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Special Issue of the Journal NanoBiotechnology "Physical Methods of Nanophotonics"

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A sharp metal tip, or conducting nanoparticles, can concentrate light and electric field. This is a primary method by which photonics systems can be adapted for characterization and fabrication at the nanoscale: nanophotonics. In the process of confining the light, new processes have been identified, and novel schemes for enhancing the effects have been invented. Our understanding and ability to manipulate light and therefore materials at the nanoscale is now blossoming and is of great interest to a variety of disciplines. Our goal with this special issue is to present the current state of understanding, key insights that permit a qualitative grasp of the phenomena, and recent ideas to improve the localization and signal level. As the number of molecules sampled decreases, as it must for increased resolution, the signal level is also reduced. One of the most important realizations in this field to date is that it is possible to obtain sufficient enhancement that measurements are still possible.

The articles in this issue can be broadly categorized as theoretical modeling, experimental characterization, or fabrication, although there is, and must be, an interplay between these in all the papers. In the theoretical paper by Tsukerman, Cajko, and Dai, the power of state of the art calculation methods for designing nanoscale optical concentrators is illustrated, and the plasmon that underlies much of the novel capabilities makes its appearance. Such advances are key to attaining measurable signal levels from small volumes. The paper by Dhawan, Gerhold, and Vo-Dinh describes the fabrication (and modeling) of nanotip arrays, in this case for surface-enhanced Raman use. Raman spectroscopy is one of the most powerful optical techniques for identifying species, for measuring stress or confinement, and for quantitative analysis. It is therefore not surprising that it is used as a demonstration vehicle for nanoscale studies. The paper by Neacsu, Berweger, and Raschke show how it can be taken to the limit of single molecule Raman, by the use of tip-enhanced illumination. The paper by Hallen describes the plasmon effects in the detection (rather than illumination) part of the process. This caps our understanding of the various differences between nano-Raman and far-field Raman, mostly due to the presence of the tip, which have been measured over the past 15 or so years. The other commonly used optical technique is fluorescence. The paper by Cade, Culfaz, Eligal, Ritman-Meer, Huang, Festy, and Richards describes the current capabilities available for this technique at the nanoscale, again tied to modeling studies so that an understanding of the processes is possible. The other two papers describe some of the most interesting efforts currently underway to fabricate nanoscale materials in a controlled fashion. Myhra uses tip-induced local anodic oxidation as a means to modify or etch nanoscale patterns into a surface, and Leggett describes how self-assembled monolayers can be used or modified with the optical fields of a sharp tip to produce patterns for their own use or as templates for further growth.

The breadth and capabilities described in this special issue show the vitality of activities in nanophotonics. The amazing achievements to date are harbingers of the applications that will be developed over the next several years.

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