SWTEST

PROBE TODAY, FOR TOMORROW

Recent Breakthrough in Tight Pitch Laser Microdrilling for MEMS Guideplates

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Outline

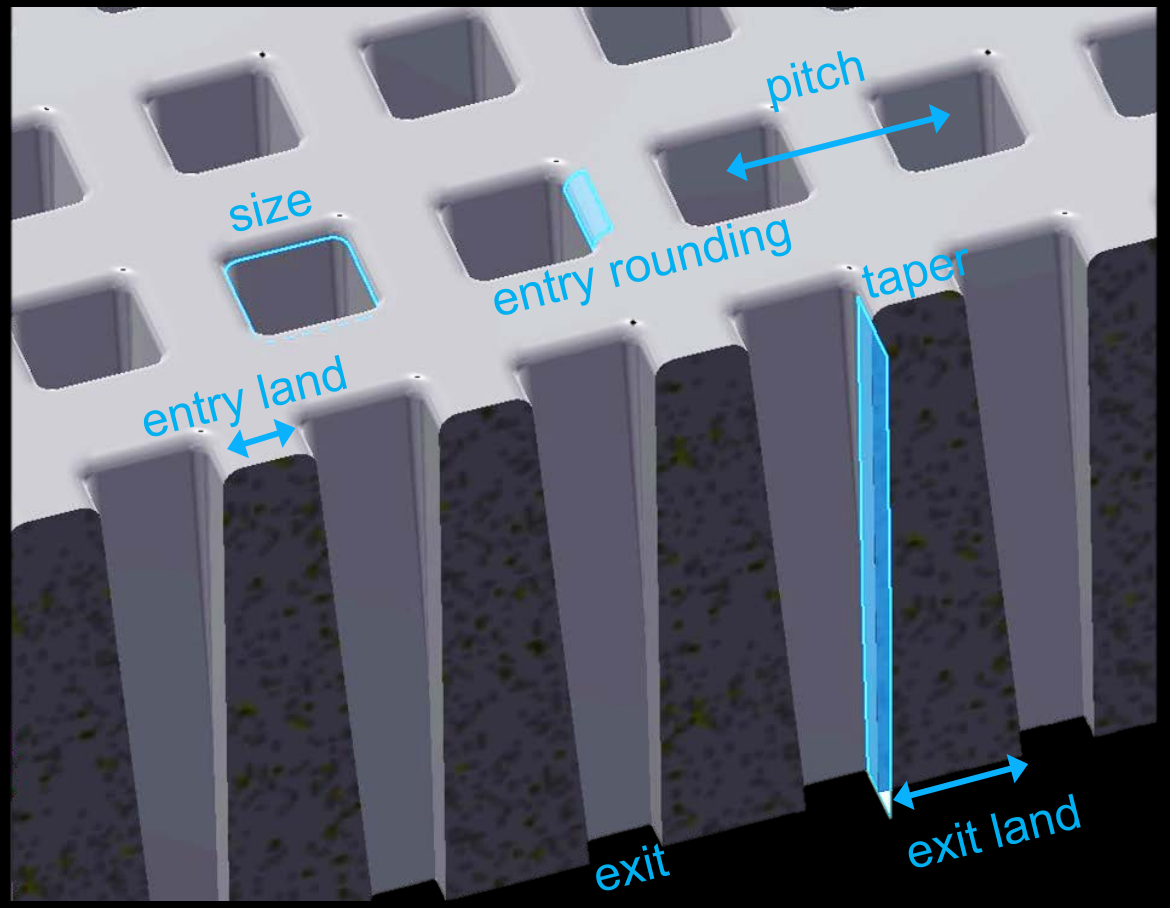
- Introduction: Oxford Lasers
- Objective: drill holes on tighter pitch
- Methods: picosecond lasers, multi-axis galvo scanners
- Results
- Discussion
- Follow-on work
- Summary

Oxford Lasers

- Founded 1977
- 17 years experience of guide plate production
- Subcontract micromachining
- Manufacture laser systems
- Multiple grants to support R&D projects for this application

Guide plate market demand

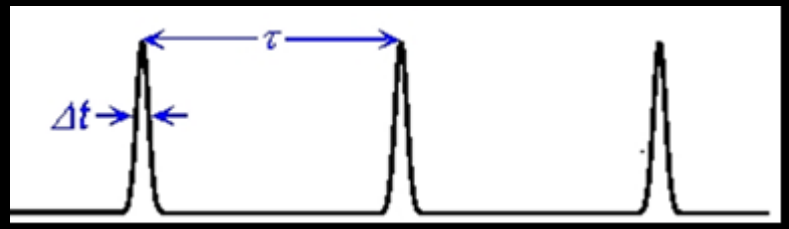
- Customers want:
  1. Tighter pitch
  2. Better repeatability
  3. Less entry rounding
  4. Smaller holes
  5. Smaller corner radius
  6. Lower position errors
- Focus on tighter pitch here
- This brings in 2 and 3



Methods

- Much customer interest in picosecond & femtosecond lasers
- Exploit improvements in laser technology
- Recent advances in beam delivery: tilted beam via multi-axis galvos

Laser pulse duration



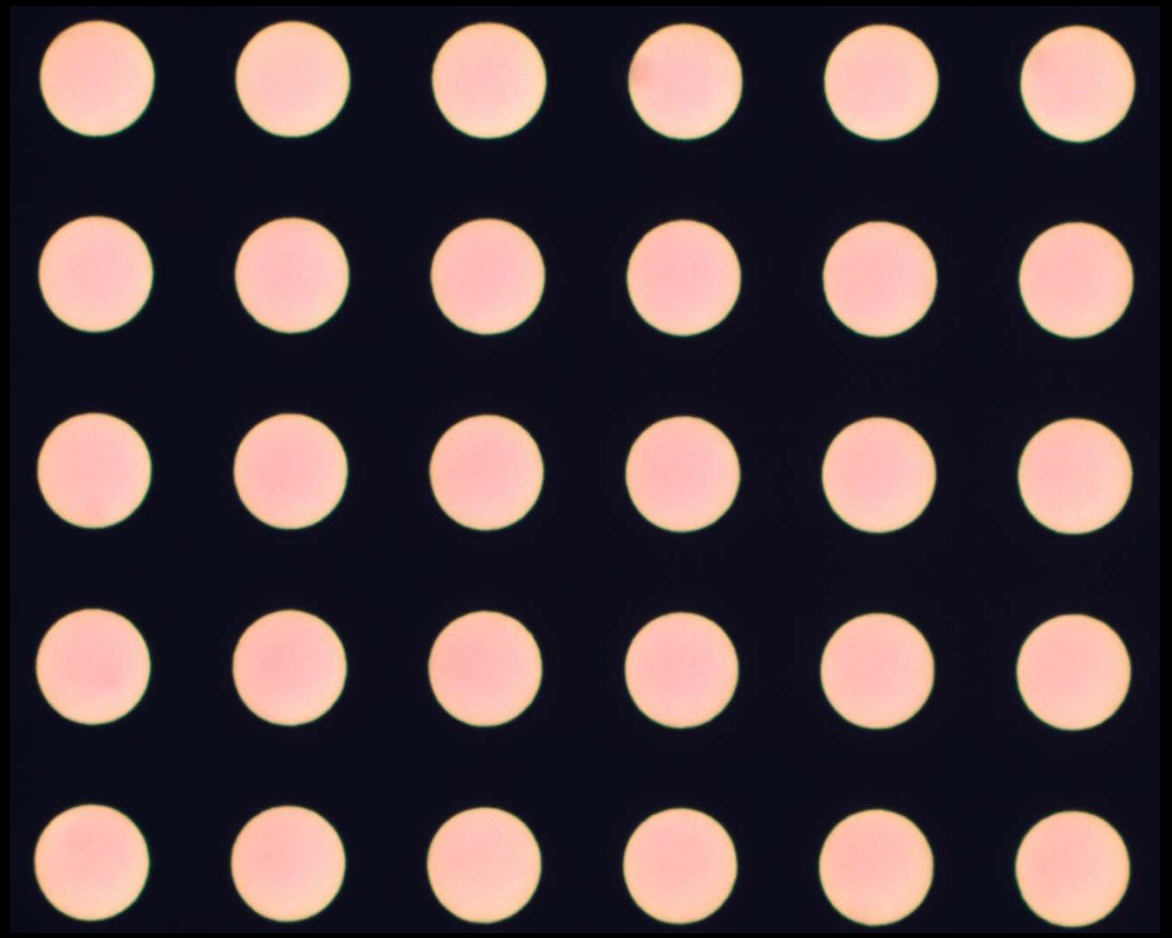
Femtosecond **Picosecond** **Nanosecond**

less debris
deterministic ablation

lower cost
more established

Picosecond laser drilled holes

- Right: array of 60µm holes
- Very consistent size, shape
  - Repeatability 0.2µm (full range)
  - Roundness, <0.8µm
- Typically with nanosecond, tighter hole pitch influences repeatability
- Improving repeatability facilitates a different route to tighter pitch

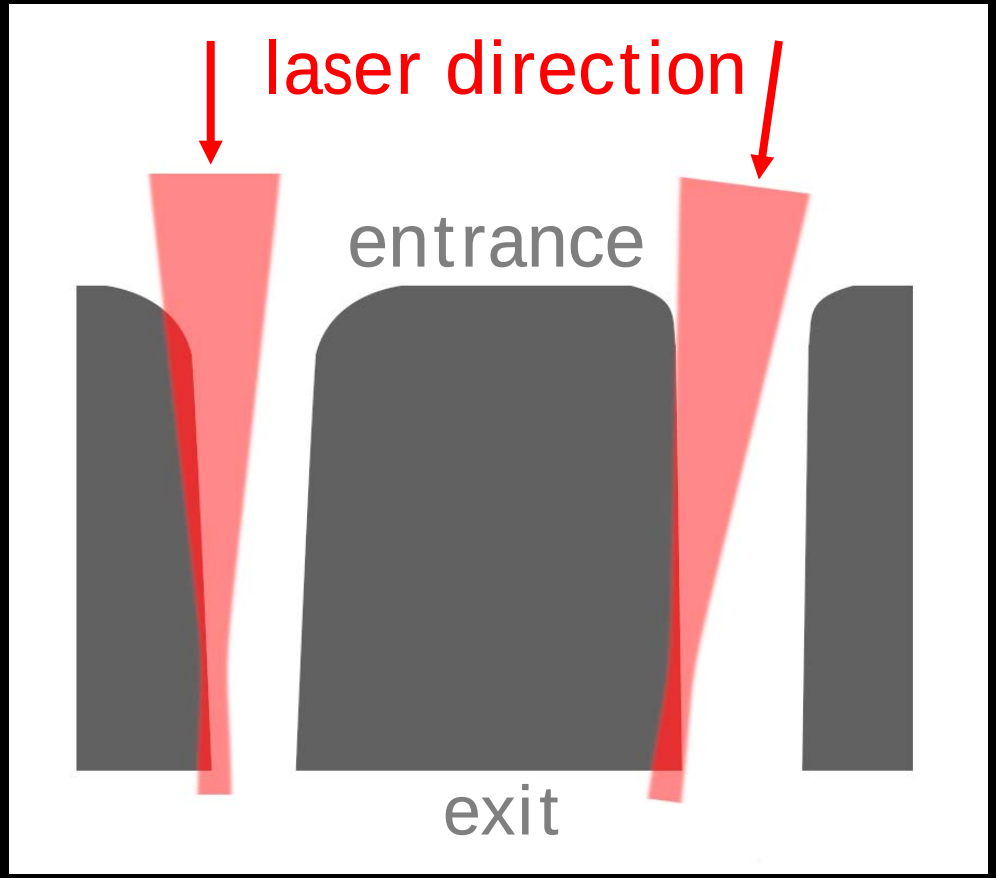


Further optimising nanosecond laser drilling

- Nanosecond lasers have advantages
- System performance can be further optimized by adding new components and novel process development
- Oxford Lasers is actively pursuing several routes
- This includes tilting the beam (today's talk)

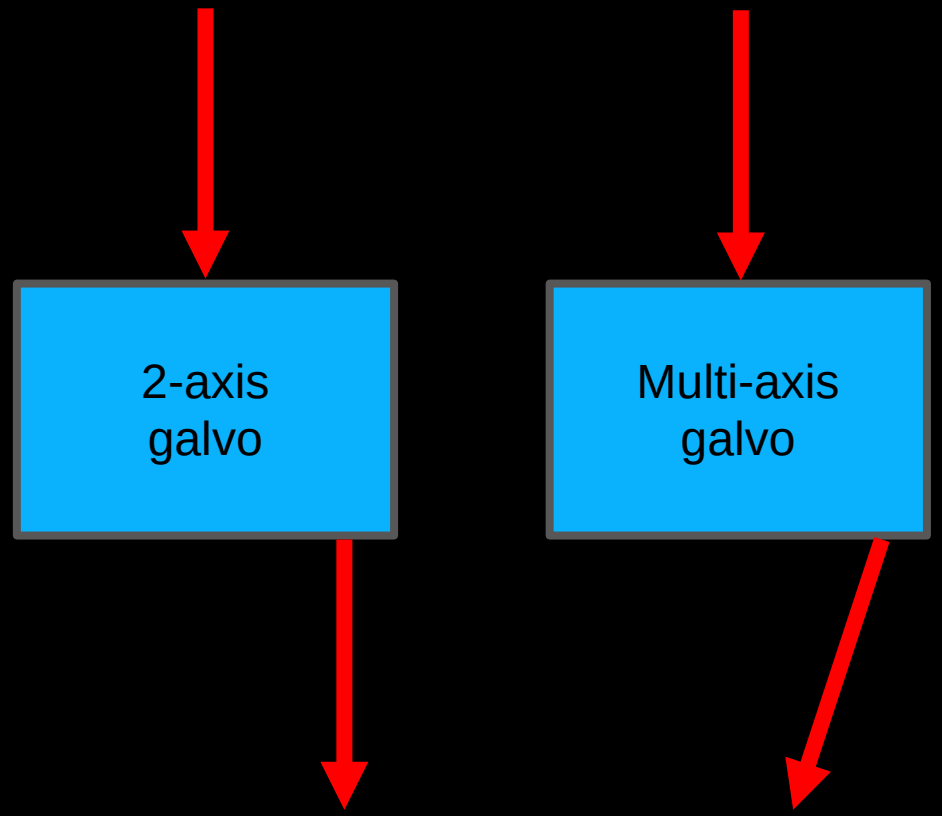
Tilting the laser beam

- Right: schematic of material cross-section (grey) and laser beam (red)
- Vertical beam on left side, tilted beam on right
- Tilted beam delivers more power to the hole exit and removes less material at the entrance (reduces rounding)



Multi-axis galvo scanners

- 2-axis galvo scanners enabled square hole drilling
  - Beam motion in X and Y only
  - Incident beam stays vertical
- Multi-axis galvos add beam angle control (two angles)
- Fifth axis can also shift laser focus in Z
- Oxford Lasers have been evaluating several such solutions

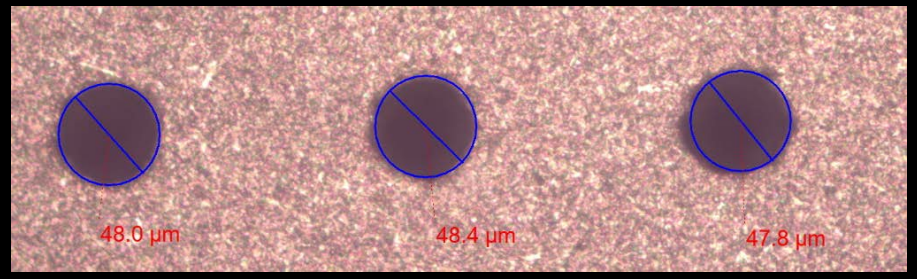


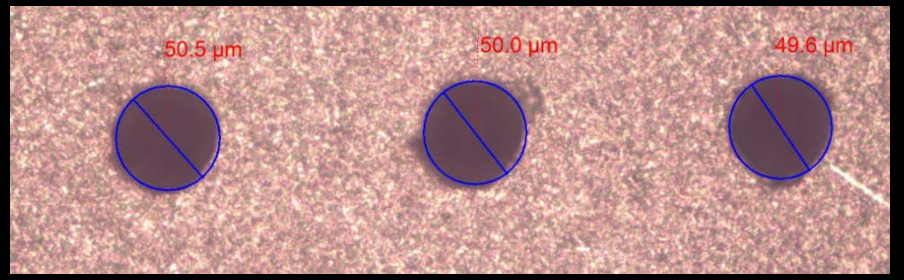
Taper control for circular holes

From +5µm PositiveTaper

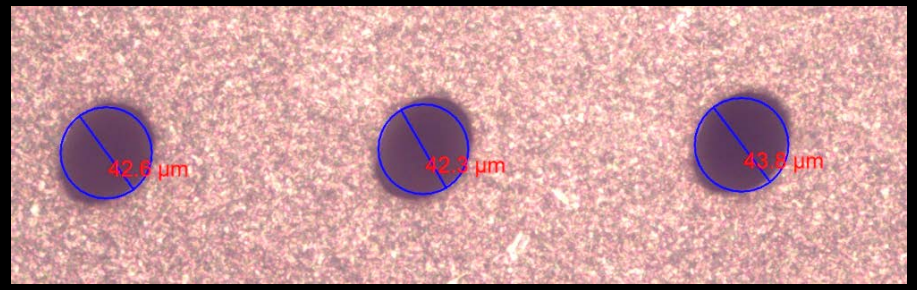
To -5µm Negative Taper

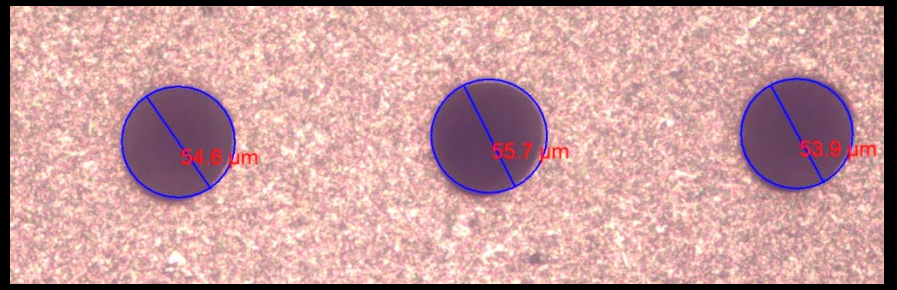
ENTRANCE





EXIT

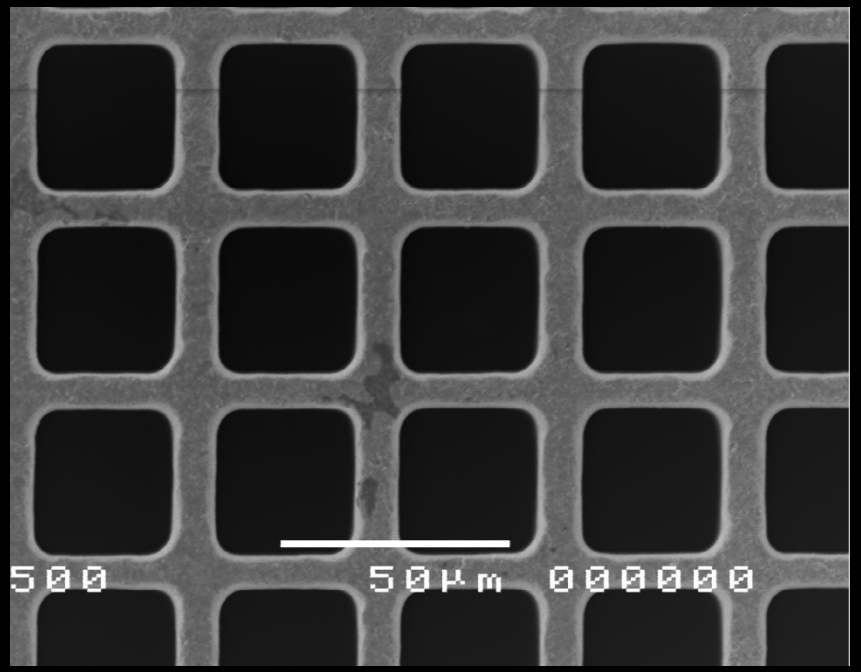


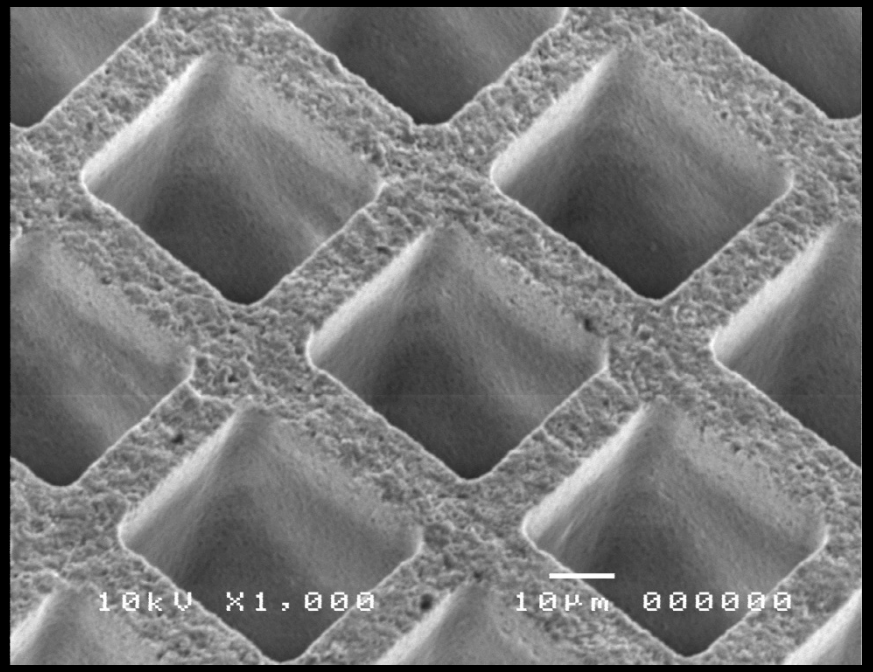


10µm exit land with multi-axis galvo

- 30µm squares on a 40µm pitch
- Picosecond laser

ENTRY

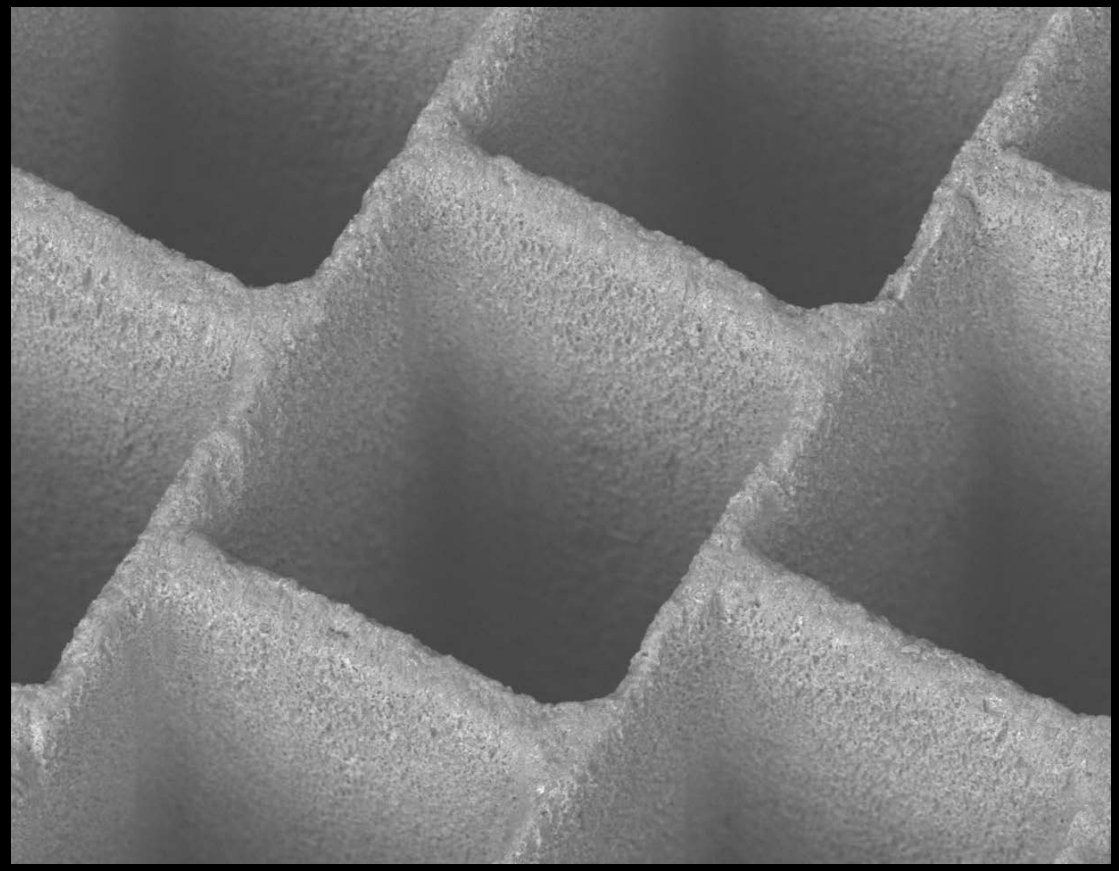




EXIT

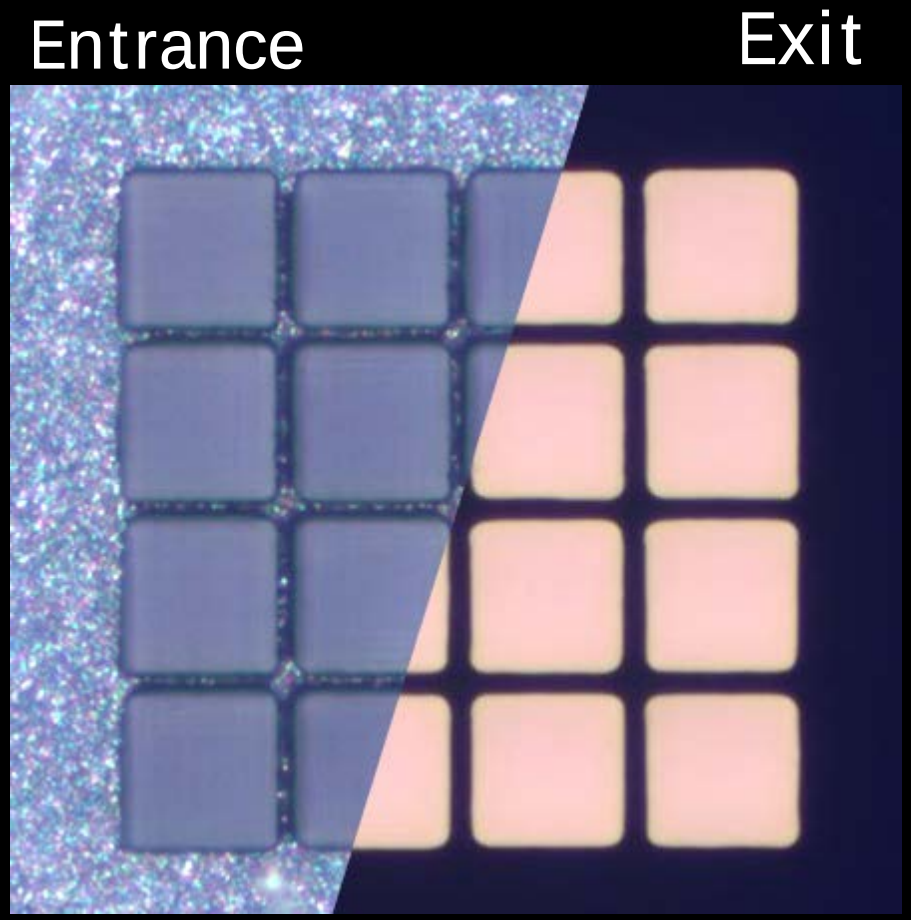
9µm exit land in 250µm SiN

- Tight pitch
- SEM image of entry side
- Walls still intact with no erosion
- Nanosecond laser



7µm exit land in 200µm thick SiN

- Easier to drill thinner substrates
- Image right shows entrance and exit images together, 50µm size
- Some darkening of the entrance but material is intact, entrance land 3.7µm
- Nanosecond laser
- Capability depends on material, thickness, part design (hole positions) etc.



Follow-on work

- Hole pitch is just one aspect of a very demanding specification
- Further optimize all aspects (drill speed, corner radius, etc.)
- Full optimization requires drilling large number of holes (millions) to ensure statistical relevance
- Measure all holes using Oxford Lasers developed automated optical metrology tool (presented last year)
- Release new drilling processes to customers when fully qualified

Summary

- MEMS guide plate roadmap demands tighter pitch holes
- Oxford Lasers runs an active R&D program delivering continuous improvement
- Drilling of high accuracy, tight pitch holes for guide plates is a complex process with many features and variables that must be simultaneously optimized
- Multi-axis drilling heads and different laser pulse durations give additional control levers, which enable tighter pitch hole drilling

Thank you for your time and attention