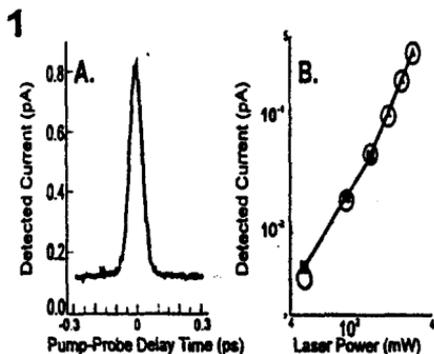

Correlated femtosecond optical spectroscopy and scanning probe microscopy

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An improved understanding of localized surface mediated reactivity would benefit from dynamical studies.¹ Toward this end, a new experimental technique for obtaining simultaneous spatial and temporal resolution of optically initiated dynamics at interfaces is presented. The method, based on the integration



QFD2 Fig. 1 (a) Time-resolved photoinduced SPM detected MPI signal. (b) Power dependence of MPI mechanism, open circles, with quadratic fit, line with solid squares, and cubic fit, line with solid triangles.

pable of spatial localization of optically induced phenomenon at interfaces. FOS-SPM has been shown to be capable of identifying and differentiating between different optoelectronic mechanisms, specifically multiphoton ionization (MPI) and optical rectification.² Recent results on the application of correlated FOS-SPM to study localized surface reactivity are presented here.

MPI from a thin (~50 nm), vacuum-deposited Ag film has been detected as a photoinduced current through the variably biased STM.² The bias dependence of the MPI signal is highly asymmetric; signal is only obtained when the surface (tip) is negatively (positively) biased, consistent with electrons being drawn more effectively to the tip when the appropriate bias is applied. The temporal profile of this signal, shown in Fig. 1a, is found to be pulse width limited, in agreement with previous studies.³ The power dependence of the MPI signal, shown in Fig. 1b, reveals a two-photon mechanism at lower powers and a three-photon mechanism at higher powers. This result is interpreted as indicating that there are a range of ionization thresholds across the different surface sites. Thus, those sites with what is effectively a lower work function or larger localized surface plasmon field⁴ may be considered as being more reactive for photoinduced process.

The correlation between surface structure and photoinduced reactivity (i.e., ionization) has been measured. SPM images of the photoinduced signal and the surface topography of an Ag film are shown in Fig. 2. The photoinduced image, shown as a contour plot overlaid on the top half of Fig. 2, highlights a correlation between the edges of topographical features and an enhancement in the photoinduced signal. This image was recorded with the insulated tip within electron tunneling distance from the surface so the photoinduced mechanism may be different than the MPI process of Fig. 1, which is based on free, ionized electrons. The bias dependence, laser power dependence, and time dependence of the signal are being studied at different locations on the surface to clarify the imaging



QFD2 Fig. 2 Simultaneous photoinduced and constant current STM topography on 50-nm Ag film. Photoinduced signal is shown as contour plot overlaid on the top half of the STM image to highlight. Height scale: 10-nm range; from black, 0, to white, 10 nm.

these features. Longer temporal responses at particular surface sites that would result from plasmon scattering and localization⁴ have not yet been conclusive; obtained.

This correlated temporal and spatial imaging establishes the first direct images of surface plasmon-enhanced reactivity on ambient metal films. Correlated measurements of nanometer scale reactivity with structural features will impact the design of optoelectronic and photochemical devices with enhanced efficiency and sensitivity.

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Optically controlled collisions of biological objects

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We have developed a new assay in which we collide two mesoscale particles using two independently controlled optical tweezers (optically controlled collision, OPTCOL). This assay enables precise examination of the probability of adhesion under biologically relevant conditions in which the components of the solution, the relative orientation, the impact parameter, and the relative collision velocity are all under the user's control.

To illustrate the utility of the OPTCOL assay, we studied the inhibition of viral attachment to a cell surface. The binding of influenza virus to its target cell (attachment) is the first