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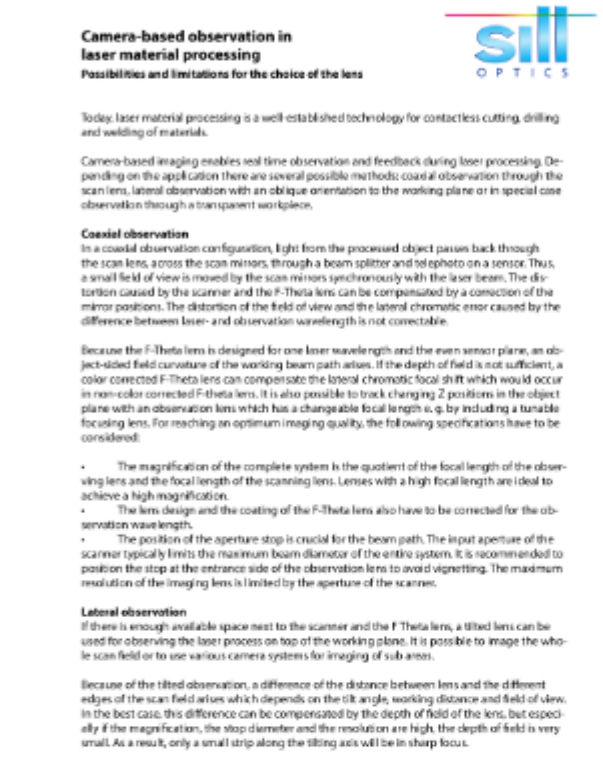

Camera-based observation in laser material processing
Possibilities and limitations for the choice of the lens

Today, laser material processing is a well-established technology for contactless cutting, drilling and welding of materials.

Camera-based imaging enables real time observation and feedback during laser processing. Depending on the application there are several possible methods: coaxial observation through the scan lens, lateral observation with an oblique orientation to the working plane or in special case observation through a transparent workpiece.

Coaxial observation
In a coaxial observation configuration, light from the processed object passes back through the scan lens, across the scan mirrors, through a beam splitter and telephoto on a sensor. Thus, a small field of view is moved by the scan mirrors synchronously with the laser beam. The distortion caused by the scanner and the F-Theta lens can be compensated by a correction of the mirror positions. The distortion of the field of view and the lateral chromatic error caused by the difference between laser- and observation wavelength is not correctable.

Because the F-Theta lens is designed for one laser wavelength and the even sensor plane, an object-sided field curvature of the working beam path arises. If the depth of field is not sufficient, a color corrected F-Theta lens can compensate the lateral chromatic focal shift which would occur in non-color corrected F-theta lens. It is also possible to track changing Z positions in the object plane with an observation lens which has a changeable focal length e. g. by including a tunable focusing lens. For reaching an optimum imaging quality, the following specifications have to be considered:

- The magnification of the complete system is the quotient of the focal length of the observing lens and the focal length of the scanning lens. Lenses with a high focal length are ideal to achieve a high magnification.
- The lens design and the coating of the F-Theta lens also have to be corrected for the observation wavelength.
- The position of the aperture stop is crucial for the beam path. The input aperture of the scanner typically limits the maximum beam diameter of the entire system. It is recommended to position the stop at the entrance side of the observation lens to avoid vignetting. The maximum resolution of the imaging lens is limited by the aperture of the scanner.

Lateral observation
If there is enough available space next to the scanner and the F-Theta lens, a tilted lens can be used for observing the laser process on top of the working plane. It is possible to image the whole scan field or to use various camera systems for imaging of sub areas.

Because of the tilted observation, a difference of the distance between lens and the different edges of the scan field arises which depends on the tilt angle, working distance and field of view. In the best case, this difference can be compensated by the depth of field of the lens, but especially if the magnification, the stop diameter and the resolution are high, the depth of field is very small. As a result, only a small strip along the tilting axis will be in sharp focus.

Camera-based Observation in Laser Material Processing

Camera-based imaging enables real time observation and feedback during laser processing. This paper gives you an overview about several methods of camera-based observation to find the best solution for your application.

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