【Grant-in-Aid for Scientific Research (S)】

Science and Engineering (Engineering)

Title of Project : Frontier of Precision Optical Metrology Created by the Ultra-Precision Optical Nano-Grid Reference Artifact and the Absolute Optical Scale Comb

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Research Project Number : 15H05759 Researcher Number : 70270816
Research Area : Production engineering, Processing studies
Keyword : Precision positioning, Measurement for machining, Ultra-precision measurement

【Purpose and Background of the Research】

Nanometric-scale measurement accuracy has been achieved with the advances in precision optical metrology based on laser interferometers and so on. Meanwhile, there is an increasing demand for higher accuracy of picometric-scale in big science, space technology, ultra-precision manufacturing, etc. Multi-axis measurement also becomes increasingly important with the progress in multi-functional equipment in industries and medical operations. Multi-axis optical metrology based on a new measurement standard is therefore required to achieve picometric-scale measurement.

The applicants have established a new academic field of precision nanometrology based on multi-axis optical metrology and self-calibration technologies in previous researches. In this research, a highly-stabilized large-area optical nano-grid and a multi-axis absolute optical scale comb will be created to take the initiative in the field of the next-generation picometric-scale precision optical metrology.

【Research Methods】

1. Fabrication of a nano-grid reference artifact

A new two-axis interference lithography setup with a high stability will be designed to fabricate large-area nano-grid resist patterns. By using the resist nano-grid pattern as the mask, an etching process will then be carried out to fabricate the nano-grid on a thermally-stable glass substrate.

2. Self-calibration of the nano-grid

A new calibration method for evaluation of the flatness and pitch deviations of the nano-grid will be proposed. A unique algorithm enables to evaluate both the nano-grid and a reference mirror in the Fizeau interferometer simultaneously.

3. Proposal of the absolute optical scale comb

A new theory of multi-axis absolute optical scale comb that can achieve a measurement accuracy on the order of 10 pm will be proposed based on the nano-grid and the optical frequency comb.

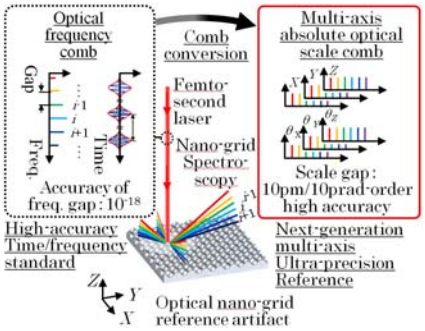

Figure 1 Multi-axis absolute optical scale comb

【Expected Research Achievements and Scientific Significance】

This research is expected to open the door to the next-generation academic field of precision picometrology based on the nano-grid and the optical absolute scale comb. A new portable standard for multi-axis measurement is also expected to be established, which could contribute to the paradigm shift to the new industrial era as represented by the Industry 4.0.

【Publications Relevant to the Project】

・X. Li, W. Gao, et al., A two-axis Lloyd's mirror interferometer for fabrication of two-dimensional diffraction gratings, CIRP Annals-Manufacturing Technology, 63, (2014) 461-464.
・W. Gao, Precision nanometrology: sensors and measuring systems for nonmanufacturing. London: Springer (2010).

【Term of Project】 FY2015-2019

【Budget Allocation】 77,700 Thousand Yen

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