Beam diameter measurement of mid-infrared lasers using semiconductor image sensor

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Mid-infrared lasers are widely used in material processing and advanced medicine. In these fields, measurement and control of the laser beam diameter are necessary because the power density of the irradiated laser beam onto the target object is crucial for the quality of processing and the safety of medical treatment. Conventionally, techniques using thermal array detectors, scanning spatial filters, and the observation of burn patterns on acrylic blocks are used for these measurements. However, these methods have drawbacks such as high cost, limited performance for real-time measurement, and toxic fumes during measurement. To address these issues, the NMIJ developed a new principle for measuring the beam diameter of mid-infrared lasers. In this method, the light-receiving surface of the silicon-based semiconductor image sensor is irradiated and spot heated using the mid-infrared laser beam to be measured. The carriers are subsequently excited via the heated spot and compose an image according to the temperature distribution. The ratio between the diameters of the thermally excited carrier distribution and the incident laser beam with a Gaussian distribution becomes constant and independent of the incident beam diameter. Therefore, the arbitrary beam diameter of the incident laser can be calculated by applying a ratio that is preliminarily evaluated for the distribution of thermally excited carriers. On the basis of this principle, we demonstrated a new method of beam diameter measurement for mid-infrared lasers that can solve the problems encountered in conventional methods.

References: T. Numata, *Appl. Phys. Express*, 15, 096502, 2022
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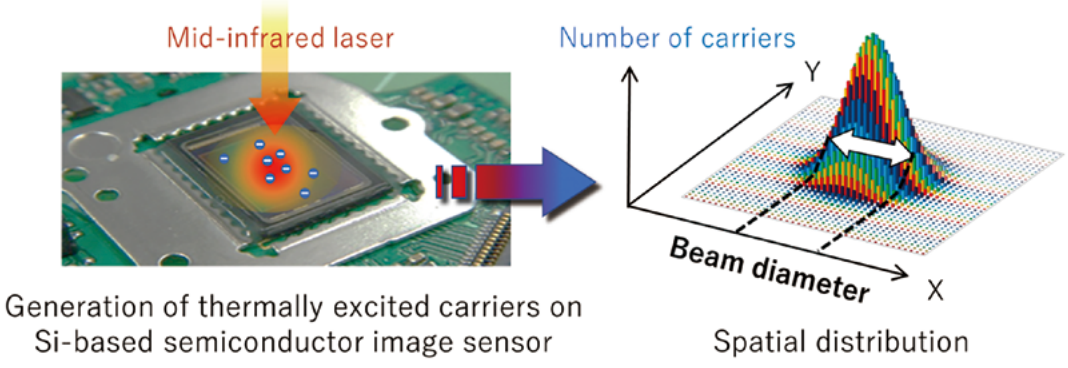

Measurement principle for beam diameter of mid-infrared lasers developed at NMIJ.