High Performance Sputtered High-k CLC LTPS TFTs on Glass Substrate

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Recently, low-temperature polycrystalline-silicon (LTPS) thin-film transistors (TFTs) have attracted attention in the development of small, high-resolution mobile displays. To improve the crystalline quality of thin poly-Si films, we have developed a continuous-wave laser lateral crystallization (CLC) technique using a diode-pumped solid-state (DPSS) laser [1,2]. This method enables us to achieve an n-channel mobility of 300 cm²/Vs when silicon dioxide (SiO₂) deposited by plasma-enhanced chemical-vapour deposition (PECVD) is used as the gate stack.

The high-k gate stack may be a key technology for improving the performance of poly-Si TFTs. Further, sputtering is a standard method employed in display manufacturing. In this paper, we demonstrate the performance of CLC LTPS TFTs with a sputtered Al₂O₃ [3] and HfO₂ [4] gate dielectric. To evaluate the device performance, we measured the capacitance equivalent thickness (CET) using split capacitance-voltage (C-V) measurements with a large channel area. The physical thickness of Al₂O₃ and HfO₂ measured by transmission electron microscopy (TEM) were 20 nm and 19 nm, respectively, with a 6-nm-thick lower SiO₂ layer. For reference, CLC LTPS TFT with a 50-nm-thick SiO₂ gate stack was prepared by PECVD. The Al₂O₃ CLC LTPS TFT exhibited a field-effect mobility of 160 cm²/Vs and an s-value of 200 mV/dec. The performances of HfO₂ CLC LTPS TFTs were almost the same as those of Al₂O₃ TFTs. The on-currents that were achieved for HfO₂ CLC LTPS TFTs were two and four times the values for Al₂O₃ and SiO₂ CLC LTPS TFTs, respectively. This was because of the high field-effect mobility, small s.s. and small CET of HfO₂ CLC LTPS TFTs. The performances of these TFTs are summarized in Table I [4]. The obtained field-effect mobility of 160 cm²/Vs for the CLC LTPS TFT with sputtered HfO₂ is larger than those of previously reported poly-Si TFTs with high-k gate dielectrics, and this is attributed to the high-quality poly-Si film. Moreover, we realized the successful operation of a CMOS inverter with an HfO₂ gate stack at Vdd = 2.0 V, as shown in Fig. 1.

Table I. Performance of CLC LTPS TFTs with SiO₂, Al₂O₃ and HfO₂ gate stack

<table>
<thead>
<tr>
<th>Gate Stack</th>
<th>Vth (V)*</th>
<th>S.S. (mV/dec)</th>
<th>CET (nm)</th>
<th>µFE (cm²/Vs)</th>
<th>Ion (µA) **</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>-2.8</td>
<td>400</td>
<td>50</td>
<td>300</td>
<td>17</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>0.5</td>
<td>200</td>
<td>18</td>
<td>160</td>
<td>35</td>
</tr>
<tr>
<td>HfO₂</td>
<td>-0.9</td>
<td>200</td>
<td>11</td>
<td>160</td>
<td>65</td>
</tr>
</tbody>
</table>

* @10⁻⁹ (A)  ** Vth = Vg - Vth = 3.0 (V)

Fig. 1. CMOS inverter made up of CLC LTPS TFTs with HfO₂ gate stack.

References