Simulation of Twin Boundary Effect on TFT Characteristics

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Recently, a new technique has been developed to fabricate Thin Film Transistors (TFTs) on a location controlled silicon single grain, by the method referred to as Micro-Czochralski or grain-filter process[1]. Since there are few or no grain-boundaries in the active region of such Single Grain TFTs (SG-TFTs), much higher mobilities (500 cm^2/Vs) than standard laser-crystallized polycrystalline silicon TFTs (poly-Si TFT) are obtained. However, device to device non-uniformities are sometimes observed and attributed to the presence of twin boundaries. We report here for the first time 3-D simulation for TFTs and use it to investigate the effect of twin boundaries in a single grain TFT. The simulations were performed by using the ISE simulator. In fig.1 we show the effect on the transfer characteristic of a single boundary, for different orientations. We find that the effective electron mobility decreases with the increase of the angle between the twin boundary and the channel direction, which is consistent with reported experiment results. Another interesting result of the simulation is that the leakage current is much higher if the twin boundary contacts the drain (fig.2). Since, the leakage current is controlled by carrier generation near the drain[2], if the twin boundary is in contact with the drain but not with the source, an asymmetry in the leakage current for source-drain swapping results. The output characteristics were also simulated, by using the ISE hydrodynamic model. We found that the position of the twin boundary is also very important for the kink effect. As shown in fig.3, a big kink effect can be observed in a device with a twin boundary near drain while no kink effect can be observed when source and drain were exchanged. This phenomenon can be observed in real devices. In conclusion, 3-D simulation confirms that twin boundaries and their orientation play a very important role in controlling the characteristics of SG-TFTs.

References:

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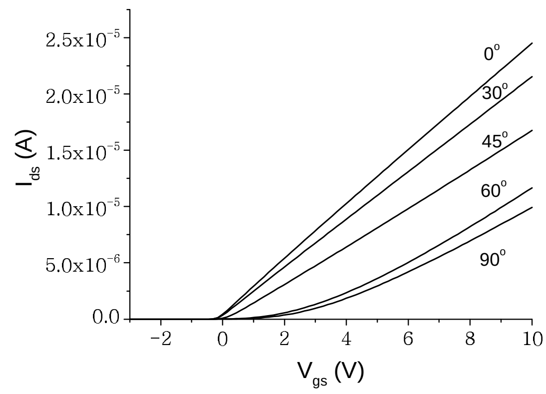

Fig.1 The simulated transfer characteristics of the SG-TFTs with one straight twin boundary in the middle of the channel. V_{ds}=0.1V. The angle between the twin boundary and the direction of channel varies from 0 to 90 degree. From top to bottom, the angle is 0, 30, 45, 60 and 90 degree, respectively.

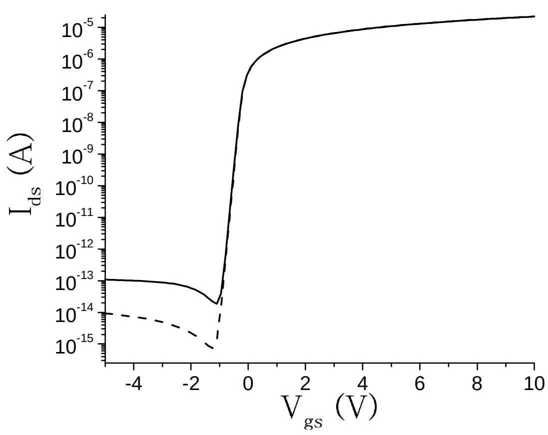

Fig. 2, The simulation results of the transfer characteristics of a SG-TFT device with a twin boundary in the channel in contact with the drain (solid line) or the source (dashed line). V_{ds}=0.1V.

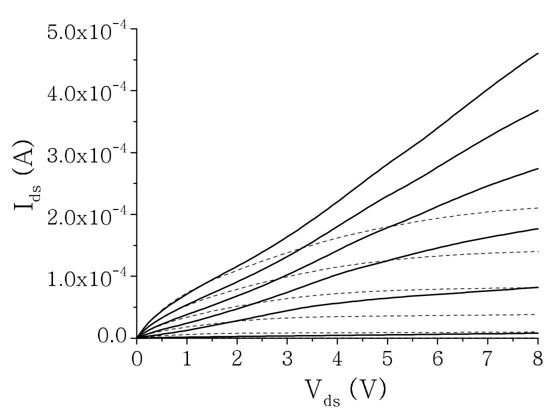

Fig.3, The simulated output curves of the SG-TFTs with a twin boundary in the channel near the drain (solid line) or near the source (dash line). From top to bottom, V_{gs} =10V, 8V, 6V, 4V, 2V, and 0V, respectively.