FEASIBILITY INVESTIGATION OF ITERATIVE OPTO-THERMAL ANALYSIS USING SCANNING PROBE MICROSCOPY

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Scanning probe microscopy (SPM) can be used to acquire surface morphology and near-field topological maps of nanostructures. Under momentum-matching conditions, surface plasmon may be formed and localized to induce intense electromagnetic fields that can be used for sensing and imaging applications. However, absorption in metal may cause thermal issues that affect morphology of metal structures, refractive indices of surrounding medium, and also weaken plasmonic effects. In this study, we report use of SPM for measuring opto-thermal responses of plasmonic nanostructures and feasibility of iterative opto-thermal analysis [1]. We have integrated probe scanning module with an inverted microscope to measure optical and thermal response of plasmonic nanostructures. An inverted microscope consists of optical elements combined with an angle-sweeping module to modulate parameters of incident light, such as wavelength, polarization, and incident angle. We have also prepared various plasmonic nanostructures to measure opto-thermal responses and compared with theoretical results based on iterative opto-thermal analysis (IOTA). The IOTA conducted by COMSOL Multiphysics^{TM} is a method in which calculation is performed iteratively in order to account for the index changes induced by plasmonic heating, thereby provides more accurate results than conventional photothermal simulation. We have calculated opto-thermal response of 50 nm gold thin film using IOTA. Figure 1 shows temperature and electric field intensity of gold thin film at incident wavelength λ = 532 nm. Temperature spectrum is different from electric field intensity due to the momentum mismatch. The differences were verified using SPM experimentally. It is expected that the IOTA allows calculation of opto-thermal response with practical accuracy for a wide range of thermoplasmonic applications.

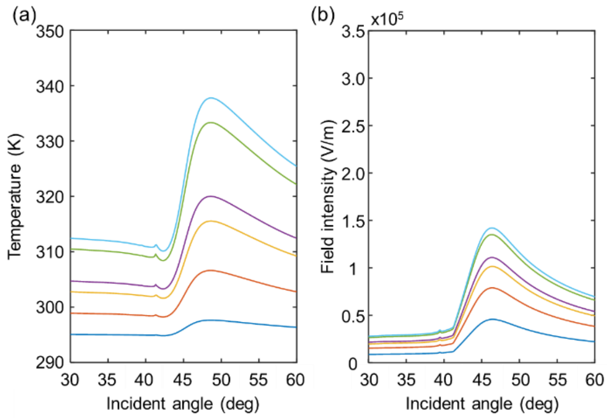

Figure 1 IOTA results: (a) temperature (b) electric field intensity obtained on 50-nm thick gold thin film at λ = 532 nm.

[1] A. Alabastri, A. Toma, M. Malerba, F. De Angelis and R. Proietti Zaccaria, “High Temperature Nanoplasmonics: The Key Role of Nonlinear Effects,” *ACS Photonics* **2**, pp. 115-120 (2015).