Ultrasensitive marker-free biomolecular THz-detection for tumor related analytics: PCR-free sensitivity, biomolecular extension and biological relevance

Genomics and proteomics hold promise to revolutionize future health care, targeting profound novel visions like predictive, preventive and personalized medicine. The enormous advance in these fields is closely coupled to the development of powerful, reliable and efficient methods to detect, identify and analyze biomolecules and their complex interaction networks. In the last decades techniques have continuously improved, providing a plethora of information for biomolecular function. Current progress is changing from "observing" dependencies, towards "understanding" mechanisms in their full interaction network. This modification, together with analytic limitations of existing detection methods, clearly indicate that new analytic tools with enhanced capabilities need to be developed.

THz technologies have demonstrated a huge potential to investigate and detect biomolecular systems, as macromolecular modes and biomolecular interactions are resonant in this frequency range. This is paving the path to label-free bioanalytic sensing. The goal of this project is the fundamental expansion of biomolecular sensing with electromagnetic (EM) radiation in the THz frequency range. Herein, three aspects are of primary interest:

- Sensitivity enhancement by 2 to 3 orders of magnitude towards PCR-free direct genetic detection and identification in human samples,
- Extension of the existing label-free sensing application from DNA sensing to RNA, DNA-protein and protein-protein interactions,
- Detailed evaluation of the quantification capability and biological relevance of THz analyses.

This activity sets upon previous label-free THz DNA activities which have already enhanced sensitivity by 8 orders of magnitude down to a wold-wide unsurpassed sub-femtomol detection level.

In order to focus this research activity and validate the application relevance of these developments, all analysis will concentrate on tumor related biomolecular sensing applications. Especially in this field, it is becoming increasingly clear, that the traditional scientific approach attempting to reduce cellular function to individual components (e.g. biomarkers) and signal transduction pathways is insufficient. It is nowadays increasingly evident that the behavior of biological systems, especially those affecting tumors, cannot be attributed to a single molecule or a single moleculular pathway, as they emerge as a result of interactions at multiple levels. In this project it will be analyzed and validated quantitatively if THz sensors based on frequency selective surfaces can provide such a multilevel biomolecular detection capability.

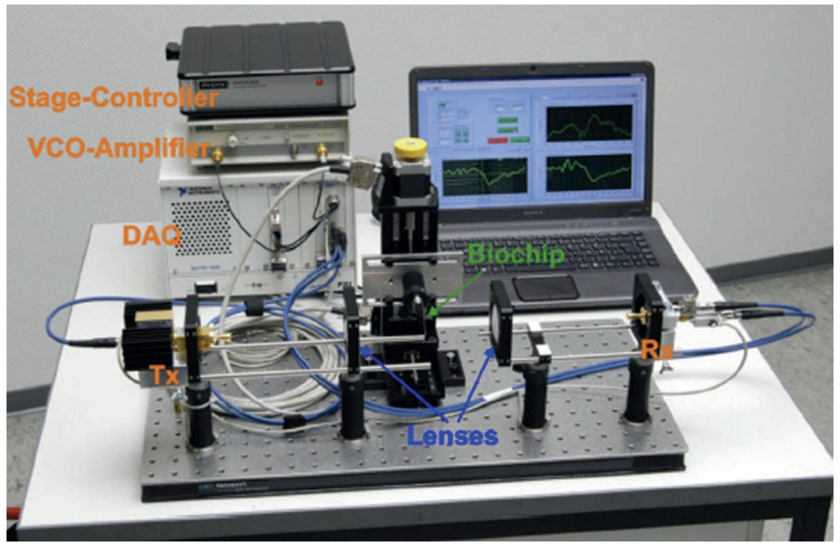
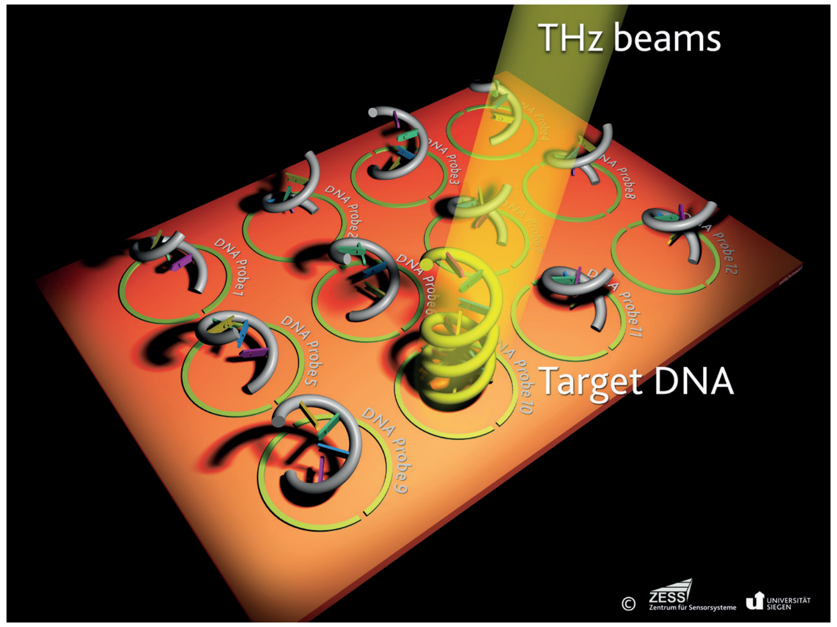


Figure 1: Biochip reader setup operating at a frequency of approximately 250 GHz.

Figure 2: Double split ring resonators with target DNA and THz readout beam (schematic representation).



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