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Author Chi-Feng Li
Author's Email Address No Public.
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Abstract
This study develops an innovative nanoscale optical encoder based on two commercially available DVD optical pick-up heads and a grating. Two DVD optical pick-up heads sharing single beam splitter and single objective lens are used so that the laser beam from the two DVD optical pick-up heads can be emitted on the objective lens, so that two laser beams can focus on the surface of the grating to form two laser spots. By adjusting the positions and angles of the two DVD optical pick-up heads, the relative distance of the two laser spots can be equivalent to one quarter of the grating pitch. When the grating moves, the surface profile of the grating can be measure directly, in order to obtain the two quadrature sinusoidal signals. Then by counting the zero crossing of these two quadrature sinusoidal signals and calculating the interpolation value of these two quadrature sinusoidal signals, the moving direction and moving displacement value of the grating can be obtained. The experiments have verified that the optical encoder developed by this study has measurement resolution less than 3 nm (±3σ), and measurement accuracy of 19 nm under the measurement range of 1 mm.

Based on the relationship between the numerical aperture (NA) of the objective lens and scale pitch, this study chooses a suitable Plano-convex lenses available on the market, so as to approximate the diameter of the focusing spots to scale pitch. Also, by using the optical path of an optical encoder similar to the nanoscale, the changes in the surface profile of the scale can be measured directly, so as to obtain the two quadrature sinusoidal signals. By counting the zero crossing of these two quadrature sinusoidal signals and calculating the interpolation value of these two quadrature sinusoidal signals, the moving direction and moving displacement value of the scale can be obtained. The experiments have verified that the optical encoder developed by this study has measurement resolution less than 0.08μm (±3σ), and measurement accuracy of0.2μm under the measurement range of 1cm.
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