Yale University Innovation Pipeline

Physical Sciences

YALE VENTURES

YV8767: Fitness Device For Tracking Repetitions For Weightlifting and Other Exercise Activity

Developed from a partnership between Yale Engineering and Yale Athletics, BULLDOG REPBOX™ is a monitoring tool to ensure and count exercise repetitions during weightlifting exercises and other repetitive exercises such as sit-ups and push-ups. A user can calibrate the device to any height with visual and audible indications used to signal when an exercise movement is properly executed, thereby encouraging consistency and automatically providing tracking for the specific exercise routine. Using a single distance sensor, the BULLDOG REPBOX™ detects, counts, and displays proper exercise repetitions. The product can also be used to detect, signal, and record when the proper zones of isometric exercises are obtained. BULLDOG REPBOX ™ is available for purchase by following the QR code below, while supplies last. Limited quantities available.

The know-how and trademarks used in connection with the manufacture and sale of the product are available for licensing from Yale University. BULLDOG REPBOX™ is currently manufactured by a firm founded by a Yale alumnus based in China.

- Patent Filings: N/A
- REPBOX US Trademark Registration Number: 7444960
- Bulldog REPBOX US Trademark Registration Number: 7511863

Innovator: Yale Center for Engineering Innovation and Design

BULLDOG REPBOX™

Yale

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YALE VENTURES

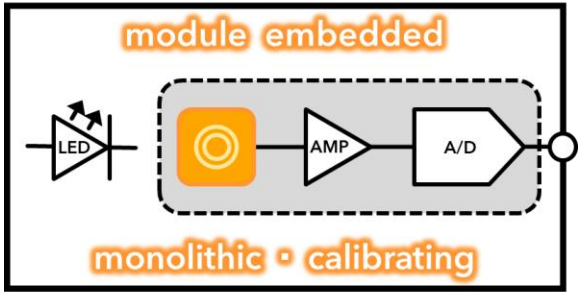
YV8573: Spectroscopic Sensors And Methods in Battery Monitoring Systems

Principal Investigator: Fengnian Xia

Background:

- Thermal runaway in lithium-ion batteries poses safety hazards due to heat generation and toxic gas emissions.
- Conventional spectrometers are bulky and expensive, relying on moving parts or large detector arrays.
- This miniaturized, on-chip spectrometer enables precise, real-time gas detection using tunable photoresponse with machine learning-based calibration.

Relevant Applications: Battery safety and diagnostics, electric vehicles, consumer electronics, industrial energy storage, wearable or portable environmental sensors



Innovation & Asset:

- **Compact Design:** Single-detector on-chip spectrometer reduces footprint and fabrication cost.
- **Voltage-Tunable Detection:** Spectral sensitivity is tuned using electrical bias, eliminating moving parts.
- **Machine Learning Integration:** Trained neural networks allow for direct direction detection of hazardous conditions without spectrum reconstruction.
- **Patent Status:** Patent pending (U.S. Application No. 18/537,331).

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YV 8526: Subvoxel SEM Based Volume Electron Microscopy (vEM)

Principal Investigator: C. Shan Xu (Xu Laboratory of vEM) & Song Pang (FIB-SEM Collaboration Core)

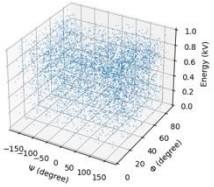
Background:

- **Resolution Limitation**: Conventional Scanning Electron Microscopy (SEM) systems have had a persistent resolution limit for 80 years, primarily constrained by the size of the scanning electron probes.
- **Conventional Approaches:** Focus on reducing the probe size to improve SEM resolution, but this often result in greater diffraction errors, which would deteriorate resolution.

Relevant Applications: Life Science, Semiconductor Industry, and Material Science.

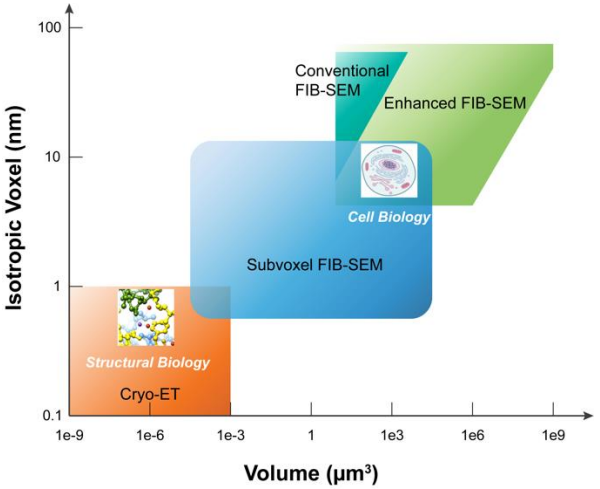
Innovation:

- **Our Invention:** A fundamentally new SEM system detects subvoxel information and reveals features smaller than the probe size using two-dimensional energy profiles, thus surpassing the longstanding SEM resolution.
- **Subvoxel SEM Architecture:** This new architecture transcends the SEM resolution limits, reaching near-atomic resolution.
- **Subvoxel FIB-SEM Integration:** Integrating the SEM subvoxel architecture with a focused ion beam that enables precise layer separation to create 3D volume EM imaging at near-atomic resolution.



Asset:

- **Patent status**: Patent pending (U.S. Application No. 63/503,396).



By bridging the resolution and imageable volume gap between cryo-ET and enhanced FIB-SEM, Subvoxel FIB-SEM will connect structural biology and cell biology. For the first time, structure and function can be probed across scales from protein domains to proteins to organelles to cells, not only in an isolated form, but also in their native tissue environments and within the holistic milieu of whole cells.

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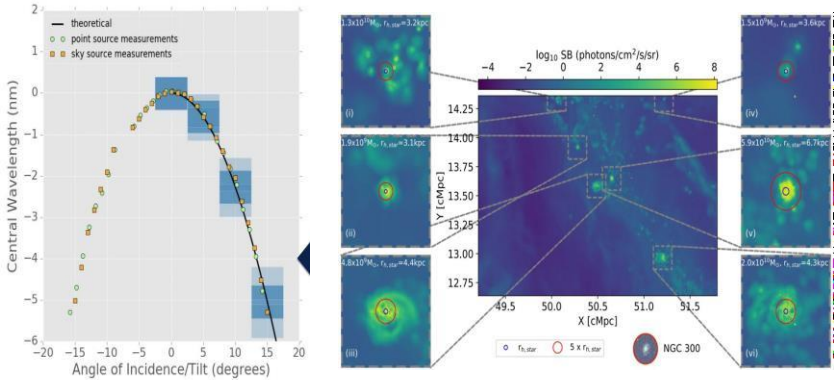
YV7813: Spectral line mapping telescope

PARTNERED

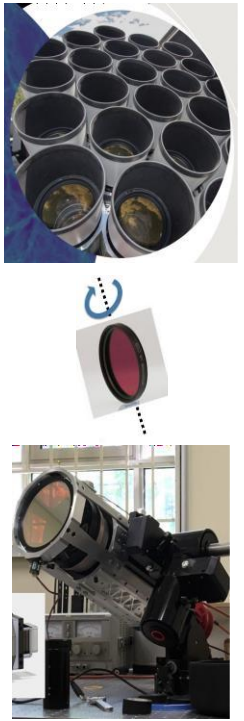
Principal Investigator: Pieter van Dokkum

DRAGONFLY™ array digitally fuses many images from smaller telescopes together.

- **Low surface brightness imaging:** DRAGONFLY™ is equivalent to a 1 meter aperture refractor (the largest in the world) and it operates at an ultra-fast f/0.39 focal ratio with an enormous (6 square degree) field of view and optical scattering an order of magnitude lower than conventional telescopes.
- **Low cubesat payload:** The segmented nature makes it extremely scalable.
- **Potent wide-area imaging spectrometer:** DRAGONFLY™ employs a tilting narrowband interference filter which means it can isolate the glow from the nearly invisible (to every other telescope) at a specific wavelength. Array can be tuned to the wavelength of interest. This is not possible with conventional, unsegmented telescopes.
- Patent issued #12,189,155



Applications: 3D spatial information for astronomy; searches for weak emissions from dark sites at specific wavelengths; Geospatial surveillance and remote sensing.



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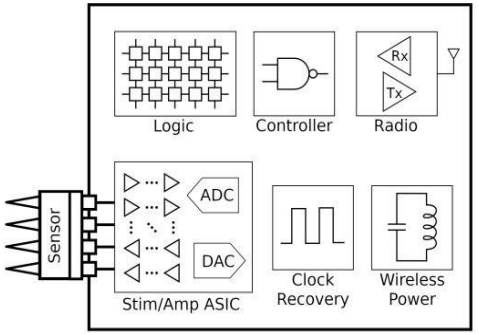
YV7805: General-Purpose Architecture for implantable Brain-Computer Interfaces (BCI)

Principal Investigator: Abhishek Bhattacharjee

BCIs record neuronal activity with high fidelity. BCI development is ever moving beyond academic labs to industry, with companies like Kernel, Mindmaze, Longeviti, Neuropace, Neurable, Medtronic, and Neuralink building new generations of fully implantable embedded BCIs.

Implanted devices have 1) device power budgets 2) RF power transmission constraints needed to mitigate the power deposited in brain tissue per strict FDA, FCC, and IEEE guidelines. This has led to a fragmented ecosystem of BCI chip designs. Yet the logic on board these devices is tailored for specific uses (e.g., seizure detection versus data recording, etc.) and for specific brain regions.



Current BCI devices placed on brain tissue employ above generalized skeleton, which faces significant safety challenges if it is to be fit for general purpose.

HALO realizes a **general-purpose architecture.**

- Novel interconnect and switch processing elements developed in Manohar lab.
- HALO achieves 4-57× reductions in power consumption versus known software alternatives.
- All processing pipelines operate under 15mW budgets with greatly reduced radio RF bandwidth.
- Evaluation suits full range of neurological disease domains: from neuronal signal extraction to seizure onset detection (epilepsy) and movement intention (paralysis and Parkinson's disease).
- The HALO team is currently (2020) taping out the first generation of HALO chips.
- Patent issued #12,236,246

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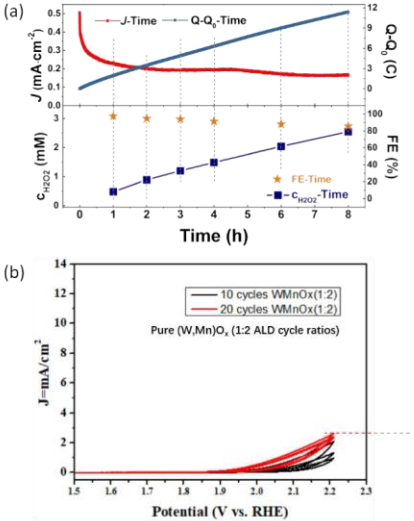
YV7659: Hydrogen Peroxide production

Principal Investigator: Shu Hu

Electrochemical production of H2O2 from water

- Membrane-less stack, no electrolyte (conventional H2O2 devices require electrolytes).
- Disinfection applications 1) H2O2 accumulation in water, or 2) H2O2 vapor in textiles.
- ALD process and novel oxide films permit compact lamination which is required for efficient H2O2 production, other catalysts cannot achieve this.
- Patent issued #11,484,865



Outperforming competitors 20mM H2O2 at >90% Faradaic Efficiency Fig. (a) above.
Stable current-voltage behavior in single-layer (Ti,Mn)Ox and bi-layer (W,Mn)Ox+(Ti,Mn)Ox coatings Fig (b) above.

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YV7199: Wafer Scale Synthesis BN/BP

Principal Investigator: Fengnian Xia

Stable Black Phosphorous epi-wafer

Black Phosphorous 2D thin films promise to surpass Graphene as the most favorable materials for future nano- and opto-electronics thin film solar, photo-detectors, and logical devices.

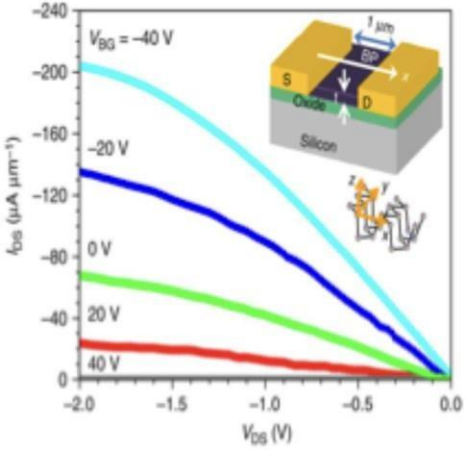
Current synthesis routes, exfoliation and plasma, face major challenges i) volume, ii) stability and iii) uniformity. Yale inventors have found a way to make high quality wafer-scale deposition possible with no device degradation in air.

Proof of Demonstration:

- Boron Nitride/Black Phosphorous heterostructures
- Suits epiwafer and flexible substrate production.
- Uniformity is sufficient for thin-film transistors.
- Atomic layer control allows fine bandgap tuning.
- A novel thin-film BN insulator prevents degradation.

Status:

- Composition and method Patent; Seeking fabrication partner for high pressure/ temperature reactor collaboration.
- Patent issued #10,636,654



5nm BP thin film growth in a FET transistor device: high carrier mobility, current saturation, tunable bandgap, and angle-dependent properties.

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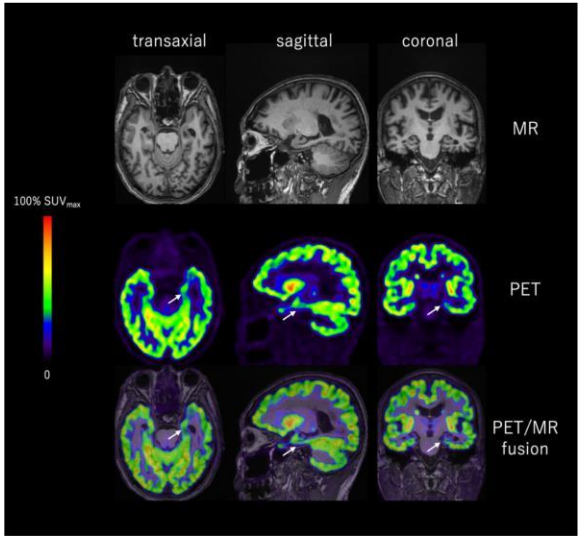
YV7160: 18F-PET ligand for measurement of synaptic density

Principal Investigator: Jason Cai

- Loss of synaptic terminals is a common feature of neurodegenerative disease and associated pathologies.
- SV2a is a marker enriched in synaptic terminals and 11C-labeled SV2a ligands have been described.
- Accurate quantitation of changes in synaptic density in specific brain regions would be useful in diagnosis and monitoring of disease progression.
- 11C-labeled ligands with short half-life are less practical for widespread imaging use. The Yale team have therefore developed novel 18F-labeled SV2a imaging ligands.
- These ligands have been evaluated in humans with neurodegenerative disease.
- Patent issued # 11,518,754
- Publication: ACS Chem. Neurosci. 10:1544 (2019)



^{18}F-SynVesT-1 PET of a ^{18}F-Florbetapir positive (amyloid positive) AD patient. SV2A binding is significantly reduced in the left hippocampus (white arrows)

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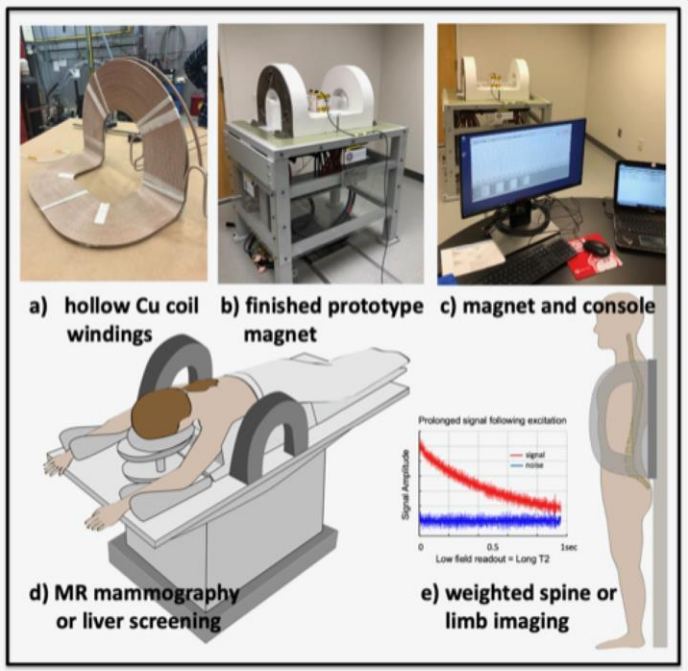
YV6849: Novel open MRI system.

Principal Investigator: Todd Constable

- An open MRI System that can be incorporated into a examination table thereby providing easier patient accessibility.
- Does not need the uniform magnetic fields of conventional MRI so avoids the cost of large, superconducting magnets and associated shielding.
- Lower cost and smaller footprint will increase availability of MRI in early clinical care.
- Could be installed in doctor offices or even made portable in emergency medical vehicles.
- A prototype has been built.
- **Intellectual Property:** US Patent issued # 11,320,505



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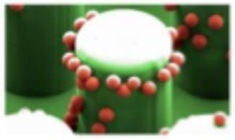
YV6761: Polymeric Micropillars

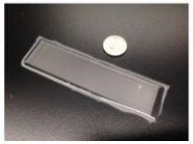
Principal Investigator: Hadi Izadi

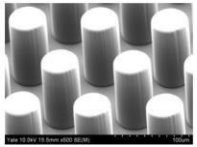
Removal of Particulate Contamination by Microfibrils

Existing dry dust decontamination techniques are limited to +10micron particles. Smaller particles can only be removed by techniques that are partially destructive to the substrate and involve cumbersome batch processing treatments. As a result Quality Assurance in cleanrooms and other critical environments is time consuming and affects product yield.



Dry (non-solvent) particle removal in art restoration.





Micro-fibrils can be tailored to specific size range

Microfibril technology is a zero-adhesion contact surface that collects impurities and contaminant particles with no damage to substrate features.

- Nondestructive over a full range of surface topologies
- May be designed to a specific cutoff Particle Size Distribution
- Removes 10micron to 100nm particles
- Uptake 10-20 monolayers per surface area.
- Compatible with any surface or contaminant.
- Water or electrostatic cleanable
- Injection molded PDMS roller prototype.

Patent issued #11,001,785

YV6697: Nano Porous GaN Diode Laser

Principal Investigator: Jung Han

Higher Efficiency GaN Laser Diode (LD)

The key factors preventing the widespread use of LD lasers in lighting are:

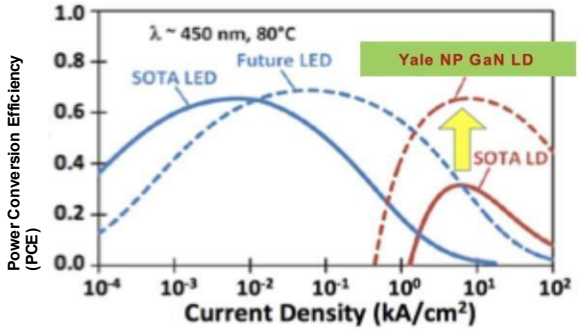
- Insufficient Power Conversion Efficiency (PCE)
- Aluminium degrades performance and lifetime.
- NP GaN offers 2X higher electrical efficiency (PCE) than commercial State Of The Art LDs.
- Brings LD PCE in line with commercial LEDs.
- NP GaN is Aluminum-free.
- Lowers the minimum current density for emission.
- Allows higher blue/green laser power output (Boosts Optical Field X3).

About Nano Porous (NP) GaN:

- A novel electrochemical etching process alters the optical index of GaN by making it nanoporous.
- This is a commercially viable process that can be implemented in any LD or LED chip facility.

Yale Patent Status:

- US Patent issued #10,554,017 “Method and device concerning III-nitride edge emitting laser diode of high confinement factor with lattice matched cladding layer”



High Power automotive and lighting applications

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YV6640: Nanopores by Soft Confinement

Principal Investigator: Chinedum Osuji

1 Nm NanoFiltration Membrane

- A self-assembled Liquid Crystal (LC) monomer film.
- Simple liquid phase roll-to-roll fabrication.
- NanoFilters now have **both** high permeability **and** narrow pore size distribution.
  - 0.9 – 1.1 nm 'cut-off'
- Tortuosity ~ zero.
  - aligned vertical orientation
- US Patent pending App #18/614,093
- Excellent membrane assembly device candidate:
  - Performance flux tested with mechanical support layer for durability.
  - Free standing/mounted on microporous mechanical supports (25mm diameter).
  - Compatible with EU food and beverage compatibility requirement.
  - The global market potential for <10nm filtration without requiring PTFE is about $40MM, and growing.
  - 1 Nm cutoff is required in high cost microelectronics filtration, gas separation and sensor markets.

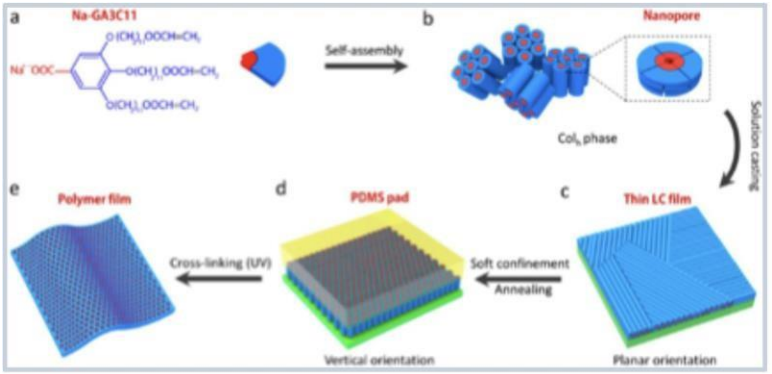

Fig. (a) – (e) Manufacturing by soft confinement is based on the self-assembly of discotic or lyotropic small molecule mesophases.

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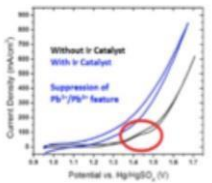
YV6156: Iridium Oxidation Catalyst

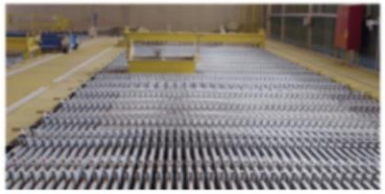
Principal Investigator: Gary Brudvig

Performance coating for electrowinning

Paint-on anti-corrosion layer reduces power costs and extends the useful life of electroplating anodes.
"Blue Solution" is a self-assembling monolayer of Iridium Oxide that preserves the clean wetted-area of the anode and mitigates soluble lead formation.



• Reduces Pb anode dissolution rate by 20%.



Example electrowinning applications: Zinc (lead/silver alloy), Nickel (lead), Copper (lead/antimony)

- Dip coat application, self-assembles - no electrodeposition.
- **6% reduction in power costs.**
- Several fold increase in useful life of the permanent anode.
- Reduce soluble lead in waste water.
- Prevents buildup of sulfate/chromate layers and flaking.
- Synthesis cost $0.75/m2.
- Stable under field conditions (tolerates organics, binders).

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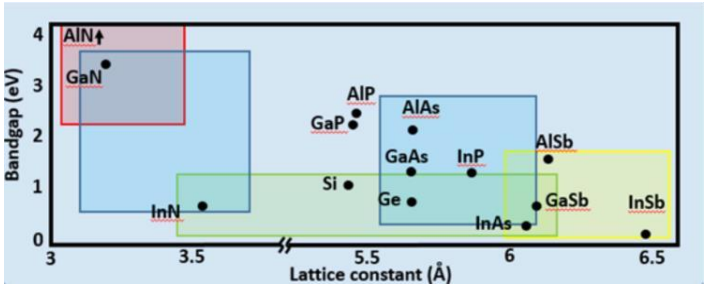
YV5811: GaN-on-Silicon or SOI

Principal Investigator: Jung Han

III-V semiconductor integration with GaN

An epitaxial growth method to deposit III–V material Gallium Nitride (GaN) on an Si or silicon- on-insulator (SOI) wafer, or any amorphous template.

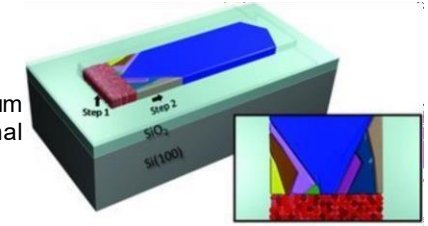
- More versatile version of the conventional Template-Assisted Selective Epitaxy (TASE), but designed specifically for GaN.
- Results in high material quality and is compatible with CMOS processes.
- System fabrication costs may be significantly lower than discrete chip packaging approaches.
- **No material defects** due to crystal lattice mismatch with Si.

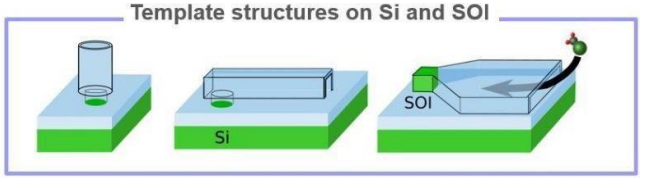


Bandgap versus lattice constant of semiconductors of technological relevance. The greater the difference in lattice constant between two materials, the more challenging their co-integration.

US Patent issued #10,435,812

Method: (1) deposition of a textured aluminum nitride seed on SiO2, **(2)** resulting longitudinal growth of gallium nitride single crystals.





TASE (above) borrows its seed region from a single-crystalline substrate, this is prohibitive for GaN.

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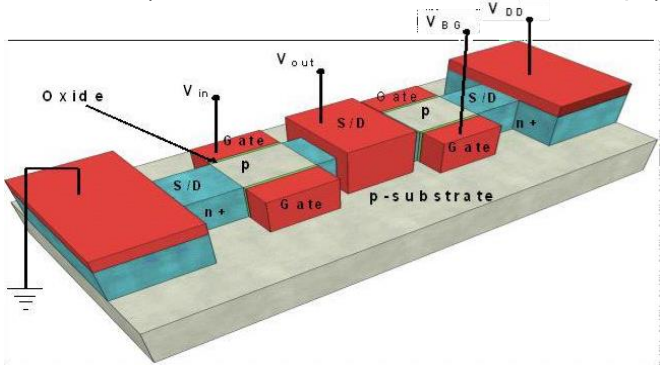
YV4977: Unipolar chip architecture

Principal Investigator: Tso-Ping Ma

Unipolar CMOS Technology for High-mobility Semiconductors and Thin-film Transistors

Unipolar CMOS solves the mobility mismatch between NMOS and PMOS by utilizing two n-channels:

- 20x higher electron mobility
- reduced overall channel width
- cheaper fabrication cost (due to fewer masks and fewer fab steps)
- lower power

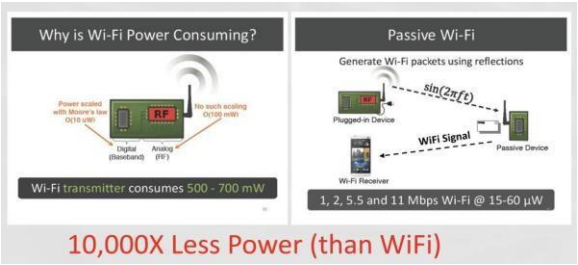


Patent issued #8,384,156

Two key commercial focus areas:

1. Low-Power, Short-Range IoT Networks

2. Low-Power, Wide-Area Networks



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Thank You