2D array of far-infrared thermal detectors: noise measurements and processing issues

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A magnesium diboride (MgB$_2$) detector 2D array for use in future space-based spectrometers is being developed at GSFC. Expected pixel sensitivities and comparison to current state-of-the-art infrared (IR) detectors will be discussed.

Key words: superconductor, thermal detectors, IR, signal-to-noise.

Introduction:
For high temperature superconducting (HTS) thin films to be used as the thermistor materials in an IR detector ease of process and noise performance are two important factors.

MgB$_2$ is a simple binary intermetallic compound with a superconducting transition at 39 K [1]. Compared to the cuprate HTSs, it has lower $T_c$ and a very sharp transition of MgB$_2$. For the foreseeable future only moderately cooled focal planes (30-90K) are feasible on space missions because of stringent mass and power budgets. The lower operating temperatures are achievable using advanced cryo-cooling technology being developed both at NASA and elsewhere. One distinct advantage of growing high quality MgB$_2$ thin films on silicon substrates is the potential for fabricating single and 2D bolometer arrays using standard micro-electro-mechanical systems (MEMS) micromachining processes.

Fig 1: Conceptual layout of the 2-D array far-IR bolometer. Each pixel: 100 x100μm.
MgB$_2$ thin film growth conditions and sample preparation have been discussed in an earlier publication [2]. The 2-D array processing and Spectral Noise Voltage Density Measurement ($S_V$) will be discussed.

Table 1 summarizes the properties of the MgB$_2$ thin film and compares the temperature noise $K_n$ values, where

$$K_n = S_V (I_{bias} dR/dT)^{-1}$$

The lower the $K_n$ value the better the S/N ratio when the film is used as a thermistor in a bolometer.

<table>
<thead>
<tr>
<th>HTS</th>
<th>$T_c$ (K)</th>
<th>$dR/dT$ (K/T)</th>
<th>$I_{bias}$ (mA)</th>
<th>$S_V$ at 10 Hz (nV/√Hz)</th>
<th>$K_n$ at 10 Hz ($10^9$ K/√Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MgB$_2$</td>
<td>38.27</td>
<td>12.4</td>
<td>4</td>
<td>0.34</td>
<td>6.8</td>
</tr>
<tr>
<td>YBaCuO</td>
<td>90</td>
<td>2.5</td>
<td>8.35</td>
<td>0.8</td>
<td>50</td>
</tr>
<tr>
<td>GBaCuO$^*$</td>
<td>90.2</td>
<td>3414</td>
<td>50 x10$^3$</td>
<td>21</td>
<td>123</td>
</tr>
</tbody>
</table>

Table 2. Properties of the MgB$_2$, YBaCuO and GBaCuO.

The noise figures are at 10 Hz.

* HTS on sapphire [3,4]. ** GdBCuO film on SiN [5]

The noise value and $K_n$ clearly show that MgB$_2$ thin films, grown on SiN/Si substrates, can provide better S/N than current cuprate-based HTS bolometers.

The results presented will show that high quality MgB$_2$ thin film can be grown on low stress SiN on Si. Present work on low thermal capacity membranes with optimal thermal conductance being micro machined/processed will be discussed. The process optimization to create the 2-D array is under way and we anticipate the characterization of the pixels soon. This in turn will allow us to verify the S/N predictions made above.
Acknowledgments

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References