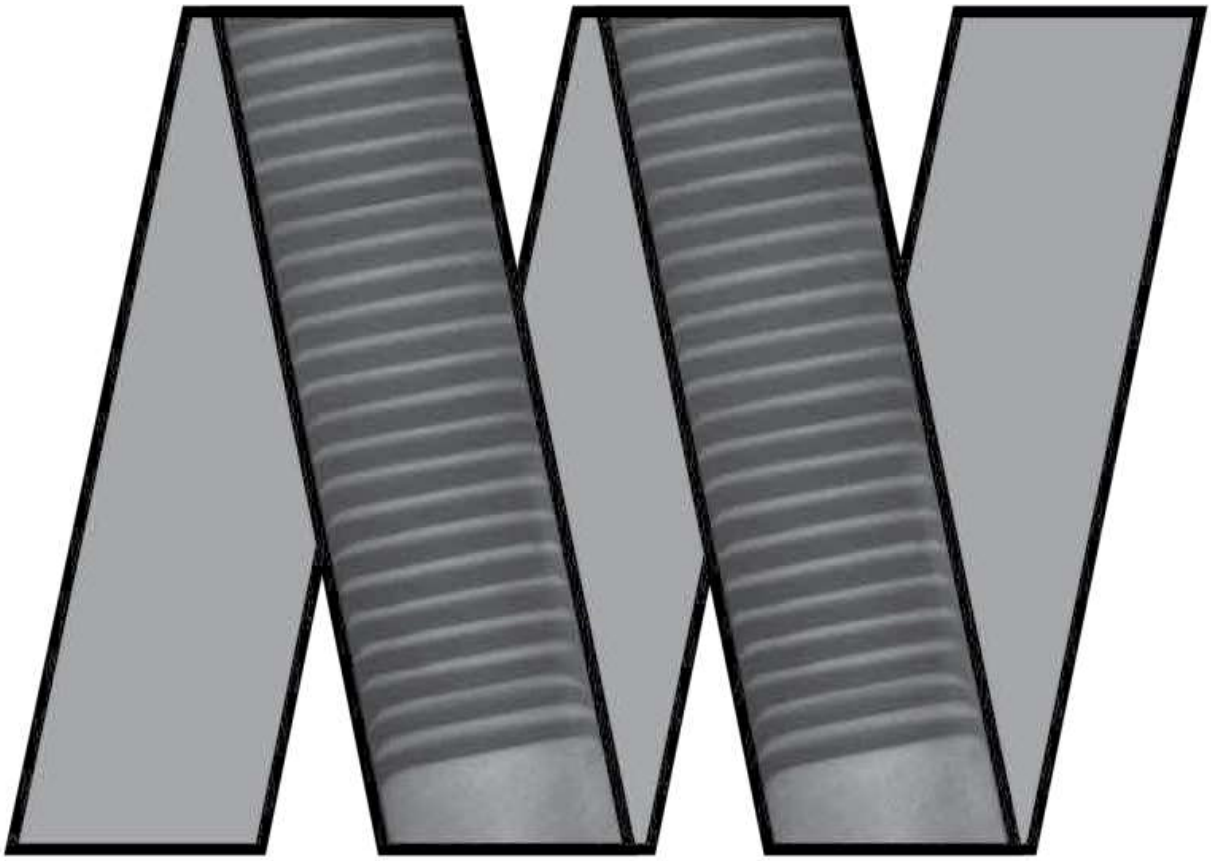

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Bias-Switchable Photoconductance in a Nanoscale Ge Photodetector Operated in the Negative Differential Resistance Regime

Raphael Böckle, Masiar Sistani, Maximilian G. Bartmann, Alois Lugstein, and Walter M. Weber

Institute of Solid State Electronics, TU Wien, Vienna, Austria
Contact: raphael.boeckle@tuwien.ac.at

Group-IV based nanodevices are an active area of research for CMOS-compatible photonic components in the visible and near-infrared region, covering the C-band optical communication range. Especially, nanowires (NWs) have gained significant interest, due to their inherent nanocylinder resonator shape, allowing light trapping in circulating orbits by multiple total internal reflections from the periphery. Importantly, leaky resonant modes in NWs provide an antenna functionality that enhances their performance, especially when embedded in metal-semiconductor heterostructures.

Here, we advance a fundamental step beyond those concepts and demonstrate a Ge NW photodetector with switchable photo-conductance, effective dark-current suppression and remarkably high polarization sensitivity. In particular, our highly sensitive Ge NW photodetector is capable of suppressing the dark current by a paramount factor of 100 by unprecedentedly using the negative differential resistance (NDR) electronic transport regime,[1] significantly enhancing the performance of Ge photodetectors. Most notably, the NDR regime further enables a bias-switchable positive (PPC) and negative (NPC) photo-conductance with relative symmetric photoconductive gains of $g_{NPC} = -1.7 \times 10^5$ and $g_{PPC} = 4.4 \times 10^5$ at $\lambda = 532$ nm.[2] Further, investigating the polarization sensitivity in the valley region of the NDR, the Ge photodetector revealed a remarkably high TM/TE ratio of 33. Importantly, utilizing our Al-Ge-Al heterostructures with reliable and reproducible contacts as an advanced material system with full CMOS compatibility for photonic applications, the proposed bias-switchable Ge photodetector platform may pave the way for innovative optoelectronic devices including compact light tunable memories, or light effect transistors.

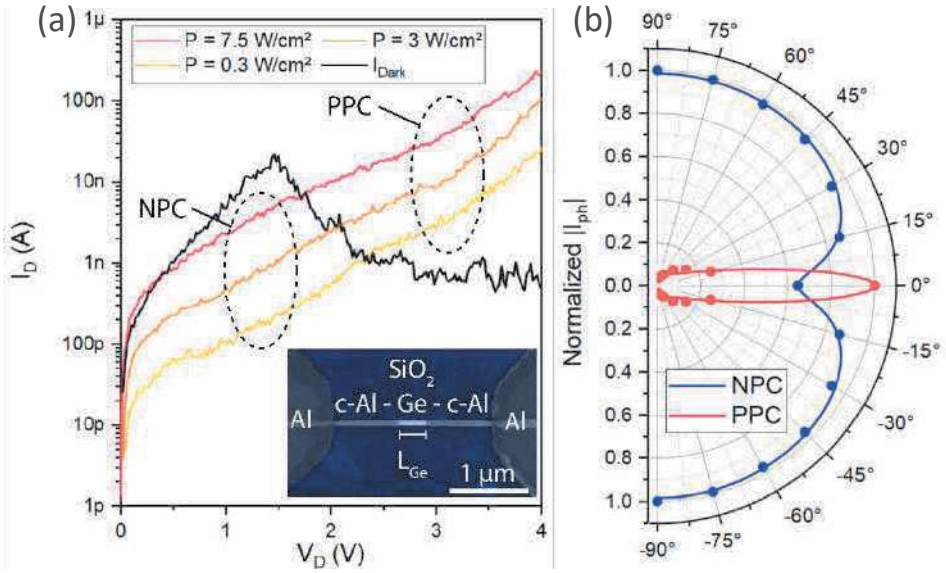

Figure 1 (a) Semi-logarithmic I/V characteristic without illumination (black) and for laser excitation at λ = 532 nm. The inset shows a false-color SEM image of the used Al-Ge-Al NW heterostructure. (b) Angle-dependent photocurrent for both PPC (red) and NPC (blue) in polar representation.

[1] R. Böckle, M. Sistani, K. Eysin, M. G. Bartmann, M. A. Luong, M. I. den Hertog, A. Lugstein, and W. M. Weber, Advanced Electronic Materials **7**, 2001178 (2021).
[2] M. Sistani, R. Böckle, M. G. Bartmann, A. Lugstein, and W. M. Weber, ACS Photonics **8** (12), 3469-3475 (2021).