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Longwave Infrared Photoresponse in Copper 7,7,8,8-tetracyano-2,3,5,6-tetrafluoroquinodimethane (CuTCNQF₄)

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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, i.e. copper 7,7,8,8-tetracyano-2,3,5,6-tetrafluoroquinodimethane (CuTCNQF₄), achieved via simple synthesis and fabrication processes.

CuTCNQF₄ crystals are synthesized via wet chemical reactions between copper iodide (5 mM) and TCNQF₄ (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 μ m are fabricated using photolithography, followed by metal deposition (Cr/Au) and lift-off. The CuTCNQF₄ 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 CuTCNQF₄ 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 CuTCNQF₄ and Au. The devices are biased at 1 V using a transimpedance amplifier. Time resolved photoresponse of a CuTCNQF₄ photoconductor subjected to mechanically chopped (20 Hz) illumination by an 8.35 μ m (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.

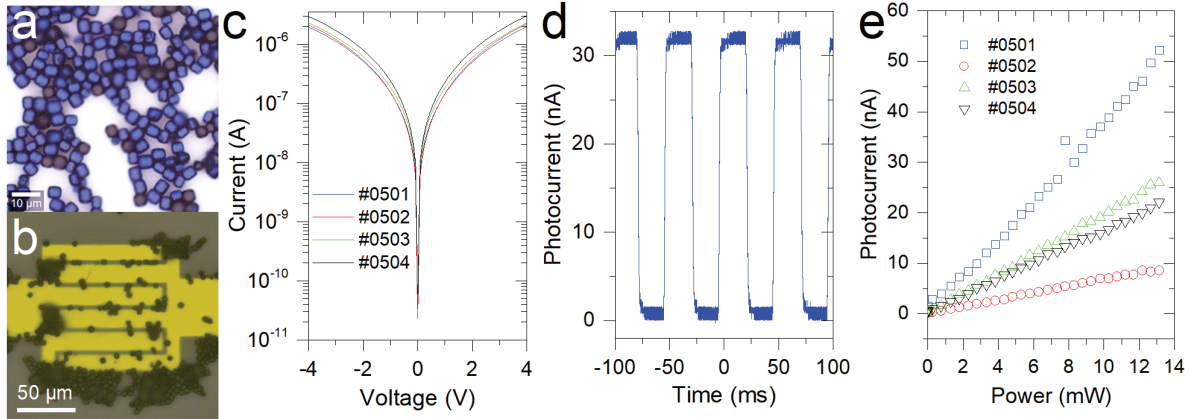


Fig. 1. Optical images of (a) CuTCNQF₄ crystals and (b) a CuTCNQF₄ based photoconductor. (c) *I-V* characteristics of four photoconductors. (d) Time resolved photoresponse in Device #0501 for mechanically chopped 8.35 μ m illumination at 8.3 mW. (e) Photocurrent vs. incident power ($\lambda = 8.35 \mu$ m) for the devices shown in (c), biased at 1V.

In summary, we demonstrate room-temperature LWIR photoconductors using CuTCNQF₄ 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 CuTCNQF₄.

References

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