How Novanta's picosecond laser sub-systems achieve high quality micro-processing

Creating zero taper and smooth surface finish via holes

The Challenge

Achieving precision in micromachining applications can be challenging, especially when working with small spot sizes where any beam imperfection is amplified. If beam roundness is not sustained over a large depth of field, micromachined features will display a lack of symmetry especially in high aspect ratio structures, such as via holes. This leads to defective material, creates waste and may require additional post-cutting processes, all of which results in extra time and cost for the end-user.

Background

Laser processing is commonly used in consumer electronics, e-mobility, medical and semiconductor industries to machine small, precise features and cuts in materials. Within the industrial environment, speed, accuracy, yield and cost are key parameters which drive the choice of laser scanning system. Ultra short pulse lasers combined with beamsteering scan head technology are employed to achieve a variety of processing features for a diverse range of materials.

The challenge remains the same whether you are cutting PCBs or probe cards, glass or stainless steel, imprecise cuts will create product defects or waste especially with complex designs. To overcome this, a high degree of control of the laser interaction with the material is required and key to this is the roundness of the focused laser beam. A circular, symmetric beam combined with precise, scan head movement delivers complete and reliable control of the processing, especially when the circular symmetry is maintained over a large depth of field. As a result, high aspect ratio holes with zero or controlled taper can be achieved for applications such as via hole drilling.

Examples of High Quality Processing With Dart

A variety of materials have been processed using Novanta's Dart 8 picosecond laser combined with a hole drilling Novanta Precession Elephant scan head. Figure 1 shows a 200 µm diameter via hole drilled through a steel plate. The closeup of the walls demonstrates both the precision and smoothness.

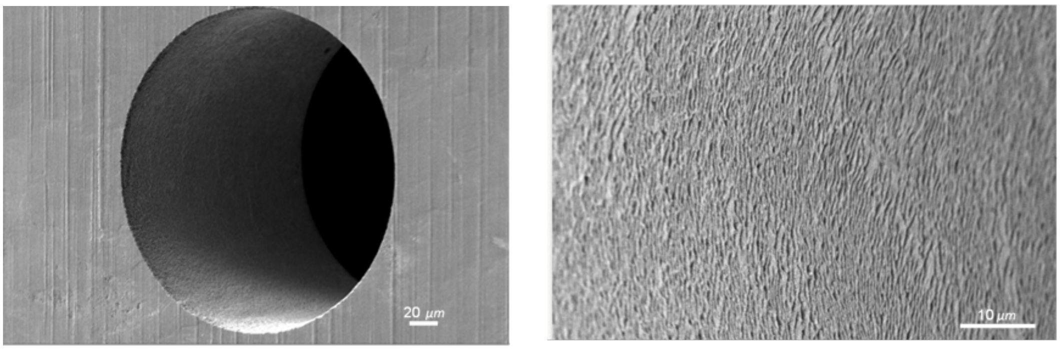

Figure 1 – 200 µm via hole drilled in stainless steel showing a high level of wall smoothness. This was achieved using a 1064 nm version of Dart.

Figure 2 shows a taper free via hole in glass with corresponding entrance and exit images. These demonstrate both circular symmetry of the cut and zero taper. In addition, the brittle material is damage free, with no signs of microcracks, a consequence of the low Heat Affected Zone (HAZ) provided by using an 8 picosecond laser.

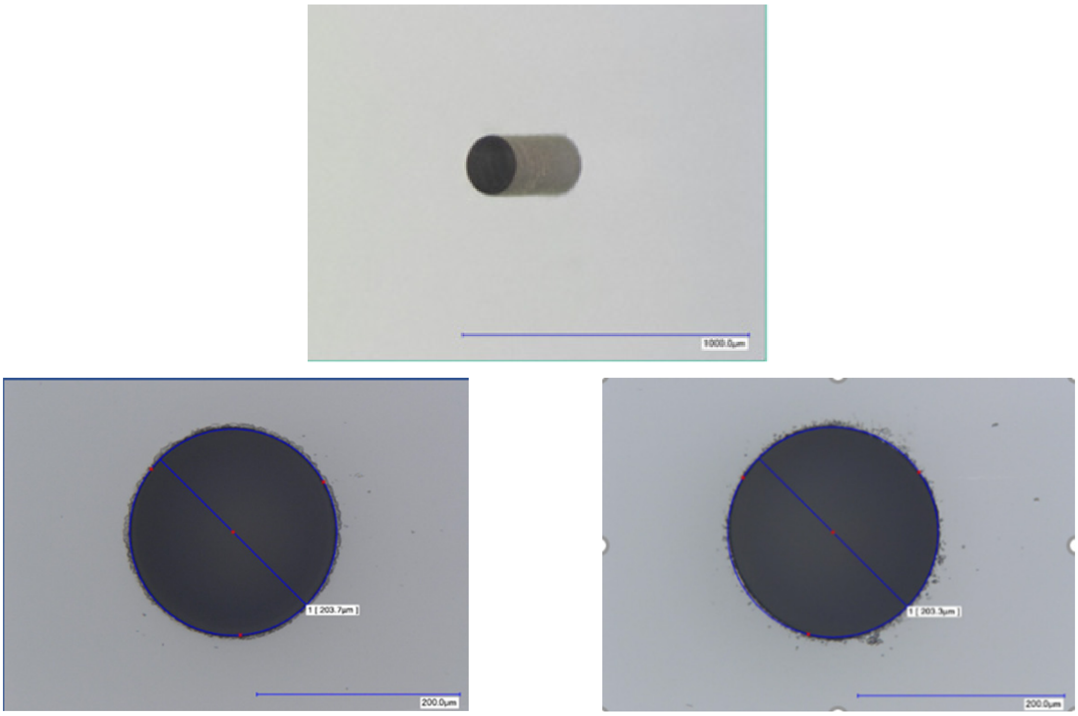

Figure 2 - 200 µm via hole drilled into a 0.7 mm glass substrate using a 532 nm laser. The diameter of the entrance and exit holes are both measured to be the same within 0.5 µm.

How does Dart achieve this?

The precision achieved in these examples is a consequence of Dart's high level of beam roundness. Figure 3 shows the beam profile of >93% sustained over a large depth of field, typically ±3 Rayleigh lengths. This facilitates the symmetric features with zero taper, smooth surface finish and the potential for high aspect ratios.

Figure 3 - Dart beam profile demonstrating the beam roundness of > 93% across ±3 Rayleigh lengths. Due to the nature of the Dart design, this performance is repeatable from laser to laser.

Dart has been designed to be used with a wide range of scan heads. In each of the examples above, the laser has been combined with a multi-axis drilling optic, the Novanta Precession Elephant. With this configuration the focal point of the laser can be moved in the X, Y and Z directions and tilted in two angles to the surface normal. Furthermore, usability tools like alignment cameras, a vision setup, an energy monitor and a polarization unit are integrated in the optics. The high level of control and monitoring results in an ability to process the most challenging of geometries such as: cylindrical and tapered holes (exit side larger than the entrance); cuts with a wall angle of 90° to the surface; and undercuts. As a further degree of freedom, the laser power on the workpiece can be dynamically varied with a fast optical attenuator. This high level of manoeuvrability and control, coupled with Dart's excellent beam quality, results in high accuracy features.

Figure 4 - Novanta's Precession Elephant scan head, paired with the Dart to deliver smooth, taper free via holes.

Dart has been specifically engineered by Novanta for OEM users, and offers a straightforward integration pathway with a single supplier for both laser and scanning sub-systems. As standard, Dart features precision boresighting specifications that reduce the complexity of optical alignment during installation. With a ruggedized, compact design, reliable pointing stability, and repeatable beam characteristics from laser to laser, Dart delivers high quality picosecond laser cutting and drilling even in tough industrial environments.

Novanta Advantage

Through our photonics technologies, we deliver finely tuned laser sources and beam delivery systems that enable customers to improve their process, increase productivity and achieve breakthrough performance. We bring unprecedented value to our customers through engineer-to-engineer collaboration, a wide range of application expertise, and state-of-the-art application labs.

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