Photoconductive terahertz receivers utilizing single semiconductor nanowires

Kun Peng[1], Patrick Parkinson[2], Lan Fu[1], Qiang Gao[1], Nian Jiang[1], Ya-Nan Guo[1], Fan Wang[1], Hannah J Joyce[2, 3], Jessica L Boland[2], Hark Hoe Tan[1], Chennupati Jagadish[1] and Michael B. Johnston.[2]

1. Department of Electronic Materials Engineering, Research School of Physics and Engineering, The Australian National University, Canberra, ACT 0200, Australia

2. Department of Physics, University of Oxford, Clarendon Laboratory, Oxford OX1 3PU, UK

3. Department of Engineering, University of Cambridge, 9 JJ Thomson Avenue, Cambridge CB3 0FA, UK

***Abstract*— We have demonstrated phase sensitive detectors of coherent terahertz radiation that use single nanowires as active elements. The single GaAs/AlGaAs nanowires acted as sensitive photoconductive elements within a gold antenna structure on quartz. The detectors were also implemented in a terahertz time domain spectroscopy (THz-TDS) system. Our devices show great promise as near-field terahertz sensors or as components for on-chip terahertz micro-spectrometers.**

I. Introduction

One-dimensional group III-V semiconductor nanowires, are promising for photoconductive optoelectronic devices owing to their nano-scale size, direct and tunable band gap, high carrier mobility (close to that in bulk materials) combined with short carrier lifetime (typically sub-nanoseconds) [1,2]. The fast photoconductive response time of these nanowires make them an attractive alternative to bulk semiconductor materials for THz detectors. In addition nanowires show great promise for highly integrated nanoscale THz devices such as a sub-wavelength detector elements for near-field imaging or integrated into an "on-chip" THz spectrometer [3]. In this work, we describe the design, fabrication, characterization and demonstration of single GaAs/AlGaAs nanowire photoconductive THz receivers.

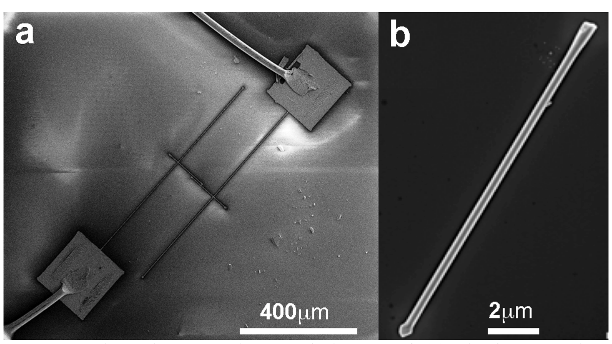

Fig. 1. Scanning electron micrograph image of (a) single nanowire THz detector. (b) Zoomed in image of single nanowire.

II. Device Fabrication

GaAs/AlGaAs core-shell nanowires were grown with the metalorganic chemical vapour deposition (MOCVD) technique via the vapour-liquid-solid (VLS) mechanism [2,4]. To fabricate the single-nanowire detectors, the as-grown substrate was cleaved into small pieces and ultra-sonicated in isopropyl alcohol solution for 30-seconds to transfer the nanowires into solution. The solution was drop cast onto z-cut quartz substrates and allowed to dry naturally. Then the quartz substrates were spin-coated with photoresist and patterned using direct-laser-write lithography technique [5]. Finally, the detector structure was metallized using electron beam evaporation to form 10/300nm Ti/Au contacts on each side of the nanowire, as shown in Fig.1.[6]

III. Results

The single-nanowire detectors were incorporated into a THz time-domain spectroscopy (THz-TDS) system in order to measure a known THz transient. The THz induced photocurrents measured from our single-nanowire detectors are shown in Fig. 2.[6] Comparing with a standard ion-implanted InP receivers, we confirmed that our nanowire detector have the sensitivity required for practical use. FDTD simulations with the same detector geometry used in the experiments were performed in the THz regime to understand the origin of the spectral response of the devices.[6]

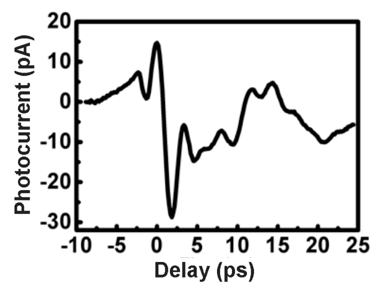

Fig. 2. Terahertz induced photocurrent generated from a single GaAs/AlGaAs nanowire photoconductive THz receiver.

Acknowledgments

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