Fully Transparent FET with High Drain Current and On-Off Ratio

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Primary CNF Tools Used: PT720/740, PVD75 sputter deposition, Autostep i-line stepper

Abstract:

We report a fully transparent thin-film transistor utilizing a La-doped $BaSnO_3$ channel layer that provides a drain current of 0.468 mA/µm and an on-off ratio of 1.5×10^8. The La-doped $BaSnO_3$ channel is grown on a 100-150 nm thick unintentionally doped $BaSnO_3$ buffer layer on a (001) MgO substrate by molecular-beam epitaxy. Unpatterned channel layers show mobilities of 127-184 $cm^2V^{-1}s^{-1}$ at carrier concentrations in the low to mid 10^{19} cm^{-3} range. The $BaSnO_3$ is patterned by reactive ion etching under conditions preserving the high mobility and conductivity. Using this patterning method, a sub-micron-scale thin film transistor exhibiting complete depletion at room temperature is achieved.

Summary of Research:

In summary, a fully transparent submicron TFT based on $BaSnO_3$ has been fabricated with a high drain current and on/off current ratio. This breakthrough is made possible by (1) high mobility bare films in combination with (2) the development of a micrometer-scale etching method that preserves the surface roughness, conductivity, and mobility of $BaSnO_3$ films.

These results demonstrate the tremendous potential of $BaSnO_3$ for the future of transparent electronics. The channel is 0.3 µm long and 0.93 µm wide. This is the first demonstration of a submicron scale $BaSnO_3$-based field effect transistor with complete depletion at room temperature. This result has been published in APL Materials January 2020. Two patent applications have been filed on the reactive ion etching of $BaSnO_3$.

References:

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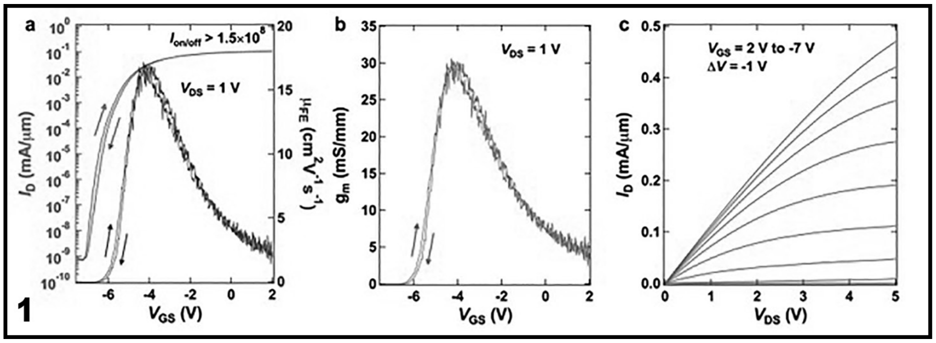

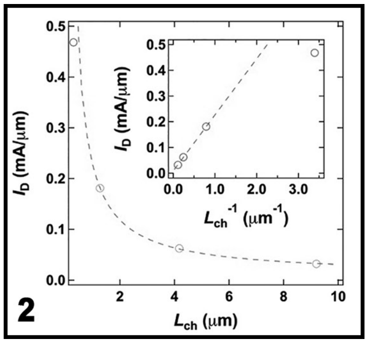

Figure 1, left: (a) The transfer characteristic of the TFT based on La-doped $BaSnO_3$ at V_{DS} = 1 V and the field-effect mobility. The peak field-effect mobility is 17.2 $cm^2V^{-1}s^{-1}$, and the on-off ratio is over 1.5×10^8. The subthreshold swing is 0.15 V dec^{-1}. (b) Transconductance of the device at V_{DS} = 1 V. The maximum transconductance is 30.5 mS/mm. (c) The output characteristic of the device at V_{GS} = 2, 1, 0, -1, -2, -3, -4, -5, -6, -7 V. The maximum drain current exceeds 0.467 mA/µm.

Figure 2, right: Drain current dependence on channel length (L_{ch}) when V_{GS} = 2 V and V_{DS} = 5 V. The drain current (I_D) is inversely proportional to the overall channel length except at the shortest channel length, showing little degradation with respect to device scaling. The deviation from linear behavior in the inset at the shortest channel length is likely due to the contact resistance and not short channel effects such as velocity saturation.