A Ge-on-Si Single-Photon Avalanche Diode Optimized for Infrared Wavelengths

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Main goal
- Create a Germanium SPAD array
- Near-infrared detection range (~1.2-1.6 μm)

Why Ge-on-Si
- Ge bandgap of 0.67eV
- Suitable for near-infrared applications

What has been done
- Simulations of various Ge structures
- Testing of other Ge photodetectors in Geiger mode

Future work
- Fabrication and test of Ge SPAD array

Specifications of Ge APDs
- Can be operated both in proportional and in Geiger mode
- Low dark counts and reasonably high sensitivity at room temperature
- Low values of reverse current, series resistance and ideality factor

Ge-on-Si SPAD Process Flow

Ge-on-Si APD Experimental Results
- Exceptionally good I-V characteristics

Toward A Ge-on-Si SPAD Array
- 4x4 Ge SPAD array designed and under fabrication
- Pixel and row decoder to address a specific SPAD pixel or entire row
- Read-out circuits for pulse shaping

Performance (APD/linear mode)

<table>
<thead>
<tr>
<th>Performance</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active area</td>
<td>4 μm²</td>
<td>40 μm²</td>
<td>40 μm²</td>
<td>μm²</td>
</tr>
<tr>
<td>Breakdown voltage for 2-20 μm²</td>
<td>9 V</td>
<td>13 V</td>
<td>13 V</td>
<td>V</td>
</tr>
<tr>
<td>Breakdown voltage for 2-50 μm²</td>
<td>11 V</td>
<td>13 V</td>
<td>13 V</td>
<td>V</td>
</tr>
<tr>
<td>Dark current @ 1 V reverse bias</td>
<td>20 pA</td>
<td>20 pA</td>
<td>20 pA</td>
<td>pA</td>
</tr>
</tbody>
</table>

Performance (Geiger mode)
- Excess bias voltage
- DCR @ Vg = 1V
- T/L, @ Vg = 3V
- FWHM Time jitter
- Performance summary

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