Quantum Dot-Based Terahertz Photoconductive Antennas

Andrei Gorodetsky, Edik U. Rafailov
Institute of Photonic Technologies
Aston University
Birmingham, UK
a.gorodetsky@aston.ac.uk

Ross Leyman
School of Engineering
University of Glasgow
Glasgow, UK
Ross.Leyman@glasgow.ac.uk

Abstract— we present novel Terahertz (THz) emitting optically pumped Quantum Dot (QD) photoconductive (PC) materials and antenna structures on their basis both for pulsed and CW pumping regimes.

Keywords — quantum dot; photoconductive antenna; terahertz generation

I. QUANTUM DOT AND MICROANTENNA DESIGN

Presented here are design considerations for the semiconductor materials in our novel QD-based photoconductive antenna (PCA) structures, metallic microantenna designs, and their implementation as part of a complete THz source or transceiver system.

Layers of implanted QDs can be used for the photocarrier lifetime shortening mechanism[1,2]. In our research we use InAs:GaAs QD structures of varying dot layer number and distributed Bragg reflector (DBR) reflectivity range. According to the observed dependence of carrier lifetimes on QD layer periodicity [3], it is reasonable to assume that electron lifetimes can be potentially reduced down to 0.45 ps in such structures. Both of these features; long excitation wavelength and short carriers lifetime predict possible feasibility of QD antennas for THz generation and detection.

In general, relatively simple antenna configurations were used here, including: coplanar stripline (CPS); Hertzian-type dipoles; bow-ties for broadband and log-spiral (LS) or log-periodic (LP) ‘toothed’ geometries for a CW operation regime.

II. EXPERIMENTAL RESULTS

Several lasers are used for antenna pumping: Ti:Sapphire femtosecond laser, as well as single-[4], double-[5] wavelength, and pulsed [6] QD lasers. For detection of the THz signal different schemes and devices were used, e.g. helium-cooled bolometer, Golay cell and a second PCA for coherent THz detection in a traditional time-domain measurement scheme. Fig. 1 shows the typical THz output power trend from a 5 um-gap LP PCA over QD Structure 2 pumped using a tunable QD LD with optical pump spectrum shown in (b).

SUMMARY

QD-based THz systems have been demonstrated as a feasible and highly versatile solution. The implementation of QD LDs as pump sources could be a major step towards ultra-compact, electrically controllable transceiver system that would increase the scope of data analysis due to the high pulse repetition rates of such LDs [3], allowing real-time THz TDS and data acquisition. Future steps in development of such systems now lie in the further investigation of QD-based THz PCA structures and devices, particularly with regards to their compatibility with QD LDs as pump sources.

REFERENCES