**Report for Take Home Exam: Silvaco**

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**Best design codes:**

[**https://github.com/yifuhhh/EE396V\_TFT/blob/master/FinalExam/BestDesign/TFT\_best.in**](https://github.com/yifuhhh/EE396V_TFT/blob/master/FinalExam/BestDesign/TFT_best.in)

**Data processing codes:**

[**https://github.com/yifuhhh/EE396V\_TFT/blob/master/DataProcess/FinalExam.py**](https://github.com/yifuhhh/EE396V_TFT/blob/master/DataProcess/FinalExam.py)

1. **Introduction**

In the report, channel length, channel height and dielectric thickness are swept to improve FOMs of TFT. Here, field effect mobility, subthreshold swing and on-current density are all improved to different extends. On-current density has been focused on as a key FOM. Dielectric thickness would be the design parametric sweep to be discussed in this report.

1. **Table of Old Device Characteristics**

|  |  |
| --- | --- |
| Figures of Merit | |
| Field Effect Mobility, µFE [cm2/V-s] | 0.16 |
| Subthreshold Swing, S [V/dec] | 0.48 |
| On-current Density, J [A/cm2] | 0.12 |
| Semiconductor Channel | |
| Channel length, L [um] | 50 |
| Channel width, W [um] | 180 |
| Channel height, H [nm] | 200 |
| Gate Dielectric | |
| Thickness, t­di [nm] | 200 |
| Metal Contact | |
| Source work function, Ws [eV] | 4.33 |
| Drain work function, Wd [eV] | 4.33 |

1. **Summary of parameter sweep**
2. Channel height (**H** [nm]): 20, 40, 80, 160, 200, 300.
3. Channel length (**L** [um]): 12.5, 25, 37.5, 50, 62.5.
4. Dielectric thickness (**tdi** [nm]): 100, 150, 200, 250, 300.
5. **Reasoning for sweeping parameter**

According to square model of TFT in saturation region( ) in Wager’s review, with the decrease of tdi, the dielectric capacity would increase, thus Id will increase in saturation region, so on-current density will increase with same channel width and height. When channel length is small, the decrease of channel length can lead to small decrease of field effect mobility. When tdi and channel length are small, SS will be small. Thus, on-current density enhancement is the focus of tdi and channel length sweep.

1. **Device analysis**

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1. **Parametric Study Conclusion**

From the sweep we can find that when the dielectric thickness decreases, the on-current density will increase rapidly. Also, the subthreshold swing will decrease when the dielectric thickness decreases, which is desirable. The field effect mobility will increase when the dielectric thickness decreases. In general, dielectric thickness will be a good parameter for tuning.

1. **Full Summary of Best Device**
   1. Figure of device

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* 1. Design choice

Here I chose to tune L, H and tdi in order to get a higher on-current density. The parameters value and outcome of the best design are listed in the following table. Parameters modified are in the color of green. The improvements are in the color of red.

From the plots for sweep of H and L we can get that, to increase the on-current density as well as reduce the subthreshold swing, channel length should decrease. Field effect mobility would increase when channel length decreases. However, when channel height decreases a lot, mobility would decrease dramatically. Taking this information into consideration, I chose to reduce H a little, while channel length and dielectric thickness are both the smallest value in the sweep respectively.

|  |  |  |
| --- | --- | --- |
| Figures of Merit | | Improvement |
| Field Effect Mobility, µFE [cm2/V-s] | 0.44 | 175% |
| Subthreshold Swing, S [V/dec] | 0.27 | -43.8% |
| On-current Density, J [A/cm2] | 14.82 | 12250% |
| Semiconductor Channel | | |
| Channel length, L [um] | 12.5 | |
| Channel width, W [um] | 180 | |
| Channel height, H [nm] | 80 | |
| Gate Dielectric | | |
| Thickness, t­di [nm] | 100 | |
| Metal Contact | | |
| Source work function, Ws [eV] | 4.33 | |
| Drain work function, Wd [eV] | 4.33 | |

* 1. Design summary table

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Figures of Merit | | | | | | | | | | | | | | |
| µFE [cm2/V-s] | 0.16 | 0.12 | 0.14 | 0.15 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.46 | 0.24 | 0.08 | 0.05 |
| S [V/dec] | 0.48 | 0.26 | 0.43 | 0.44 | 0.46 | 0.46 | 0.17 | 0.47 | 0.48 | 0.47 | 0.27 | 0.37 | 0.57 | 0.66 |
| J [A/cm2] | 0.12 | 0.24 | 0.23 | 0.19 | 0.14 | 0.09 | 0.53 | 0.25 | 0.12 | 0.09 | 1.53 | 0.37 | 0.04 | 0.01 |
| L  [um] | 50 | 50 | 50 | 50 | 50 | 50 | 12.5 | 25 | 37.5 | 62.5 | 50 | 50 | 50 | 50 |
| W  [um] | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 | 180 |
| H  [nm] | 200 | 20 | 40 | 80 | 160 | 300 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| t­di  [nm] | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 100 | 150 | 250 | 300 |
| Ws [eV] | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 |
| Wd [eV] | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 | 4.33 |

* 1. Plots for sweep of H and L

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