Molecular imaging with scanning near-field apertureless microscopy

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Direct molecular imaging has a great deal of appeal for the detection and characterization of complex molecules such as extended DNA strands and proteins. Most of the methods to date have required either a large number of molecules (such as gene sequencing) or have measured the structural features of a single molecule (such as AFM). One technique that would give both structural and chemical information for a single molecule would be very useful. We have been studying just such a technique. This new optical imaging technique is based on perturbing a laser spot with an AFM tip. Ultimate sensitivities approaching 1Å are believed to be possible. Specifically, the near field signal depends on the polarization of the source, the local susceptibility of the sample, and the resolution is not limited by the illuminating wavelength. Yet, the precise nature of this technique is still under discussion with a major ongoing effort to determine the nature of the imaging process and the overall usefulness of the technique. Hence, we are concentrating our first efforts to determine the range of usefulness of the technique. We report on apertureless near-field optical imaging and discrimination of nanosphere fluorescent size standards. We have recently demonstrated the discrimination of optical properties below the diffraction limit using a mix of dyed and undyed 50nm diameter nanospheres. A FWHM measure of the current optical resolution of our instrument is 15nm with 3nm minimum feature sizes. We have subsequently extended the applicability of this technique to biological samples and have observed the near field optical structure of polytene chromosomes. We also report simulations of the imaging process based on a dipole coupling model that support our experimental observations. Based on our experimental and theoretical understanding we believe that the extension of this technique to molecular scale imaging and spectroscopy is not only possible but also feasible in the near future. The subsequent imaging and identification of single molecules will have profound applications in molecular recognition and drug discovery.