論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Plasmonic modification of magnetic properties on metal nanostructures
著者(和文)	菊池祐介
Author(English)	Yusuke Kikuchi
出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第11151号, 授与年月日:2019年3月26日, 学位の種別:課程博士, 審査員:田中 拓男,原 正彦,大友 明,一杉 太郎,和田 裕之,三宮 工
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第11151号, Conferred date:2019/3/26, Degree Type:Course doctor, Examiner:,,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	応用化学　系 応用化学　コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　（工学）
学生氏名： Student's Name	菊池　祐介	指導教員（主）： Academic Supervisor(main)	田中　拓男
		指導教員（副）： Academic Supervisor(sub)	

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

This thesis entitled "Plasmonic modification of magnetic properties on metal nanostructures" presents a study of the interaction between the localized surface plasmon excitation and the magnetic properties focusing the magneto-optical Kerr effect and magnetic anisotropy energy. The research of the magneto-plasmonics, a field that merges the concepts from plasmonics and magnetics, has started just one decade ago from the observation of the large magneto-optical effect at the resonant wavelength of surface plasmons. However, there remain suspicion that magneto-optical effect enhancement really comes from the surface plasmon excitation. Moreover, magneto-plasmonics is still in its infancy and there is still much unexplored physics to be discussed. This work's significance is showing the clear evidence of the plasmon excitation-induced magnetic properties modification. First, this work provides a clear evidence that magneto-optical Kerr effect is enhanced by the localized surface plasmon excitation, and demonstrates that plasmon excitation is effective to improve the performance of magneto-optical device. Second, this work gives the first demonstration of surface plasmon modification of the magnetic anisotropy energy in magnetic material. Through the consideration of the possible mechanism, the presence of plasmon-induced magnetocrystalline anisotropy is suggested.

In Chapter 1 "Introduction", the background knowledges of plasmonics and magneto-optics are presented to promote the understanding of contents in this thesis. A review of the current research on magneto-plasmonics is also introduced.

Chapter 2 "Construction of the longitudinal magneto-optical Kerr effect measurement system" presents the theoretical framework and experimental results of magneto-optical Kerr effect. This chapter begins with the explanation of the origin of the magneto-optical effects from the macroscopic view. The discussion moves to how to experimentally evaluate the magneto-optical Kerr effect. Next, theoretical analysis of the L-MOKE activity in Co thin film with different polarized light is carried out. The shaped-induced L-MOKE activity anisotropy is also discussed. In the rectangular-shaped Co nanostructures without plasmon resonance, the L-MOKE activity is almost stable even though the polarization direction of incident light is changed. This makes it possible to conclude that the shape-induced L-MOKE enhancement can be ignored in the fabricated Co nanostructure.

In Chapter 3 "Enhancement of longitudinal magneto-optical Kerr effect in rectangular-shaped Au/Co/Au nanostructure by localized surface plasmon resonance", the work for the relationship between the L-MOKE activity enhancement and the localized surface plasmon (LSP) excitation is

summarized. First, the fabrication procedure of rectangular-shaped Au/Co/Au nanostructures is demonstrated. From the transmission spectrum results of Au/Co/Au nanostructures, the wavelength of the LSP resonance can be tuned by changing the short axis length of rectangular structure. Moreover, the LSP excitation on or off can be switched by changing the polarization direction of incident light. From the evaluation of L-MOKE activity by changing the polarization direction in Au/Co/Au rectangular nanostructures with systematically varied short axis length, the largest L-MOKE activity is shown under the LSP excitation, concluding that it has a clearly relationship between the strong enhancement of L-MOKE activity and the LSP excitation. For the next step, let me evaluate the magneto-optical figure of merit (FOM), which reflects the signal-to-noise ratio of MO signal in magneto-optical devices, to discuss the effectiveness of plasmon excitation for the performance of magneto-optical devices. The resulting that the addition of plasmonic Au layer to Co layer plays an important role for improve not only MO activity but also FOM.

Chapter 4 “In-plane magnetic anisotropy energy increase in Au/Co/Au nanostructure by localized surface plasmon resonance” presents the work for the modification of in-plane magnetic anisotropy energy (K_u) in Au/Co/Au nanostructure by LSP resonance. The evaluation method of magnetization curves in square-shaped Au/Co/Au nanostructures through the L-MOKE and polar magneto-optical Kerr effect (P-MOKE) measurements is explained. From the transmittance spectra results, LSP excitation can be switched by changing the wavelength of incident light. L-MOKE curves and P-MOKE curves in Au/Co/Au nanostructure are shown for both LSP resonant wavelength and off-resonant wavelength. Comparing the saturation fields of P-MOKE and L-MOKE curves, Au/Co/Au nanostructure has a magnetic anisotropy and the easy magnetization axis is parallel to the film plane. The significant increase of saturation field is shown in P-MOKE curves when LSP resonance is excited. Through the estimation of K_u from the P-MOKE and L-MOKE curves, K_u increases because of LSP resonance. Through the discussion of the possible mechanism of K_u increase by LSP resonance from the perspective of the thermal effect on the magnetic anisotropy energy, it is concluded that the magnetocrystalline anisotropy energy modification would play a key role to increase an effective in-plane magnetic anisotropy energy increase by LSP resonance.

Chapter 5 “Summary” gives the summary and conclusions in this thesis.