Development of a Multifunction Prototype for the Carrier Profiling of Semiconductors by Scanning Frequency Comb Microscopy

Mark J. Hagmann, Member, IEEE, NewPath Research L.L.C.

We have described a method to generate a microwave frequency comb (MFC) which has hundreds of measurable harmonics in the tunneling junction of a scanning tunneling microscope with a metal sample electrode [1]. With semiconductor samples the harmonics have an attenuation that varies inversely with the local carrier density at the tunneling junction [2].

A block diagram of the prototype is shown in Fig. 1. Three methods for carrier profiling that are based on the MFC [3], and a fourth method where terahertz radiation is generated within the tunneling junction, are already implemented virtually in the prototype. Parallel and deterministic operation of two or more of these methods with simulations is made possible by basing this system on a field-programmable gate array (FPGA). Thus, different types of information about the semiconductor could be obtained in a fast and efficient manner with optimization and analysis in real time. The unique combination of simulations and measurement tools in a single instrument will facilitate maintenance and debugging as well as the optimization and characterization of each component and the full system. User-friendly LabVIEW software will be used with subpanel and tab control to access and combine the various functions. At present, in the development stage, each component that will later be attached to the FPGA is simulated but the physical parts may be switched in and out with the simulated components.

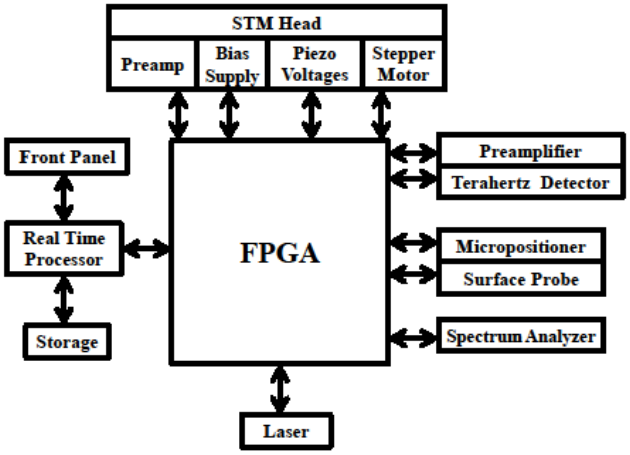

Fig. 1. Block diagram of the prototype.

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References:

1. M.J. Hagmann, F.S. Stenger and D.A Yarotski, "Linewidth of the harmonics in a microwave frequency comb generated by focusing a mode-locked ultrafast laser on a tunneling junction," J. Appl. Phys. 114 (2013) 23107.

2. C. Rhoades, J. Rasmussen, P.H. Bowles, M.J. Hagmann and D.A. Yarotski, "First measurements of a microwave frequency comb with a semiconductor sample in a scanning tunneling microscope," 2016 IEEE Workshop on Microelectronics and Electron Devices, DOI: 10.109/WMED.2016.7458278.

3. M.J. Hagmann, "Inside-out approach for sub-nm resolution carrier profiling in semiconductors," 2016 IEEE Workshop on Microelectronics and Electron Devices, DOI: 10.109/WMED.2016.7458251.

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