# NON INVASIVE ULTRAFAST OPTOELECTRONIC SAMPLING OF GaAs DEVICES

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Abstract

After describing the main characteristics of the electro-optical sampling technique for ultrafast integrated circuits and solid state devices, we discuss the performance of the ultra short pulse laser systems required for the use of this technique. In particular, we briefly describe a new technique for the real time analysis of the stability of this class of lasers.

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Work sponsored by C.N.R. and M.P.I. of Italy

In the last decade, there has been a tremendous development of new integration techniques (Very Large and Ultra Large Scale Integration) accompanied by a shortening of responsivity times very often in the scale of picosecond. As an example, we can remind the devices built by the molecular beam epitaxy technique, for which responsivity times shorter than ten picoseconds have been achieved. This progress is requiring for new characterization techniques which must satisfy different conditions such as: high frequency bandwidth (>1 THz), low interaction with the under test device, good spatial resolution and high sensitivity.

All these requirements can be easily met by using the electro-optical sampling technique (EOST) [1-4] which is completely non destructive, has a sensitivity lower than a milli volt, a frequency bandwidth even larger than ten terahertz and a spatial resolution of the order of one micron.

The basic principle of the EOST is particularly simple. In fact, with reference to Fig.1, the EOST makes use of an ultra short pulse laser system which delivers a polarized beam on the under test device. If the semiconductor material, the device is made of, is electrooptical (e.g. Gallium Arsenide) then the voltage in any given point of the device can be measured through the measurement of the induced rotation of the polarization of the reflected laser beam with respect to that of the incident one.

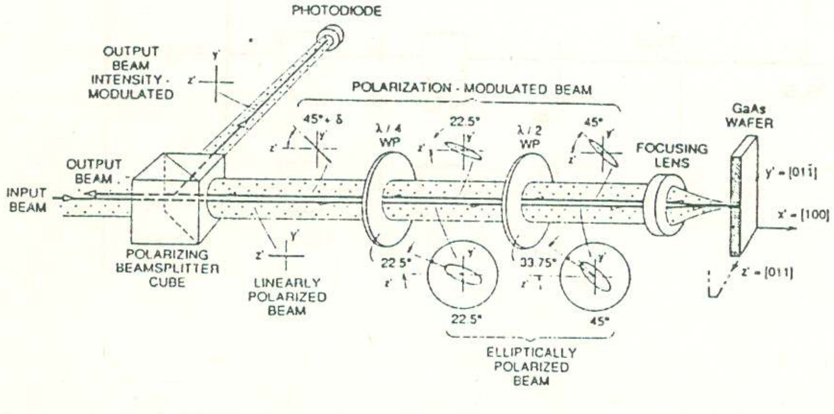


Fig. 1 Schematic of an apparatus for direct sampling of GaAs integrated circuits.

On the other hand, if the device material is not electro optical (e.g. Silicon), then the measurement must be performed by taking advantage on an additional probe made with an electro optical crystal (e.g. Lithium Niobate) and placed very close to the under test device.It is obvious that the sensitivity, in this second case, can be worse than that available in the first case.

Then any voltage signal in any point of an integrated circuit can be easily sampled by the EOST. The sampling frequency is given by the repetition frequency of the laser pulses (of the order of 100MHz up to 1GHz), the time resolution is given by the pulse length (>10 fs), the spatial resolution is fixed by both the wavelength and the beam quality ( for pure $TEM_{00}$ modes is of the order of one micron).

On this line of argument, the full exploitation of this technique is strictly related to the quality of the pulsed laser system. In fact, the pulse length stability can infer the precision by which the fast transients in the under test device can be resolved, possible excitation of higher order transverse modes or mode size fluctuation increase the spatial resolution.

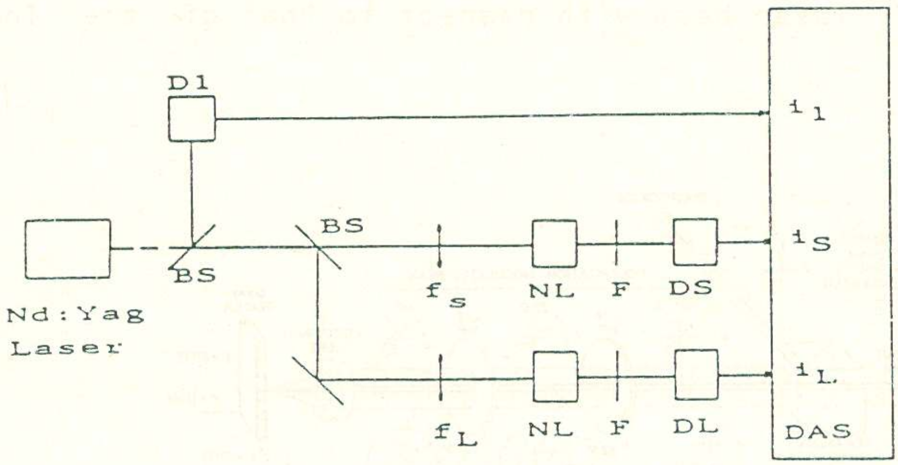


Fig. 2 Schematic of the pulse stability analyzer.The filter F suppresses the first harmonic to make sure that the detectors DS and DL detect only the second harmonic radiation produced in the two nonlinear crystals (NL). S and L refer to the two channels with short ($f_s$) and long ($f_L$) focal length lenses, respectively. DAS means a data acquisition system that by a proper comparison between the three signals allows us to monitor the pulse to pulse fluctuations.

Therefore, the laser source should work only on the fundamental transverse mode and should be characterized by a very small jitter time and a very high repeatibility of the laser pulses. In order to keep all these parameters under control, at the Electronic Dpt. of Napoli, where a short pulse laser system is available, we have designed and successfully tested, in cooperation with Stanford University (CA), a new technique [5-7] to monitor, in real time, the pulse to pulse fluctuations of mode size, pulse length and mode coupling effects (see Fig.2).

As a final remark, we explicitely stress that the technique can be easily used for any pulsed laser system indipendently of the pulse length from milli to femtoseconds [7].

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