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ECHO-LESS PHOTOCONDUCTIVE SWITCHES FOR HIGH-RESOLUTION TERAHERTZ TIME-DOMAIN SPECTROCOPY


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Overview

Interdigitated photoconductive (iPC) switches are powerful and convenient devices for time-resolved spectroscopy, with the ability to operate both as sources and detectors of terahertz (THz) frequency pulses. However, reflection of the emitted or detected radiation within the device substrate itself can lead to echoes that inherently limit the spectroscopic resolution achievable from their use in time-domain spectroscopy (TDS) systems. We demonstrate a design of iPC switches for THz pulse emission and detection that suppresses such unwanted echoes and provides high-resolution in frequency. As a proof-of-principle, the 2_1\_2_1 and the 1_2\_2_1 rotational lines of water vapor have been spectrally resolved, demonstrating a spectral resolution below 10 GHz.

1. A buried metal interdigitated photoconductive switch

![Schematic of a standard photoconductive switch](image)

- Pre-photolithography sample. The MBE grown sample is wafer bonded to a gold-coated host Si GaAs substrate. The substrate and the AlGaAs (5%) layer of the MBE grown wafer are removed, exposing the LT-GaAs active region with the echo-blocking metal plane 6 μm below the surface.
- Measurement of carrier lifetime in the LT-GaAs active layer (optical pump – THz probe technique).
- Blue line: variation of THz reflectivity of LT-GaAs layer after a 100ns – 800ns excitation optical pulse at t=0ps.
- Red line: Numerical fit s(t) = τ\text{exp}\left(\frac{-t}{\tau}\right)
- Switch as a detector of THz pulses.

2. Experimental characterization as emitter

![Experimental setup for emitters’ characterization](image)

- No effect of buried metal on radiation diagram (numerical calculation).

3. LT-GaAs layer for switches as detectors

![Schematic of a buried metal interdigitated photoconductive switch](image)

- Calculated electrical potential U for an applied voltage of 4V.

4. Time traces and echo suppression

![Time traces and echo suppression](image)

- Resolution limited only by echo in detection crystal (42 ps time window).
- THz power concentrated in a single pulse: higher peak amplitude for a given polarisation bias electrical field.
- E_{bias}=10 kV/cm

5. Spectral resolution improvement

![Spectral resolution improvement](image)

- Rotational lines of water are resolved
- With standard delay lines, few ns time windows might be achieved, resulting in sub-GHz resolution.

Conclusions:

- THz pulse generation and detection with echo suppression.
- High-resolution in the spectral window 500 GHz – 3.5 THz experimentally demonstrated.
- Demonstration of 9 GHz spectral resolution from 2_1\_2_1 and 3_1\_2_1 water vapour rotational lines measurement.
- Perspectives: better understanding of spectroscopic properties, including influence of the distance between electrodes and the buried metal plane.


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