論文 / 著書情報
Article / Book Information

題目(和文)	ナノスケール材料の光学的および光物理的特性における表面プラズモンポラリトンの影響の研究
Title(English)	Study of the effect of surface plasmon polariton on optical and photophysical properties of nanoscale materials
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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12863号, 授与年月日:2024年9月20日, 学位の種別:課程博士, 審査員:VACHA MARTIN,三宮 工,早水 裕平,相良 剛光,金子 哲
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第12863号, Conferred date:2024/9/20, 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	材料 系 材料 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	Qiwen TAN	審査員主査： Chief Examiner	Martin VACHA

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

In this thesis, we investigated the influence of surface plasmon polaritons (SPPs) on the optical and photophysical properties of various nanoscale materials. The research was divided into three distinct projects, each focusing on different aspects of SPP interactions with nanomaterials. The key findings from these projects are summarized below.
In the chapter 2, we explored the interaction between CdSe/ZnS core-shell quantum dots and surface plasmon polaritons generated on gold nanohole arrays. Our results demonstrated that the presence of SPPs significantly enhances the photoluminescence (PL) of quantum dots at both ensemble and single-particle levels. Through 3D FDTD simulations, we observed an average absorption enhancement of 3.19 and 2.81 times, depending on the sample structure. Experimental measurements further revealed that the total PL enhancement from the quantum dots, attributed to SPPs, averaged 4.7 and 4.58 times, indicating a notable difference between absorption and emission enhancements. This discrepancy is attributed to pure emission enhancement, which underscores the coupling between excitons in quantum dots and SPPs.
Chapter 3 demonstrated the fabrication of supramolecular nanofibers through the self-assembly of tris(phenylisoxazolyl)benzene molecules. These nanofibers functioned as optical waveguides, with the larger diameter fibers showing notable fluorescence guidance when excited by a focused laser. The deposition of these nanofibers on gold nanohole arrays resulted in significant leakage of the waveguided light, with spectra matching the resonance wavelength of SPPs. We proposed that the observed phenomena were due to the excitation of SPPs via the waveguide's evanescent field or the direct enhancement of leakage by the modified density of states near the plasmonic substrate.
In the chapter 4, we investigated exciton diffusion in supramolecular nanofibers self-assembled from a complex bis(benzamide) molecule. Our experiments demonstrated that these nanofibers, when deposited on both flat gold and gold nanohole arrays, exhibit an exciton diffusion length exceeding 400 nm. Notably, nanofibers aligned with the direction of the nanoholes on the arrays showed a maximum exciton diffusion length of 1100 nm. This extended diffusion length indicates that SPPs enhance the efficiency of Förster energy transfer between nanofiber monomers, thus promoting exciton diffusion within the nanofibers.
The findings from these three projects collectively highlight the significant role of surface plasmon polaritons in enhancing the optical and photophysical properties of nanoscale materials. The interaction between SPPs and quantum dots leads to substantial photoluminescence enhancement, while in supramolecular nanofibers, SPPs facilitate optical waveguiding and extend exciton diffusion lengths through enhanced Förster energy transfer. The findings in the thesis contribute to our understanding of plasmon-nanomaterial interactions and open up new possibilities for designing advanced photonic and optoelectronic devices. Future research could further explore the mechanisms underlying these enhancements and investigate the potential applications of these findings in areas such as light-harvesting and sensing.
Overall, this thesis demonstrates that surface plasmon polaritons can play a crucial role in enhancing the properties of nanoscale materials. This could lead to exciting new developments in nanotechnology and materials science.