Longwave Infrared Photoresponse in Copper 7,7,8,8-tetracyano-2,3,5,6-tetraflouroquinodimethane (CuTCNQF$_4$)

Sivacarendran Balendhran$^1$, Aviraj Ingle$^2$, Wei Yan$^3$, Nima Sefidmooye Azar$^3$, Hyungjin Kim$^{4,5}$, Rajesh Ramanathan$^3$, James Bullock$^3$, Ali Javey$^{4,5}$, Vipul Bansal$^2$, Kenneth Crozier$^{1,3,6}$

1. School of Physics, The University of Melbourne, Parkville, Victoria-3010, Australia.
2. NanoBiotechnology Research Laboratory (NBRL), School of Science, RMIT University, Melbourne, Victoria-3001, Australia.
3. Department of Electrical and Electronic Engineering, The University of Melbourne, Parkville, Victoria-3010, Australia.
4. Electrical Engineering and Computer Sciences, University of California at Berkeley, Berkeley, California-94720, USA.
5. Materials Sciences Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA.

The detection of light in the longwave infrared (LWIR) region is crucial for many applications such as environmental monitoring, thermal imaging and surveillance. Many commercial LWIR photodetectors involve complex fabrication processes, require cryogenic temperatures or exhibit slow photoresponse. Hence, there is a continuous pursuit of developing room-temperature, on-chip LWIR photodetectors, using simple fabrication processes [1]. Metal-organic charge transfer complexes typically have a narrow bandgap, which allows them to absorb LWIR wavelengths [2]. Here, we report room temperature LWIR photoresponse in one such charge transfer complex, ie. copper 7,7,8,8-tetracyano-2,3,5,6-tetraflouroquinodimethane (CuTCNQF$_4$), achieved via simple synthesis and fabrication processes.

CuTCNQF$_4$ crystals are synthesized via wet chemical reactions between copper iodide (5 mM) and TCNQF$_4$ (5 mM) in acetonitrile at 60 °C, for 90 min. The synthesized crystals are separated by centrifugation, washed with ethanol and dried in ambient atmosphere. Interdigitated electrode (IDE) devices with an electrode gap of 5 μm are fabricated using photolithography, followed by metal deposition (Cr/Au) and lift-off. The CuTCNQF$_4$ crystals are suspended in ethanol, drop cast onto the IDE and aligned across them using dielectrophoresis.

Fig. 1a and b show the optical images of drop cast CuTCNQF$_4$ crystals and a photodetector based on them. The crystals that are aligned in-between the electrodes act as photoconductors. Fig. 1c plots the current-voltage ($I-V$) characteristics of four photoconductors, similar to the one shown in Fig. 1b. The $I-V$ curves show a back-to-back Schottky behaviour indicating a symmetric metal-semiconductor-metal junction between CuTCNQF$_4$ and Au. The devices are biased at 1 V using a transimpedance amplifier. Time resolved photoresponse of a CuTCNQF$_4$ photoconductor subjected to mechanically chopped (20 Hz) illumination by an 8.35 μm (8.3 mW) quantum cascade laser is shown in Fig. 1d. The devices also show a linear trend in photoresponse with incident power as plotted in Fig. 1e. The power dependant photoresponse is recorded using a lock-in amplifier.

In summary, we demonstrate room-temperature LWIR photoconductors using CuTCNQF$_4$ crystals. The material synthesis and device fabrication involve simple and scalable processes. By optimizing the device architecture to increase the photosensitive area, we envision cost effective, room temperature LWIR photodetectors based on CuTCNQF$_4$.

References
Author/s:
Balendhran, S; Ingle, A; Yan, W; Azar, NS; Kim, H; Ramanathan, R; Bullock, J; Javey, A; Bansal, V; Crozier, K

Title:
Longwave Infrared Photoresponse in Copper 7, 7, 8, 8-tetracyano-2, 3, 5, 6-tetraflouroquinodimethane (CuTCNQF)

Date:
2021-06-01

Citation:

Persistent Link:
http://hdl.handle.net/11343/294856