SIXLINE
SEMICONDUCTOR

The Carbon Upgrade for a Silicon World

www.sixlinesemi.com
Madison, WI, USA

Enables Next-Generation Carbon Electronics for AI and ALL High-Performance Electronics

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- **SixLine produces semiconducting carbon never before possible commercially**
- **<u>Strong industry engagement and LOIs</u>**
- **Phased tech development**
  1. **Next gen wireless**

     Total Market: $42B
     (Wireless Components)

     $
  2. **Faster AI/computing with lower energy usage**

     Total Market: $14.4B
     (AI Materials)

     $

WHY NOW?

THE SILICON PERFORMANCE WALL

Wireless Performance Limits

Advanced 5G, 6G demand is hitting the physical limits of GaAs and Si. We need higher frequency and better linearity.

AI Energy/Processing Crisis

By 2040, ICT will consume 25% of global energy. Silicon efficiency has plateaued while AI demand explodes.

The Bottleneck

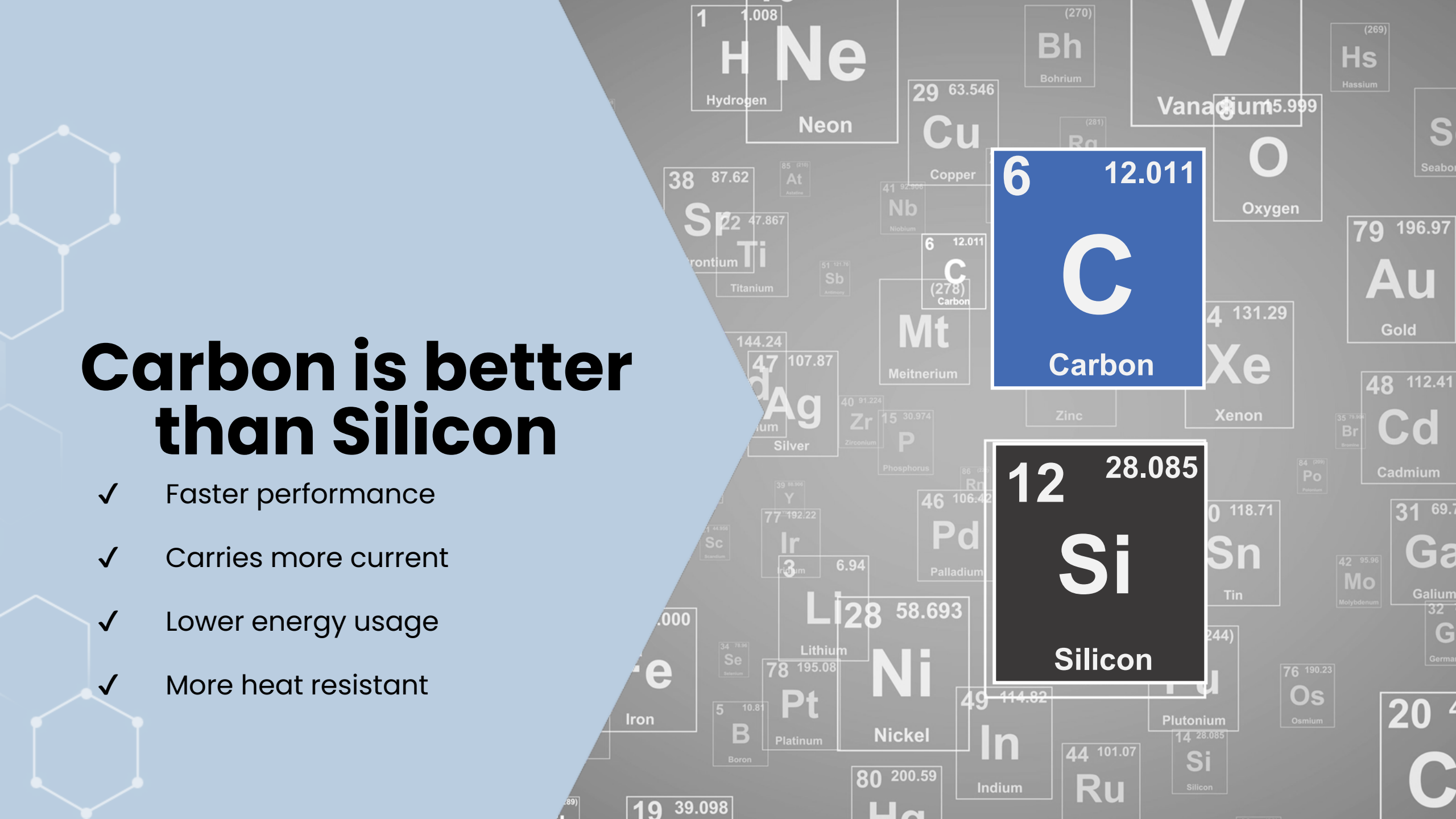
Performance is stalled by power, heat, and lithography resolution. Current materials like Si and GaAs are limiting.

ADD AI NEEDS MORE CLEARLY

The next paradigm shift requires a new material foundation

Carbon is better than Silicon

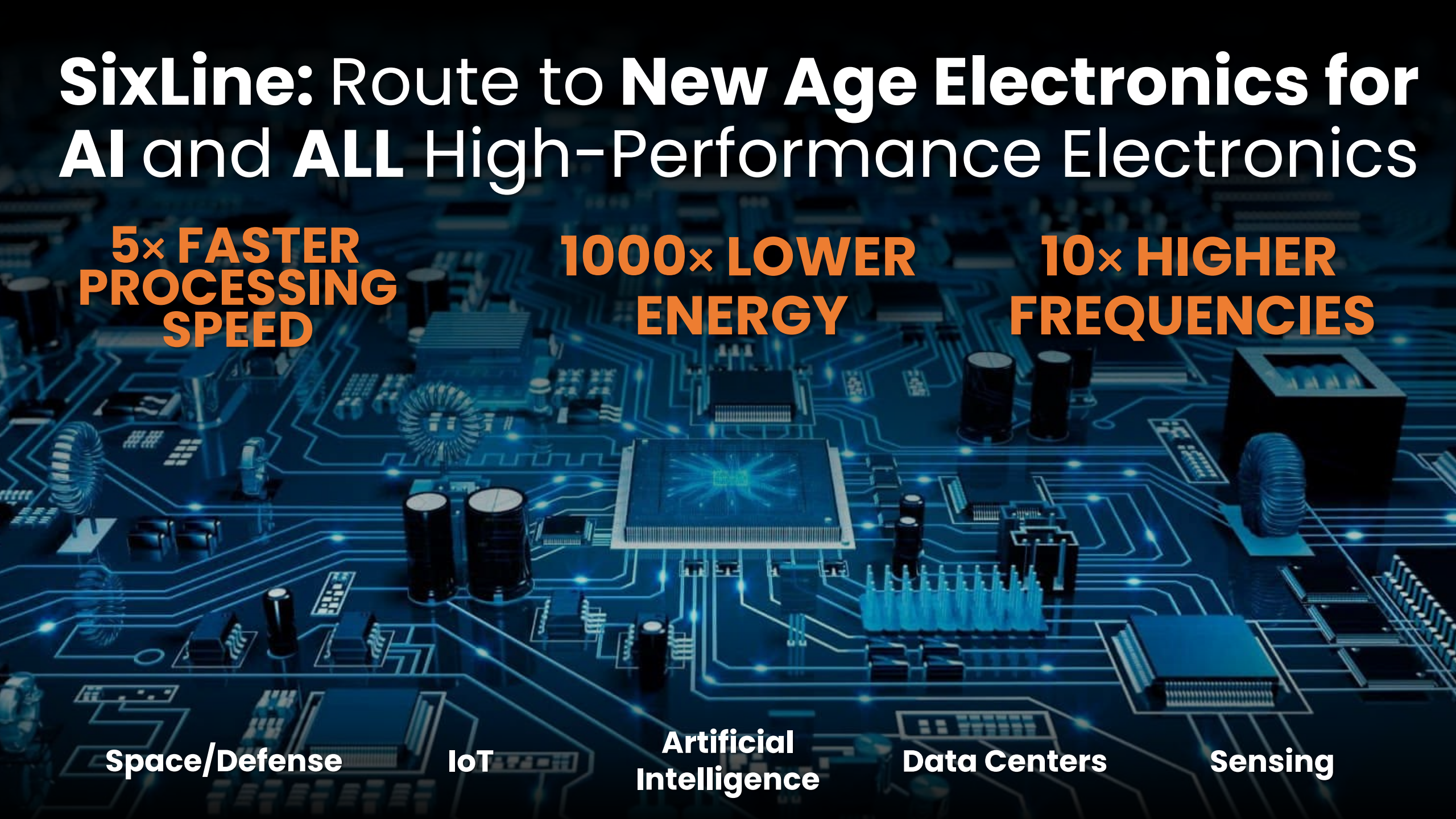
- ✓ Faster performance
- ✓ Carries more current
- ✓ Lower energy usage
- ✓ More heat resistant



The Breakthrough

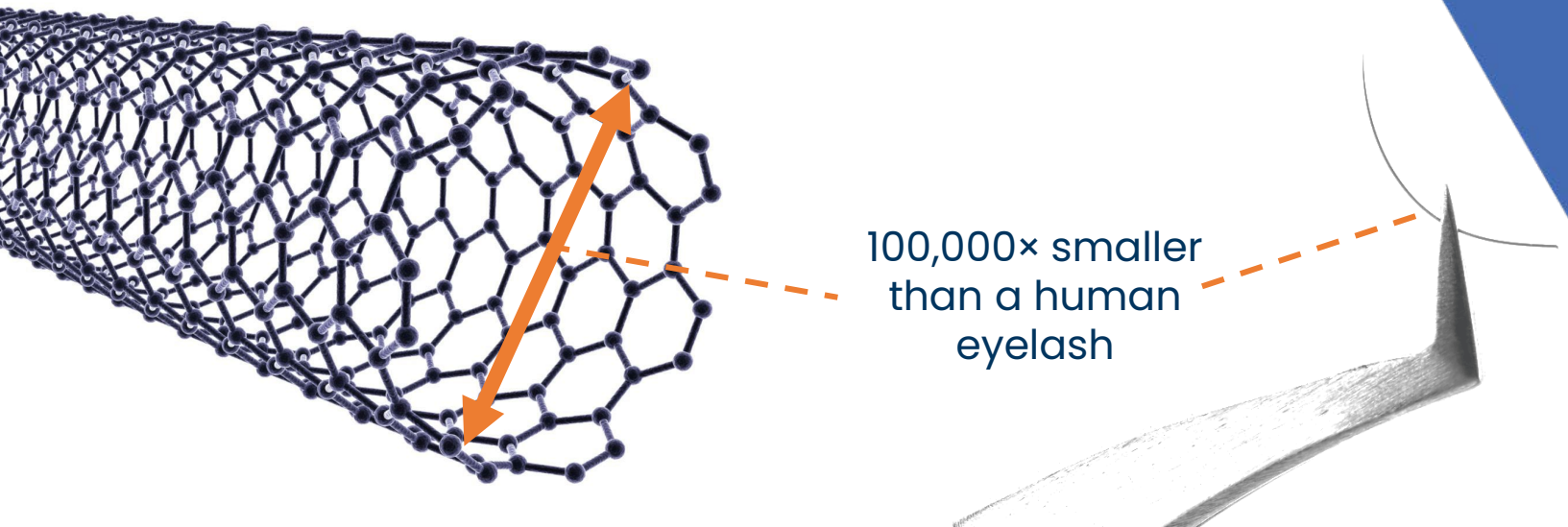
SixLine Enables Semiconducting Carbon Never Before Possible

SixLine: Route to **New Age Electronics for AI** and **ALL** High-Performance Electronics



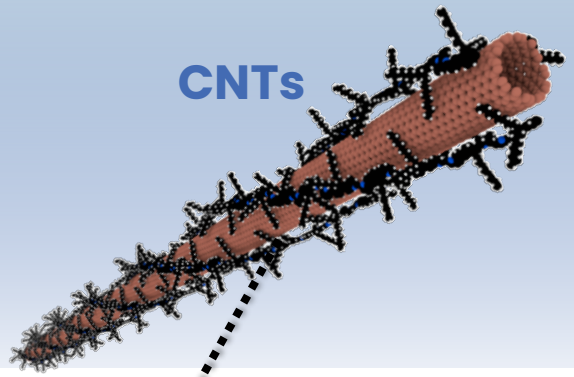
SixLine's Technology

Leveraging Carbon Nanotubes (CNTs) in Commercially Compatible Processes



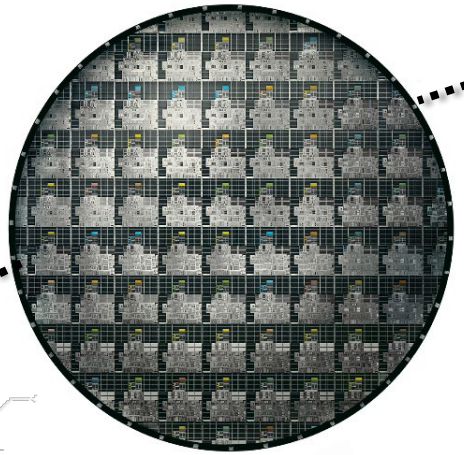
SixLine Integration into Electronics

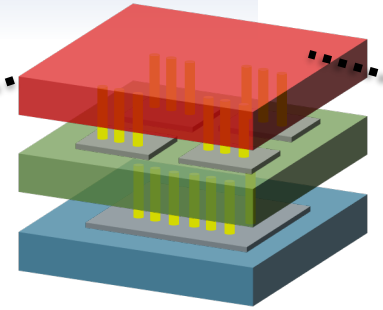
SIXLINE MEETS COMMERCIAL REQUIREMENTS



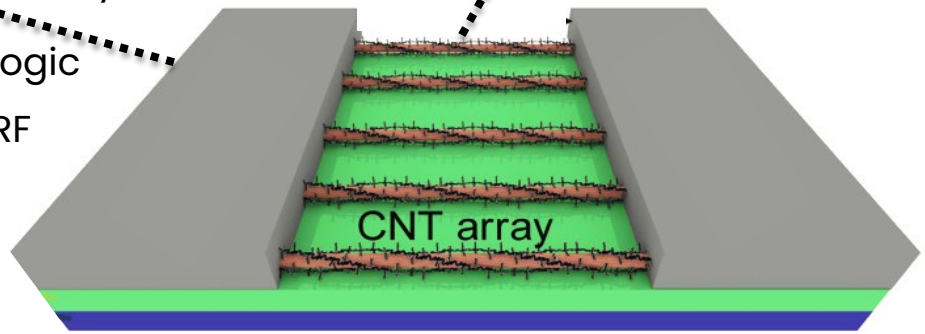
Functional blocks

Electronic wafers/dies

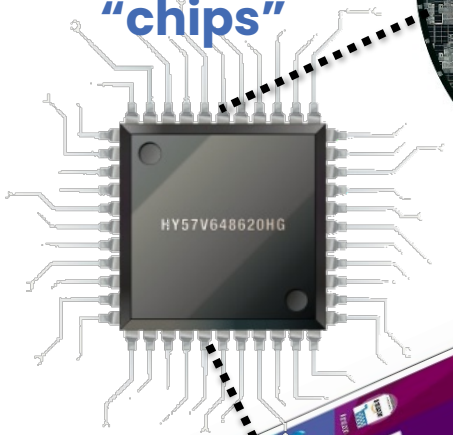




Transistors



Packaged "chips"



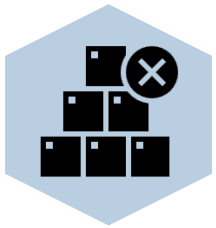
Electronics

SixLine Tech Characteristics

- ✓ Semiconducting
- ✓ Highly-aligned
- ✓ Film (i.e., multiple CNTs)
- ✓ Scalable
- ✓ High throughput
- ✓ 3D integration

Previous Nanotube Tech Has Failed

30-YEAR CHALLENGE



Poor control over organization

Low electronic quality

Lab benchtop scale

Slow processes

NANTERO

IBM

30-year challenge to create ideal CNT films

CARBON TECHNOLOGY INC

CARBONICS

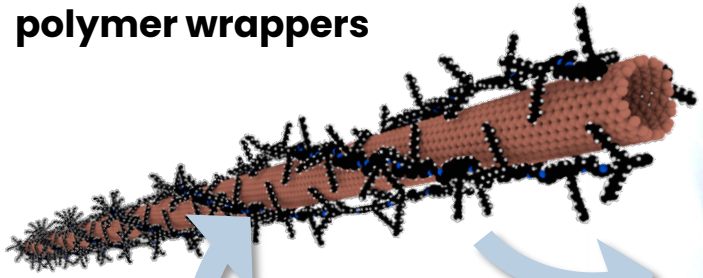
Aligned Carbon

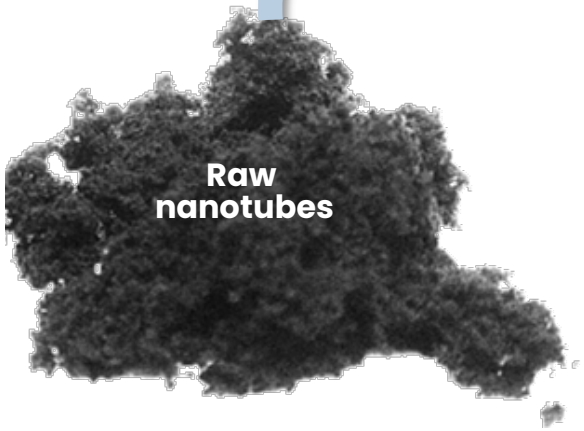
SixLine's Processes to Produce Semiconducting Carbon

STRONG IP LIBRARY

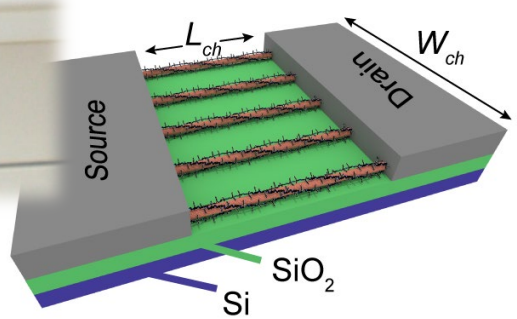
IP protecting certain wrappers/removing wrappers

1) Isolate semiconducting nanotubes via removable polymer wrappers

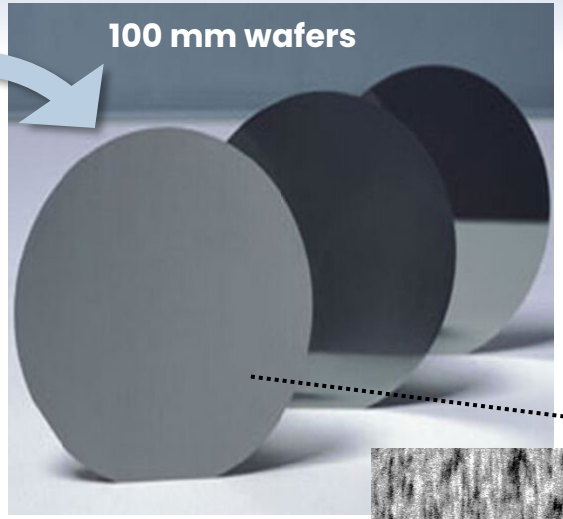




2) Electronics-grade, high-purity semiconducting nanotube ink

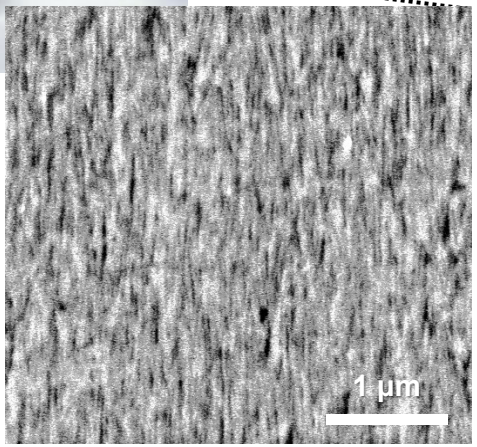


3) Scalable CNT alignment



SixLine has IP protecting alignment processes

High-performance devices



SixLine has IP claims protecting composition of matter of the nanotube films and nanotubes films integrated into transistors

7 patents with process and composition of matter protection

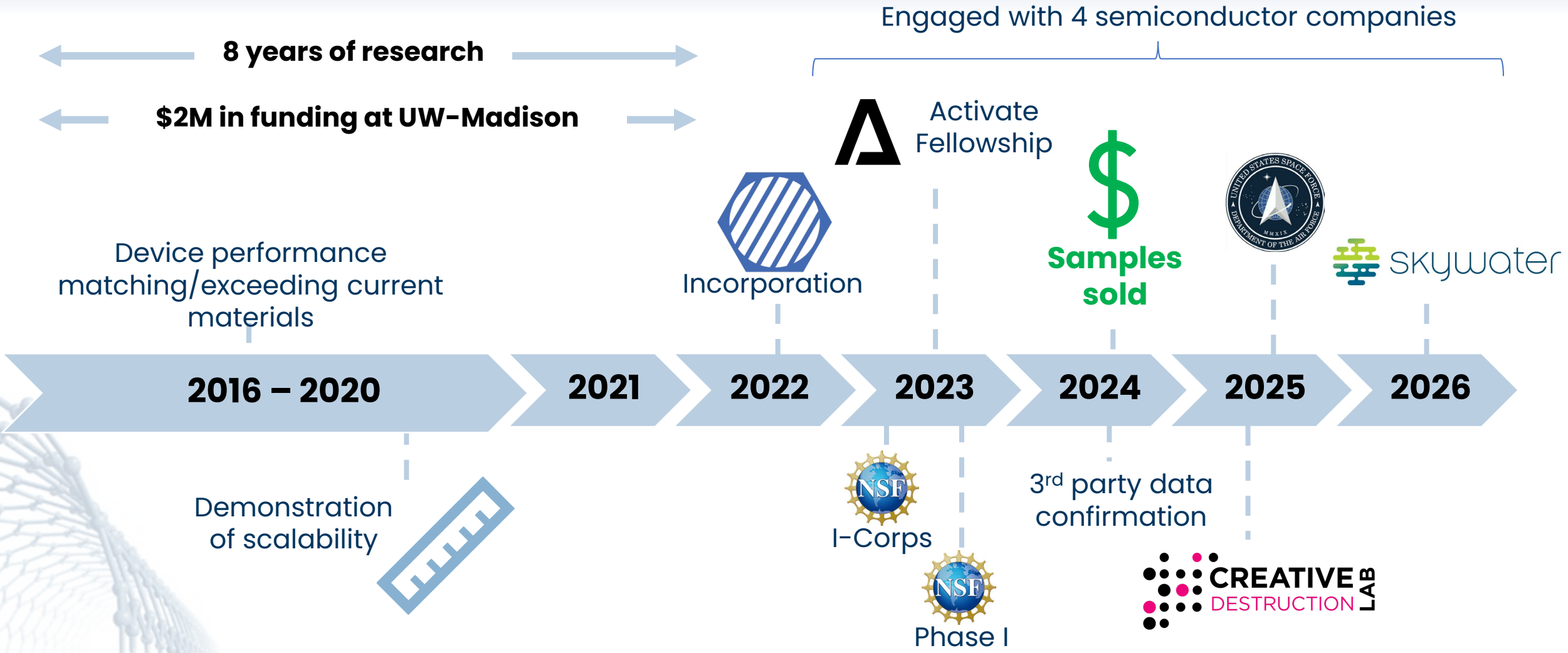
SixLine SURPASSES Competitors

SUPERIOR CNT FILM CHARACTERISTICS

		Other CNT Companies			
CNT Film Feature	**SixLine**	**Carbon Tech Inc.**	**Aligned Carbon**	**NANTERO**	**Peking Spinout**
Density (μm^{-1})	**250**	**5 – 10**	**5 – 10**	**70**	**200**
Alignment	**±4°**	**±1°**	**±1°**	**±90° (random)**	**±8°**
Semiconducting Purity	**>99.99% (likely >99.9999%)**	**>98%**	**>98%**	**>99.9999%**	**>99.9999%**
Time to Coat 200 mm Wafer	**~2 s/120 s**	**7 hr**	**7 hr**	**7 – 9 hr**	**6 hr**
Temperature	**Room**	**High**	**High**	**Room**	**Room**

Strong Technology and Company Traction

BREAKTHROUGH SCIENCE DRIVEN TO COMMERCIALIZATION



Strategic Roadmap to Market

WIRELESSS COMMUNICATION → AI/COMPUTING

PHASE 1 (2026+)

Wireless Components

Targeting the $42B RF components market. **Revenue through sales of high-performance RF switches and LNAs**.

PHASE 2 (2029+)

AI & Computing

Solving the AI energy and speed barrier. Licensing process to tool manufacturers and **selling nanotube inks to chip fabrication facilities**.

PHASE 1: WIRELESS

Our films are near-spec for high-performance RF today. We are currently scaling for fab integration.

- Partnering with commercial fabs (2026).
- Experimental RF devices match realistic simulations, providing roadmap to exceed incumbent Si and GaAs performance.
- Collaborate with tool manufacturers and work with contract manufacturers and fabrication facilities.

PHASE 2: AI/Computing

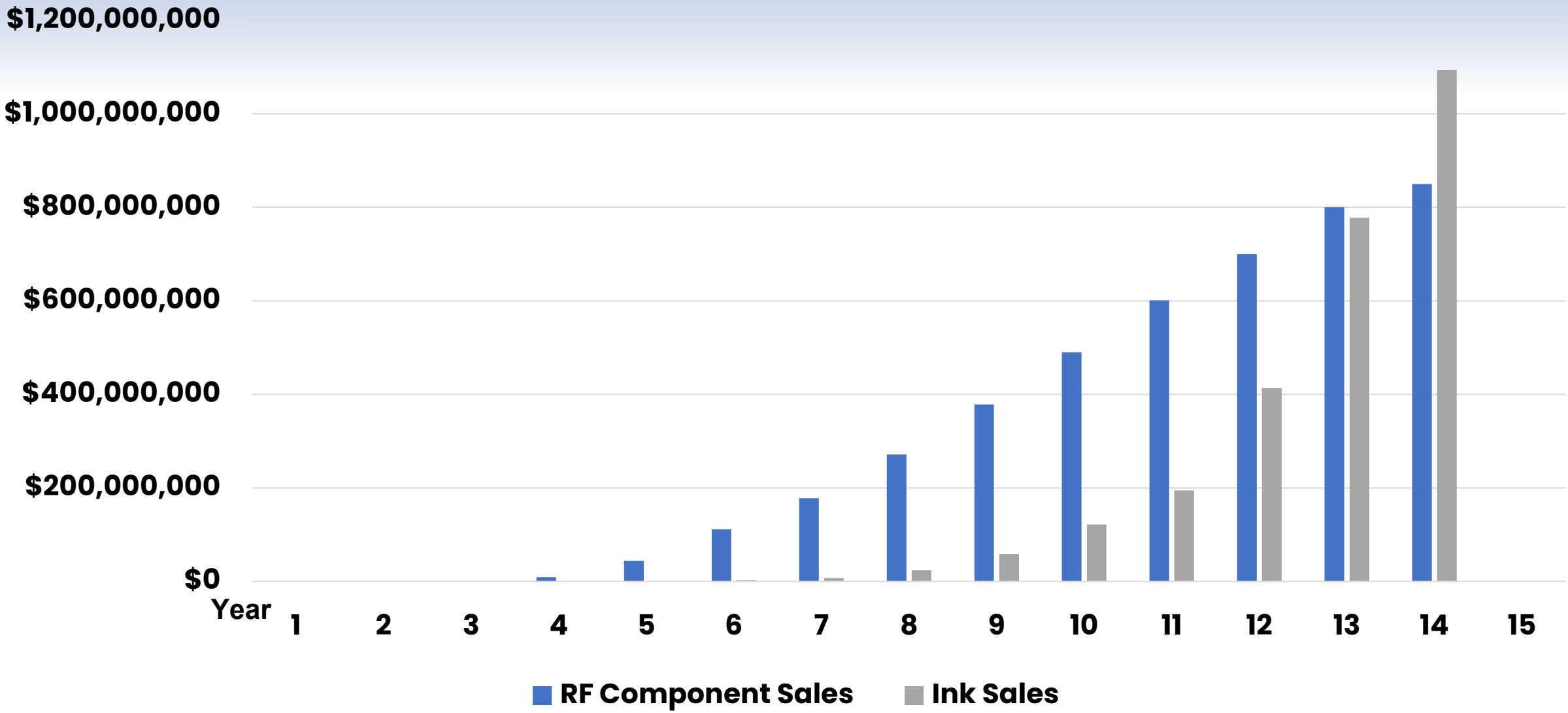
The “razer-and-blades” business model for semiconducting carbon.

As technology matures, SixLine moves to the ultimate prize: **The foundation of all future high-performance computing.**

We license our processes to tool manufacturers and sell proprietary high-purity inks directly into logic/computing fabs. **This is a recurring, high-margin revenue model at global scale.**

Large Projected Revenues

WIRELESSS COMPONENTS → AI/COMPUTING MATERIALS



Strong Management Team

SIGNIFICANT MATERIALS, INDUSTRY, AND STARTUP EXPERIENCE

- Technology co-inventor
- 14 years technical research experience
- Extensive entrepreneurship training

Katy Jinkins, PhD
CEO, Co-founder

- Expert in nanotube electronic devices
- Technology co-inventor
- Professor at UW-Madison

Prof. Mike Arnold, PhD
Chief Technical Advisor, Co-founder

- >20 years startup experience
- Negotiated exit for Virent while serving as COO/CFO
- Commercialized nanotech products for superconductors and hypersonic applications

Jeff Moore
Strategy/Commercial Support

- Expert in nanotube assembly and chemistry
- Technology co-inventor
- Professor at UW-Madison

Prof. Padma Gopalan, PhD
Technical Advisor

Ongoing search for technical/industry advisors

JOIN THE CARBON REVOLUTION

$1.1M

Pre-Seed Fundraise ($725k remaining)

Technical Milestones
Scale alignment to 200mm wafers; integrate into commercial fab; create initial prototype CNT RF switches.

Pre-seed Unlocks
Multiple customers purchasing CNT wafers; strategic industry funding.

The Future
Sets the stage for packaged RF components and entering AI/computing markets.

OUR PARTNERS

Activate

WARF
Wisconsin Alumni Research Foundation

skywater

Confidential Industry Partners

OUR FUNDING

NSF

rpv

SAFAR™ PARTNERS

Activate

www.sixlinesemi.com | katy@sixlinesemi.com

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Appendix

SixLine's Technology Advantages

SixLine enables necessary performance and integration for semiconductor electronics

SixLine's 1st Target: Radiofrequency (RF)

CNT-Based RF Devices	CNT Device Property
Faster, smaller, more energy efficient electronics, streaming more data with lower lag	10× higher frequencies
	Larger data bandwidths
	Intrinsic linearity
	Direct integration with silicon logic

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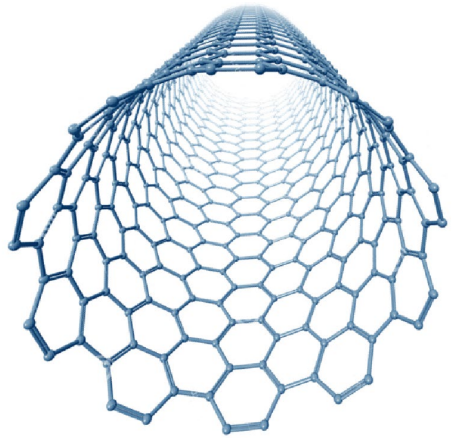

SixLine's Longer-Term Market: Logic/Computing

CNT-Based Logic Devices	CNT Device Property
Faster electronics, with more computational power, and up to 1000× lower energy usage	5-20× lower power usage (2D FETs)
	Enables 3D heterogeneous integration
	5× current density

Nanotubes on industry roadmaps

Tech & Business Milestones

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Extensive government grant funding planned in addition to equity funding rounds

$1.1M Pre-Seed ★ | **$3-5M Seed** ★ | **$8M Series A** ★ | **$20M Series B** ★ | **2030 Exit opportunity** ●

2025	2026	2027	2028	2029	2030

Hiring plan:
Key hires

- 3 FTE (CEO, Engineer, Scientist)
- 4 FTE (Tech Director)
- 10-12 FTE (CTO, BD, PM, Device Designer, Lead Scientist, Scaling)
- 15-20 FTE (COO, Scientists/Engineers, Office Manager)

Capabilities/partnerships for equipment, device, manufacturer, raw material supply

- (2)
- (3)
- (6)
- Start scoping contract manufacturers
- Commit contract manufacturers

Tech Development for wireless manufacturing → **RF Component sales**

- **Process scalability**
- **Wireless/RF device performance**

200 mm wafer | 300 mm wafer | Automated process tool

RF switch FET
Target:
F_t = 100 GHz

RF switch FET
Target:
F_t = 5 THz
(informed by industry experts)

Component validation
Packaged RF switch
F_t = 5 THz

Development for computing

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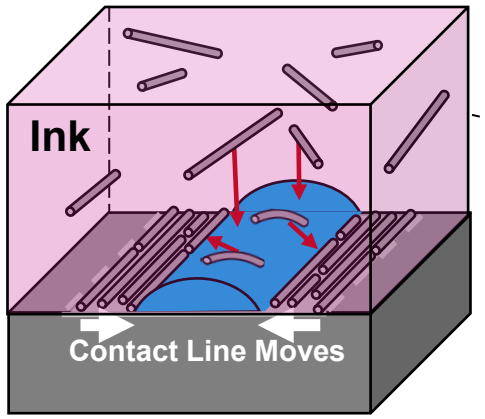
Technical Approach & Current Progress

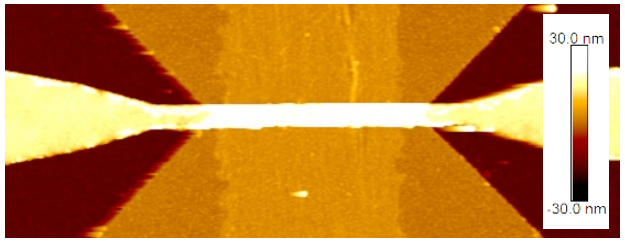
- Multiple solution-based, room temperature alignment techniques
- Exceptional p-type device performance
  - n-type can be achieved with gate stack control
- High alignment and packing densities enable superior current densities, transconductance, at low applied bias
- Devices that challenge or exceed incumbent materials

Alignment Processes

ShASAM-W

2D nanotube liquid crystals at liquid/liquid interfaces



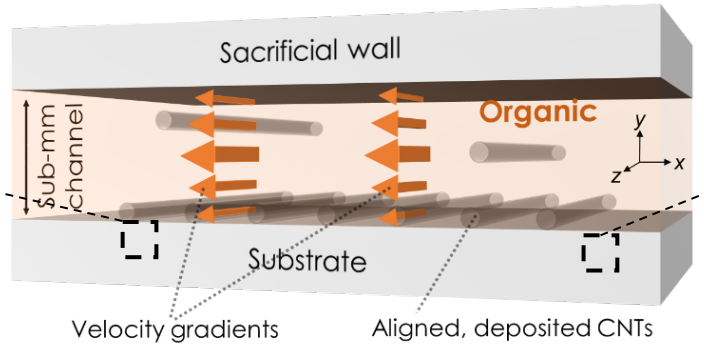


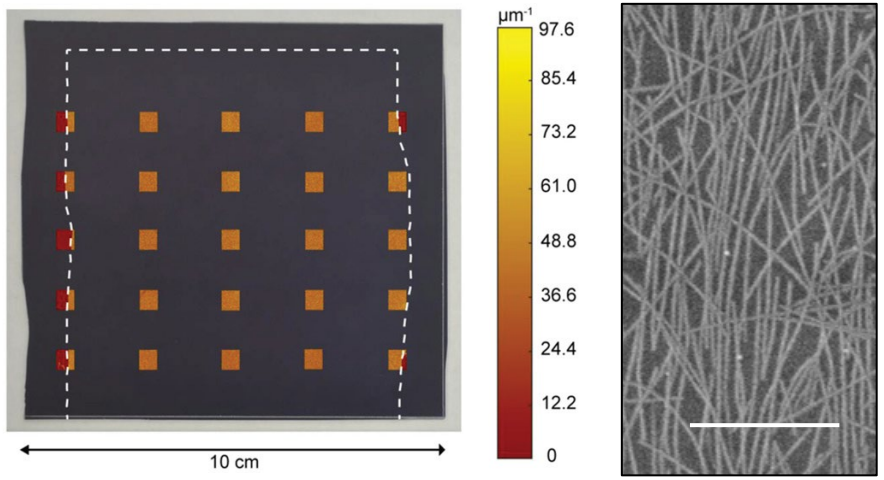
10 um stripes, aligned with device patterns

CNTs (aligned within ±4°) at 200 – 250 μm^{-1}

ShASAM

Application of shear on bulk ink, across substrate

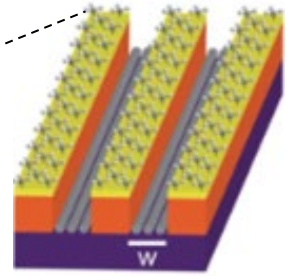


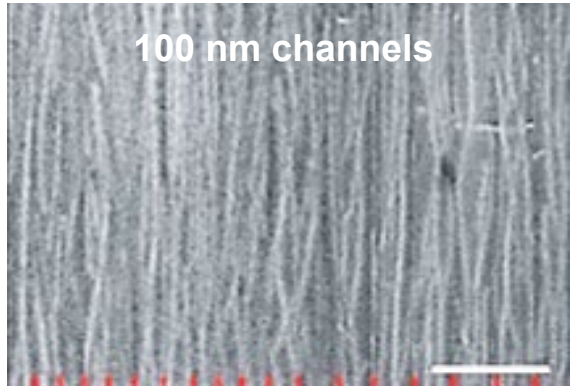


CNTs (aligned within ±20°) at ~70 μm^{-1}

ShASAM-C

Application of shear on bulk ink, across substrate patterned with chemical/topographic channels





CNTs (aligned within ±7°) at ~100 μm^{-1}

Exceptional Gen 1 DC & RF Performance

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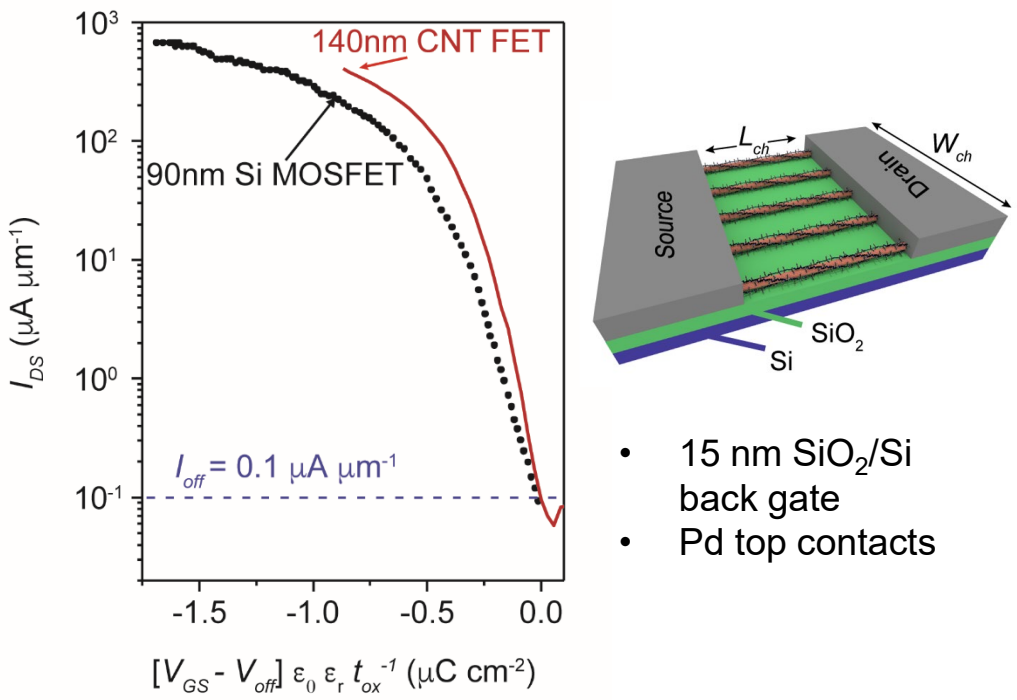
Strong device performance from Gen I alignment technique with similar alignment as TaFISA

DC device performance outperforms Si, GaAs



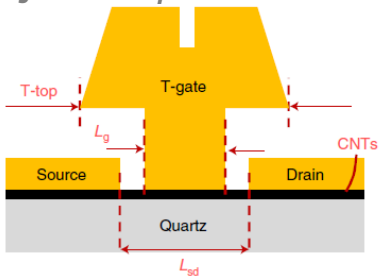
- 15 nm SiO_2/Si back gate
- Pd top contacts

Data normalized by gating efficiency

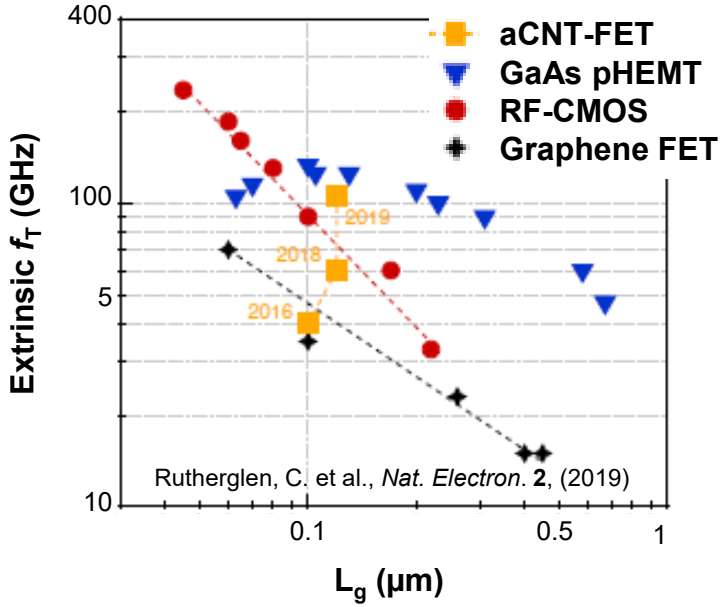
Brady G. J., et al. *Sci. Adv.* **2**, e1601240 (2016)

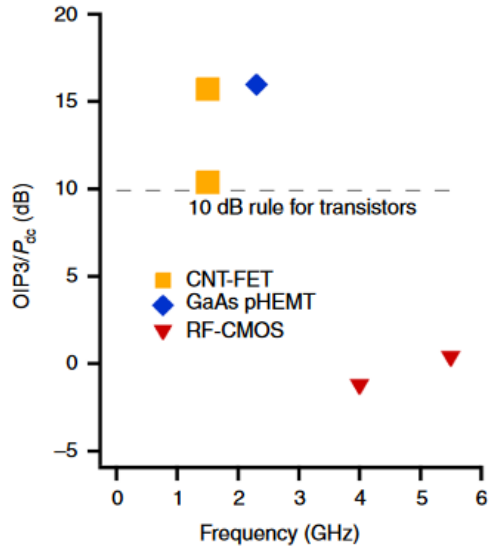
Nanotube RF performance of 100 GHz

Projected f_T >300 GHz for 60 CNTs/μm at 100 nm L_g



- T-gate
- Al_2O_3 gate material
- Single-crystal quartz substrate
- Pd top contacts





Realistic projected nanotube performance significantly exceeds conventional materials

High Density Nanotube Arrays

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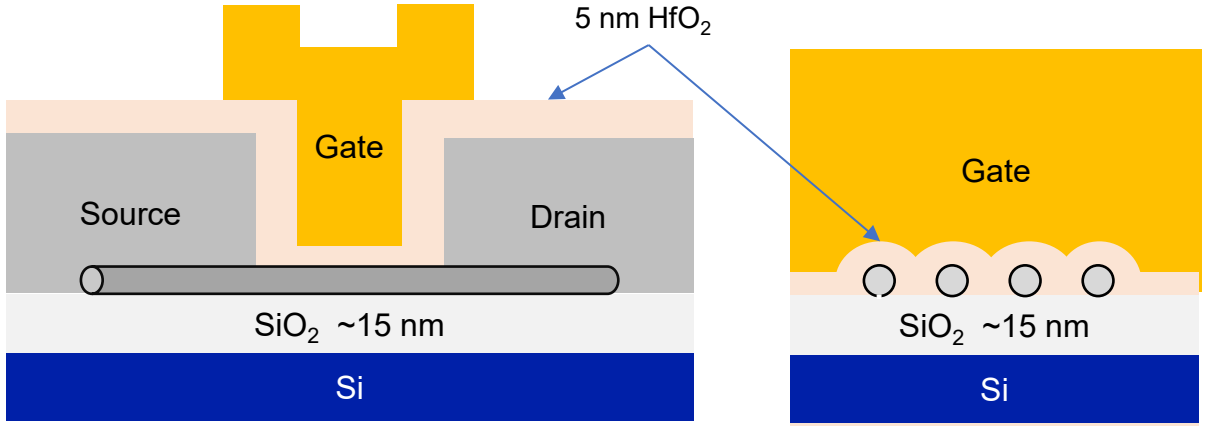
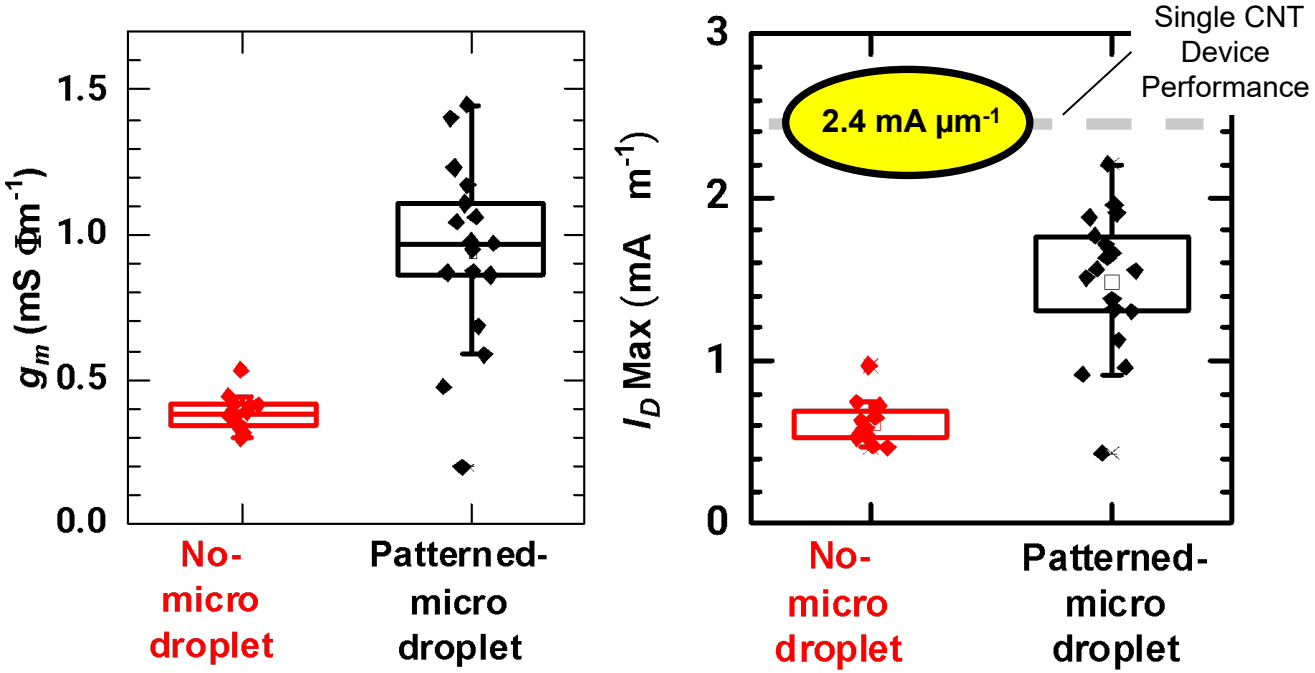
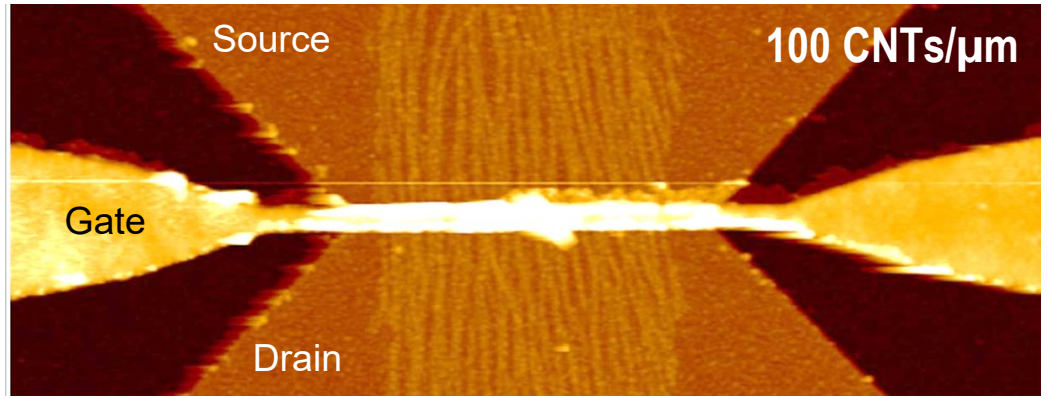
Locally patterned, ideal packing densities of aligned CNTs for high-performance electronics

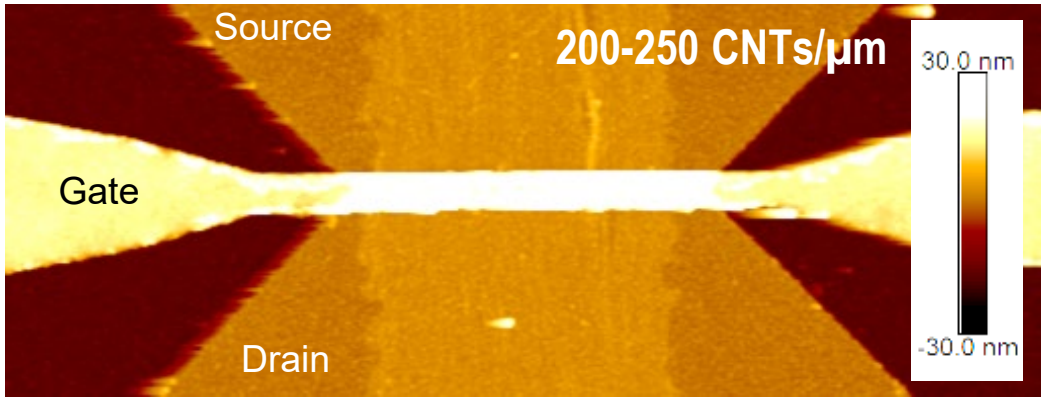




No-microdroplet array



Patterned-microdroplet array



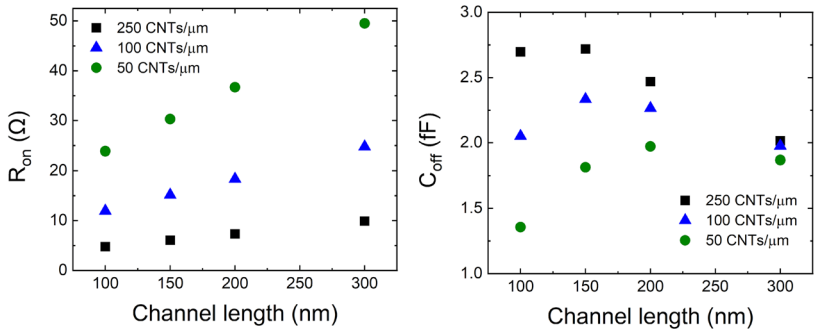
Foradori, Arnold, et al., ACS Nano (2024)

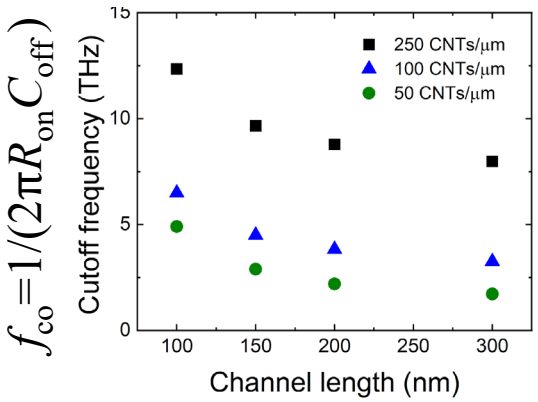
High-Performance RF Devices based on Aligned Carbon Nanotubes

RF Switches

Low **on-state resistance** and **off-state capacitance** for THz RF switches

COMSOL simulations for CNT FET RF switches

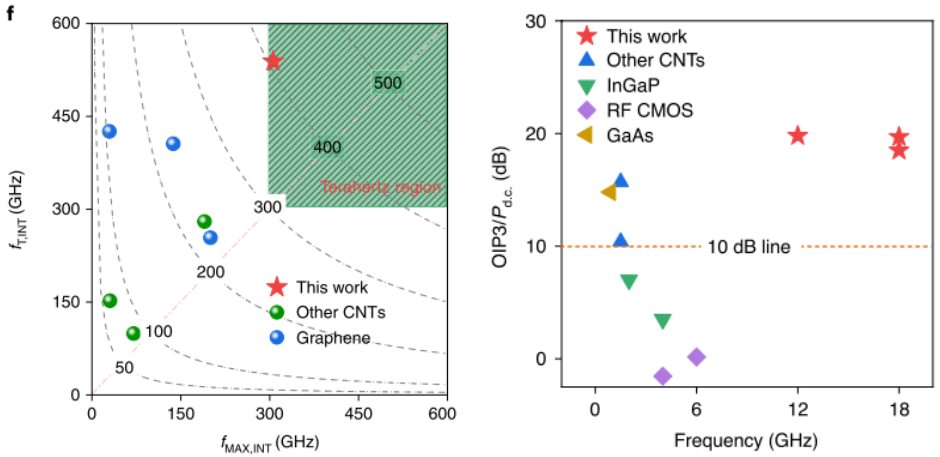




CNT-based RF switches: 5-10× > $R_{on}C_{off}$ cutoff frequencies compared to projected 22nm FDSOI (1 THz)

RF Amplifiers

Superior **electronic properties** and **low device parasitics** can lead to THz cutoff and maximum oscillation frequencies with high linearity for next generation low-power RF amplifiers



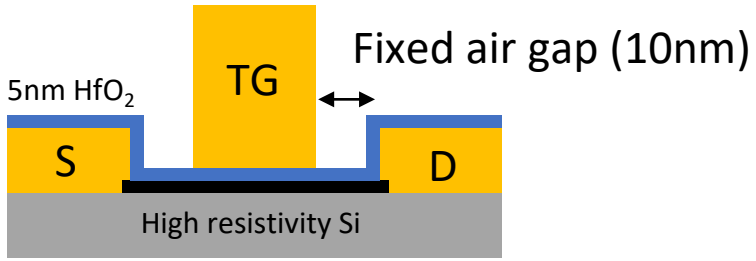
Shi, H., Ding, L., Zhong, D. *et al.* Radiofrequency transistors based on aligned carbon nanotube arrays. *Nat Electron* **4**, 405–415 (2021)

Peking University: f_t = 551 GHz and f_{max} = 1024 GHz, respectively (L_g = 35 nm)

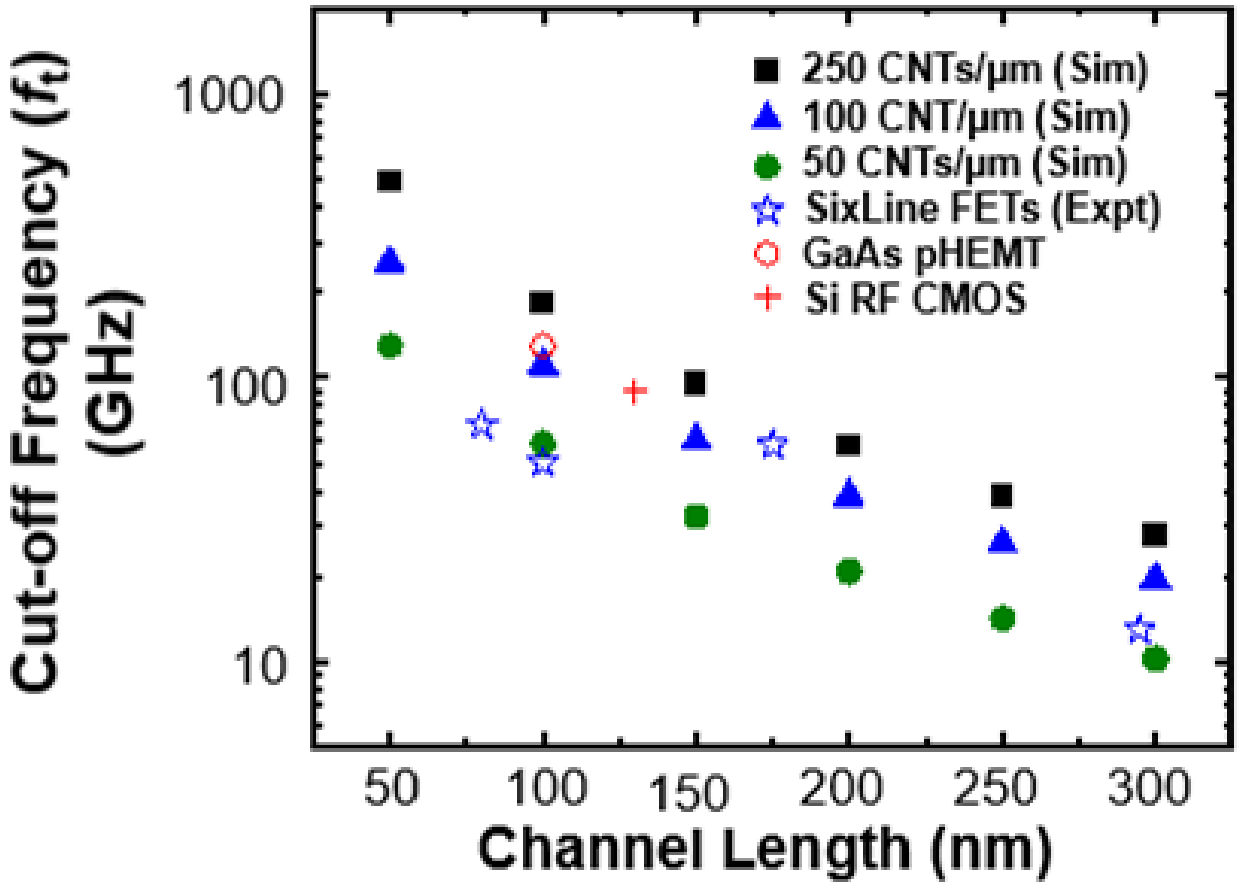
CNT RF FET Performance

Recent initial experimental results (2025) match simulations—routes to significant performance improvement in progress

Top gate (I-gate) FETs



Current I-gate and undoped architectures limit frequency performance by increasing resistances—improved architectures in progress



○ Chih-Sheng Chang, Chih-Ping Chao, J. G. J. Chern and J. Y. -C. Sun, "Advanced CMOS technology portfolio for RF IC applications," in *IEEE Transactions on Electron Devices*

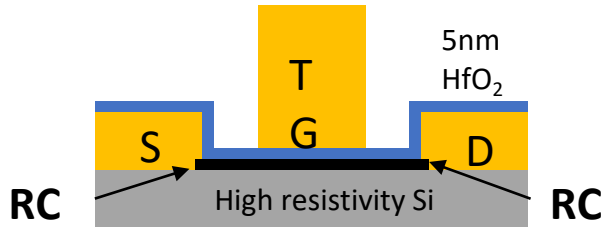
+ A. Bessemoulin, J. Tarazi, M. G. McCulloch and S. J. Mahon, "0.1-μm GaAs PHEMT W-band low noise amplifier MMIC using coplanar waveguide technology,

Next Steps for Improved Performance

1) Reduce contact resistance (2RC)

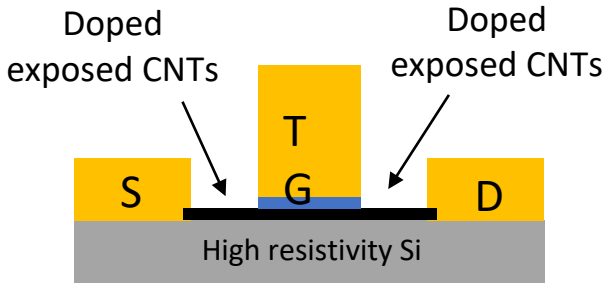
30kΩ /CNT → 15kΩ /CNT

3x improvement



2) Dope ungated regions of CNTs

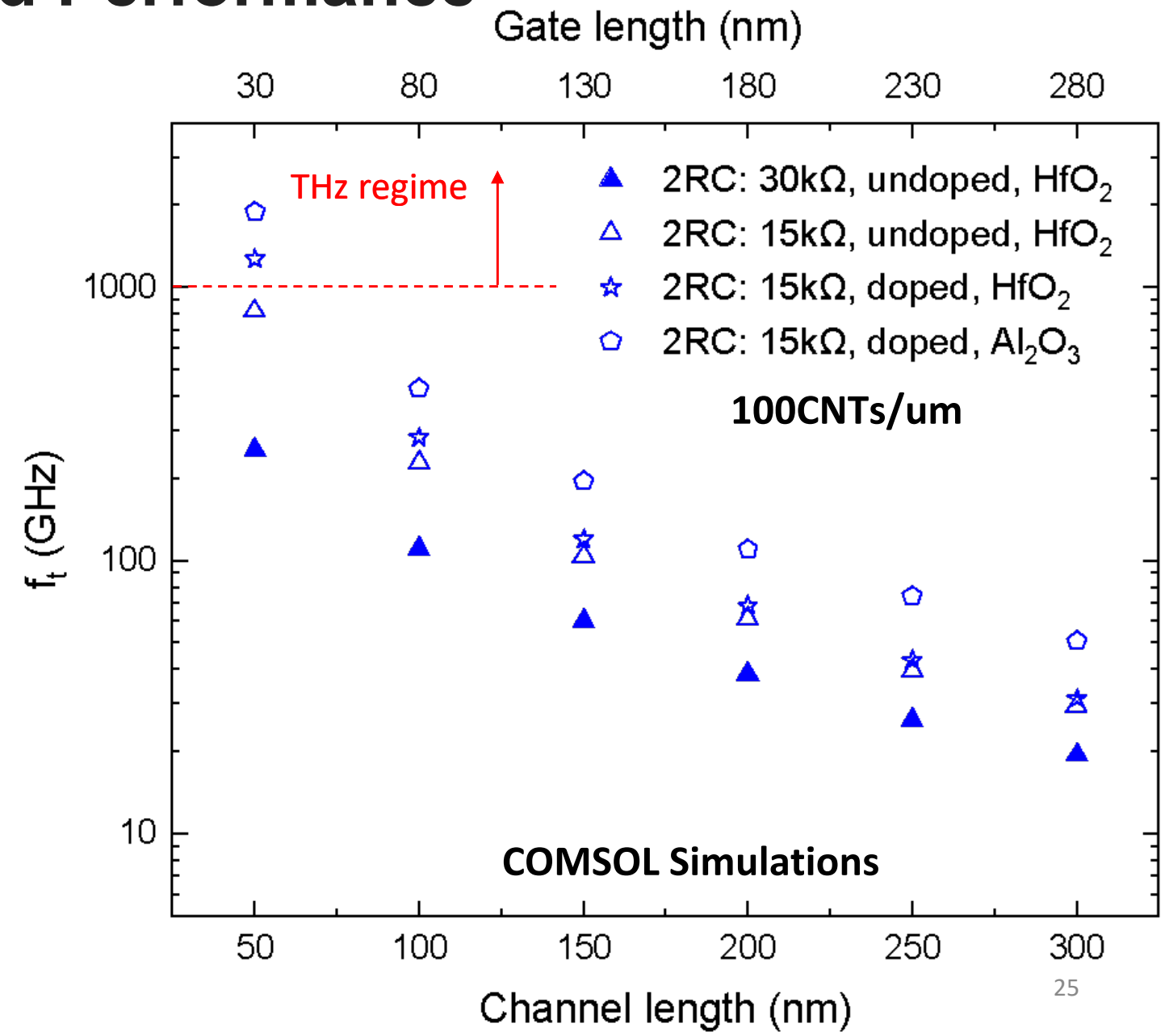
5x improvement



3) Use lower κ gate oxide

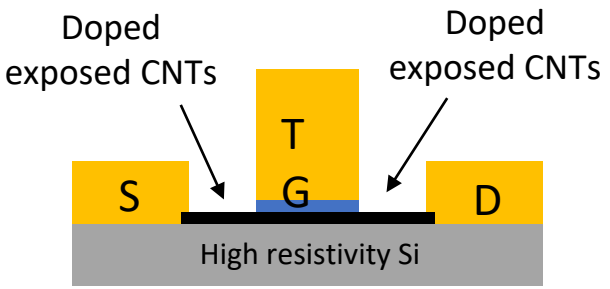
8x improvement

HfO_2 κ: 20 → Al_2O_3 κ: 7

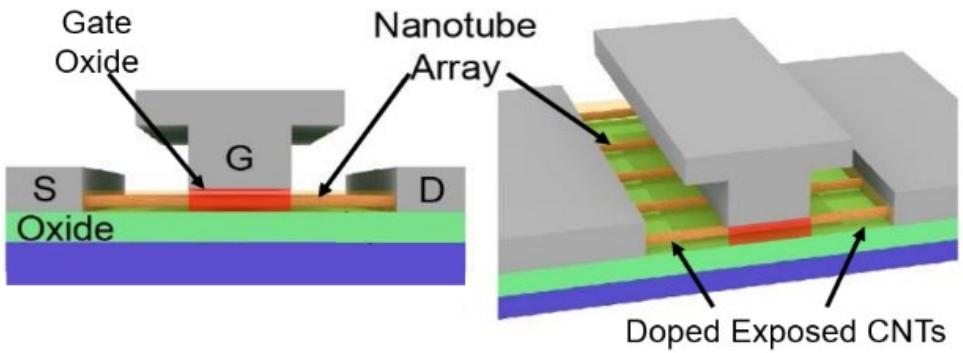


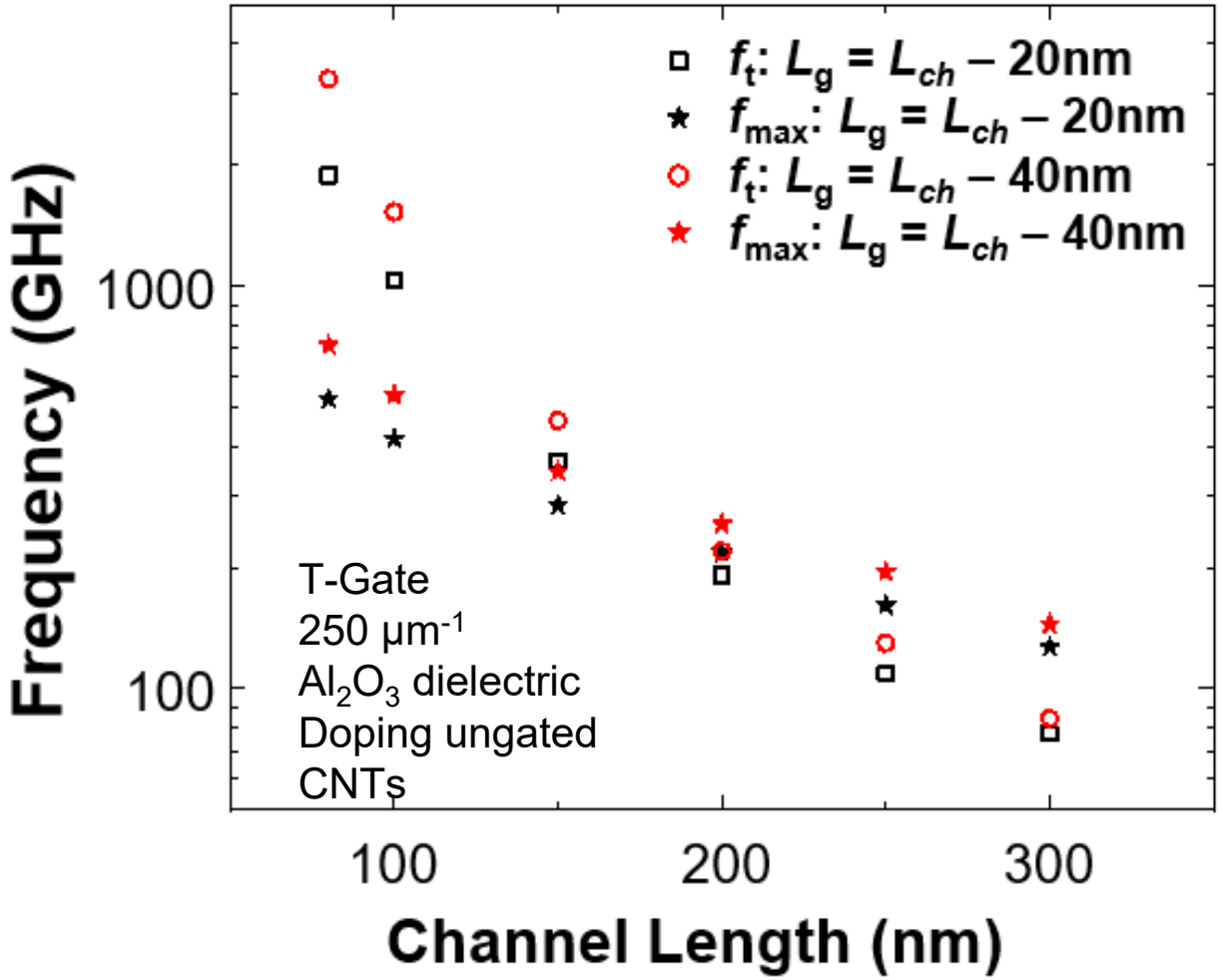
Next Steps for Improved Performance: T-Gate

I-Gate Architecture



T-Gate Architecture





Intellectual Property

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DATE	FILING TYPE	NUMBER	TITLE	INVENTORS	STATUS
2023	U.S. Patent Application	US P230360US01	“Patterned surface water assisted packing density and alignment enhancement of carbon nanotube arrays”	Michael Arnold, Sean Foradori	Filed
2022	U.S. Patent Application	US 17/591,711	“Selected-area deposition of highly aligned carbon nanotube films using chemically and topographically patterned substrates”	Padma Gopalan, Jonathan Dwyer, Katherine Jinkins, Michael Arnold	Filed
2021	U.S. Patent	US11631814	“Two-dimensional carbon nanotube liquid crystal films for wafer-scale electronics”	Michael Arnold, Katherine Jinkins, Padma Gopalan	Approved
2020	U.S. Patent	US10873026	“Alignment of carbon nanotubes in confined channels”	Michael Arnold, Katherine Jinkins, Gerald Brady, Padma Gopalan	Approved
2018	U.S. Patent	US10074819	“Floating evaporative assembly of aligned carbon nanotubes”	Michael Arnold, Padma Gopalan, Gerald Brady, Yongho Joo, Harold Evensen	Approved
2017	U.S. Patent	US9728734	“Aligned carbon nanotubes for use in high performance field effect transistors”	Michael Arnold, Padma Gopalan, Gerald Brady, Yongho Joo	Approved
2016	U.S. Patent	US9327979	“Methods for removing polymer coatings from single-walled carbon nanotubes”	Padma Gopalan, Michael Arnold, Yongho Joo, Gerald Brady, Matthew Shea	Approved