HIGH-PERFORMANCE SCHOTTKY-BARRIER IR-CCD IMAGE SENSORS

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High-performance PtSi and Pd$_2$Si Schottky-barrier (SB) IR-CCD image sensors were recently developed. These monolithic focal plane arrays (FPAs) are attractive for many thermal and short-wavelength infrared (SWIR) applications.

The SB FPAs developed at RCA Laboratories are summarized in Table 1. These arrays were fabricated as two-level polysilicon n-type buried-channel CCDs with PtSi and Pd$_2$Si SB detectors. The 25 x 50, 32 x 63, and 64 x 128 interline-transfer FPAs have detector-area efficiencies (fill factors) of 17, 25, and 22%, respectively. Fill factors approaching a value of 50% are expected in the next generation of higher density SB FPAs.

The cross-sectional view of the recently developed "thin" high-performance PtSi SB detectors is illustrated in Fig.1. In this structure a very thin and very uniform layer of PtSi, formed on the p-type silicon substrate, is separated from an aluminum reflector by a layer of a deposited SiO$_2$ dielectric. The optimal thickness of the silicide layer is in the range of 20 to 100Å, while that of the SiO$_2$ layer is in the range of 2000 to 6000Å. The resistivity of the p-type silicon substrate is in the range of 30 to 50 ohm-cm. The performance of a 25 x 50 FPA with such "thin" PtSi SB detectors was described in 1980.$^1$

Responsivity and quantum efficiency (Q.E.) measured as a function of wavelength of the high-performance PtSi and Pd$_2$Si SB detectors is shown in Fig.2. The devices 1H and 2M (see Figs.2 and 3) represent two types of PtSi SB detectors. One has a higher quantum efficiency and the other is more tolerant to temperature variations. Note, that for the PtSi detector 1H-75 operated at a temperature of 80K, quantum efficiencies of 4.0 to 1.0% in the spectral range of 3 to 4.5 μm and cut-off wavelength in excess of 6.0 μm were achieved. The Pd$_2$Si detectors operated at a temperature between 120 and 140K have cut-off wavelength of 3.6 μm and quantum efficiency in the range of 1.0 to 8.0% in the SWIR band. The measured dark (leakage) current characteristics as a function of temperature of the above of PtSi and Pd$_2$Si SB detectors are shown in Fig. 3. The dark current density as a function of the reverse bias voltage for the two types of PtSi SB detectors is shown in Fig.4.

The quality of thermal imaging obtained with a 64 x 128-element PtSi IR-CCD TV camera is illustrated in Fig.5. The PtSi FPA is operated in a liquid nitrogen Dewar at about 80K with the frame rate of 60 f/s and f/1.5 germanium optics. Additive type of electronic compensation was used to correct for small variations.
in the dark current of the PtSi SB detectors.

References

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<thead>
<tr>
<th>Type of FPA</th>
<th>Chip Size (mil2)</th>
<th>Pixel Size (um2)</th>
<th>Fill Factor</th>
<th>Type of SBD</th>
<th>Year</th>
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<td>40 x 200</td>
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<td>26 x 60 Interline Transfer</td>
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<td>64 x 128 SPS 1T</td>
<td>384 x 384</td>
<td>120 x 60</td>
<td>22%</td>
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Table 1. SB FPAs developed at RCA.

Fig.1. High-performance PtSi SB-detector structure.

Fig.2. Measured responsivity and Q.E. of PtSi and Pd2Si SB detectors.

Fig.3. Dark current vs. temperature of PtSi and Pd2Si SB detectors.

Fig.4. Dark current density as a function of bias voltage for PtSi SB detectors.

Fig.5. Thermal image detected by 64 x 128 IR-CCD TV camera.