

“Ultraviolet” Holes

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The prefix “micro” originates in ancient Greek and means “small”. However, “small” is no longer enough if we are to do credit to the minute dimensions of micrometers and nanometers (1 millionth and 1 billionth of a millimeter) involved in modern microtechnology. These are exactly the orders concerned in the micro-processing of materials using excimer lasers, allowing the ablation rate, the structure size and the 3D geometry to be set precisely by means of the optical setup. These benefits are utilized in the production of inkjet foils for inkjet printers. The holes in these foils determine the ink quantity and the size of the various ink dots (Fig. 1). Optical UV high-performance systems are required to enable the printer to print what is expected.

Lenses for excimer lasers

At the beginning of the nineties, MicroLas (MicroLas Lasersystem GmbH, Göttingen/Germany) was requested to develop optical systems for materials processing using UV excimer laser light. In addition to its own illumination optics, MicroLas required a further optical imaging system with diffraction-limited, high-resolution lenses which had to meet specific application requirements concerning material, sturdiness and life cycle. Since excimer lasers emit in the ultraviolet spectral range – the two most important wavelengths are 248 nm and 308 nm, with 193 nm now gaining more and more ground – special, UV-compatible, fused silica and calcium fluorite must be used for the objective lenses. A further challenge to be met by the lenses was posed by the laser’s high peak power of up to several MW within the typical laser pulse lengths ranging between 20 and 30 ns.

MicroLas was seeking a partner who would be able to meet these requirements, and opted for Carl Zeiss in Jena. This marked the beginning of a period of good cooperation in the design and production of various lens types – 5x and 2.5x demagnification with image fields of 10 mm, 18 mm and 30 mm – which are now successfully used in materials microprocessing with excimer lasers.

Optical systems drilling microholes

A major component of the UV optical systems from MicroLas is a cylindrical lens system which shapes and homogenizes the field of illumination. For example, the excimer laser beam with a typical width of 15 mm x 30 mm is reshaped into a homogeneous field measuring 70 mm x 4 mm which illuminates a mask. The chromium-coated mask features a pattern with openings through which the laser light is guided onto the substrate where it produces a linear hole array (Fig. 2). The structures on the mask, x times larger than the final structures, are demagnified using a UV lens. In the case of inkjet foils, the Ablatar lens 5/0.13 (exposing wavelengths 248 and 546 nm) from Carl Zeiss is used to demagnify the mask onto a

Design to prolong the service life

Carl Zeiss has adapted the used lens to the special conditions of the ablation process, giving special consideration to the depth of the drilled holes (in short).

The telecentric stop is located on the object side. To ensure that the images of the homogenizer foci (illumination light sources) do not destroy the lens elements, this telecentric stop is arranged at a considerable distance in front of the first lens element. The illumination of the stop is set to 0.5 to 0.7 times the maximum aperture of 0.13. Furthermore, the MicroLas illumination optics is designed in such a way that as many foci as possible are generated to implement quasi-continuous illumination of the aperture diameter.

surfaces setting the limits. With the further enhanced MicroLas arrays, 5,000m pulses, and even higher rates at the wavelength 308 nm, are anticipated. The typical 200m pulses per month therefore result in exchange intervals of currently >10 months and probably two years in the future.

Inkjet foils and more

The technology of producing inkjet foils using UV laser light is unsurpassed in both precision and economy thanks to Ablatar lenses from Carl Zeiss. The production of inkjet foils is the major application at present; further industrial applications, e.g. in display technology and printed circuit board production, are in the pipeline. Optical systems will continue to play a major part in the economic efficiency and reliability of microtechnologies.

Fig. 1: Typical element of an HP inkjet printer cartridge with ejected ink drop. The ink drop is forced out through the precisely drilled hole by the heating of a resistor (photo courtesy of Hewlett Packard, Corvallis, USA).

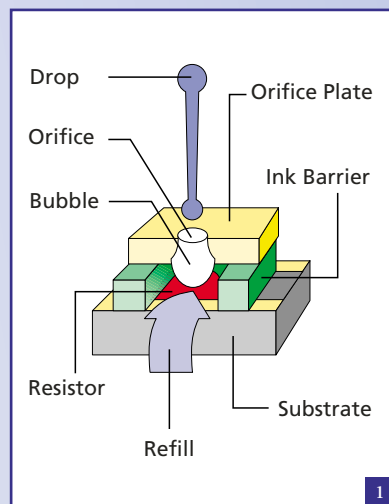


Fig. 2: Diagram of the imaging beam path. The laser light is homogenized and projected into the lens stop via the field lens shown. The high-performance lens demagnifies the illuminated mask and images it telecentrically in the processing plane.

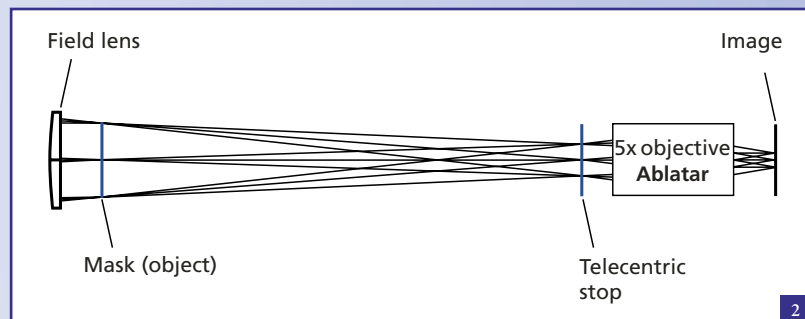
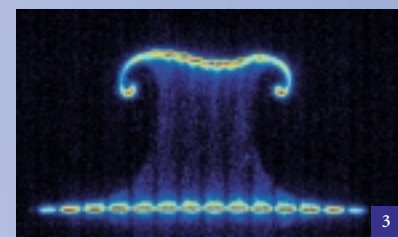
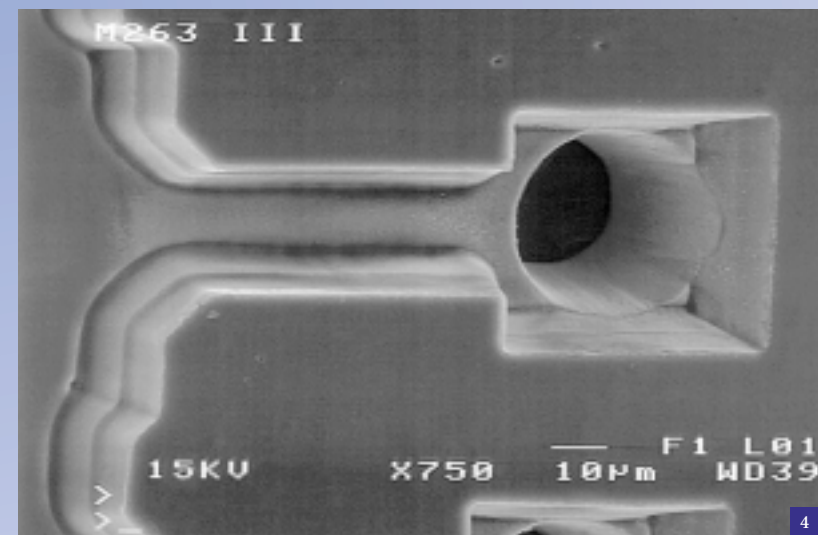


Fig. 3: Fluorescent light of the ablation cloud approx. 5 ms after ablation. The image shows illumination dots measuring approx. 50 µm, and the ablation cloud above them. The camera was positioned from the side.



polymide foil by the factor 5. This increases the mask intensity on the transparency 25-fold and creates an intensity or energy density of approx. 600 to 800 mJ/cm² (20 ns pulse length). The images of the mask openings on the polymide result in the ablation of the material in layers by approx. 0.2 µm per pulse (Fig. 3). With approx. 200 to 300 pulses, precise drilled holes are created in this way. Their diameters lie between 20 and 50 µm. A finished jet plate (Fig. 4) is 50 µm thick and displays a hole array which is approx. 12 to 15 mm long. During the production procedure, these drilled foils are subsequently mounted on inkjet cartridges.



in short

Specifications of the Ablatar lens 1 : 5/ 0.13/ 248/ 546.

Demagnification:	5x
Transfer length:	800 mm
Numeric aperture:	0.13, diffraction-limited
Telecentricity:	< 0.5° at the edge of the image field
Image field:	18 mm



Fig. 4: Photo of a single nozzle and the ink chamber of a Lexmark 12A1970 ink cartridge taken with a scanning electron microscope (photo courtesy of Lexmark Inc., Lexington, USA).