The lenses are placed 1.2 mm center-to-center and have 15 bright zones.

The figure also illustrates the device programming capability. A voltage is applied to the pixels along the diagonals of an 8 × 8 array while the others are grounded. In this experiment a phase device was used, which explains the bright background. An average efficiency of 26% was achieved with the 514 nm line of an argon laser. Amplitude programmable arrays of microlenses have also been fabricated with an average conversion efficiency of about 8%.

As illustrative examples of the applications envisaged with these micro-optic components, we have demonstrated the generation of programmable coherent beam arrays with a two-dimensional arrangement of binary Fresnel micro-lenses.[5] We have also shown their use in an optical cross connect with broadcast capability that can be remotely controlled.

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FEMTOSECOND TECHNOLOGY

SURFACE DYNAMICS ON THE FEMTOSECOND TIME SCALE: A REAL-TIME STUDY OF DESORPTION

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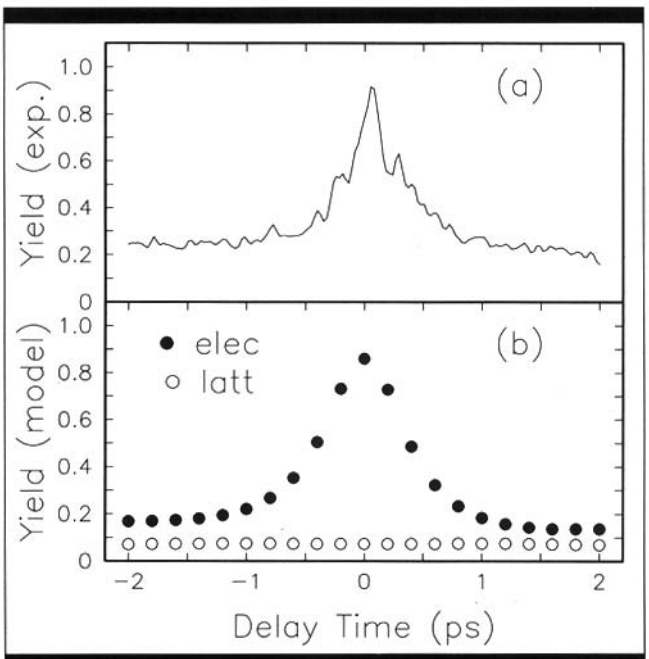
Energy flow between a molecule and a surface is critical in determining the evolution of surface processes such as absorption, desorption, and fragmentation. Energy transfer between an adsorbate and the substrate occurs on a very short time scale, typically in the range of 10^{-15} - 10^{-10} s. Information on these rapid processes has generally been inferred from spectroscopic data. Recently, however, significant progress has been made in probing surface dynamics directly in the time domain. Elegant linear and nonlinear optical techniques have been applied to determine lifetimes[1] and dephasing rates[2] of vibrational excitation in adsorbates.

The nature of energy flow between the substrate and a molecule in the process of leaving the surface—a prototypic surface reaction—has been the object of study by our group.[3,4] Real-time measurements with subpicosecond laser pulses have permitted desorption to be examined on a time scale approaching that of a single molecule-surface vibration.[4] This was accomplished by means of a correlation scheme in which the total desorption yield is determined as a function of the separation between two subpicosecond excitation pulses. Part (a) of the figure displays results for the model system of nitric oxide (NO) molecules adsorbed on a Pd(111) surface.



TWO-PULSE CORRELATION TRACES. THE DESORPTION YIELD IS PLOTTED AS A FUNCTION OF THE TEMPORAL SEPARATION OF THE PULSES. (a) EXPERIMENTAL DATA FOR NO DESORBED FROM Pd(111) BY 400 FS PULSES OF 620 NM RADIATION. (b) MODEL CALCULATION ASSUMING FULL EQUILIBRIUM WITH THE SUBSTRATE ELECTRONIC TEMPERATURE (FILLED SYMBOLS) AND THE LATTICE TEMPERATURE (OPEN SYMBOLS). (AFTER REF. 4).

The width of the correlation trace indicates that the desorption process occurs within 1 ps. This extremely short time scale has important implications for one of the long standing issues concerning molecule-surface interactions: the relative importance of electronic and lattice

excitation on the center-of-mass motion of an adsorbate. Despite theoretical arguments in its favor, compelling experimental evidence for coupling to electronic excitation in thermal processes has been lacking. For the subpicosecond excitation of the present experiment, the electronic degree of freedom of the substrate is effectively decoupled from the photons. This allows the electronic temperature to rise considerably above that of the lattice for an interval of roughly 1 ps.

With a suitable model of the transient electronic and lattice heating, calculations for the correlation trace can be performed. Part (b) shows the expected behavior in the limiting cases where full equilibrium of the molecular motion with either the electronic or the lattice temperatures of the metal is assumed. The experimental data are clearly incompatible with a mechanism based on lattice heating and demonstrate unambiguously the importance of the electronic channel for desorption. Thus, the nonequilibrium excitation created with femtosecond laser pulses permits an experimental discrimination of electron and photon coupling to the motion of an adsorbate. These studies demonstrate the potential of ultrafast optical techniques in elucidating fundamental problems in the field of surface dynamics.

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SELF-MODELOCKING: ULTIMATE SIMPLICITY IN ULTRASHORT PULSE GENERATION

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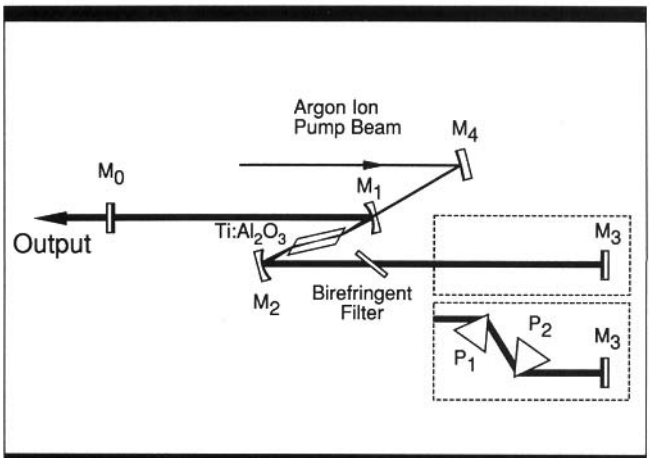
For the past 25 years or so, there have been many sustained research programmes devoted to the study of the techniques by which ultrashort ($\lesssim 10^{-12}$ s) laser pulses can be generated. Whereas spectral purity can be ensured by constraining the laser to operate on a single axial or longitudinal mode of the resonator, the production of picosecond or shorter pulses demands that many longitudinal resonator modes must be precisely locked in phase



SCHEMATIC OF CAVITY ARRANGEMENT OF SELF-MODELOCKED TI:SAPPHIRE LASER. THE INSET SHOWS THE INTRACAVITY PRISM PAIR USED FOR GROUP VELOCITY DISPERSION COMPENSATION (FROM REF. 5).

by a process that is referred to as modelocking.

During the mid to late 1980s, the concept of coupled nonlinear cavities was pioneered by Mollenauer and coworkers through their demonstration of the soliton laser.[1] A more generalized manifestation of this scheme—involving both normal (*i.e.*, non-soliton-supporting) and anomalous dispersion fiber or a semiconductor diode amplifier as the nonlinear element of the coupled cavity—has given rise to the technique called coupled-cavity[2] or additive-pulse[3] modelocking. This has been applied to a wide range of laser types and femtosecond pulse generation has been demonstrated. Although the frequency-tunability offered by broadband gain media can be accessed, the requirement to accurately match the "control" nonlinear cavity to the master cavity adds some unwelcome complexity to the practical arrangements.

The 1990s have already provided a significant and exciting advance to modelocking so that the desirable features of femtosecond pulse durations and uncompromised frequency-tunability can be obtained using a much simplified procedure. This approach, first reported at CLEO® '90 for a titanium-sapphire laser, is described as self-modelocking.[4] This designation was chosen because no components were added to the standard laser cavity for the specific purpose of modelocking. Indeed, using the configuration illustrated in the figure, pulses as short as 3 psec could be