Tailorable Doping-spike PtSi Infrared Detectors Fabricated by Si Molecular Beam Epitaxy*

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ABSTRACT

Si-compatible detectors are among the most promising infrared (IR) sensors for large focal plane array applications because they can be easily integrated with Si VLSI readout multiplexer. Furthermore, by utilizing the mature Si processing technologies, they provide advantages of uniformity, reliability, and low cost. State-of-the-art PtSi focal plane arrays, with array sizes of 640x 480 and 1024 x 1024 have been previously demonstrated by several companies, providing high resolution IR imaging in the 1-5 μm region at 77K. Extrinsic Si detectors, such as Si:As IBC, provide a wide responsive spectrum (cutoff at 28 μm) operating at <12K.

There is a great interest in developing Si-compatible detectors responsive in the 8-14 μm long wavelength infrared (LWIR) region with a higher temperatures (> 65 K). One approach involves reducing the effective PtSi Schottky barrier by incorporating a p^+ doping spike at the PtSi/Si interface. Previous barrier-reduction efforts involved the incorporation of a relatively thick (>50Å) p^+ layer at the PtSi/Si interface which creates a potential spike near the PtSi/Si interface for tunneling. However, the detector performance was greatly degraded due the additional tunneling process required for IR detection, and the detector dark current was drastically increased due to the tunneling contribution.

In this paper, we demonstrated that by thinning the p^+ layer to - 10Å, the effective Schottky barrier heights can be reduced without the formation of a potential spike, and consequently, the undesired tunneling process can be eliminated. This approach requires significantly higher concentrations of the spikes ($>10^{20}$ cm^{-3}), atomically sharp doping profiles, and low growth temperatures, and was accomplished by utilizing molecular beam epitaxy (MBE) growth techniques. The doping-spike PtSi detectors were fabricated on double-side polished Si (100) wafers with a resistivity of 30 Ω-cm. The 10-Å-thick p^+-Si layers were grown by MBE at 450 "C using elemental boron as the dopant source. The PtSi layers were formed *in-situ* by depositing undoped Si and Pt followed by annealing at 400°C. The dark current characteristics of the doping-spike PtSi detectors were found to be thermionic emission limited, given by $J_o = A^{**} T^2 \exp(-q\phi_B/kT)$. The detector spectral responses were measured with back-side illumination using a 940K blackbody source. By varying the doping concentrations of the 1-rim-thick doping spikes from 1×10^{20} cm^{-3} to 2×10^{20} cm^{-3}, PtSi cutoff wavelengths were successfully extended to 14, 18, and 22 μm for the first time, with effective optical potential barriers of 0.09, 0,069, and 0,057 eV, determined by Fowler plots, with C_1's comparable to those of conventional PtSi detectors with similar PtSi thicknesses.

In conclusion, we have extended the cutoff wavelength of doping-spike PtSi IR detectors to the LWIR region by incorporating a 10-Å-thick p^+ MBE doping spike at the silicide/silicon interface. The cutoff wavelength increases with increasing doping concentration of the doping spikes. The tailorable cutoff wavelength allows the optimization of the trade-off between the spectral response and the cooling requirements.

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