# Section 4
# BRIEF UPDATES

## 4.A Progress Toward Terahertz Electronics

In a recent issue of the LLE Review[1], a novel technique for time-resolving electrical signals with subpicosecond resolution and $\mu$V sensitivity was reported. This technique is based on the inherently fast ($<10^{-15}$s) Pockels effect induced in a traveling-wave electro-optic modulator by the signal under study. The signal-induced birefringence is probed with 100-fs optical pulses. When operated in a "velocity-matching" arrangement, a theoretical limit of 500 fs was achieved. This limit is due to the diameter of the optical-probe beam waist. In the previous result, shown in Fig. 33a (or Fig. 21c of Ref. 1), the signal generated by a photoconductive detector when triggered by a 100-fs optical pulse exhibits double-hump behavior. It was hypothesized that this waveform was a direct consequence of the relatively low TEM cutoff frequency of the traveling-wave modulator. The leading edge of the signal waveform was attributed to the "direct-wave" or TEM field, whereas the second hump was thought to be due to an additional TM wave propagating noncollinearly with the electrodes and consequently arriving at a later time at the sampling point. This time delay was found to be close to the delay calculated for the physical dimensions and effective dielectric constant of the transmission line.

To eliminate the TM wave, we raised the TEM cutoff frequency of the traveling-wave modulator by decreasing the substrate thickness from 250 $\mu$m to 100 $\mu$m. The result is shown in Fig. 33b, where the signal exhibits only the TEM contribution. A small foot is displayed at the leading edge of the step function; this is attributed to electrical

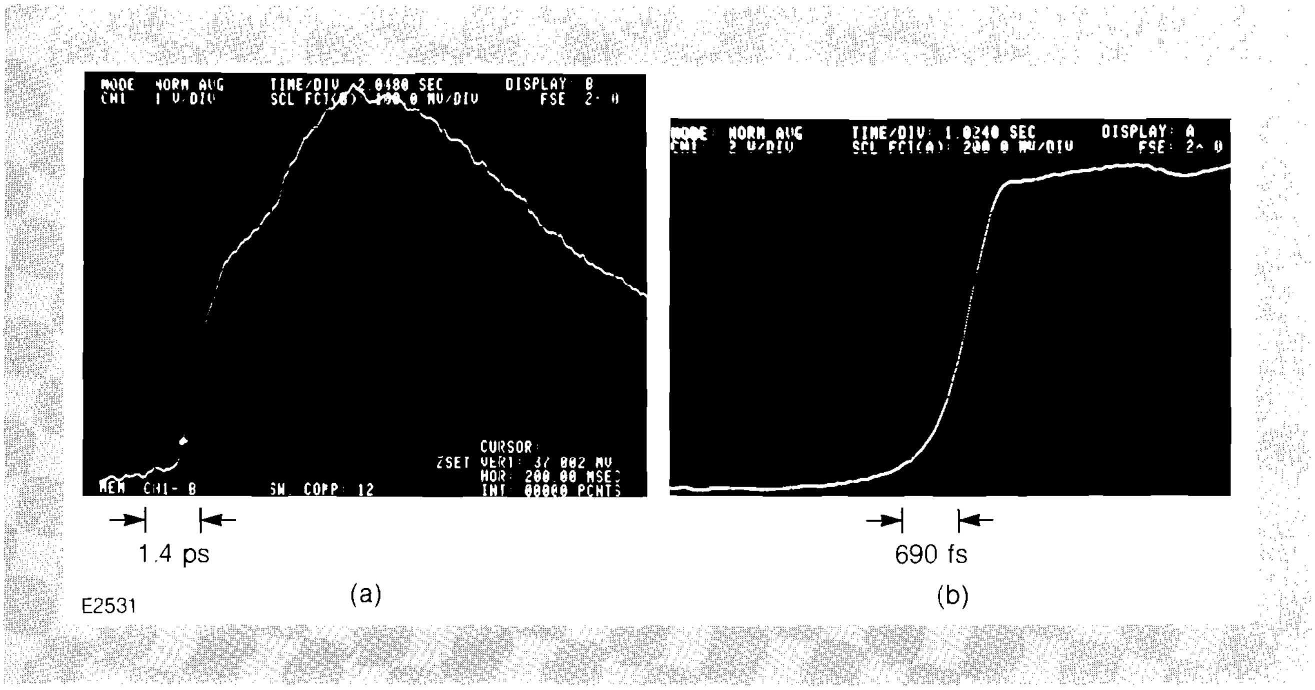


*Fig. 33*
*Response of a Cr-doped GaAs photoconductive detector as measured by a 100-fs focused laser pulse with beam diameter less than 20 μm.*
*a) 250-μm substrate*
*b) 100-μm substrate*

dispersion experienced by the signal as it propagates approximately 100 microns from the source to the sampling point. The fastest slope of the leading edge is indicative of an intrinsic sampling time of 500 fs (10%-90%).

This result shows that electronics with an unprecedented bandwidth of 1 THz can be achieved. It represents an improvement from one to two orders of magnitude over the state of the art in electrical sampling. Consequently, we expect this technique to have profound implications for the study of laser-semiconductor interactions in the propagation of electrical pulses and the characterization of ultra-fast electronic components.

REFERENCES

1. LLE Review **11**, 22 (1982).