（様式 5）

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学位（博士）論文要旨

(Doctoral thesis abstract)

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論 文 題 目 (Title)	金属ナノ周期構造による光学素子に関する研究 Research on optical element based on periodic metal nanostructure

論文要旨（2000 字程度）
(Abstract(400 words))

Micro-scaled polarization elements are required for integrated optical systems for the use of Laguerre-Gaussian beam converter, optical measurement systems, and holographic optical systems. In this study, micro-scaled metal nanofin arrays for the use of half-wave plates with high conversion efficiency were proposed and demonstrated. Fabricated Au nanofin array shows retardation of 165° and transmittance of ~50% simultaneously at the wavelength of 633 nm. Furthermore, in order to evaluate, micro-scaled Laguerre-Gaussian beam, phase and polarization resolved scanning probe microscopy was proposed and constructed. The optical setup consist of hollow cantilever probe, heterodyne interferometer, confocal optical microscopic setup and polarization beam splitter. Periodic variation of polarization state was observed using this setup.

The metal nanofin array half-wave plate array is expected to be a part of Laguerre-Gaussian beam converter which is used in the high-resolution optical measurement, incident light of plasmonic optical element, integrated optical data storage devices. Vertically integrated multiple optical element can also be realized using proposed polarization elements. Phase and polarization resolved evaluation setup will promote this kind of vertically integrated system.

This thesis consists of 7 chapters.

In the 1st chapter, applications and requirements for micro-scaled polarization elements were shown. For realization of micro-scaled polarization elements, metasurface optical elements were introduced and discussed. The metasurface based on metal grating for the use of 1/2 wave plates was proposed.

In the 2nd chapter, principles of polarization conversion based on the optical propagation among materials were explained. Polarization conversion through the metal waveguide, scattering, and geometric phase were discussed.

In the 3rd chapter, design method of metal nano-grating-based metasurface wave plates was discussed. Transmittance and retardation of nano-gratings were calculated through two calculation method, theoretical model and numerical calculation with Finite-difference time-domain method. From the calculation results, 2 types of nano-structure, “air-gapped” and “embedded ” Au nanofin array with the period of 400 nm were proposed for high conversion efficiency 1/2 wave plates. Transmission characteristics of several kinds of metals and dielectrics were also discussed.

In the 4th chapter, fabrication methods and polarization conversions of air-gapped metal nano-gratings were demonstrated. The nano-coating method was adopted for fabrication of high-aspect-ratio metal gratings. The retardation of 170° and high transmittance reaching 40% at the wavelength of 633 nm for TM polarization were demonstrated for Au nanofin array. Lower transmittance of TE polarization compared with TM polarization was also measured. Retardation generation for ultra-violet wavelength was also demonstrated using Al nano-grating.

In the 5th chapter, fabrication methods and polarization conversion of embedded-type metal nanofin array were demonstrated. Fabricated embedded type Au nanofin array shows retardation of 165° and transmittance of ~50% for both TE and TM polarizations simultaneously at the wavelength of 633 nm. Small dispersion of retardation was also demonstrated. Generation of Laguerre-Gaussian beam was demonstrated through the interferometric measurement.

In the 6th chapter, polarization and phase resolved measurement setup was proposed for the use of evaluation of transmitted light passing from the micro-scaled polarization elements. Distribution of the micro-scaled polarization was obtained.

In the 7th chapter, contents of this thesis were summarized.

（英訳）※和文要旨の場合（400 words）