Overview

Silicon Nitride has been a popular choice of material for vertical probe cards because of its excellent thermal, mechanical and electrical properties. In recent years, polyimide, such as Cirlex®, has become available in thicknesses up to 0.125". This material also has good properties for use in Vertical Probe cards. Previously the only drilling method was mechanical drilling for which drill wear and positioning reduce production rates and yields. We report on laser drilling that produces high quality holes at high production rates and high yield. In both materials, holes with diameters as small as 1.2 mil (30 microns) have been produced.

Results

Figure 1 illustrates the range of holes that can be laser drilled.

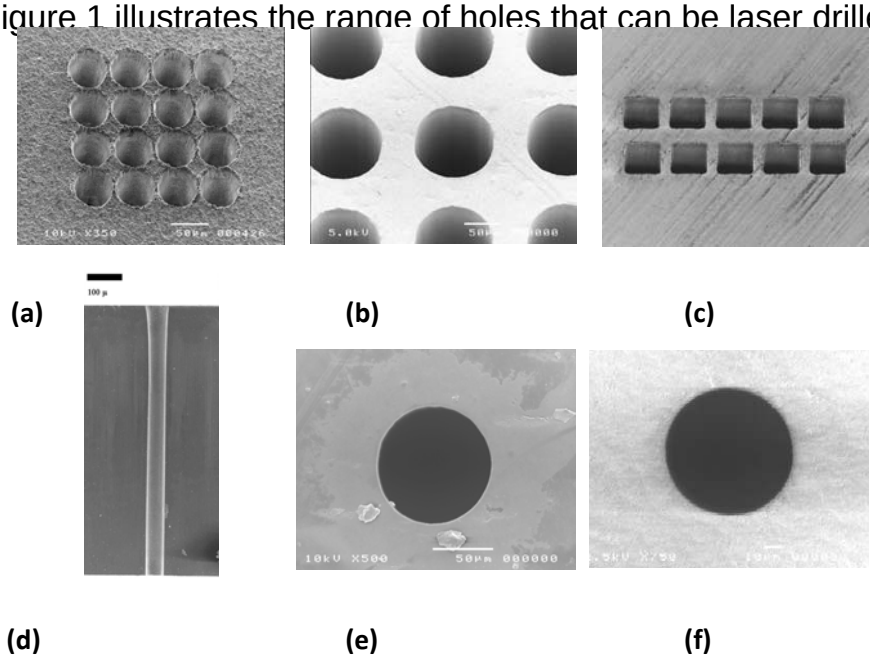

Fig. 1. (a) 2 mil dia hole in alumina, (b) 4 mil diameter hole in polyimide, (c) 2.4 mil rectangular holes in SiN, (d) 2 mil dia hole cross-section in polyimide, (e) 3.2 mil dia hole in polyimide and (f) 3.2 mil dia hole in SiN

Polyimide is an easier material to drill with mechanical methods than SiN. For laser drilling it shows a lower ablation threshold than SiN but also presents certain challenges in terms of increased taper and damage to the material. We have developed laser drilling processes which overcomes these challenges.

Comparison of Laser-Drilled Holes in Silicon Nitride and Polyimide Vertical Probe Cards

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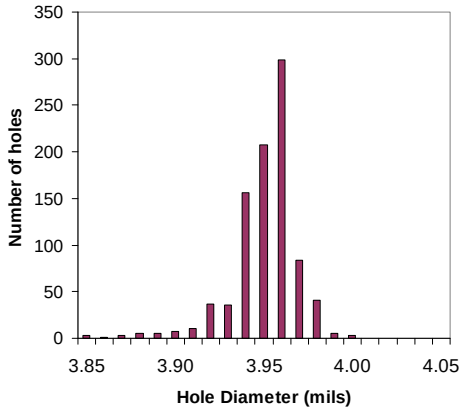
It can be seen that the holes are very round and parallel and free of damage.

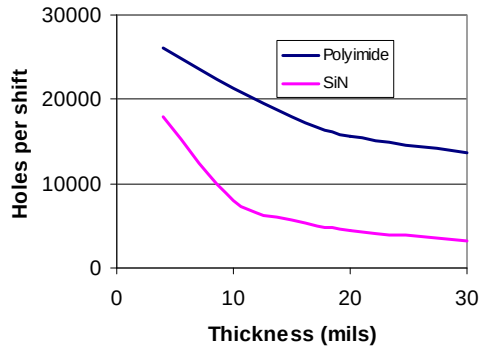
Figure 2 illustrates the excellent repeatability and accuracy of the laser drilling process.



Radial position error	0.15 mil (+/-2σ)
Diameter error	0.07 mil (+/-2σ)
Circularity error	0.05 mil (+/-2σ)

Fig.2 Typical results from 1000 hole array

Fig. 3 shows the drill time required versus thickness. It demonstrates that polyimide offers the possibility of much higher production throughput. This can be very significant in 300mm wafer probing where pin count can reach 25,000.



Drilling of polyimide requires a very different set of laser tool parameters to silicon nitride. However, these parameters are stored on the tool and enable easy switch-over between the two materials.

Comparison of laser drilling with mechanical drilling

- Mechanical drilling used successfully for > 25 years.
- Laser drilling used successfully for > 8 years
- Laser drilling typically 3x to 6x faster
- Mechanical drilling can suffer from drill breakage, wear and wander
- Laser drilling does not suffer any direct wear from the drilling process

Whilst mechanical drilling has proven viable for probecards with lower pin-count, as the industry moves to larger area and higher pin-count, then there must be doubts as to whether mechanical drilling can deliver the yield and throughput required. Unlike mechanical drilling, the laser beam is not worn or degraded by the drilling process and the typical maintenance interval on the machine is >5000 hours. Therefore the expected yield from laser drilling is high and this has been confirmed by the early indications of laser drilling of cards with 10,000 - 20,000 holes. The combination of higher throughput and higher yield gives an approximate cost per hole for laser drilling which is 4 times lower than mechanical drilling. With the drive to reduce testing costs this should be of significant interest to the semiconductor wafer test industry.

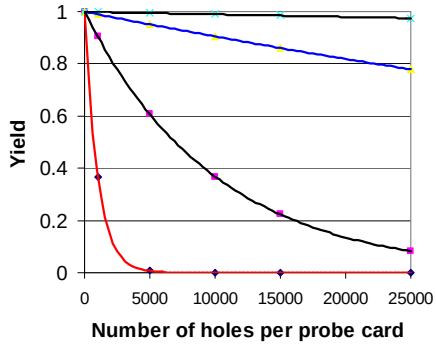


Fig.4. Illustrating the effect of single hole drilling success on the yield of the probe card drilling operation for single hole drilling successes of 99.9%, 99.99%, 99.999% and 99.9999%.

Conclusions

Laser drilling has demonstrated production-quality results in both silicon nitride and polyimide and this tool is now being more widely adopted in the probecard manufacturing industry. With throughputs up to 6 times higher than mechanical drilling and with higher yield, it seems likely that laser drilling will be increasingly used as pin diameters decrease and pin count increases.