Ultra-fast Superconducting THz Detectors based on YBCO and Niobium Nitride

A.Kuzmin[1], A. Schmid[1], J. Raasch[1], S. Wuensch[1] K. Ilin[1] M. Siegel[1],
J.L. Steinmann[2], A.-S. Müller[2]

[1]*Institute for Micro- and Nanoelectronic Systems, Karlsruhe Institute of Technology, Karlsruhe, Germany*
[2] *Laboratory for Applications of Synchrotron Radiation, Karlsruhe Institute of Technology, Karlsruhe, Germany*

Terahertz detectors based on the high-temperature superconductor $YBa_2Cu_3O_{7-x}$ (YBCO) and on ultra-thin niobium nitride (NbN) offer both a high sensitivity and a fast response time. For direct THz detection response times of 16 ps (FWHM) for YBCO and 150 ps for NbN have been demonstrated [1], [2]. A sub-gap THz response relies on the vortex-assisted mechanisms [3]. Detectors work as hot-electron bolometers for the photon energies, which are larger than superconducting gap. The NbN hot-electron bolometers have a significantly higher sensitivity and proofed to be working in high THz region but they are approximately 10 times slower and require 4-K operation temperatures.

An important application, where such unprecedented speed and sensitivity are required, is the single-shot analysis of THz pulses of high repletion rates (10^8 – 10^9 Hz), generated by the electron synchrotrons. In the so-called low-α mode of operation, when the electron bunch length is shorter than the wavelength, the Coherent Synchrotron Radiation (CSR) of very high brilliance is possible. It results in few ps-long, high-intensity, few-cycle electromagnetic pulses. The spectrum of these pulses lies mainly in the 0.1 – 1 THz range. Due to electron-bunch instabilities the characteristics of every pulse could vary due to bursting effect [4]. In order to understand and control this phenomenon one would need to analyse every pulse individually. Low-resolution spectroscopy at few frequency points could shed a light on bursting effects. We present results of our efforts to build frequency selective few-pixel arrays of the ultra-fast YBCO and NbN detectors for the analysis of THz CSR.

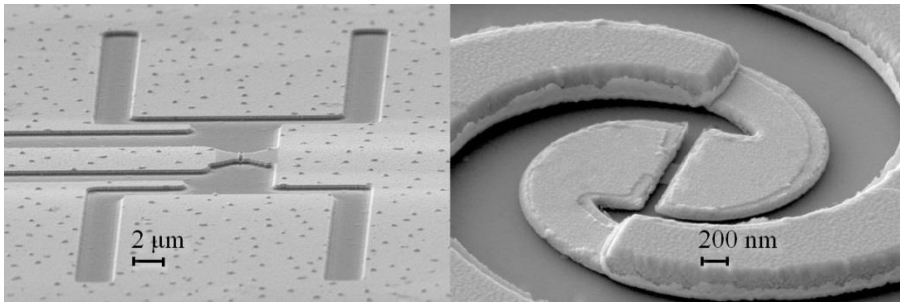

Fig.1. (left) SEM picture of an ultra-fast YBCO detector coupled with planar antenna; (right) SEM picture of an ultra-fast NbN detector with broadband log-spiral antenna for 1 - 6 THz range.

References

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