: Andover MA
- IPO: 1999 (NASDAQ MKSI)
- Selling in ~100 countries
- In 2023
 - Revenue: \$3.6B
 - Employees: ~10,000
 - Engineers & Scientists: ~1,900
 - R&D Investment: ~\$288M
 - Worldwide Patents: ~3,800⁽¹⁾

(1) Patents consist of issued patents for MKS and Atotech as of December 31, 2022.