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# Quantitative Evaluation of Efficiency of Surface Plasmon Excitation with Grating-Assisted Metallic Nanoantenna

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**Abstract :** This work deals with background signal suppression in tip-enhanced near-field optical microscopy (TENOM). The background appears because an optical signal is detected not only from the subwavelength area beneath the tip but also from a wider diffraction-limited area of laser’s waist that might contain another substance. The background can be reduced by using a taper probe with a grating on its lateral surface where an external illumination causes surface plasmon excitation. It requires the grating with parameters perfectly matched with a given incident light for effective light coupling. This work is devoted to an analysis of the light-grating coupling and a quest of grating parameters to enhance a near-field light beneath the tip apex. The aim of this work is to find the figure of merit of plasmon excitation depending on grating period and location of grating in respect to the apex. In our consideration the metallic grating on the lateral surface of the tapered plasmonic probe is illuminated by a plane wave, the electric field is perpendicular to the sample surface. Theoretical model of efficiency of plasmon excitation and propagation toward the apex is tested by fdtd-based numerical simulation. An electric field of the incident light is enhanced on the grating by every single slit due to lightning rod effect. Hence, grating causes amplitude and phase modulation of the incident field in various ways depending on geometry and material of grating. The phase-modulating grating on the probe is a sort of metasurface that provides manipulation by spatial frequencies of the incident field. The spatial frequency-dependent electric field is found from the angular spectrum decomposition. If one of the components satisfies the phase-matching condition then one can readily calculate the figure of merit of plasmon excitation, defined as a ratio of the intensities of the surface mode and the incident light. During propagation towards the apex, surface wave undergoes losses in probe material, radiation losses, and mode compression. There is an optimal location of the grating in respect to the apex. One finds the value by matching quadratic law of mode compression and the exponential law of light extinction. Finally, performed theoretical analysis and numerical simulations of plasmon excitation demonstrate that various surface waves can be effectively excited by using the overtones of a period of the grating or by phase modulation of the incident field. The gratings with such periods are easy to fabricate. Tapered probe with the grating effectively enhances and localizes the incident field at the sample.

**Keywords :** angular spectrum decomposition, efficiency, grating, surface plasmon, taper nanoantenna
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