Single-photon avalanche GeSn detectors on Silicon for 2 µm wavelength detection and beyond

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Photodetectors have hit the physical limit in terms of sensitivity with a raising need for detection of extremely low light intensity down to a single-photon [1]. Single-photon detection has revolutionized secure communication by implementing Quantum key distribution (QKD) and there have been recent demonstrations of quantum communications over 500 km distance using metropolitan optical fiber infrastructure. In addition, object reconstruction with less than one photon per pixel is now feasible owing to recent developments in computational imaging techniques [1,2]. Single-photon LIDAR is therefore required in order to efficiently recreate complex landscapes with high surface-to-surface resolution while using the least amount of illumination. When time-correlated single-photon counting (TCSPC) is crucial, superconducting nanowire single-photon detectors (SNSPDs) and SPADs are the recommended detecting technologies. SNSPDs have outperformed all other single-photon detectors in the literature, but they were not able to achieve all these results in a single device due to trade-offs. Furthermore, their cryogenic (< 1 K) operation represents a significant barrier to the development of a miniaturized and reasonably priced detecting system. However, Group IV Ge-on-silicon SPADs grown epitaxially are scalable, compatible with CMOS technology, and demonstrated promising photon counting performance at 1.33 um at a temperature that can be reached with noncryogenic thermoelectric cooling [3,4].

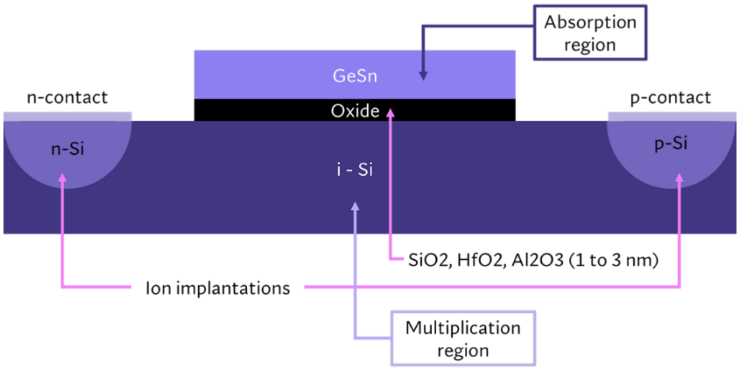

Fig. 1. Schematic of a lateral GeSn SPAD achieved by bonding on Silicon.

In this work, the design of lateral GeSn SPADs is investigated using TCAD simulations for the electric field distribution across the device indicating the drawbacks of the intrinsic doping of GeSn. Lateral GeSn SPADs can be achieved either by bonding GeSn membranes onto a Si substrate as shown in Fig. 1 or by etching down GeSn and implant Si region surrounding it. By increasing the Sn content in the GeSn alloy, the single photon performance can be extended further beyond 2 µm wavelength [5,6]. These extended wavelength SPADs shall be promising for short-wave infrared single photon LIDAR, quantum communication, and biomedical imaging applications, to name a few.

References

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