Ultra-fast Terahertz Schottky Diode Detector

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***Abstract*—An ultra-fast terahertz Schottky diode detector with a response time less than 20 ps is presented in the paper. The detector allowed us to measure not only the duration of the light pulses in the Novosibirsk terahertz free electron laser (NovoFEL) but also the time structure of these pulses in unstable regimes. This is important for determining the NovoFEL impulse power and for studying and suppressing its different instabilities.**

I. Introduction

The time resolution of light pulses in free electron lasers is very important. This is needed, first of all, for determining the real impulse FEL power. Frequently used calculation of the power by the radiation spectral width is not strongly correct, because this parameter determines only the coherence time in a linear spectral device. In the case of unstable FEL generation this time can be a small part of a full light pulse. Second, in many cases the light pulse structure reflects the type of instability as a result of which this structure appeared. For example, modulation instability causes the sub-structure of the light pulse with the period equal to the so-called slippage length.

Though submicron Schottky diodes operate up to far-infrared frequencies, their signal response time is much larger and depends on the outer parasitic circuit parameters. For this reason in paper [1] we were going to perform the experiments by an interferometric method with a sufficiently slow nonlinear Schottky diode detector [2].

II. Results

Our recent experiments have shown that a specially manufactured Schottky diode detector can have a very shot response time. The detector must be constructed according to the rules of the 50 ohm technique. In particular, the antenna system of the ultra-fast detector is very simple and primitive (Fig.1). A decrease in the detector sensitivity was not so important in our case because the NovoFEL has a very high pulse power. A measured value of volt/watt sensitivity was 30-50 mV/W in the linear regime at a wavelength of 150 μm. A bias of 0.1-1 mA was needed for the detector.

We performed our experiments using a Tektronix 50 GHz sampling oscilloscope. In this case a good pulse to pulse stability is needed. The integral pulse stability was controlled by another slow Schottky diode detector. In many cases this was sufficient because the shape of the light pulse registered by the ultra-fast Schottky detector did not change (Fig.2). In the case of modulation instability only a slightly resolved

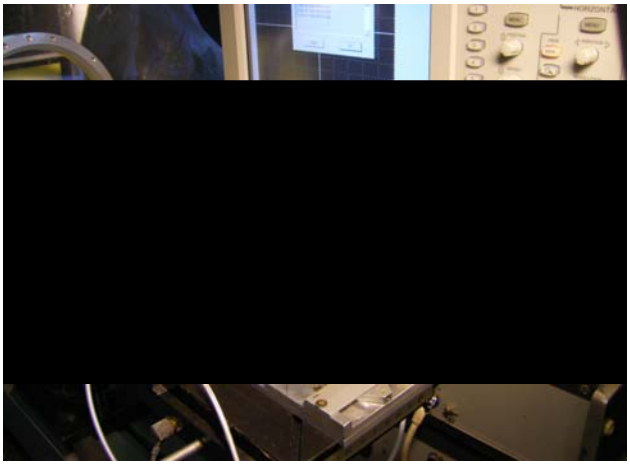

Fig.1. The ultra-fast Schottky diode detector connected to a sampling Tektronix oscilloscope.

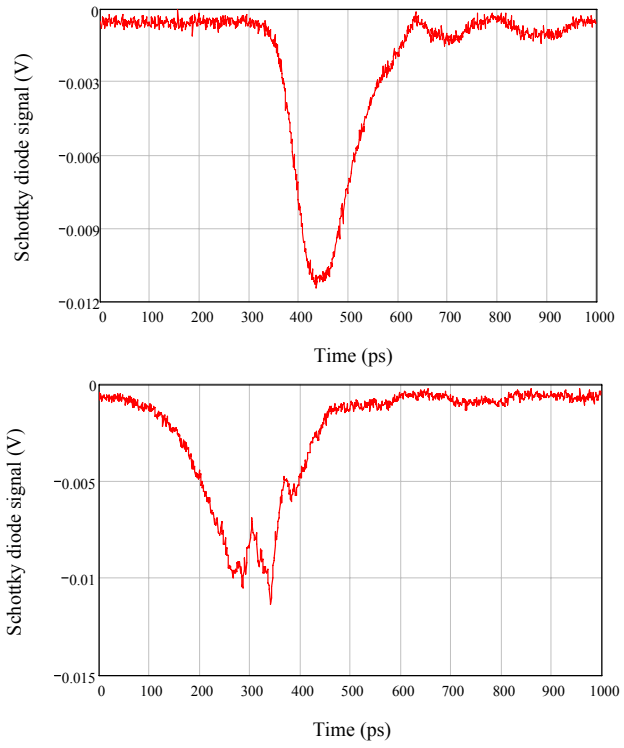

Fig.2. NovoFEL light pulses in stabilized (upper oscillogram) and routine regime without special stabilization (lower oscillogram).

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sub-structure of light pulses was observed due to jitter of sub-pulses from pulse to pulse [3]. Some applications of the ultra-fast detector are presented in [4].

In the near future we are going to observe the light pulse structure more clearly with the help of a direct 30 GHz oscilloscope. In this experiment we plan to measure also the real response time of the ultra-fast Schottky diode detector. Now this parameter is defined as a value less than 20 ps.

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