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論文 / 著書情報
Article / Book Information

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著者(和文)	Rahul Kumar
Author(English)	Rahul Kumar
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種別(和文)	論文要旨
Type(English)	Summary

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（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	Electrical and Electronics Engineering 系 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of (Engineering)
学生氏名： Student's Name	RAHUL KUMAR	指導教員（主）： Academic Supervisor(main)	KOTARO KAJIKAWA
		指導教員（副）： Academic Supervisor(sub)	

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

Recently there is a huge growth in the research areas related to metamaterials, as by using them we can achieve extraordinary properties which are not present in naturally found materials. Various kinds of metamaterials have shown numerous exotic properties and practical applications in the different areas of physics. One such class of metamaterials named as hyperbolic metamaterials (HMM), shows hyperbolic dispersion of light waves and supports the unusual enlargement of wavenumbers. HMM provide strong field confinement and enhancement, as well as an increment in the photonic density of states, and have recently attracted much attention for applications in nano-photonics. HMM can be realized by several structures, such as periodic metal-dielectric multilayers, plasmonic nanorod arrays etc. One of the other possible structures is cylindrical HMM (CHMM), exhibiting strong anisotropy due to the hyperbolic dispersion. In this thesis, we show that using such HMM structures we can achieve extra-ordinary scattering and absorption of light, with potential applications in different areas of nano-photonics.

Usually, an effective-medium approximation (EMA) is employed to simplify the HMM structure and understand its optical properties. However, it has been found that even though the EMA is able to qualitatively express the properties of HMMs, it occasionally shows significant discrepancies due to the neglect of some microscopic effects. Initially in this thesis, we did a comparative analysis of the accuracy of the two different EMA models for estimating the scattering property of CHMMs in different configurations. We established that cylindrical EMA model is comparatively better than planar EMA model.

Further, we focused on the phenomena of superscattering (SSc) obtained from CHMMs. We show that CHMMs consisting of practical materials and epsilon near zero materials, can be designed to exhibit SSc phenomenon in the visible region. By using FDTD simulation analysis we confirm the presence of whispering gallery like resonance modes at the SSc conditions. We achieved up-to 2-fold and 4-fold enhancement in the scattering performance by using CHMM consisting of practical and ENZ materials, respectively. Such superscatterers can have significant practical applications in sensing, spectroscopy, bio-medical imaging and other applications that need efficient manipulation of scattering of light.

For the next objective, we analysed the light absorption properties of CHMM. We employed an optimization scheme based on machine learning using neural networks (NN). We found that by using the trained NN, we can do fast and accurate approximation and optimization of the CHMM for desired optical property. Through this approach, we obtained optimized CHMM structures showing enhanced absorption property with up-to 5-fold enhancement, which can have potential applications in energy harvesting.

Finally, we propose that such CHMM structures can be fabricated using atomic layer deposition, customized thermal evaporation, electro-chemical deposition etc. Experimental characterization of such structures can be possible by using dark-field microscopy, cathodoluminescence based spectroscopy and other techniques.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).
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