Controlling Single-Photon Emission with Ultrathin Transdimensional Plasmonic Films

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Properties of a two-level quantum dipole emitter (DE) near an ultrathin transdimensional (TD) plasmonic film are studied theoretically [1]. TD quantum materials are ultrathin films of precisely controlled thickness, films made of finite number of monolayers—a regime that is neither 3D nor 2D but rather something in between, turning into 2D as thickness tends to zero, challenging to study what the 3D-to-2D continuous transition has to offer to improve material functionalities [2]. Such materials offer high tailorability of their electronic and optical properties not only by altering their chemical and/or electronic composition (stoichiometry, doping) but also by merely varying their thickness (number of monolayers) [3-5].

Using realistic experimental parameters, the spontaneous and stimulated emission intensity profiles are computed as functions of the excitation frequency and film thickness, followed by the analysis of second-order photon correlations to explore the photon antibunching effect [1]. It is shown that TD plasmonic films can greatly improve photon antibunching with thickness reduction, allowing one to control the quantum properties of light and make them more pronounced. The theoretical predictions can be tested in experiments similar to those reported recently for epitaxial TiN films with thicknesses below 10 nm grown on MgO substrates and covered with an AlScN passivation layer [4], with nanodiamond NV-centers as DEs deposited right on the varied-thickness passivation layer.

Knowledge of the features reported is advantageous for the room-temperature solid-state single-photon source device engineering and in general for quantum information application development with TD nanomaterials.

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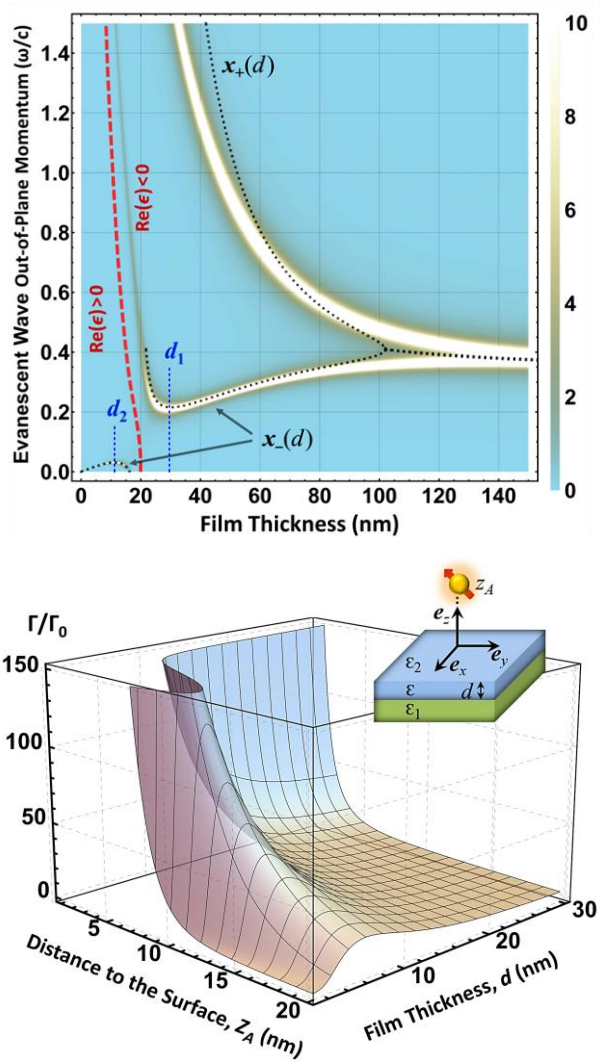

Fig.1. (Top) Plasma mode distribution as a function of TD film thickness (derived from *p*-evanescent wave reflection coefficient for TiN slab [5]). (Bottom) Spontaneous emission rate relative to vacuum (averaged over three dipole orientations) for the DE coupled to the modes shown on top, as a function of the film thickness and DE position near the film surface where the evanescent contribution to the spontaneous emission is dominant.

References

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