# Data Analysis Results of TowerJazz Test Structures

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# Presentation Outline

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- Investigated devices were CMOS structures located on TID_TJ180_v2 test chip

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- Primary results of threshold voltages are of un-irradiated nMOS transistors

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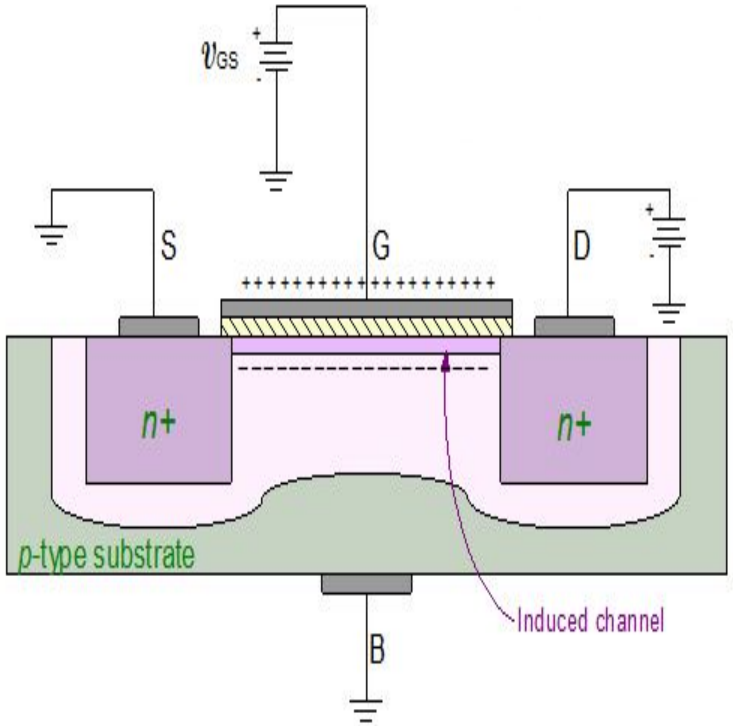
# Measurement Conditions (1)

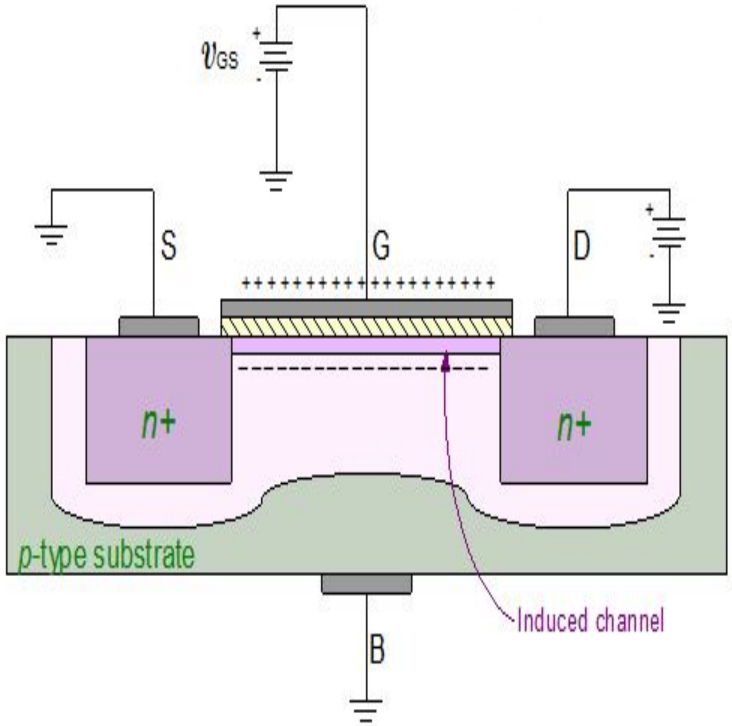
- Gate voltage sweep from 0V to 1.8V was performed on 26 nMOS transistors with various W/L
- Source and substrate terminals were connected to common ground
- Drain voltage was kept at maximum value of 1.8V to keep operation of transistor in saturation mode




n-channel MOSFET cross-section

# Measurement Conditions (2)

- Compliance currents of $10^{-5}A$ order were set to drain and source
- Current limit of $10nA$ was also set to gate
- These measures were taken to protect the test sample




n-channel MOSFET cross-section

# Presentation Outline

# Fitting Method (1)

- Main goal is to extract threshold voltages from the dataset
- Shockley $1^{st}$ order transistor model in saturation region was applied

$$I_{ds} = \begin{cases} 0 & V_{gs} < V_{th} \\ \frac{\mu_n C_{ox} W}{2L}(V_{gs} - V_{th})^2 & V_{gs} > V_{th} \end{cases}$$

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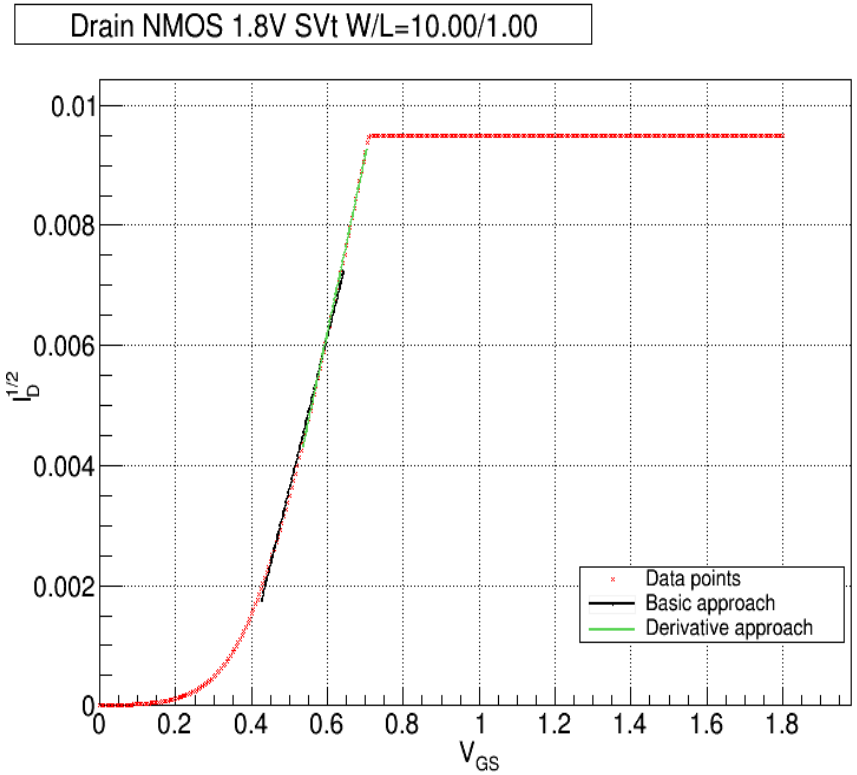
- This allowed linear fitting
- The main concern was to select fitting region
- 2 approaches were implemented

# Fitting Method (3)

- $1^{st}$ option was to exclude all the data point correspond to less than 20% or greater than 80% of the maximum drain current value
- $2^{nd}$ option - all the points are excluded that correspond to less than 80% of the maximum $\frac{dI_{ds}^{1/2}}{dV_{gs}}$
- Results are prepared for both approaches



# Presentation Outline

# Results (1)

| Name | W/L | $V_{th}$ Derivative | $V_{th}$ Basic | $\lvert\Delta V\rvert$ | $\lvert\Delta V\rvert$ in % |
|---|---|---|---|---|---|
| AD01 | 0.44/0.18 | 0.396 | 0.402 | 0.006 | 1.49 |
| AD02 | 0.70/0.18 | 0.437 | 0.429 | 0.008 | 1.86 |
| AD03 | 1.00/0.18 | 0.444 | 0.426 | 0.018 | 4.23 |
| AD04 | 2.00/0.18 | 0.426 | 0.393 | 0.033 | 8.40 |
| AD05 | 10.00/0.18 | 0.404 | 0.347 | 0.057 | 16.43 |
| AD06 | 10.00/0.36 | 0.417 | 0.371 | 0.046 | 12.40 |
| AD07 | 10.00/0.54 | 0.404 | 0.368 | 0.036 | 9.78 |
| AD08 | 10.00/1.00 | 0.387 | 0.357 | 0.03 | 8.40 |
| AD09 | 10.00/2.00 | 0.378 | 0.361 | 0.017 | 4.71 |
| AD10 | 10.00/10.00 | 0.354 | 0.355 | 0.001 | 0.28 |
| AD11 | 0.70/0.18 | 0.542 | 0.528 | 0.014 | 2.65 |
| AD12 | 1.00/0.18 | 0.546 | 0.531 | 0.015 | 2.82 |
| AD13 | 2.00/0.18 | 0.520 | 0.489 | 0.031 | 6.34 |
| AD15 | 10.00/1.00 | 0.467 | 0.439 | 0.028 | 6.38 |
| AD16 | 1.80/0.18 | 0.454 | 0.428 | 0.026 | 6.07 |
| AD17 | 5.00/0.50 | 0.420 | 0.392 | 0.028 | 7.14 |
| AD18 | 100.00/10.00 | 0.324 | 0.297 | 0.027 | 9.09 |
| AD19 | 0.22/0.18 | 0.360 | 0.363 | 0.003 | 0.83 |
| AD20 | 0.50/0.18 | 0.417 | 0.419 | 0.002 | 0.48 |
| AD21 | 10.00/0.18 | 0.414 | 0.357 | 0.057 | 15.97 |
| AD22 | 10.00/1.00 | 0.388 | 0.356 | 0.032 | 8.99 |
| AD23 | 10.00/10.00 | 0.354 | 0.355 | 0.001 | 0.28 |
| AD24 | 2.98/0.19 | 0.464 | 0.435 | 0.029 | 6.67 |
| AD25* | 4.10/0.55 | 0.402 | 0.394 | 0.008 | 2.03 |
| AD26* | 5.85/1.11 | 0.385 | 0.373 | 0.012 | 3.22 |
| AD27* | 9.35/2.24 | 0.367 | 0.359 | 0.008 | 2.23 |

*Enclosed-Layout-Transistors

# Results (2)

- Maximum difference in results $|\Delta V|_{max} = 0.057\text{V}$
- Minimum $|\Delta V|_{min} = 0.001\text{V}$

| Name | W/L | $V_{th}$ Derivative | $V_{th}$ Basic | $\lvert\Delta V\rvert$ | $\lvert\Delta V\rvert$ in % |
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| AD04 | 2.00/0.18 | 0.426 | 0.393 | 0.033 | 8.40 |
| AD05 | 10.00/0.18 | 0.404 | 0.347 | 0.057 | 16.43 |
| AD06 | 10.00/0.36 | 0.417 | 0.371 | 0.046 | 12.40 |
| AD07 | 10.00/0.54 | 0.404 | 0.368 | 0.036 | 9.78 |
| AD08 | 10.00/1.00 | 0.387 | 0.357 | 0.03 | 8.40 |
| AD09 | 10.00/2.00 | 0.378 | 0.361 | 0.017 | 4.71 |
| AD10 | 10.00/10.00 | 0.354 | 0.355 | 0.001 | 0.28 |
| AD11 | 0.70/0.18 | 0.542 | 0.528 | 0.014 | 2.65 |
| AD12 | 1.00/0.18 | 0.546 | 0.531 | 0.015 | 2.82 |
| AD13 | 2.00/0.18 | 0.520 | 0.489 | 0.031 | 6.34 |
| AD15 | 10.00/1.00 | 0.467 | 0.439 | 0.028 | 6.38 |
| AD16 | 1.80/0.18 | 0.454 | 0.428 | 0.026 | 6.07 |
| AD17 | 5.00/0.50 | 0.420 | 0.392 | 0.028 | 7.14 |
| AD18 | 100.00/10.00 | 0.324 | 0.297 | 0.027 | 9.09 |
| AD19 | 0.22/0.18 | 0.360 | 0.363 | 0.003 | 0.83 |
| AD20 | 0.50/0.18 | 0.417 | 0.419 | 0.002 | 0.48 |
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Thank you for your attention!

# References

1. nMOS structure illustration, Tales Pimenta, Robson Moreno and Leonardo Zoccal, ⇒ Link to picture