EFFICIENT DRILLING OF CERAMIC FILMS WITH PICOSECOND LASERS

A special laser process for ceramic components allows very thin ceramic films to be drilled with high speed and precision. Optimal tuning of picosecond laser, lens, and scanner results in high productivity while maintaining very tight production tolerances.

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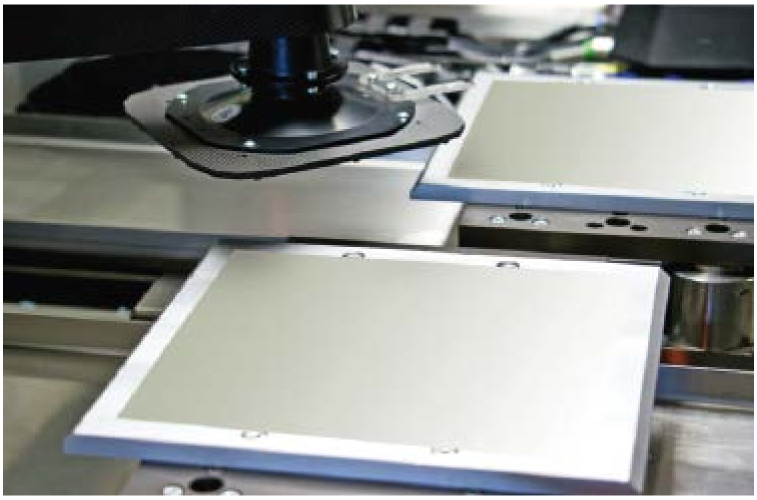
A wide variety of ceramic components is increasingly being used in electronic devices. They are either part of the housing or are the innovative basis for passive or active electronic modules. For production reasons, laser processing is called for, because the material is too hard for mechanical processing.

Speaker holes, holes for controls or camera apertures are cut or drilled into ceramic housings, and ceramic films are drilled or structured for structural elements. Special laser processes have been developed for these various applications.

Thin ceramic films are needed to produce miniature coils for electrical microcircuits. The films are perforated with thousands of microscopic holes. A newly developed laser process drills 200 000 holes 15 µm to 25 µm in diameter in less than 40 seconds on a 130 mm by 130 mm section of the surface to be processed. The position of the drilled holes varies no more than 2 µm from the target value.

To achieve this high speed and maximum precision, a laser process was developed that combines the performance of an ultra-short pulse laser with the optical precision of a precisely corrected telecentric lens.



In order to double the throughput, two ceramic films can be processed simultaneously. Therefore, the laser beam is split and directed to two independently controlled scanners

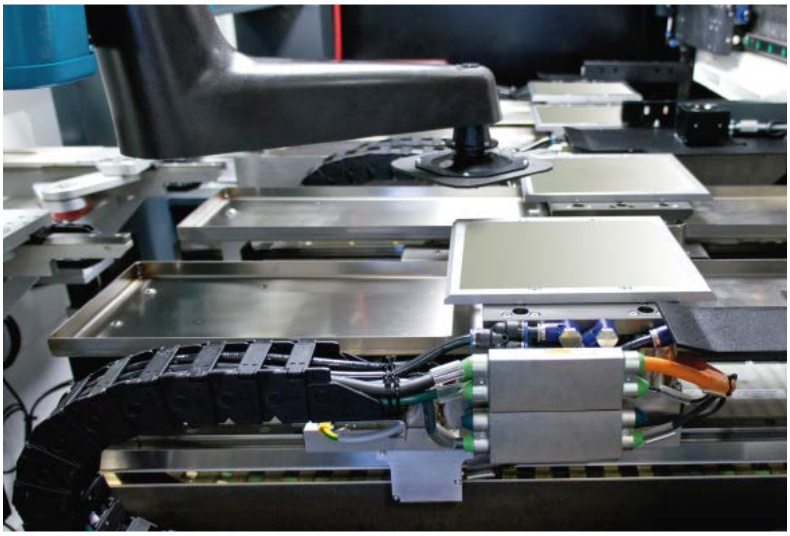
Maximum of 100 laser pulses per hole

Ultra-short laser pulses are necessary to prevent the material from melting and forming craters. This is because with a pulse length of 6 ps to 10 ps, the material's thermal relaxation time is much longer than the pulse length. Due to the acceleration in the laser beam's electrical field, only the electrons are excited, while the atoms remain "cold." The lattice bonds are dissolved before the material starts to thermalize. This means that the material is removed before it can warm up. The result is a precise hole with no melt cratering.

The ceramic film to be processed is 15 μm to 50 μm thick, and the carrier foil is 30 μm to 50 μm thick. Drilling a hole takes 50 to 100 laser pulses. This involves laser sources that emit beams within the visible spectrum. An IR laser cannot drill holes of this size due to the larger wavelength and the larger focal diameter associated with it, and for internal reasons, the customer did not want a UV laser.

High precision through improved optics

The laser beam is guided by a biaxial galvano scanner to a telecentric lens that ensures precise focus on the ceramic film. These two components were custom developed at customer request and provided the high speed and maximum precision needed during the process.



The square ceramic film with an edge length of 130 mm is dropped by a Bernoulli gripper on the table

With a telecentric lens, curvature of field is unavoidable but can be corrected. However, in this case it did not occur, and a lens system of various types of glass was used. This is because the picosecond laser places demands on the optical material that can only quartz glass can meet. It is distinctive not only for its extremely low absorption, but also for its low color center formation tendency—even when a laser beam crosses the quartz glass with extremely high pulse peak output. An additional mobile quartz glass lens that shifts the focus position compensates for the image field's curvature. The optics was therefore improved with a mechanical actuator whose position depends on the image field's curvature. A specially developed 3D calibration tool determines the position.

Time and speed

The laser process's speed is largely determined by the number of laser impulses per hole and the time the galvano scanner needs to move to the each drilling position.

With pulse energy in the microjoule range, the laser needs no more than 100 pulses to drill a hole, which means about 0.1 ms at the given rate of repetition. The galvano scanner takes considerably longer to swing the mirror to the next position. This takes 0.25 ms, which places the highest demand on the scanner's dynamics. To save time, a status computer does the regulation, rather than a PID controller. The voltage pulse that deflects the mirror is therefore calculated ahead of time and not readjusted.

The higher speed is mainly achievable by digitizing the controls. Previously, the position of the galvanometer axis was still determined by analog components, a shading element that was moved in front of a photo diode. Some scanner manufacturers are currently testing a digital encoder to speed up the controls. However, this process has not reached mass production.

40 seconds per workpiece

Therefore, setting the mirror and boring the hole takes 0.35 ms. To drill 100 000 holes in a 130 mm^2 by 130 mm^2 ceramic film, it takes a total of less than 40 seconds—including unavoidable buffer times. To process two ceramic films at the same time, splitting the beam between two independently controlled scanners was considered when the system was being designed. This can double the throughput, making it possible to bore 200 000 holes in less than 40 seconds.

This laser process was first developed specifically for mass production of miniature coils. Twenty to forty ceramic films are stacked and aligned with orientation marks so that the holes lie precisely above each other. Then up to 100 000 spools with a core diameter of only 200 μm can be cut from this stack.