Optical angle sensor based on laser autocollimation with a photodiode array and a multi-longitudinal-mode laser

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An attempt has been made in this paper to achieve the wide measuring range of the optical angle sensor based on laser autocollimation while maintaining a high resolution. A new optical head employing a multi-longitudinal mode laser as a laser source and a multi-element PD as a photodetector is designed and developed. Experiments have been carried out to evaluate the basic characteristics of the developed optical head.

In the production of precision instruments, an angle is an important physical quantity that is better to evaluate together with a length, and its importance is increasing, especially in the field of precision engineering (Gao et al., CIRP Ann. Manuf. Technol., 2015). Angle sensors based on laser autocollimation (Ennos et al., Precis. Eng., 1982) can detect angular displacement with high sensitivity by converting the angular displacement of the measurement target into the displacement of a focused light spot on a photodetector. With the employment of a photodiode (PD) as the photodetector, a resolution of 0.001 arc-second has been realized so far (Shimizu et al., Opt. Express, 2016). However, the sensitivity of the sensor strongly depends on the diameter of the focused laser beam on the PD, and there is a trade-off between the sensitivity and the measurement range.

In response to the background described above, an attempt is made in this paper to expand the measurement range of an angle sensor based on the laser autocollimation method by introducing a multi-longitudinal mode laser as a laser source. By projecting the laser beam onto a reflective-type diffraction grating, a group of the first-order diffracted laser beams can be obtained. With the employment of the photodiode array, the first-order diffracted beams can be obtained, while expanding the measurement range compared to a conventional laser autocollimator employing a PD and a single-mode laser source.