Constructive use of metal-semiconductor contact effects in thin-film transistors

Radu A. Sporea

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e-mail: r.a.sporea@surrey.ac.uk

Conclusions

1. Creatively exploring design variables may lead to interesting solutions
   - Electronic device physics
   - Human-environment interaction
   - Paper
2. Industry collaboration increases relevance for academic research
3. Talent is everywhere – taking a chance pays off most of the time

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Wonderful things happen here
Surrey is 6th in *The Guardian* league table 2015 and 11th in *The Times* and *Sunday Times Good University Guide* 2015.
Electronic Engineering
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in the Guardian League Table 2015
Elektra2013
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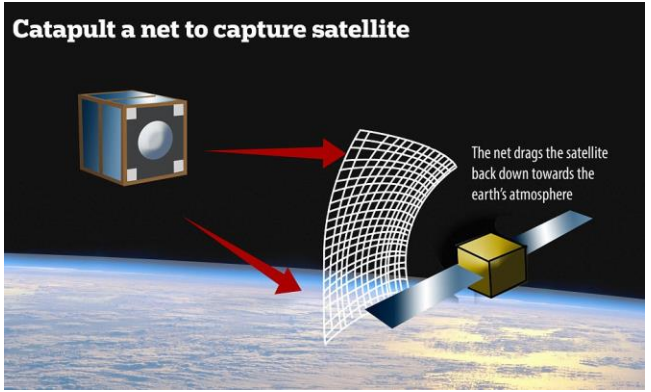
Applications of our research

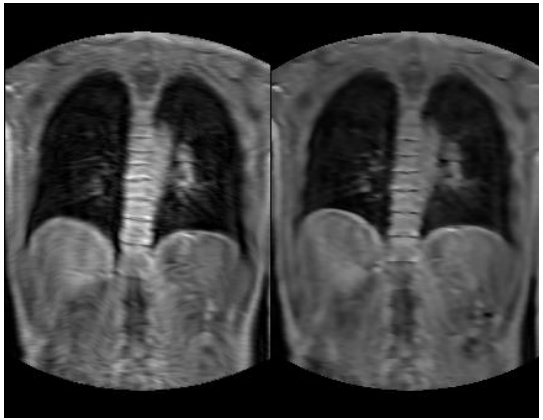
- Surrey has pioneered the manufacture of small scale satellites, Galileo project
- Space robotics and vehicles
- Propulsion systems and navigation
- Satellite Remote sensing & Disaster Monitoring
- Autonomy and Control Systems
- RemoveDEBRIS from space

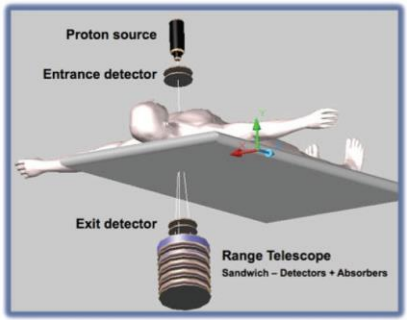


What we do: Vision, Speech and Signal Processing

Applications of our research

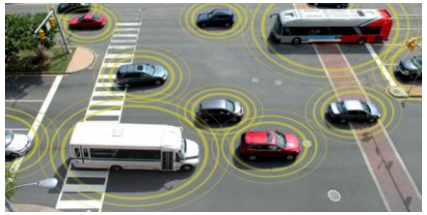
- Computer Vision & Graphics
- Pattern Recognition
- 3D Video and Audio
- Machine Learning and AI
- Biometrics & security
- Digital Signal Processing
- Media content and streaming
- Medical Imaging





What we do: 5G Innovation Centre (5GIC)

The largest international research Centre of Excellence in new generation mobile technologies and Internet of Things (£70m+ investment); in healthcare & dementia care, data and cyber security, and autonomous vehicles



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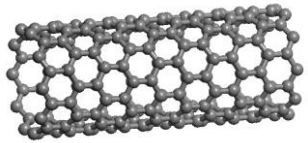
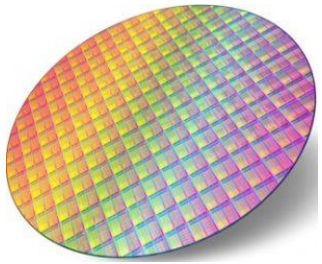
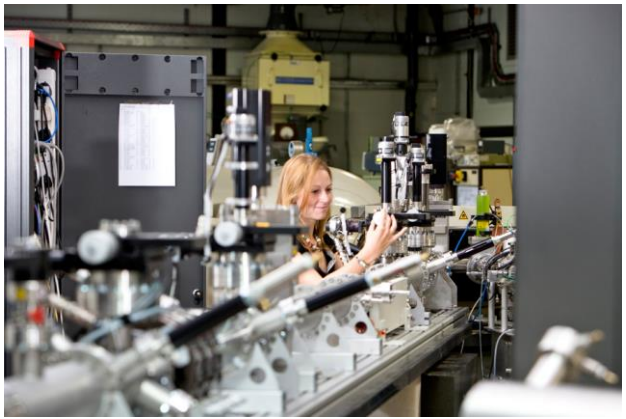
Applications of our research

- All aspect of nanoscience and nanotechnology
- Graphene and new materials
- Functional Nanomaterials
- Energy production and storage
- Solar cells & batteries
- Printable & plastic electronics
- UK Facility for Ion Implantation







Advanced Technology Institute

Quantum technologies
Photonics
Spintronics

Ion implantation

Nanoelectronics
Flexible and printed

RF and metrology

NPL South Hub

Outline

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   - Paper
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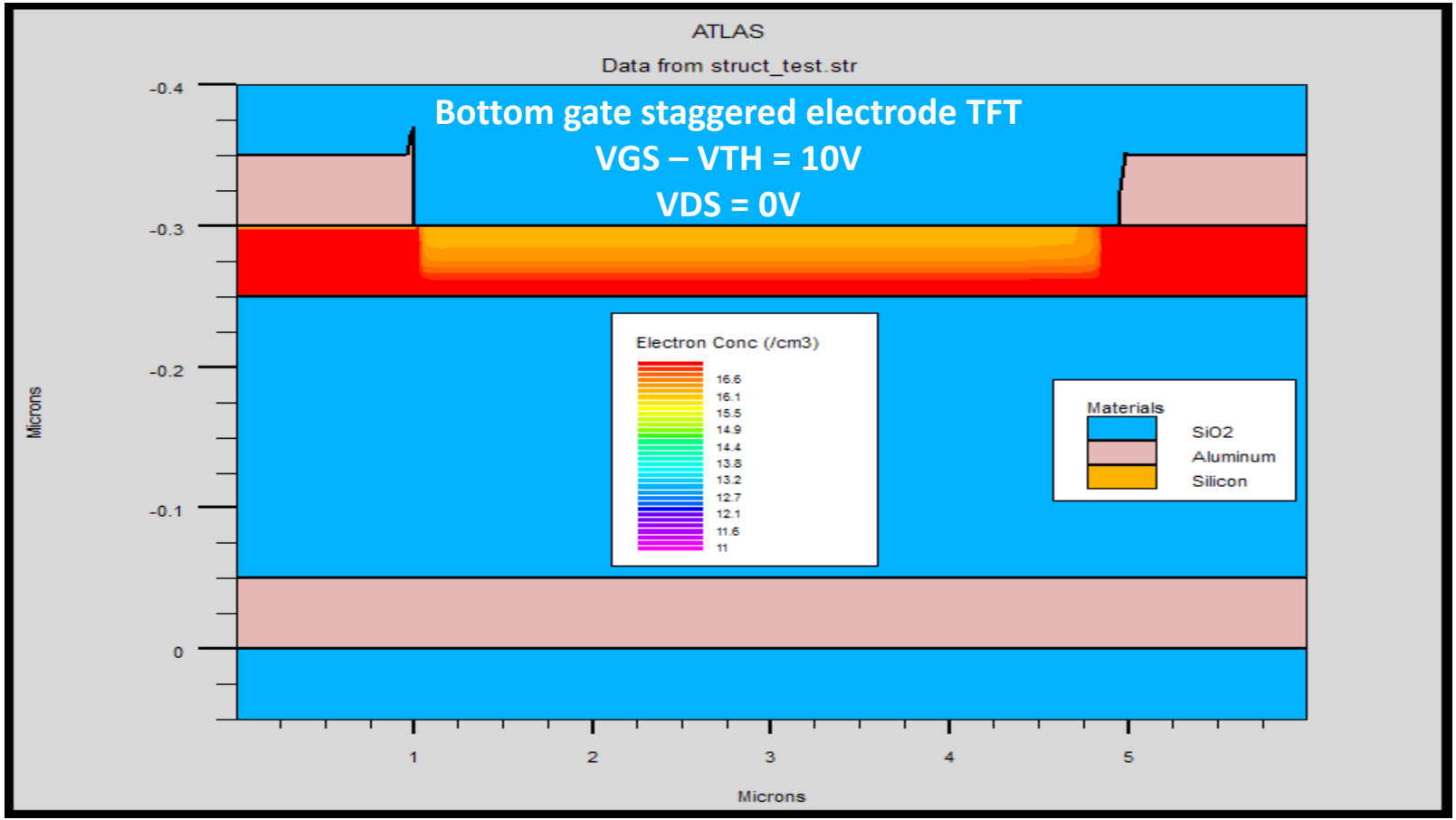
The source-gated transistor (SGT)



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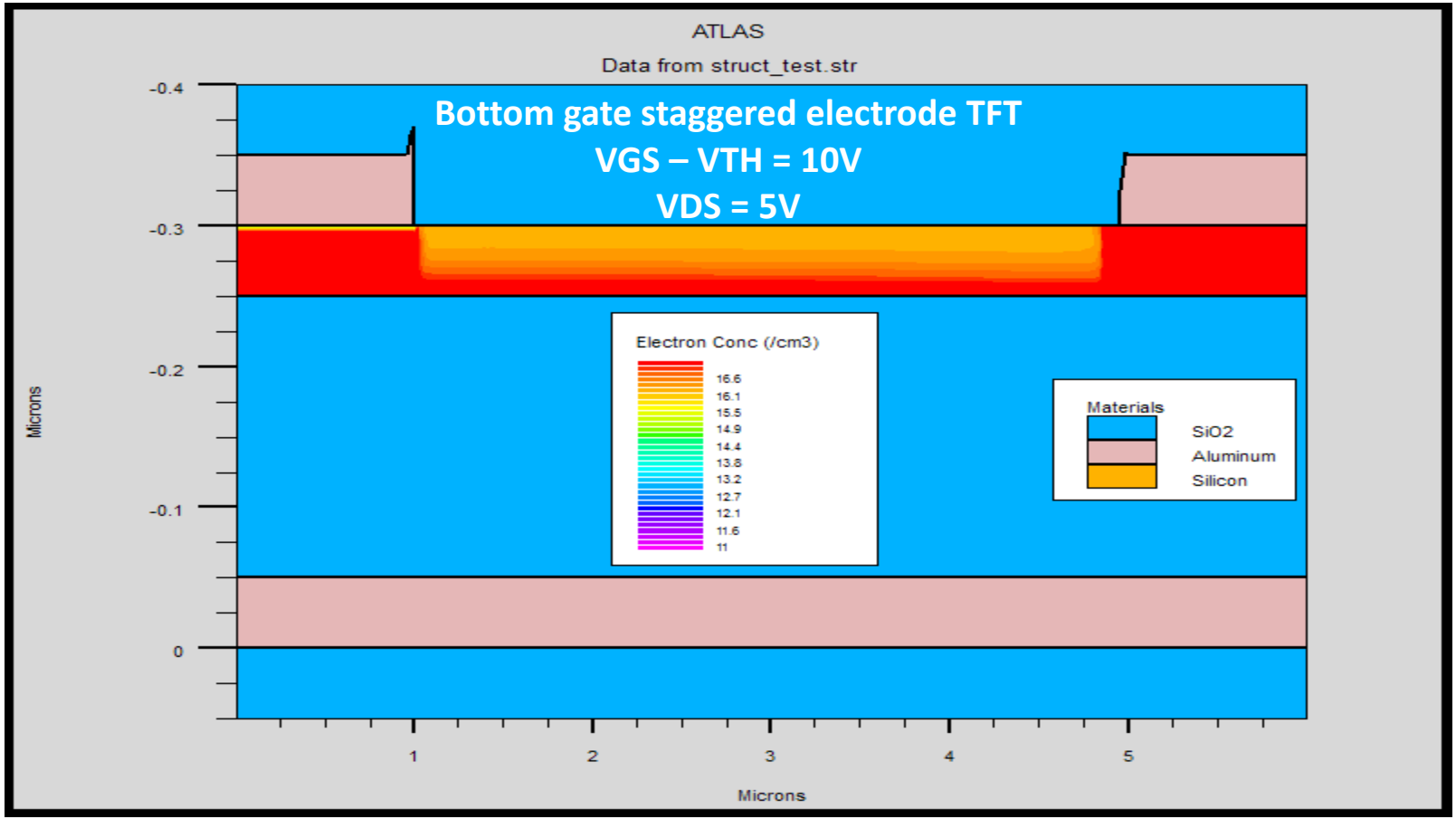
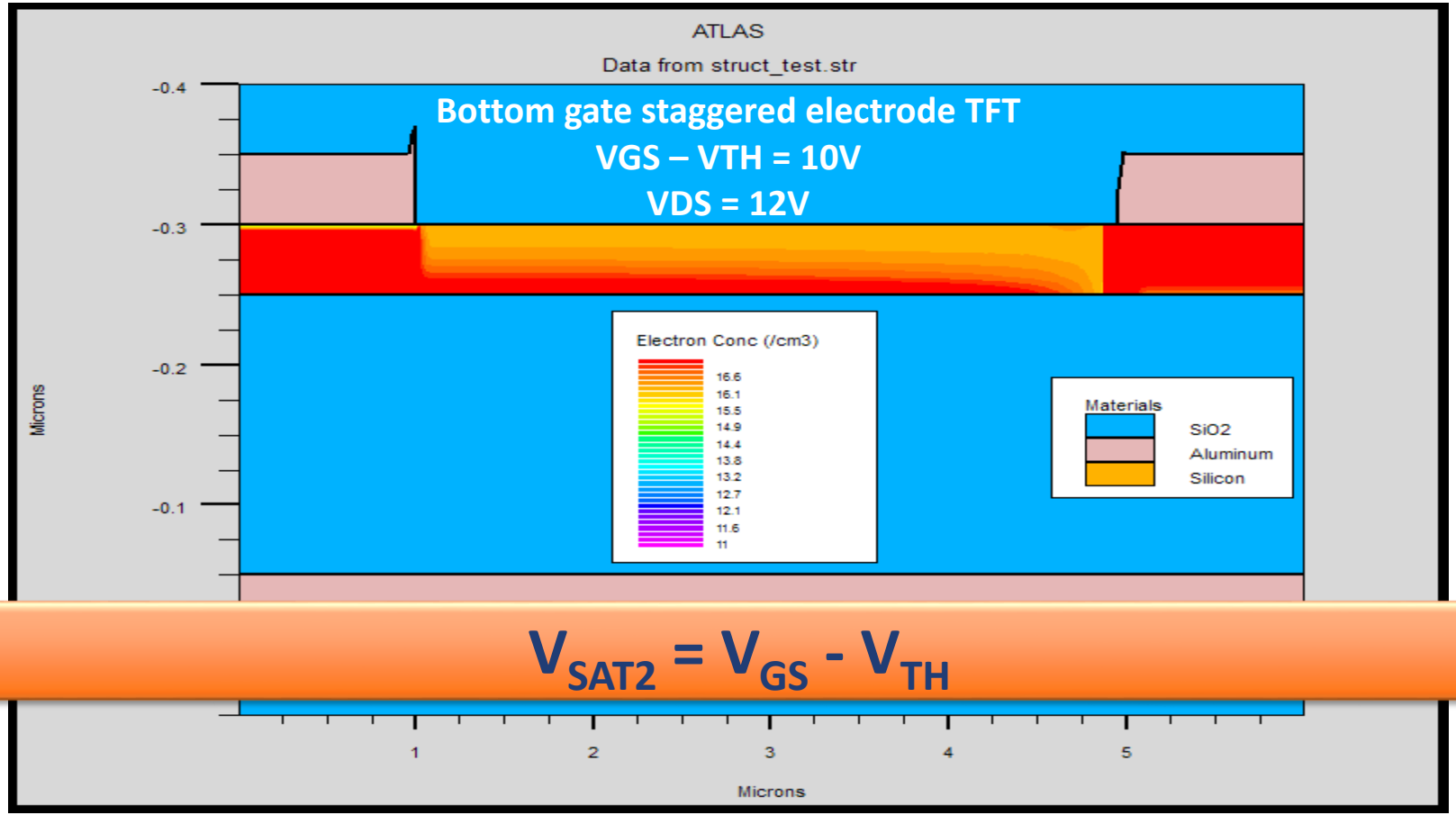
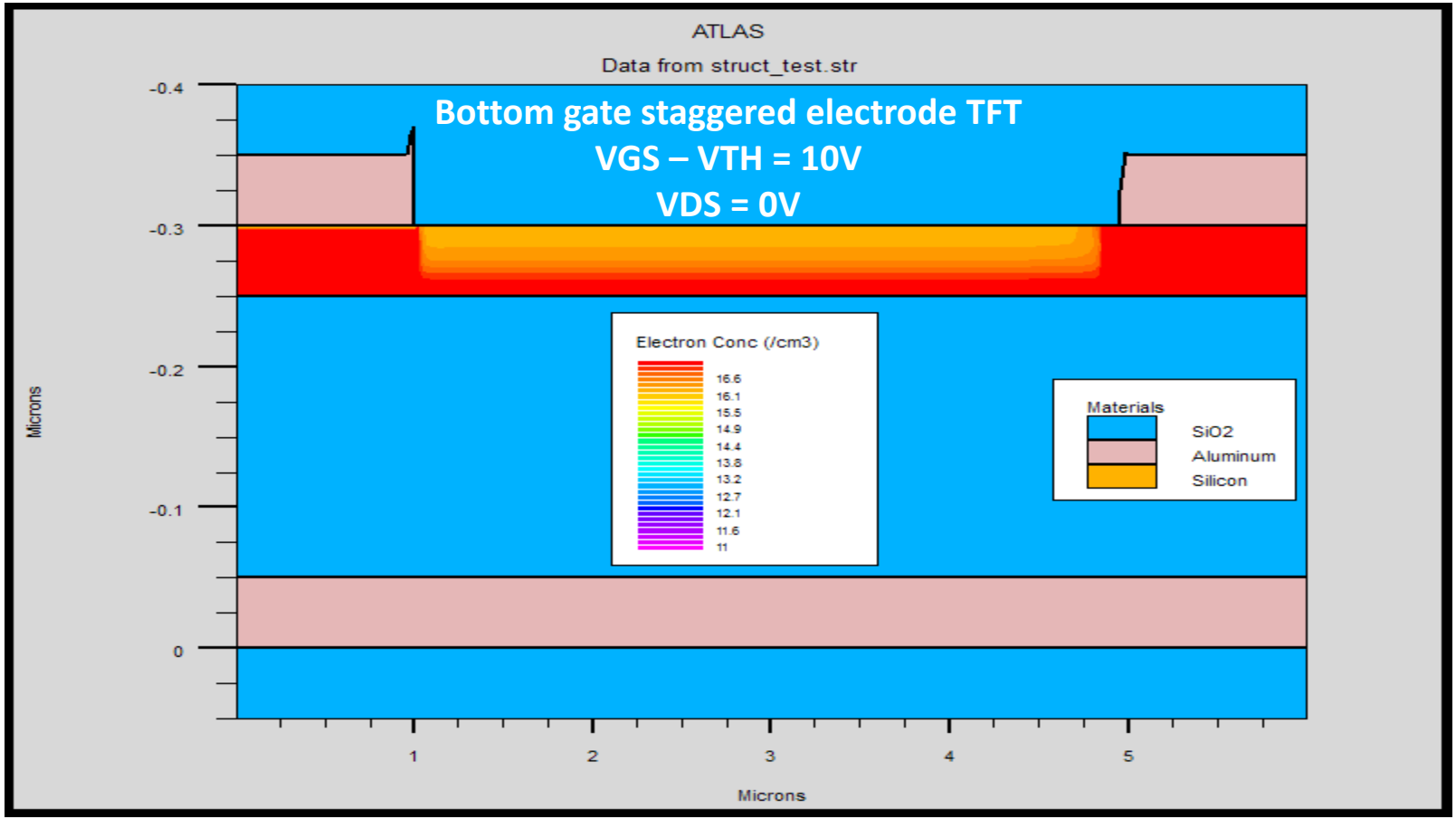


The source-gated transistor (SGT)



$$V_{SAT2} = V_{GS} - V_{TH}$$

The source-gated transistor (SGT)



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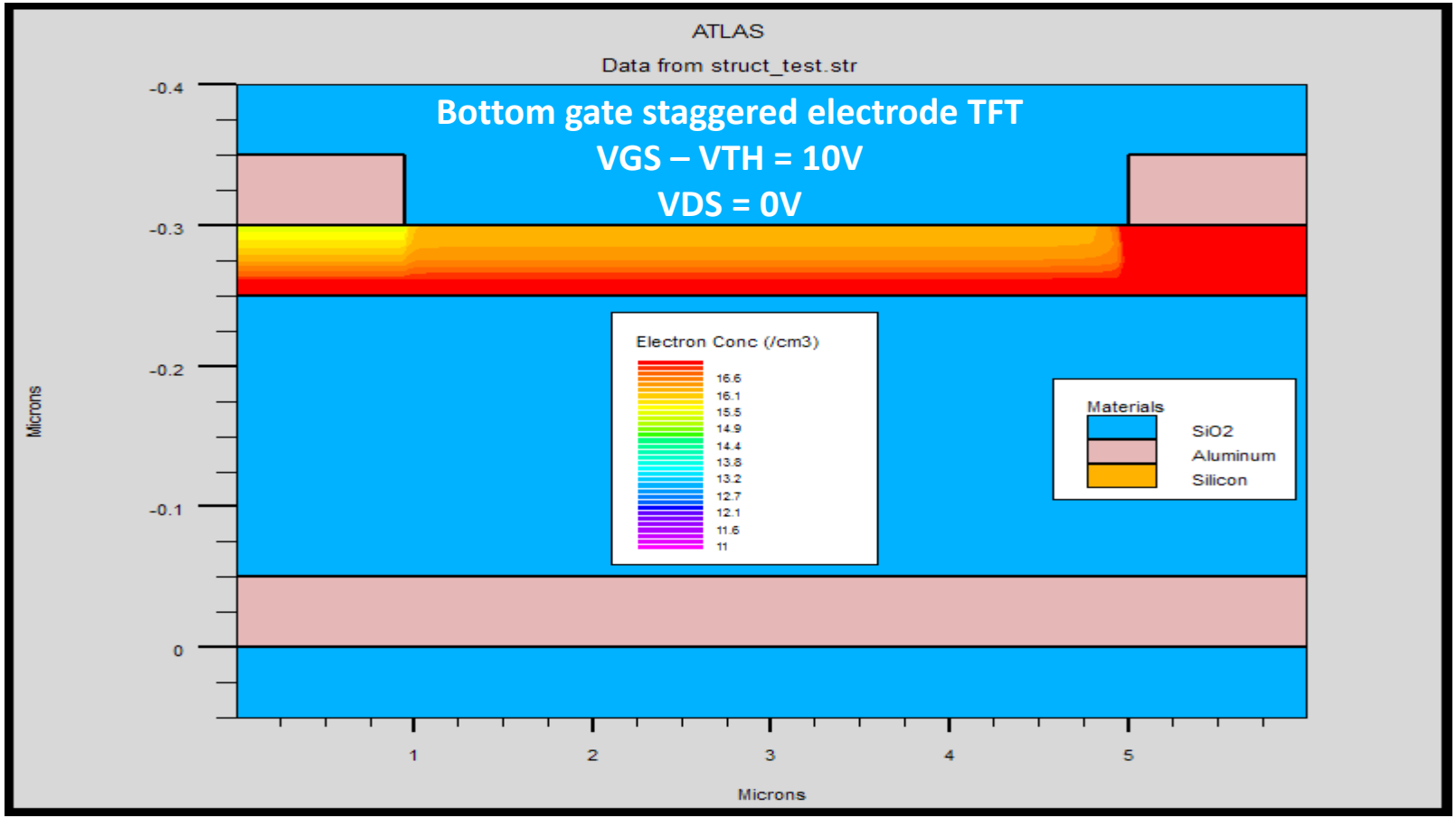

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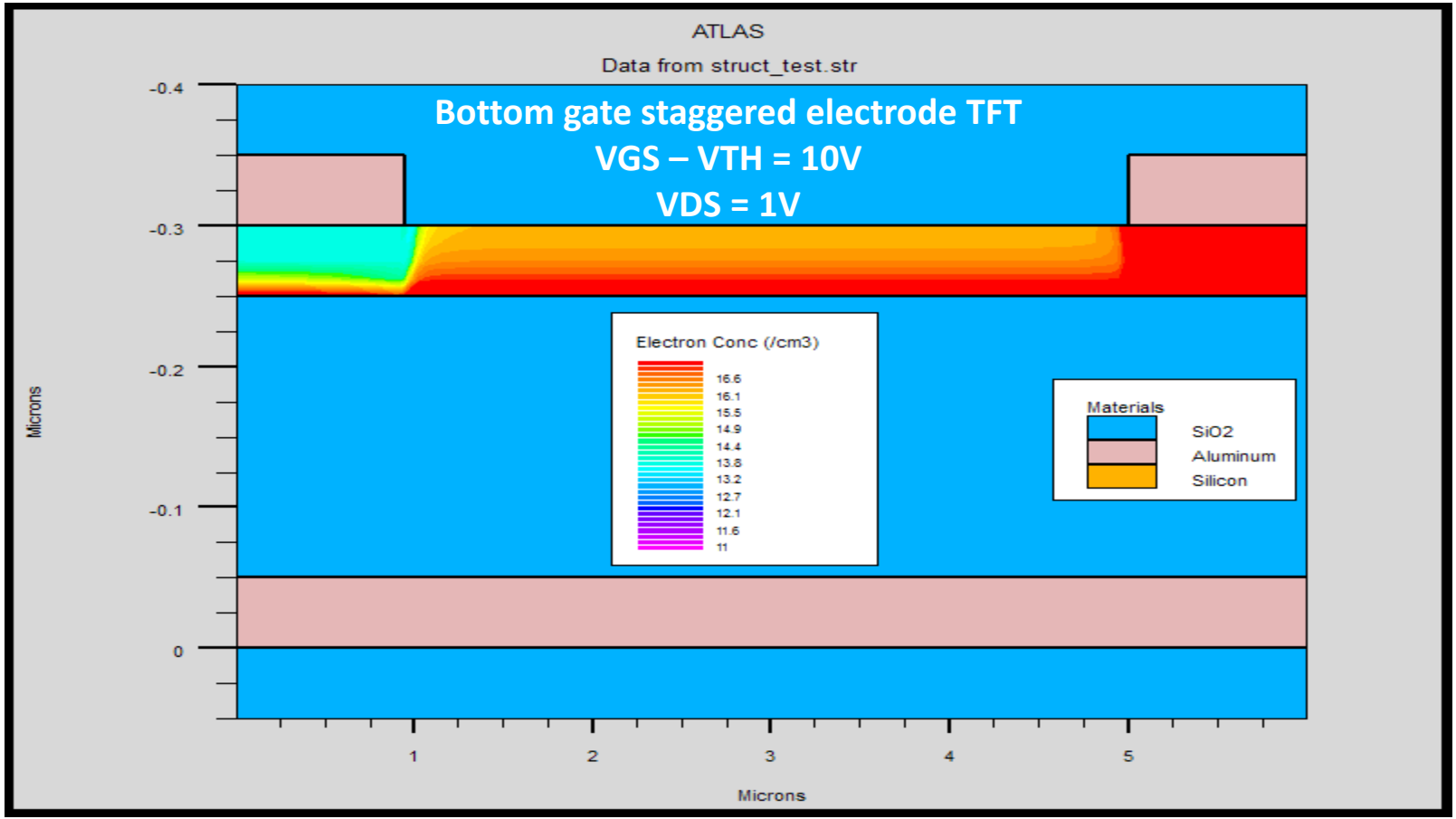

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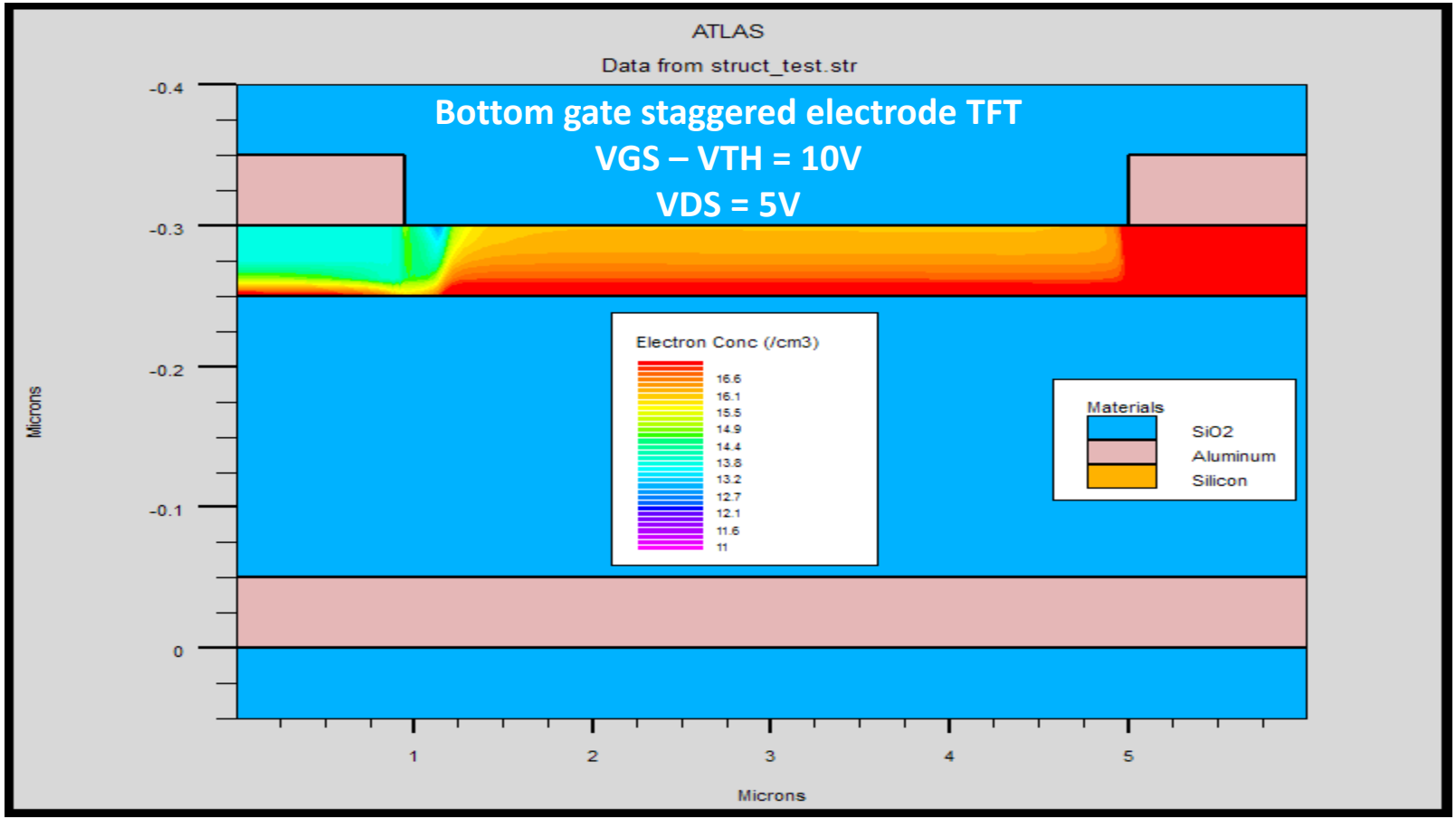

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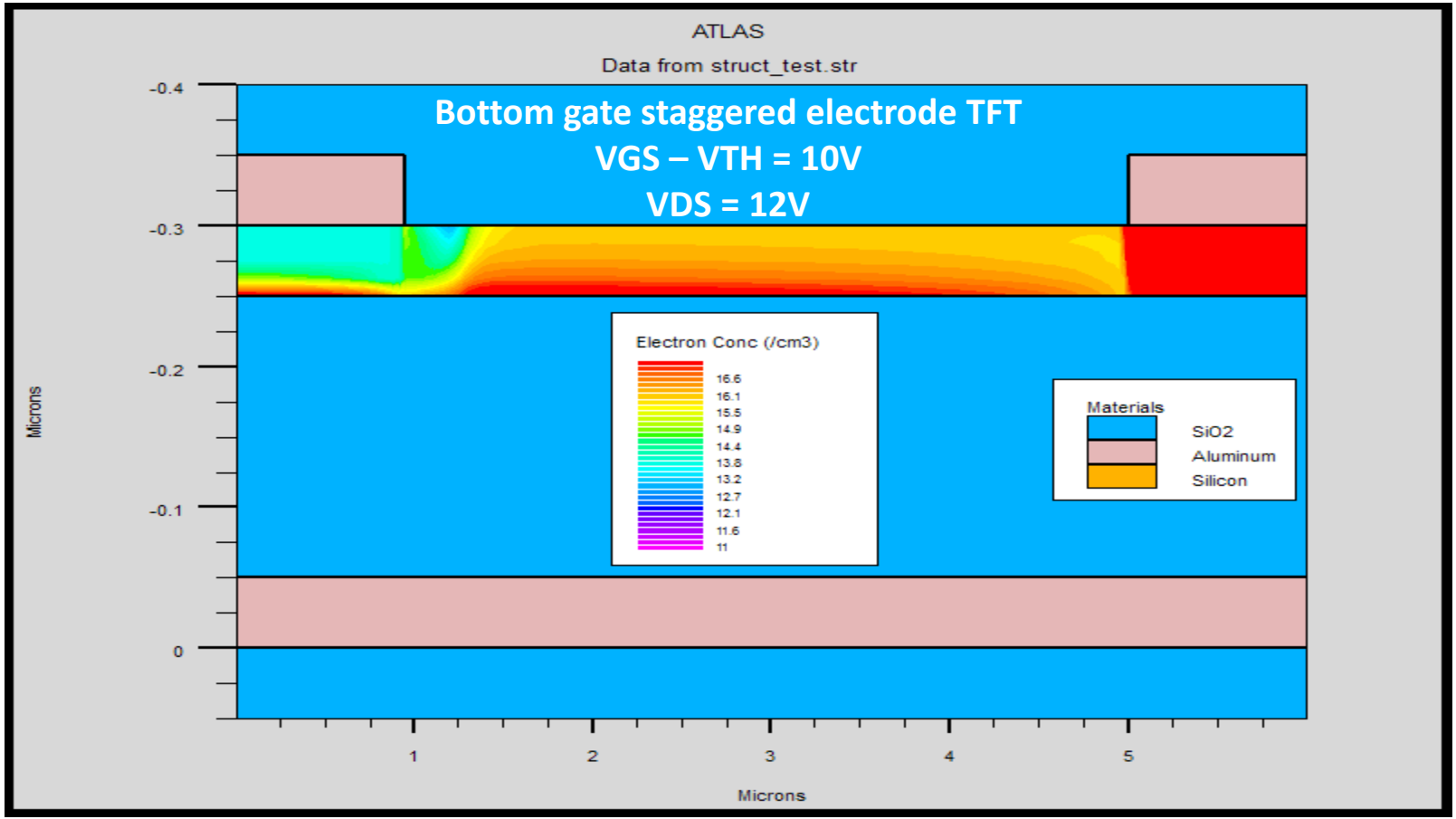

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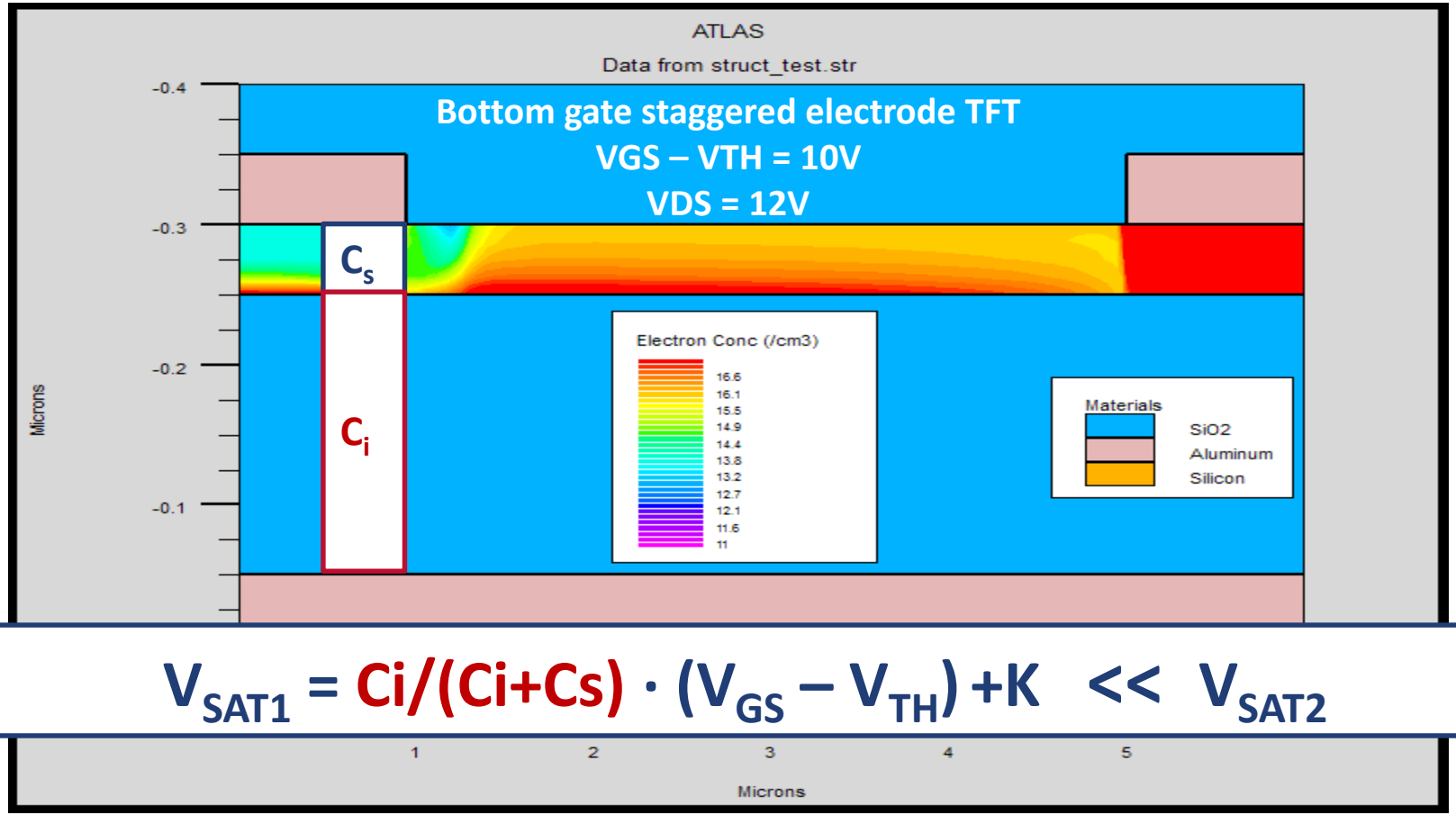
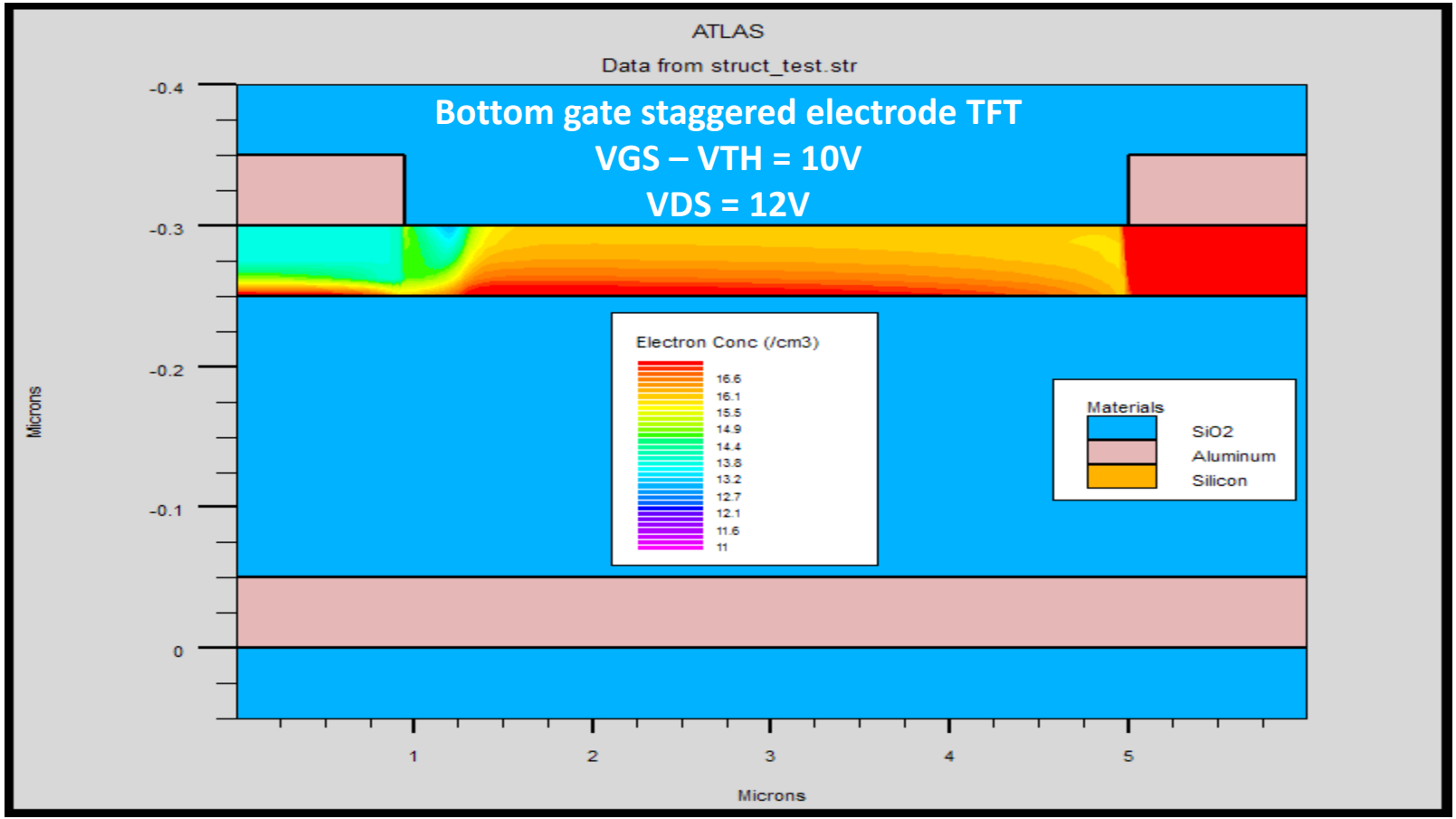


$$V_{SAT1} = Ci/(Ci+Cs) \cdot (V_{GS} - V_{TH}) + K \ll V_{SAT2}$$

The source-gated transistor (SGT)



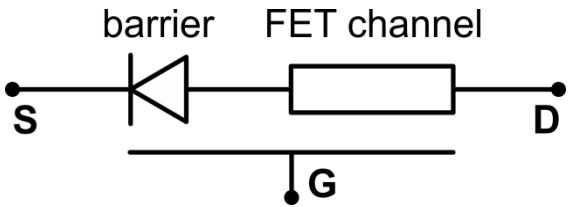
The source-gated transistor (SGT)

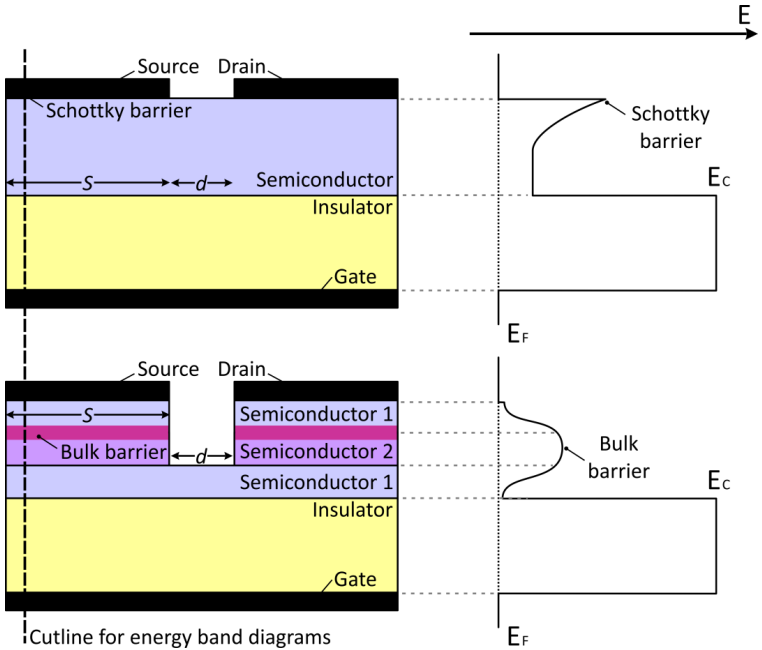
Virtually any material system

Contact barrier (but not necessarily Schottky)

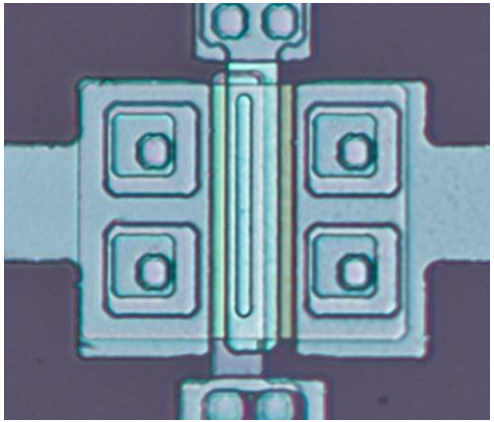
Fully depleted semiconductor at the source

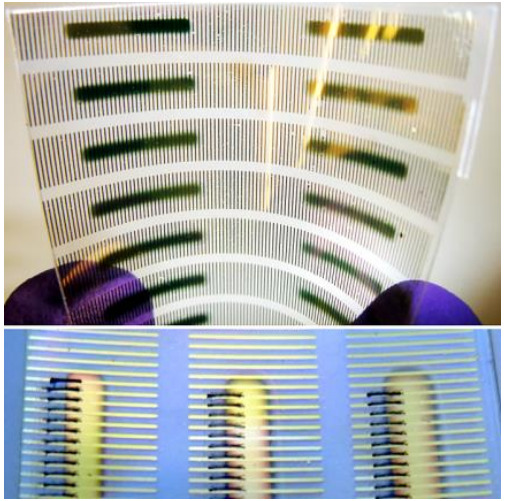
Can be made alongside conventional TFTs

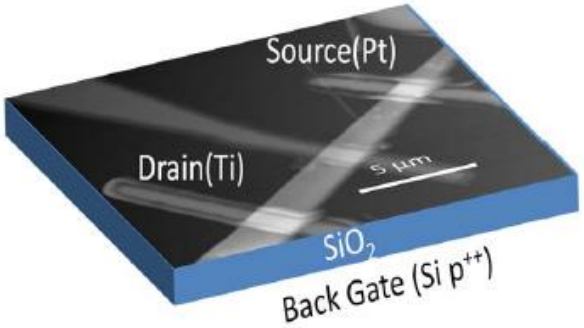


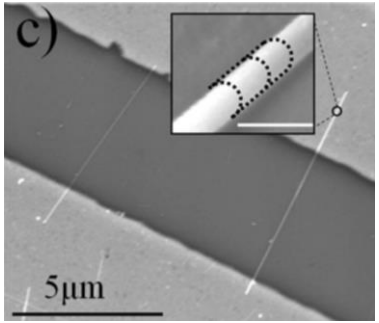


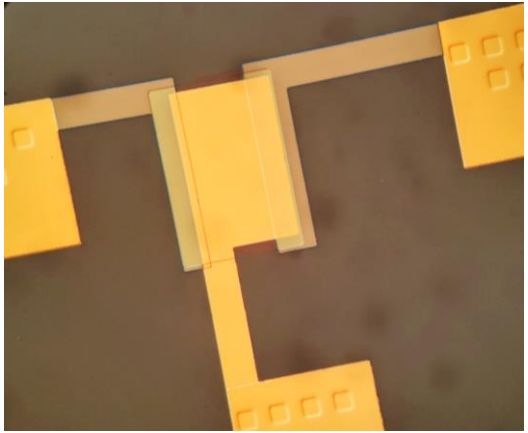
SGT: material systems











Schottky SGT vs FET

Low saturation voltage
Low output conductance (sat.)

Tolerance to short channel effects
Tolerance to process variations

Improved bias stress stability

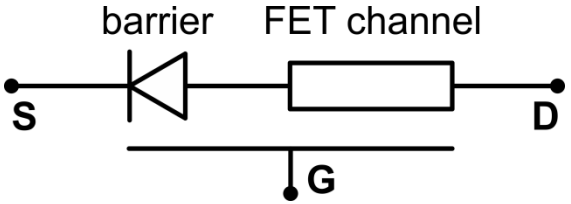
But…

Lower ON-current than FETs

Low ON dynamic range

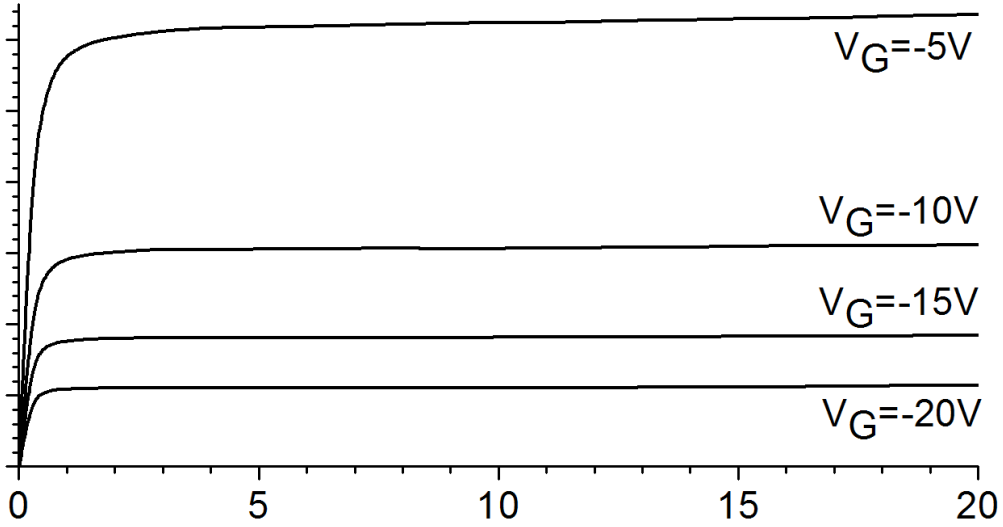
High temperature coefficient

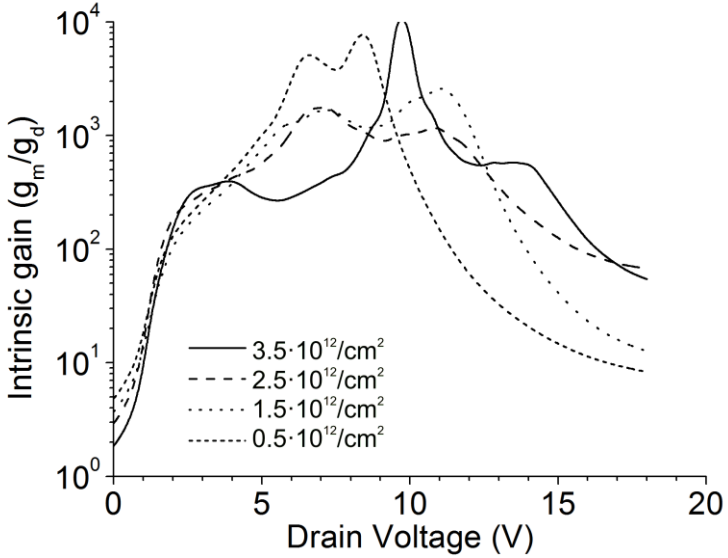
SGT applications: analog



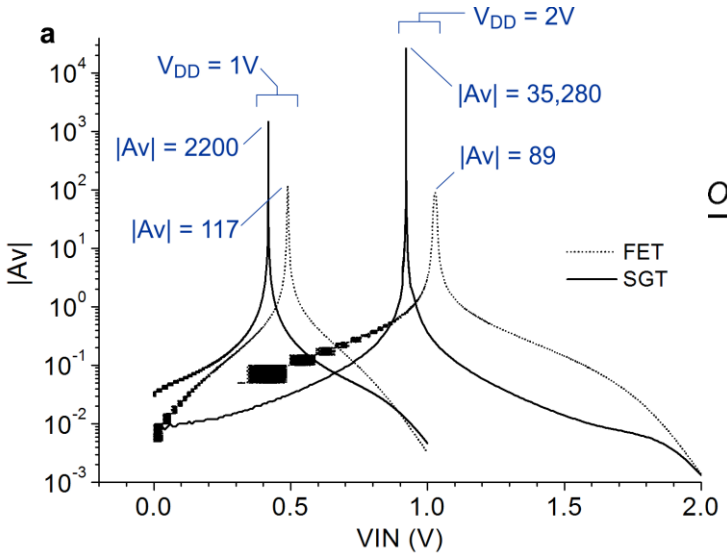
Intrinsic Gain in Self-Aligned Polysilicon Source-Gated Transistors

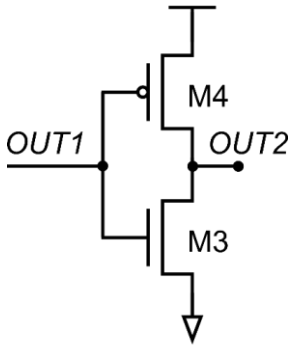
Radu A. Sporea, *Member, IEEE*, Michael J. Trainor, Nigel D. Young, John M. Shannon, and S. Ravi P. Silva

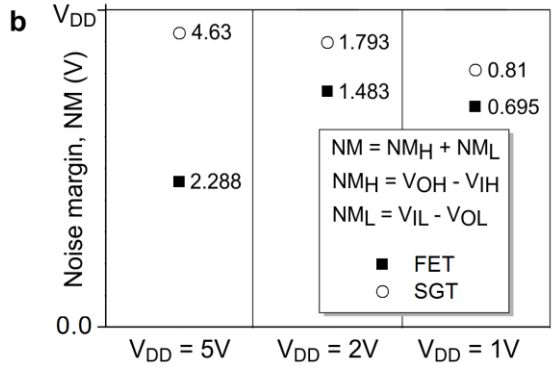




SGT applications: digital







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Source-gated transistors for order-of-magnitude performance improvements in thin-film digital circuits

R. A. Sporea, M. J. Trainor, N. D. Young, J. M. Shannon & S. R. P. Silva

Altmetric score (what's this?)

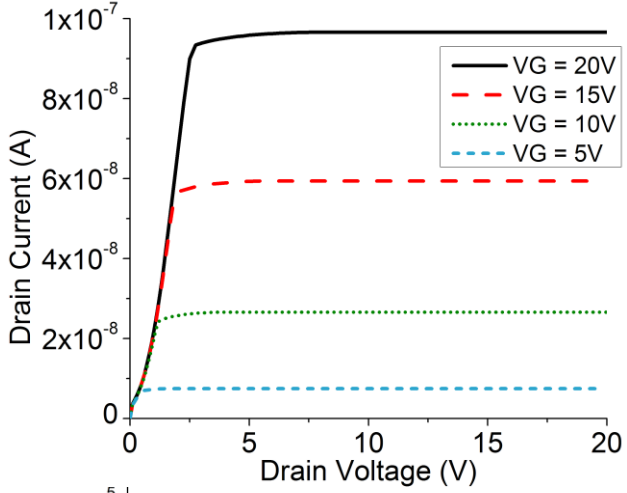
Tweeted by **4**
On **3** Facebook pages
Picked up by **3** news outlets

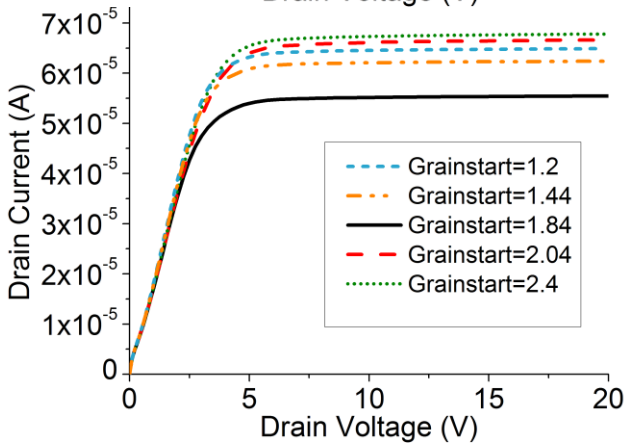
This Altmetric score means that the article is:

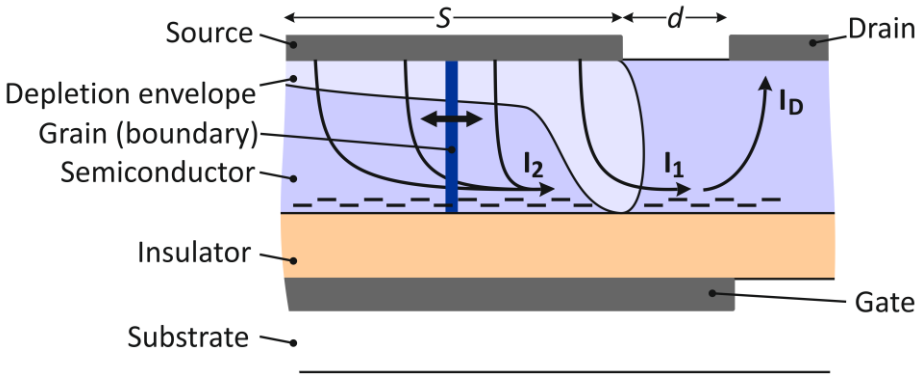
- in the 94 percentile (ranked 4,737th) of the 82,649 tracked articles of a similar age in all journals
- in the 92 percentile (ranked 54th) of the 719 tracked articles of a similar age in *Scientific Reports*

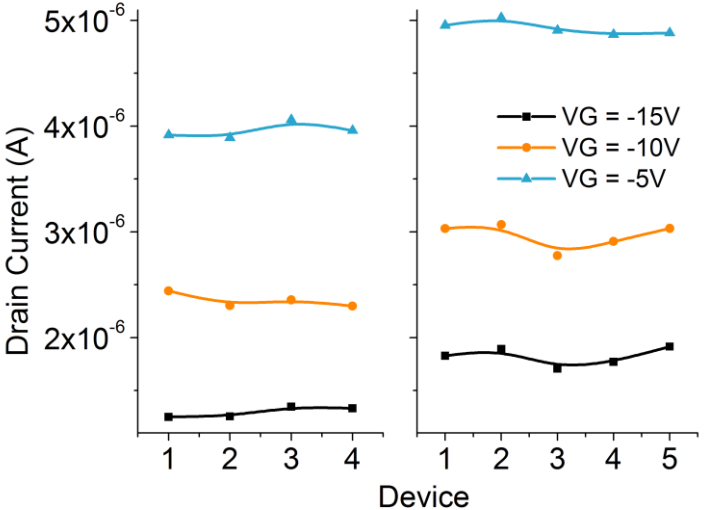
Analog: material quality – polycrystalline

Unpublished

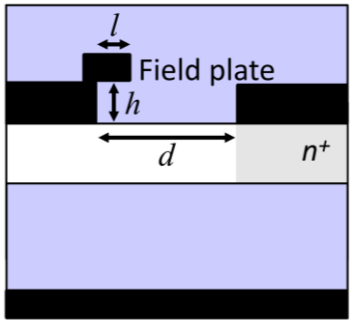


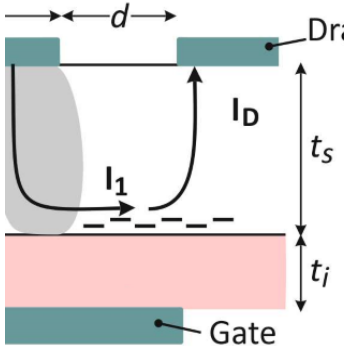


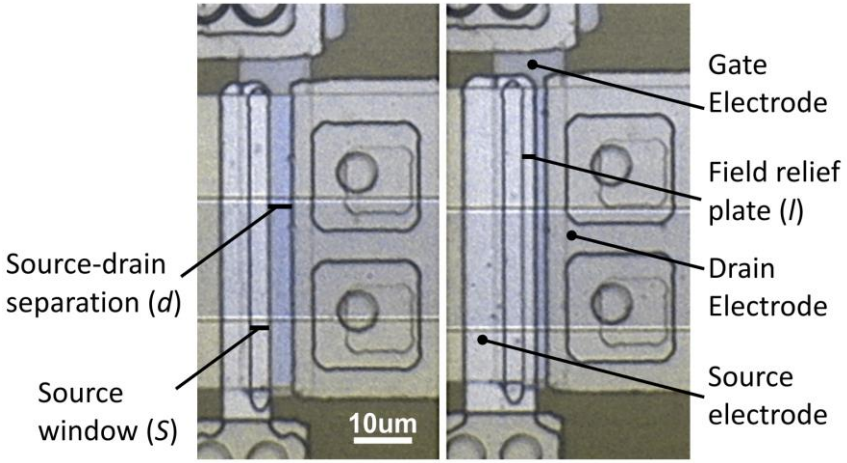


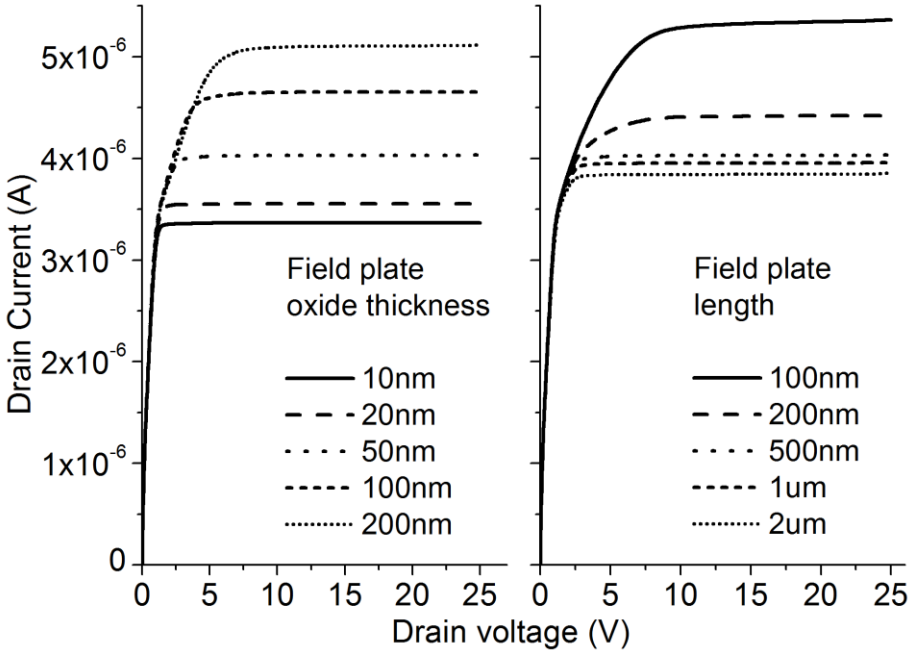


Analog: barrier screening



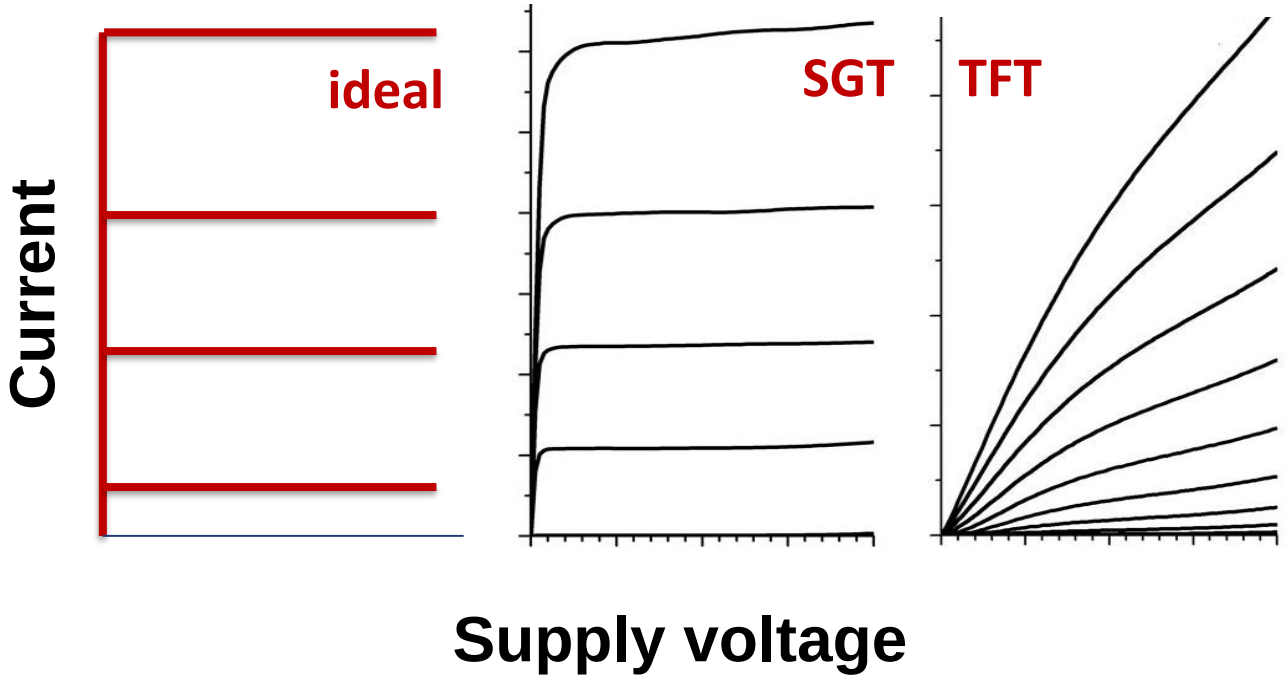






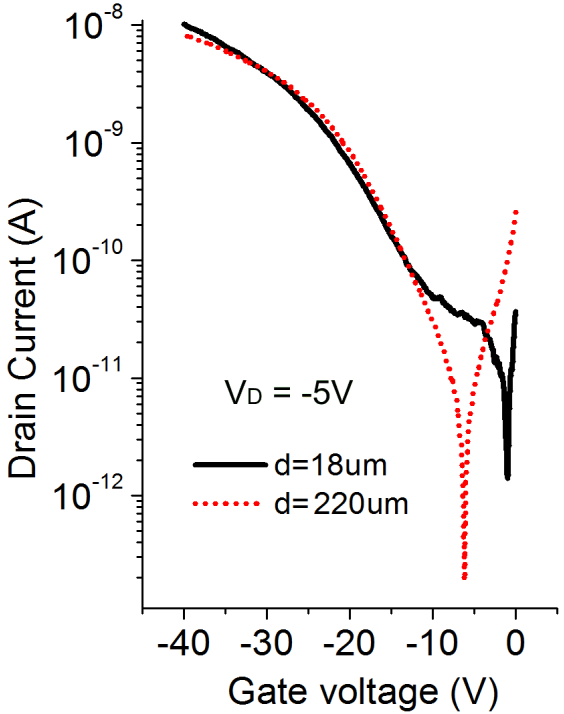
IEEE T-ED, **59**, 2180, (2012)

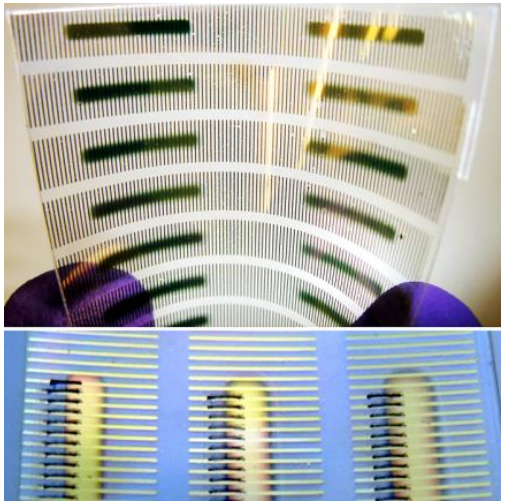
Analog: high intrinsic gain…

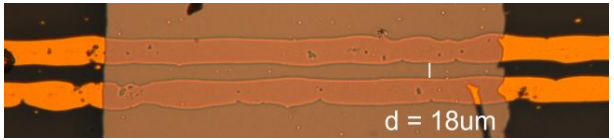


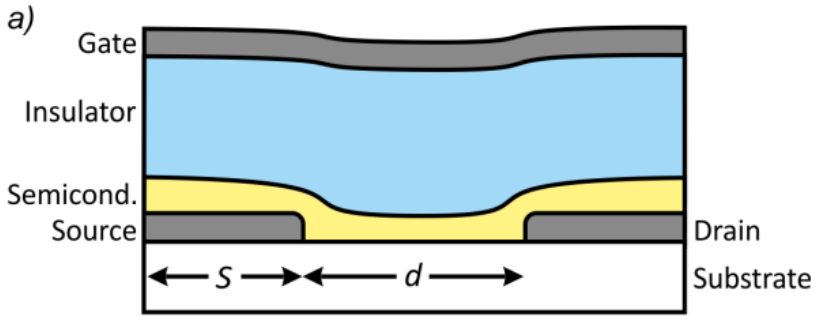
Analog: geometrical variations

ICFPE 2014









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Low output conductance (sat.)

Tolerance to short channel effects
Tolerance to process variations

Improved bias stress stability

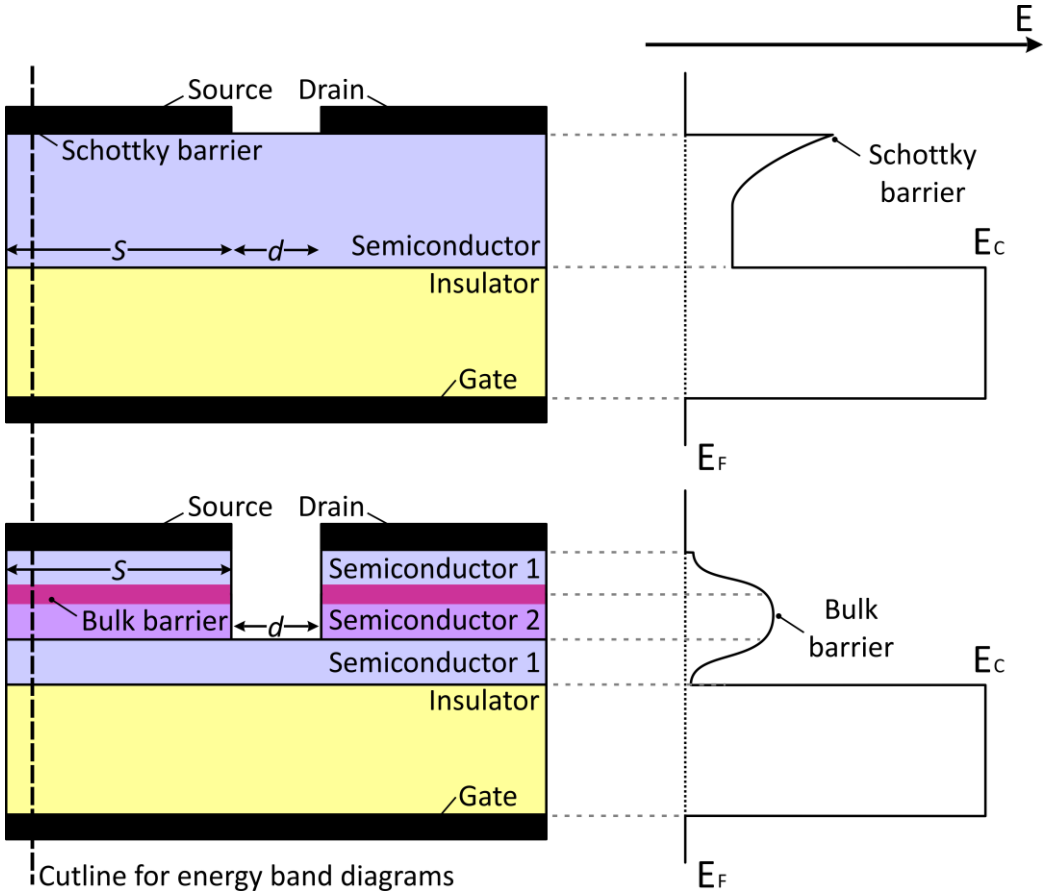
But…

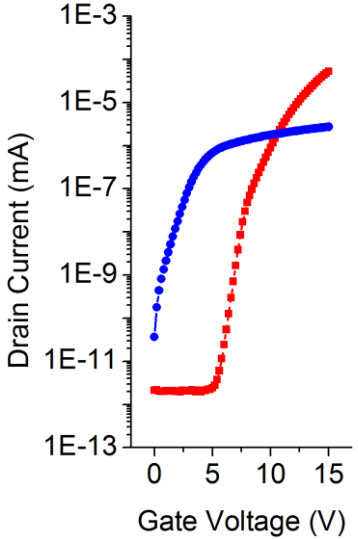
Lower ON-current than FETs

Low ON dynamic range

High temperature coefficient

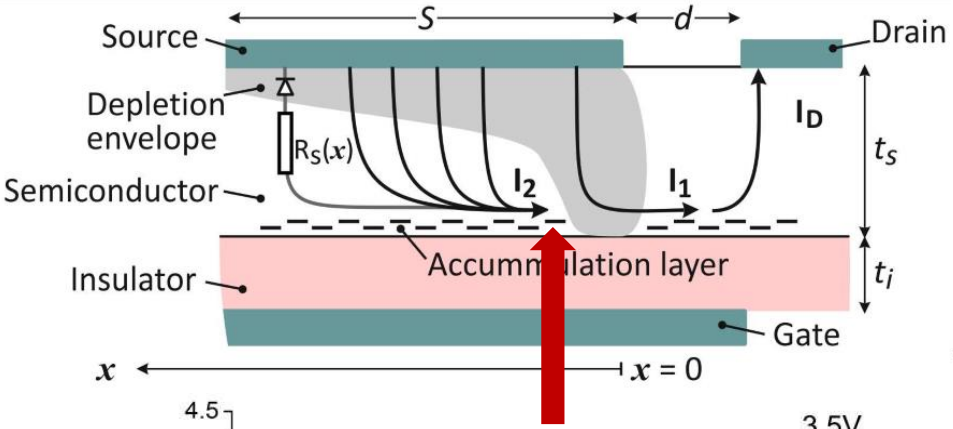
Heterostructure and bulk barrier SGTs

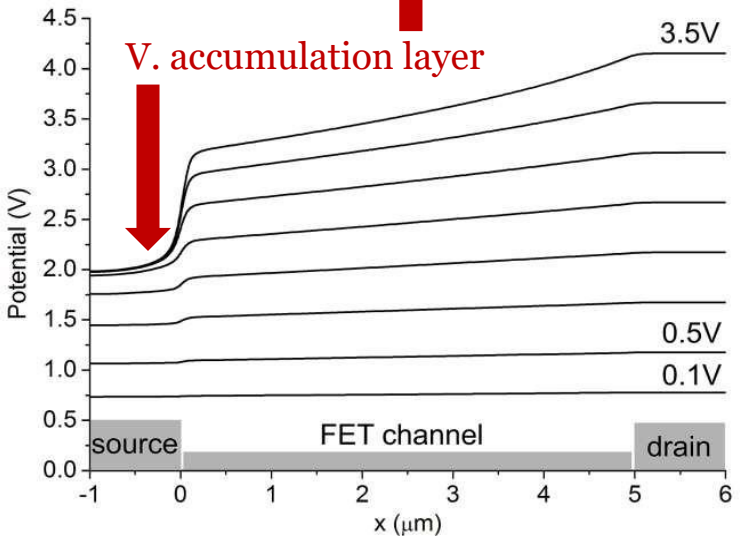




MRS f16, Boston

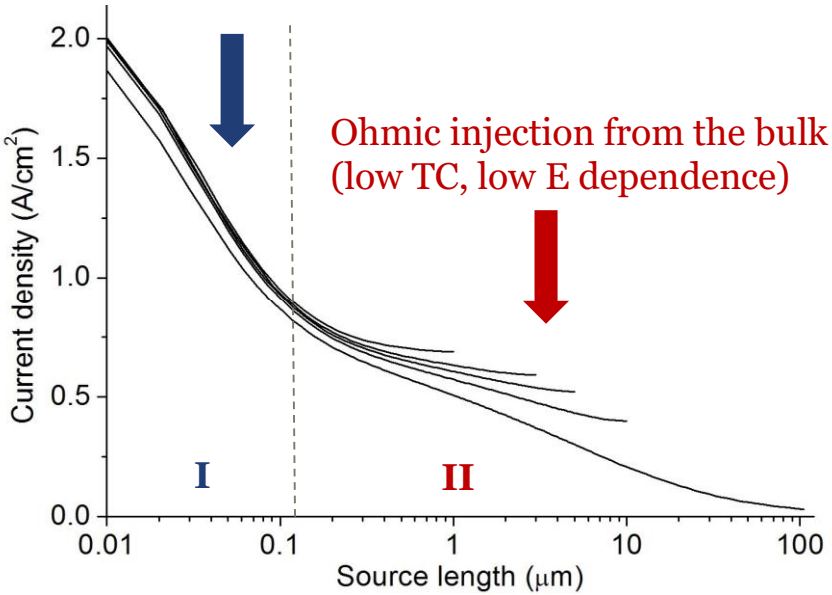
Current injection: modes of operation





Injection in the depletion region
(high TC, high E dependence)

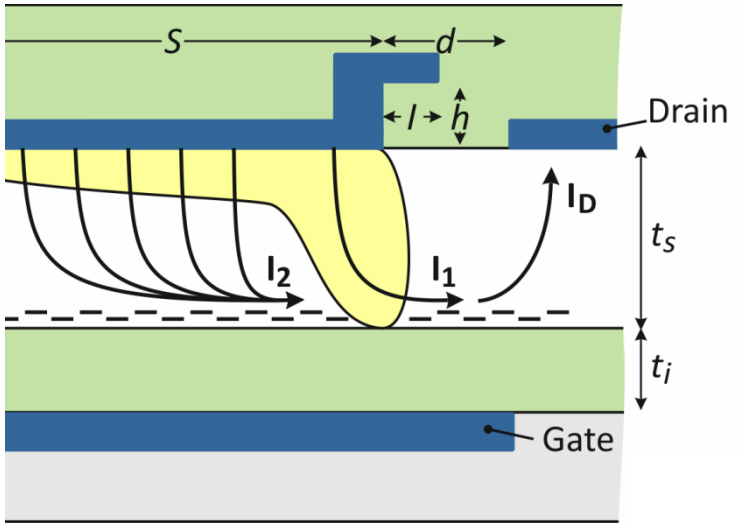
Ohmic injection from the bulk
(low TC, low E dependence)

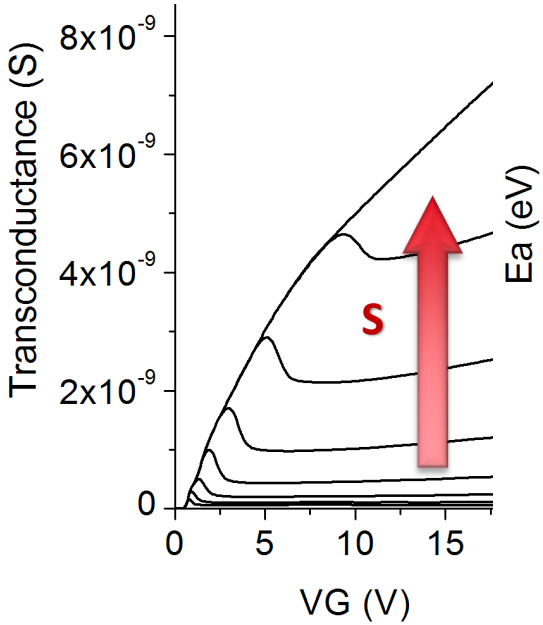


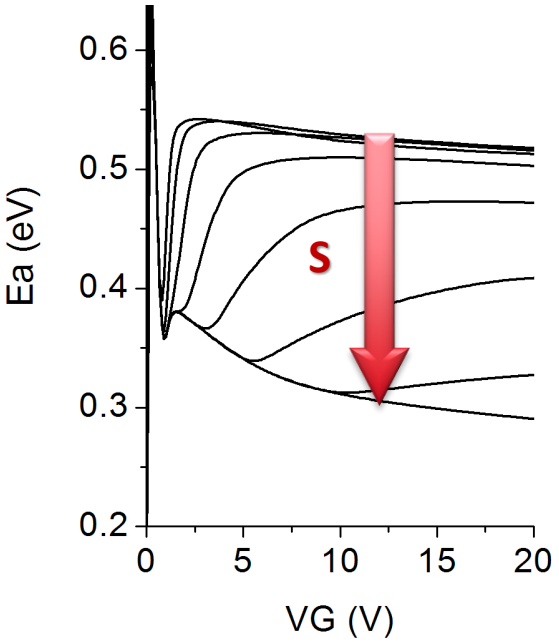
CAS 2017, Sinaia

Current injection: modes of operation

Temperature dependence of drain current on source length



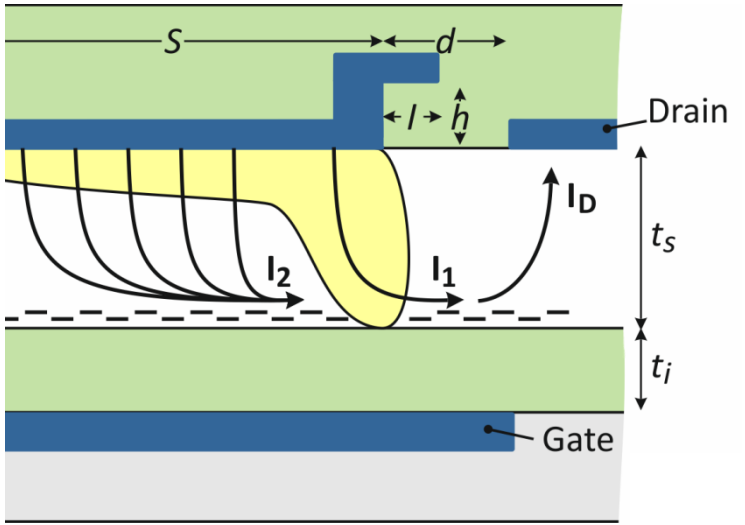


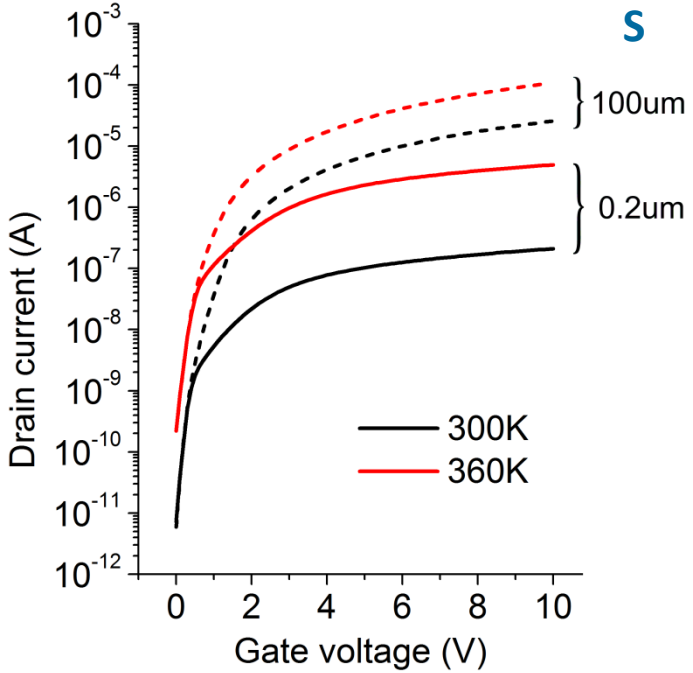


Sporea, R. A. et al., *JAP* **117**, 184502 (2015).
Valletta, A., Mariucci, L., Rapisarda, M. & Fortunato, G., JAP **114**, 064501 (2013).
Shannon, J. M. et al., *IEEE T-ED* **60**, 2444–2449 (2013).

Current injection: modes of operation

Temperature dependence of drain current on source length





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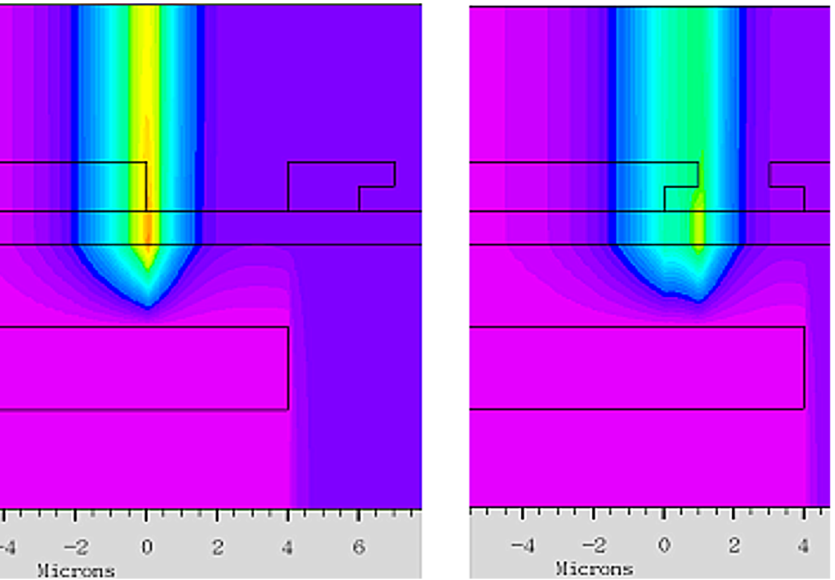
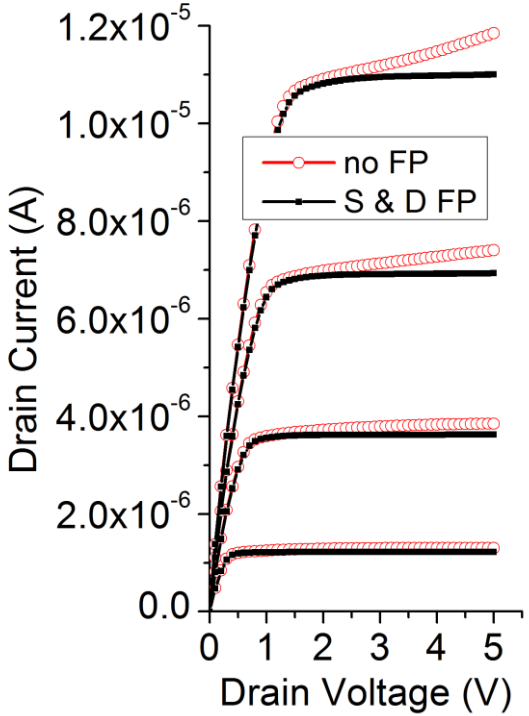
Analog: barrier screening

Simple field relief structures reduce current dependence on temperature





Analog: barrier screening

Simple field relief structures reduce current dependence on temperature

Temperature dependence of the current in Schottky-barrier source-gated transistors

R. A. Sporea[1], M. Overy[1], J. M. Shannon[1] and S. R. P. Silva[1]

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J. Appl. Phys. **117**, 184502 (2015); http://dx.doi.org/10.1063/1.4921114

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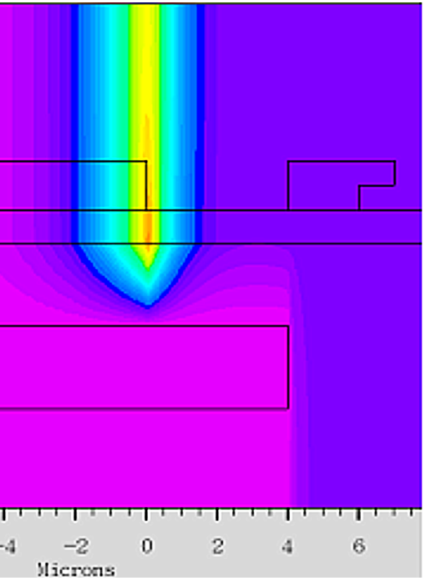

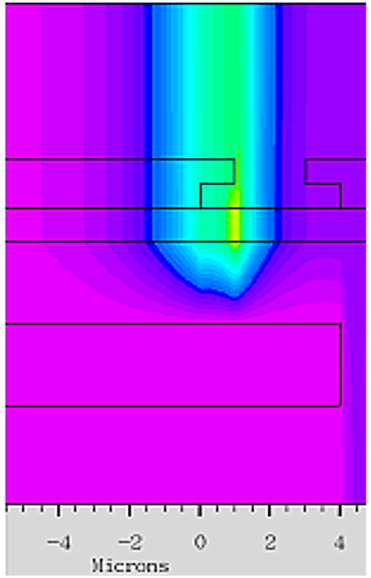

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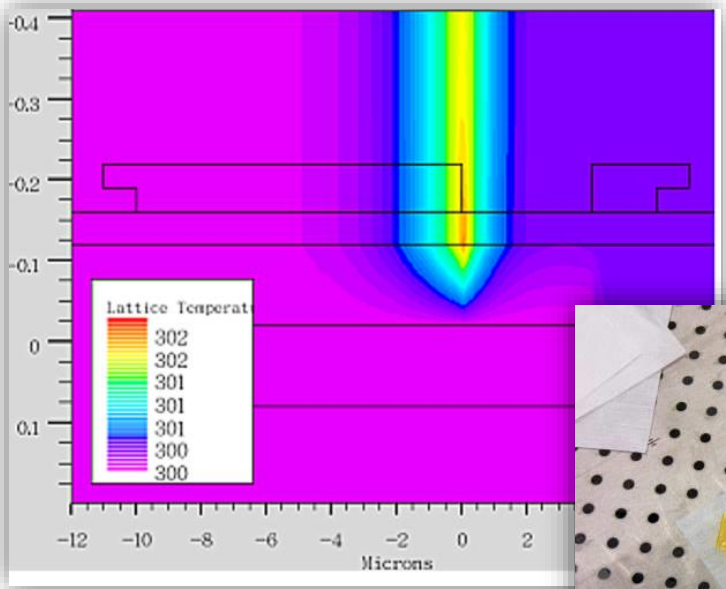

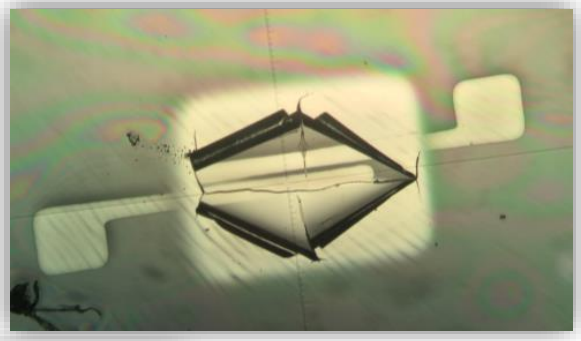

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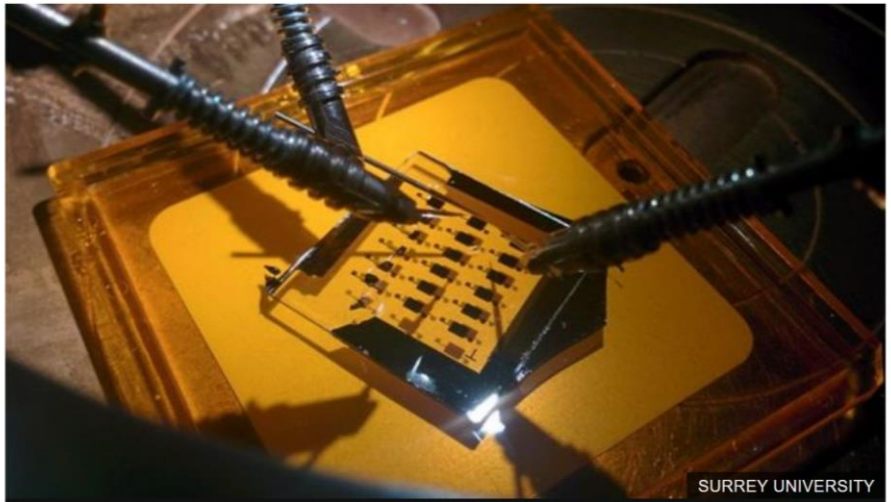

Source gated transistors, like these made on glass at Surrey University, could help deliver flexible electronics

Outline

1. Creatively exploring design variables may lead to interesting solutions
   - Electronic device physics
   - **Human-environment interaction**
   - Paper
2. Industry collaboration increases relevance for academic research
3. Talent is everywhere – taking a chance pays off most of the time

Human-environment interaction

“We interact with the floor every single second of our existence. Why don’t get any data out of it?”

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Augmented paper

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Other Investigators:	**Revill, Dr G**	**Bober, Professor M**	**Scarles, Professor C**		
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The Royal Academy of Engineering

Thank you for your attention!

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Summary

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