Undershoot Current in Thin Film Transistors

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As reported before[1], the switch-on transient current of Thin Film Transistors (TFT) is different from the static value. The TFT transient behaviour is very important for the performance of TFT circuits. In this paper, we investigate the switch-on transient behaviour of high mobility (~500 $cm^2 V^{-1}s^{-1}$) single grain Silicon TFTs fabricated by the grain filter method[2]. The gate insulator was ECR-PECVD oxide. The drain current I_{DS} was measured by applying a square wave to the gate and keeping V_{ds} constant at 0.1V. The transient current was fed to a current-voltage amplifier and read by a storage oscilloscope. The measurement was automated by using Labview. The results are shown in fig.1, for different gate voltages. The transient current is lower than the static value and we call "undershoot" the difference between the two. This behaviour is different from that observed before in poly-Si TFTs and Silicon on Insulator (SOI) devices, where I_{DS} exhibits an "overshoot", which can be explained by a combination of floating body and generation-recombination dynamics[1]. The undershoot current can be fitted to a decaying exponential law, with the time constant of about 200ms. For comparison, control SOI devices, with the same gate size and the same ECR-PECVD gate oxide were fabricated. The transient current shows quite similar undershoot current behaviour to that of single grain TFTs. This suggests that a relaxation process in the gate oxide is responsible for the effect. As shown in fig. 2, the undershoot value has a linear relationship with the gate voltage. So the effect cannot be due to the injection of electrons or holes into the gate oxide since the injection current should be nonlinear with electric field. We propose that the presence of mobile ions in the gate oxide is responsible for the undershoot current. We find that the drift kinetics of the ions in the oxide is quite similar to that of mobile protons in SiO_2 film as reported by K. Vanheusden, et al[3]. To further characterise the oxide, MOS devices with ECR-PECVD oxide were fabricated. As shown in fig.3, the dielectric constant of ECR-PECVD oxide shows a large frequency dispersion at low frequency, which is consistent with the conclusion that there is a relaxation process of the space charge in the oxide layer.

References:

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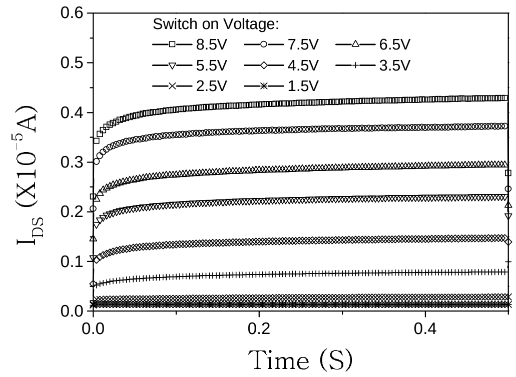

Fig.1 Undershoot current observed in a 3.2m×2.9µm n-channel single grain silicon TFT. V_{DS}=0.1V. V_{GS} is stepped from 0 to its maximum value V_{GSmax} in 20 ns. V_{Gsmax} values are indicated in the figure.

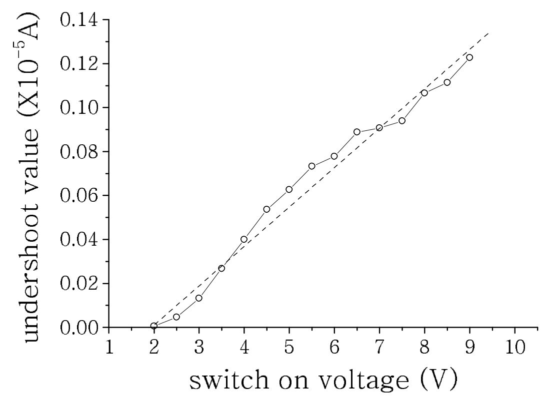

Fig. 2, The undershoot value for the 3.2um×2.9um single grain silicon TFT under different switch on voltages. V_{DS}=0.1V.

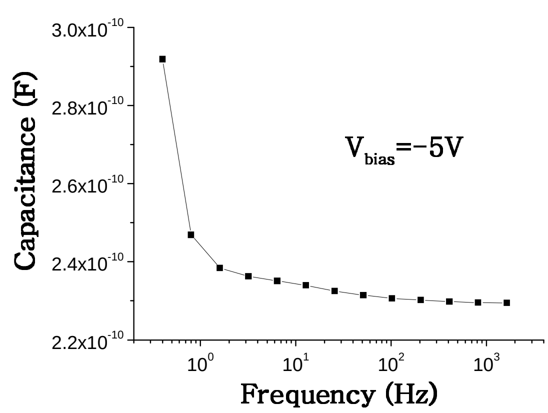

Fig.3, The capacitance of the MOS devices measured at the bias voltage of -5V. The doping level of the p-Si wafer is 10^{16}. The top electrode is Al.