CMOS COMPATIBLE SOI MESFETS FOR EXTREME ENVIRONMENT ELECTRONICS

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Goal

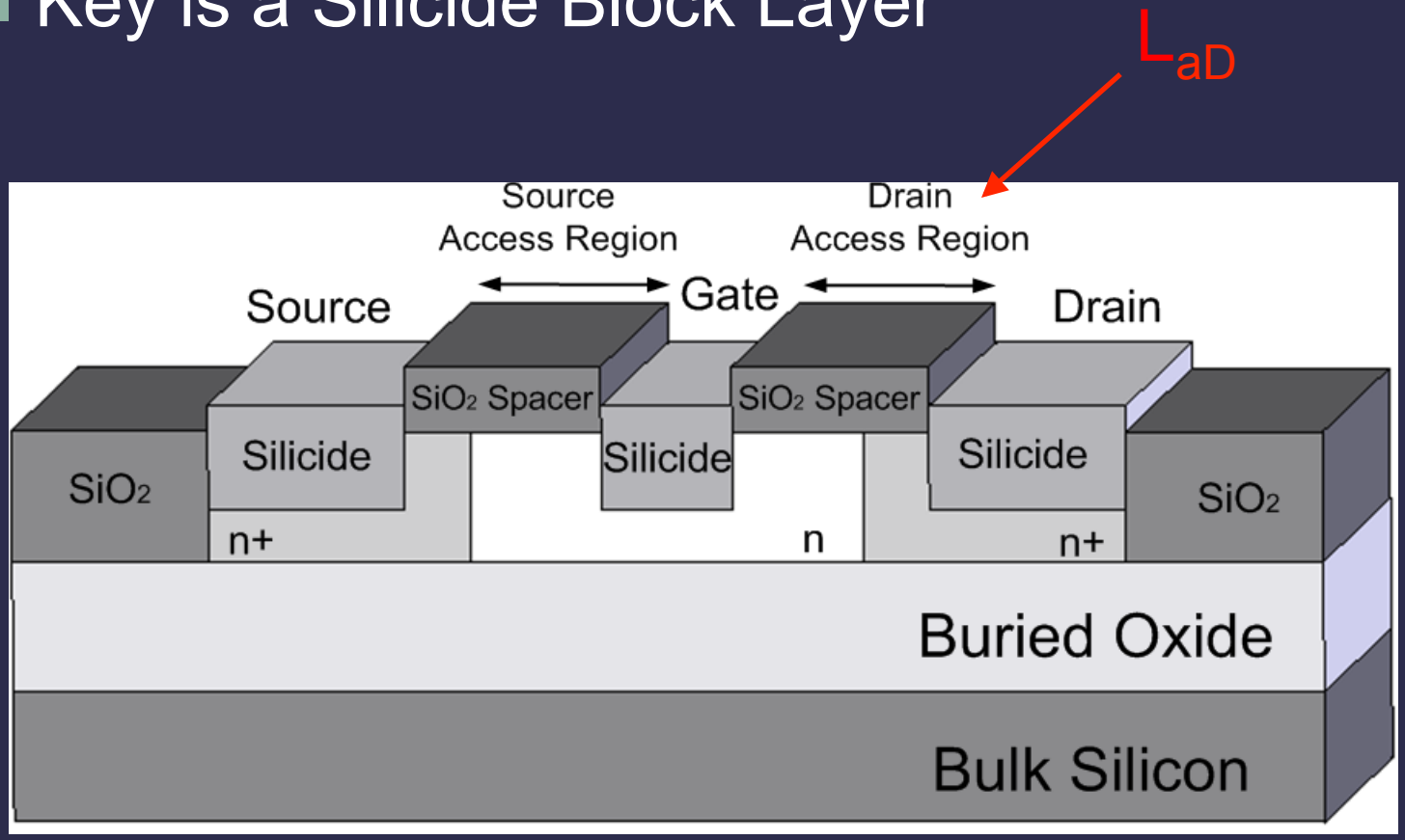
- The development of robust electronics on silicon technology
  - CMOS makes up large portion of market
    - Lowers Cost
  - Current trend is scaling down size
    - Also scales Voltage tolerance
    - Thinner Gate oxide increases Single Event Upset
  - Solution: Silicon MESFET
    - No gate oxide automatically more robust

Challenge

- To produce a silicon based MESFET on a standard process
  - Utilizing Silicon-On-Insulator (SOI)
  - Standard process that has grown in popularity
  - Apple G5 processors are made on SOI

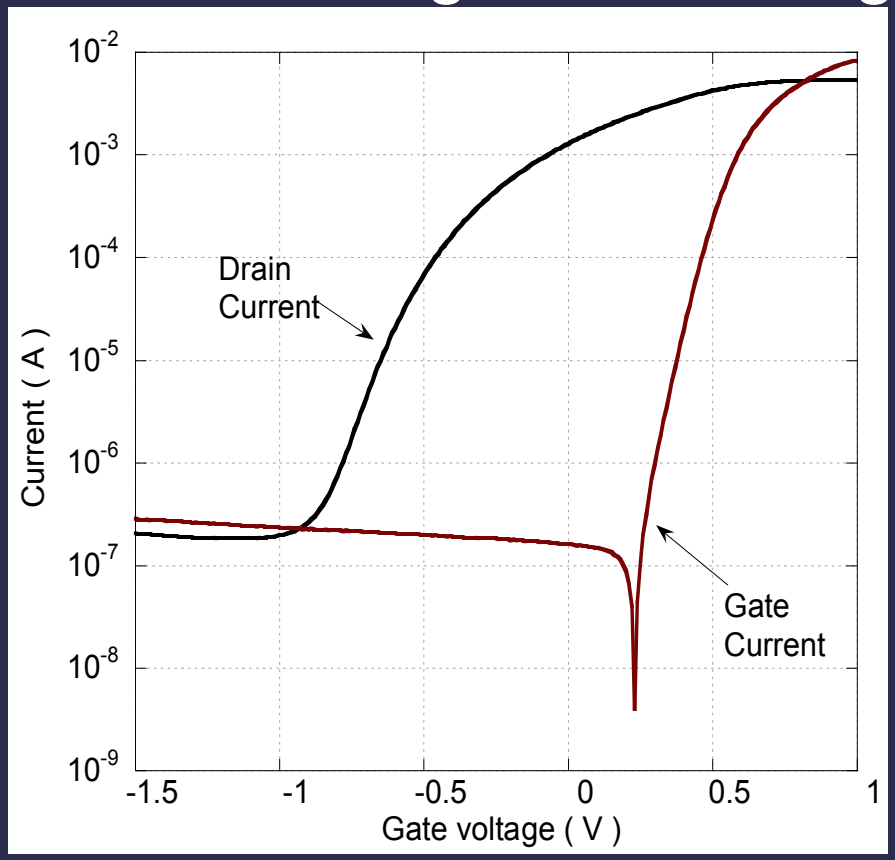
Device Fabrication

- Produced at 3 Standard SOI-CMOS foundries
- Key is a Silicide Block Layer



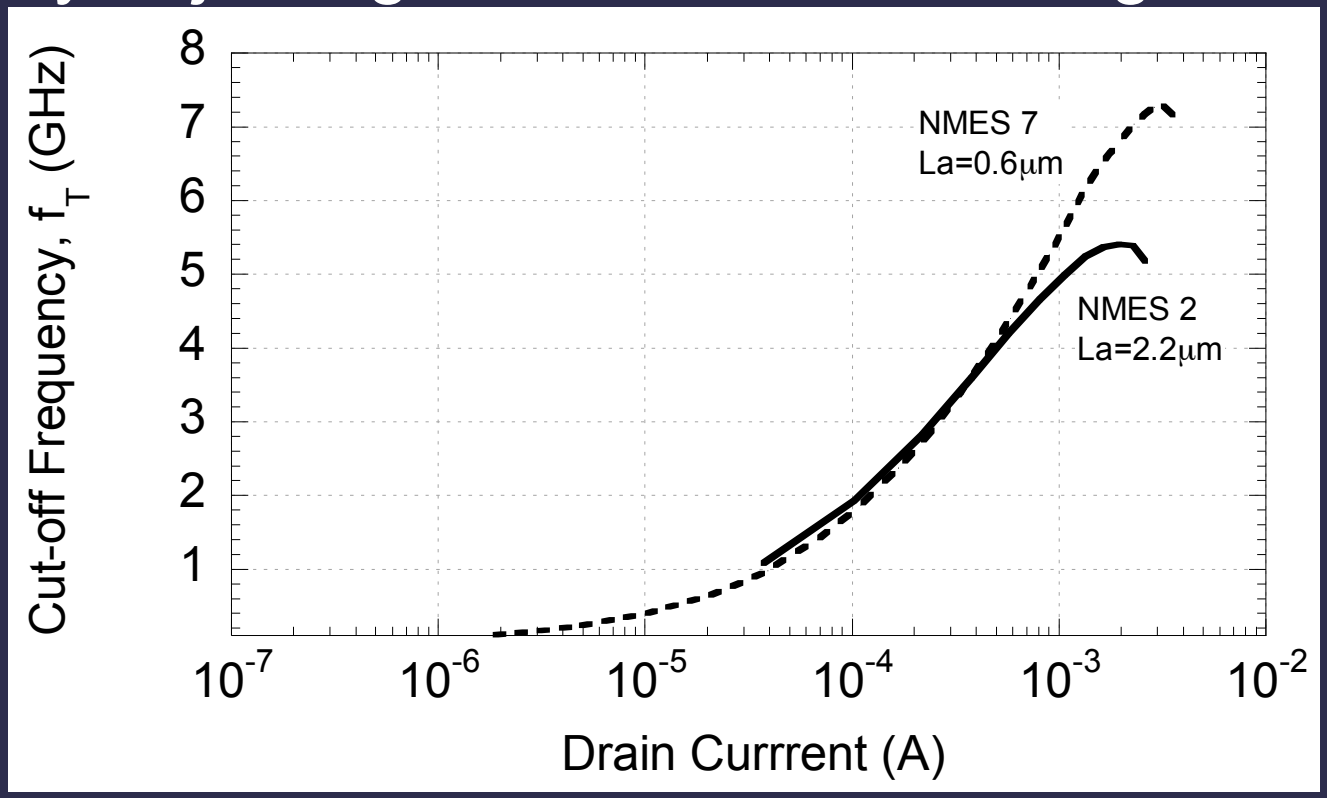
Device Characteristics

- L_g = 0.6μm L_{aD} = L_{aS} = 0.6μm
- Over 4 orders of magnitude change in I_d



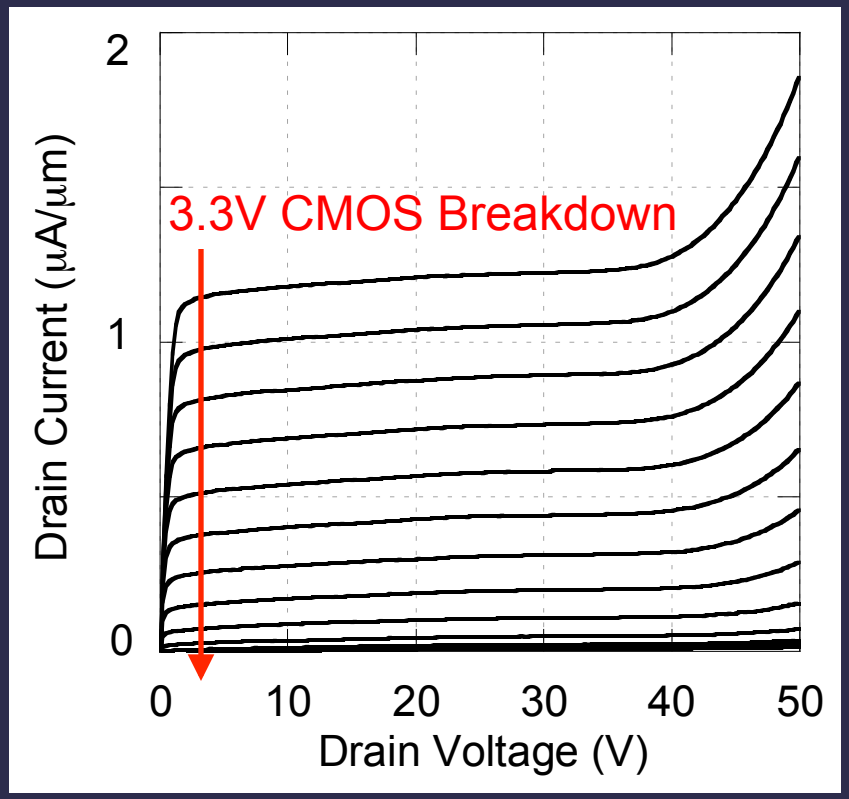
RF Figure of Merit

- Multi Giga-hertz operation
- By adjusting the Drain Access Region



High Voltage Device

- By increasing the Drain Access Region, similar to an LD-MOSFET

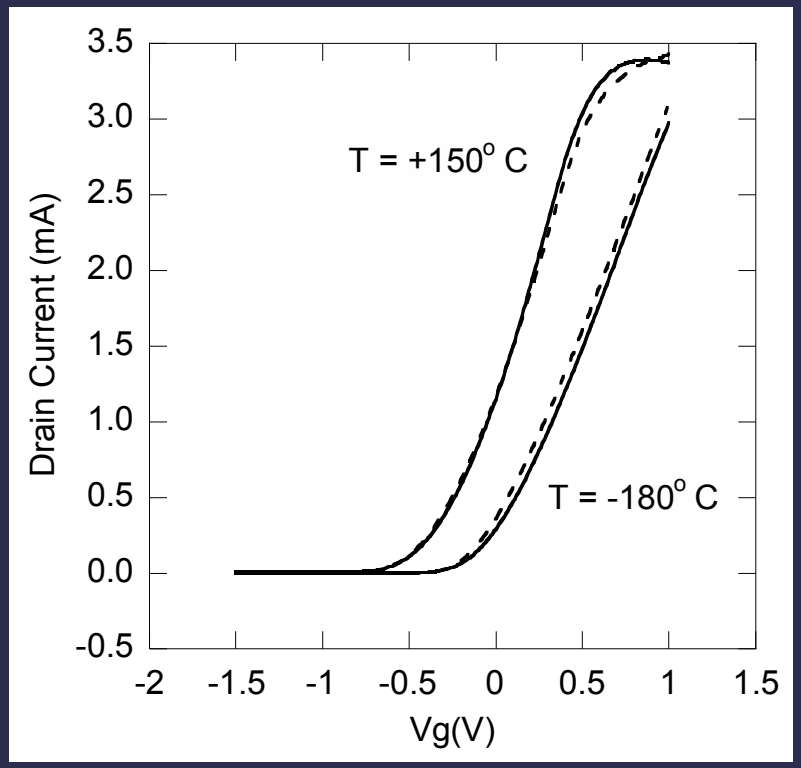


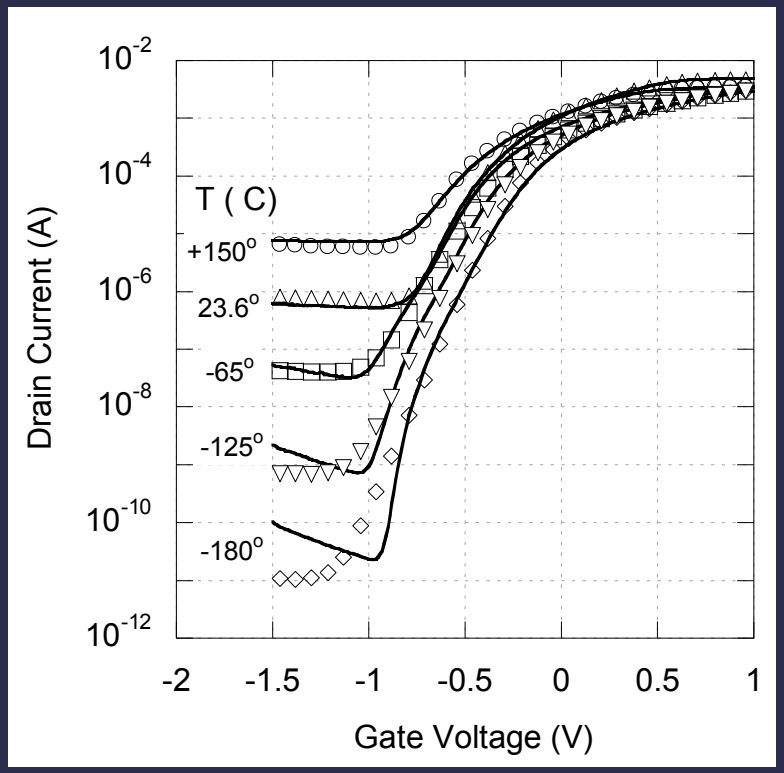
TOM3 SPICE MESFET Model

- GaAs MESFET modeling for over 30years
- Most advanced MESFET model
- Easily fit silicon MESFET to the model by matching measured data to parameters

TOM3 SPICE MESFET Model

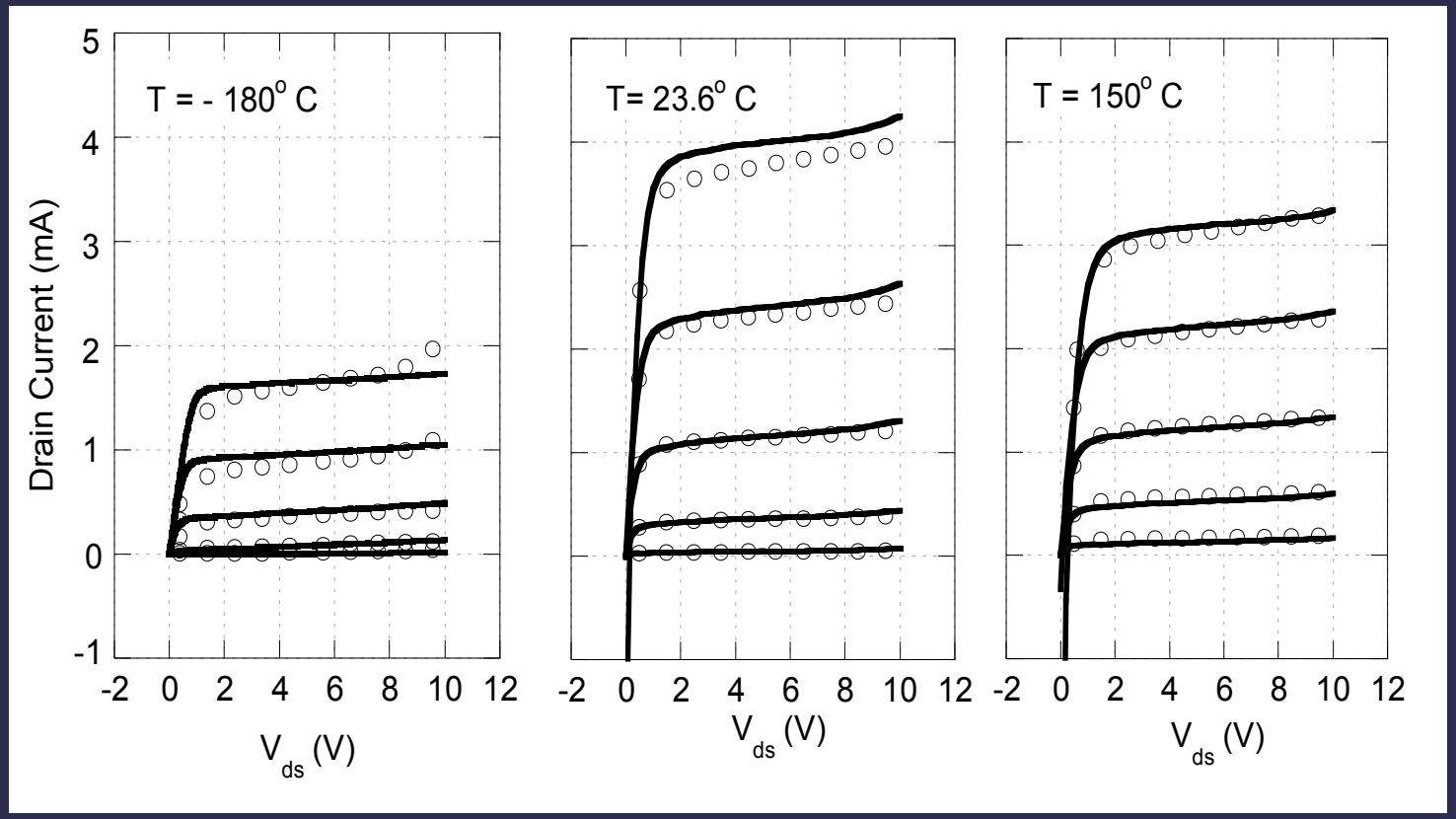
- Lunar and Martian Temperature range
- Dashed line and open figures are simulated data





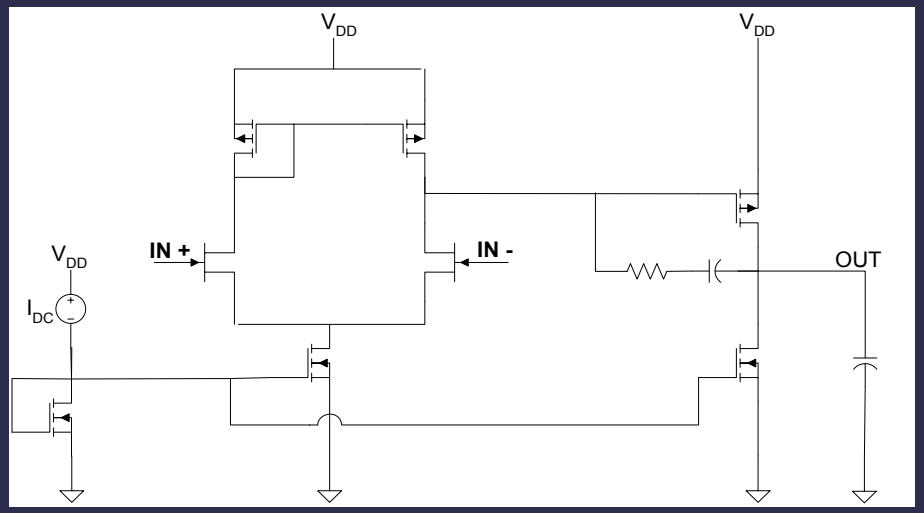
Family of Curves

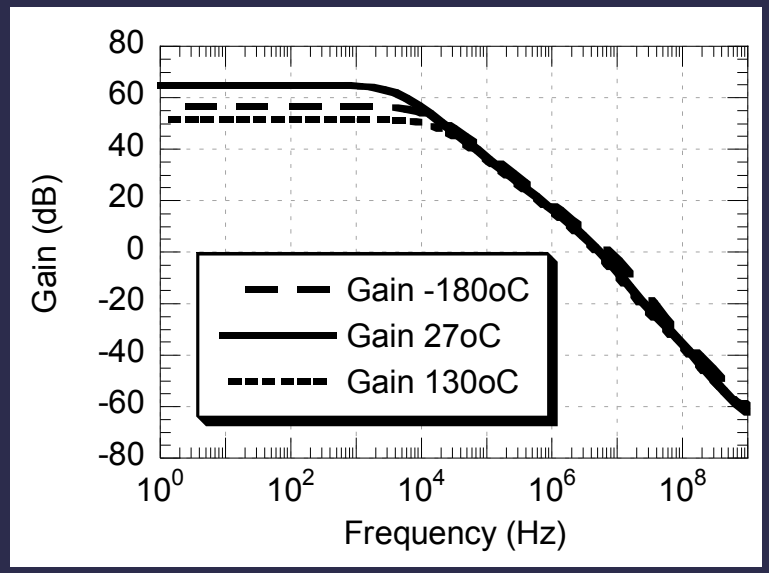
- At three temps -180°C, 23.6°C, 150°C
- Gate Voltages from top to bottom: 0.5, 0.25, 0 -0.25, and -0.5 V



OTA - MESFET CMOS Integration

- Standard 2 stage Operational Transconductance Amplifier design utilizing MESFETs for the input pair

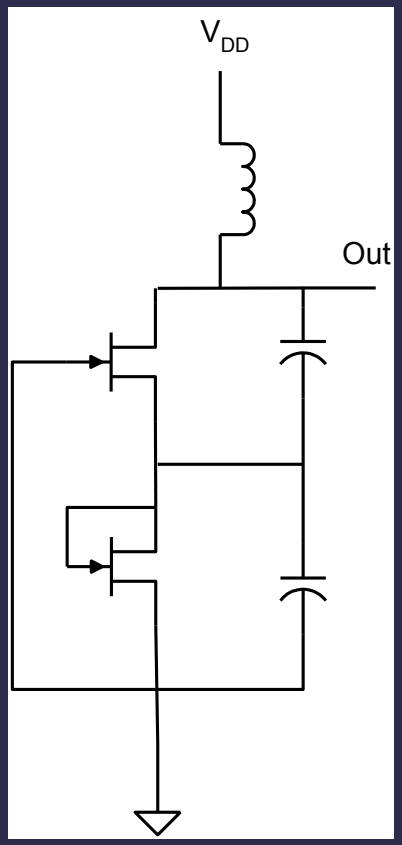


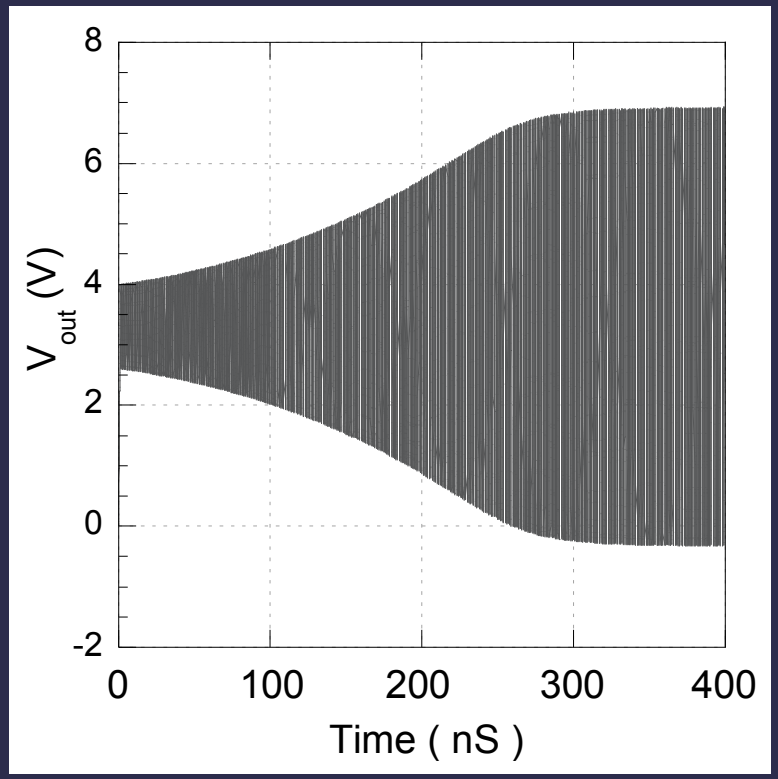


Temp	DC Gain	Gain*BW Product	DC current	Power
-180°C	57 dB	7.6 MHz	76.65uA	0.252mW
27°C	66 dB	5.4 MHz	55.67uA	0.183mW
130°C	52 dB	4.9 MHz	62.3uA	0.205mW

VCO – Colpitts Oscillator

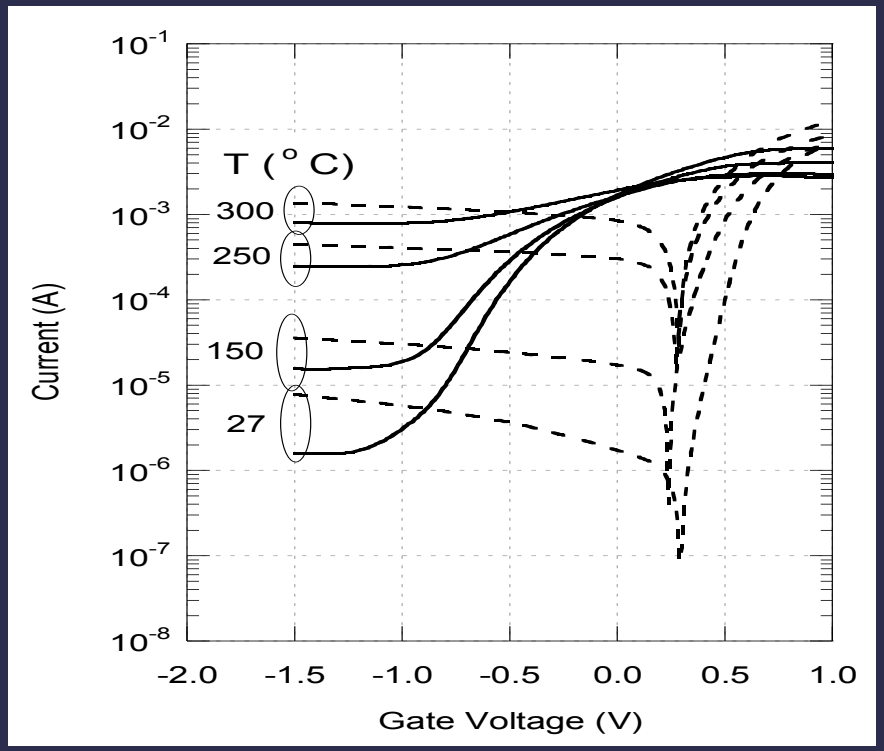
- High voltage swing





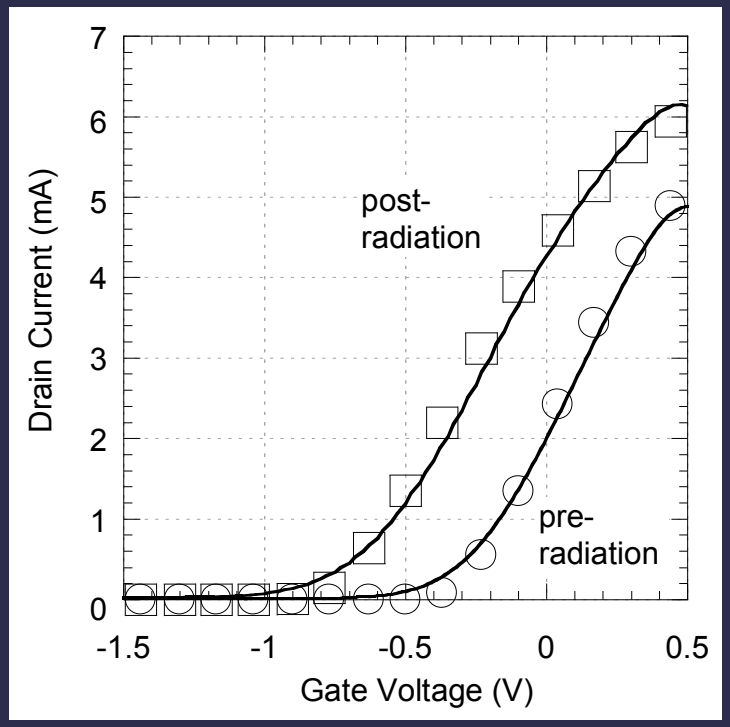
Extension of Temperature For Venus

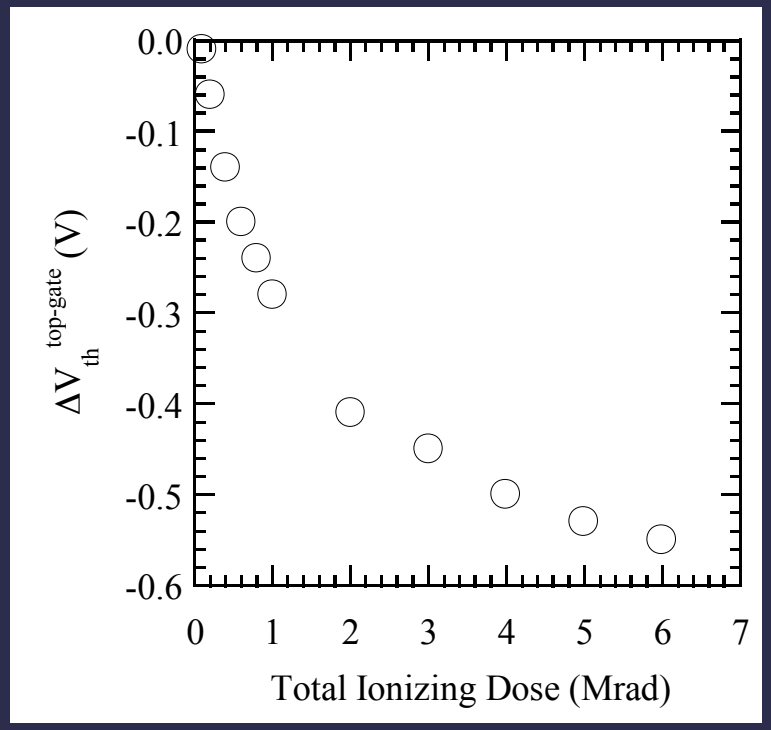
- 27°C has ratio of 4000 on-current to off-current
- 300°C has ratio of 3
- 250°C upper bound for this technology, ratio 10



Radiation Test to 6 Mrad

- Aracor 4100 Semiconductor Irradiation System (40kV X-rays)
- Threshold voltage shift, behavior like SOI MOSFETs





Conclusion

- CMOS compatible process
- Easily described by a commercially available TOM3 MESFET model
- High voltage device on Low voltage CMOS
- Good RF characteristics
- Radiation tolerant to at least 6 Mrad
- High-performance extreme environment electronics

Acknowledgments

- Financial support from:
  - JPL
  - NASA
  - AFRL
  - DARPA