平成 29 年 3 月 13 日

応用物理学会北海道支部
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応用物理学会北海道支部

講演会のお知らせ

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演題：Towards plasmon-enhanced linear and non-linear quantum elements
講師：Oliver Benson 氏
　　（フンボルト大学・教授）
日時：平成 29 年 3 月 30 日（木）　9:30〜10:20
場所：電子科学研究所 １階 セミナー室 1-2
共催：応用物理学会北海道支部　（共催団体：電子科学研究所）

講演の要旨

Surface plasmon polaritons, or in brief 'plasmons', can confine the electromagnetic field much more tightly than it is possible with purely dielectric structures. Thereby, a very strong coupling of the electromagnetic field and matter can be realized. On the fundamental level even single emitters such as atoms, molecules or quantum dots can control the transmission of light rendering quantum non-linear elements [1] possible. Critical dimensions of architectures for such elements are in the nanometer range [2]. In addition, plasmonic structures will inevitably introduce loss, which has to be minimized or compensated. For this reason precise fabrication, assembly, and characterization of the emitters as well as of the plasmonic structure is crucial for predicting the performance of plasmonic elements.

We first discuss a plasmonic-dielectric structure where a single emitter, in our case a single organic DBT molecule, shall be coupled to a plasmonic waveguide. The structure, resembling the single photon transistor according to the design by Chang et al. [1], also includes a grating coupler and a dielectric-plasmonic transducer. In this way an efficient coupling of free-space light to plasmons is possible. We precisely describe fabrication and characterization of the fabricated chip. We find very good agreement with rigorous numerical simulations [3]. Based on these findings we perform a numerical optimization and calculate concrete numbers for the performance of a realistic structure.

Another part of the talk concerns novel plasmonic material for enhanced photon collection and formation of plasmon-hybrid particles. The approach relies on growth of heavily doped semiconductor oxides [4]. Based on this material platform layered structures with 'tailored' metals and dielectrics can be fabricated. As an example we report on realization of hyperbolic metamaterials operating at near- and midinfrared frequencies using Ga-doped ZnO and Sn-doped In2O3 as metallic component [5]. The hyperbolic dispersion manifests by occurrence of negative refraction and propagation of light with wave vector values exceeding that of free-space. Control of the doping level allows for systematic adjustment of the frequency range with hyperbolic dispersion from the mid-infrared up to almost one micrometer. When coupling single photon emitters to hyperbolic metamaterials, ideally embedded into them, a dramatic enhancement of spontaneous emission is expected. We discuss experiments in this direction.

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