

*Exceptional service in the national interest*

# Diagnostic

## A look into front and back end-of-the-line

### Introduction:

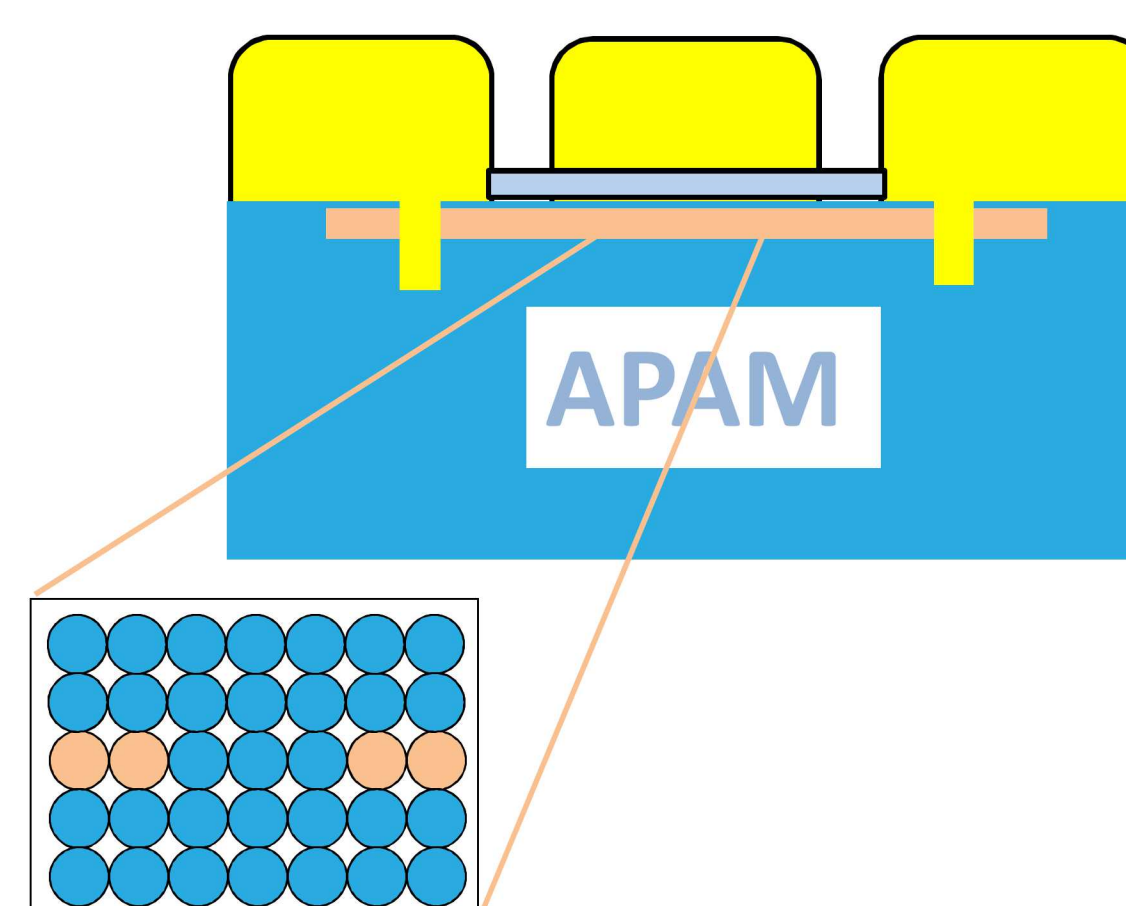
The FAIR DEAL fabrication team designs and fabricates devices for all experimental thrusts. We perform all the fabrication except the addition of the atomically-precise, advanced manufactured (APAM) device itself. Here we present a subset of the devices that have been designed to address specific thrust challenges.

### Impact:

Our design team combines a shared knowledge of STM operation, cryogenic measurement, and device fabrication to create designs that meet the requirements of all these capabilities. This enables the rest of the team to request designs to address specific topics without having to understand the tooling limitations for any of the capabilities (STM, measurement, fab). Our team also provides guidance on the feasibility of integrating new fabrication processes into the APAM process flow. Leveraging the MESA fab facility, devices are typically built on-site in a few days.

Micro Fab Team: DeAnna Campbell, Mark Gunter

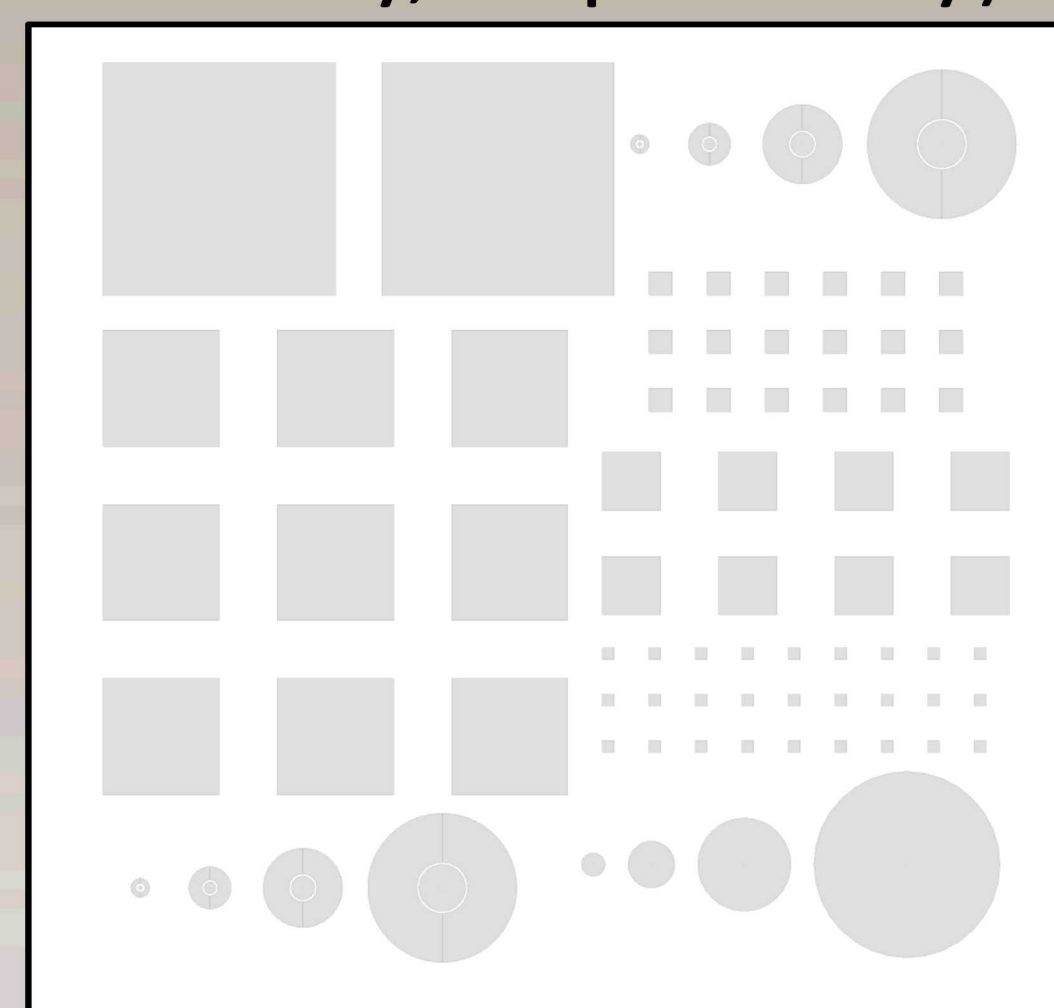
### Thrust 1: APAM-enabled Devices



### Capacitors

CV measurements to evaluate APAM compatible gate stacks

Measurements: CV (thresholds, defect density, trap density)



- Si
- Delta Doped Layer
- Epi Si
- Al<sub>2</sub>O<sub>3</sub>
- TaN
- Al
- Gold

Device Physics

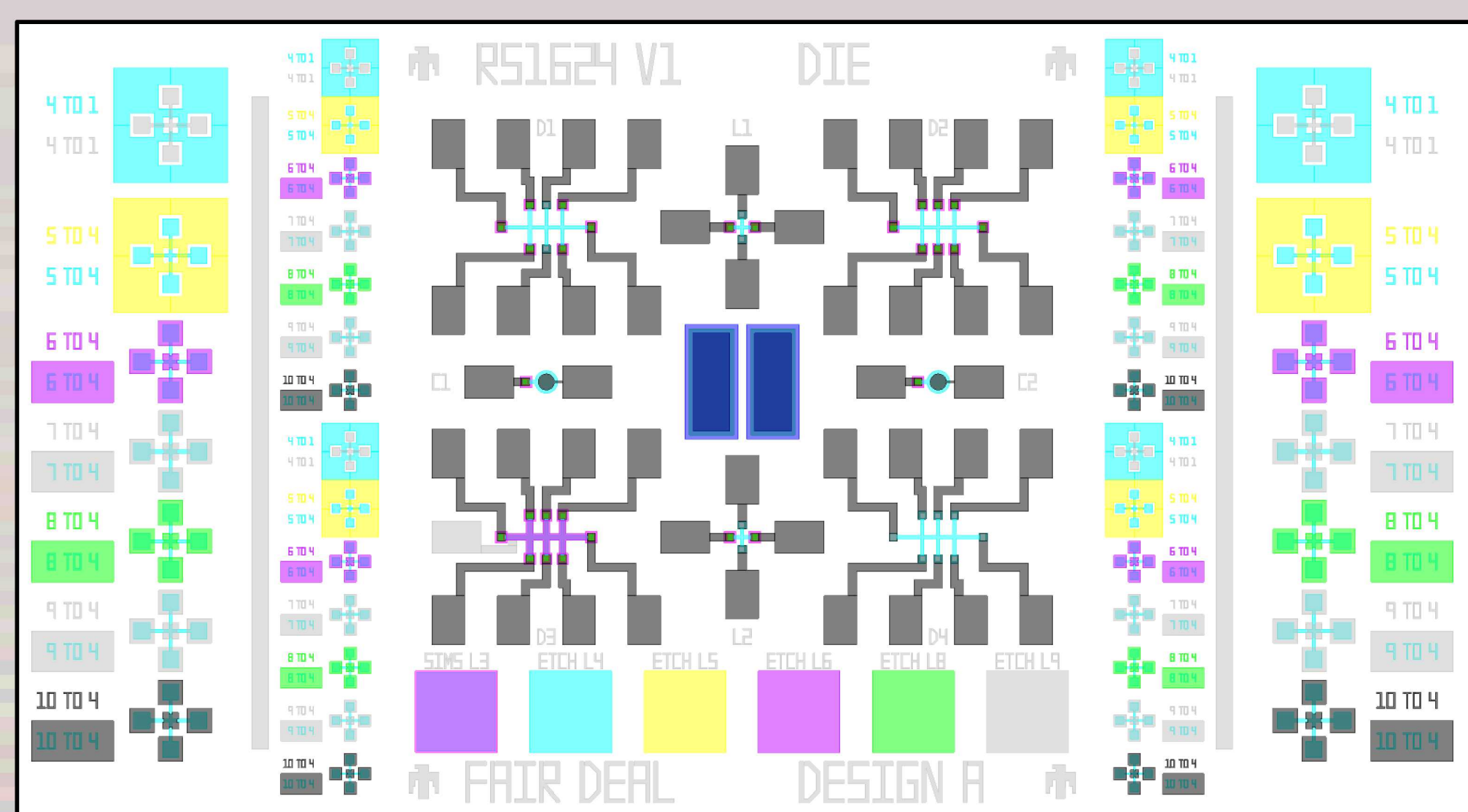
FAIR

Micro

### Room Temperature Hall Bars

Room temperature evaluation platform

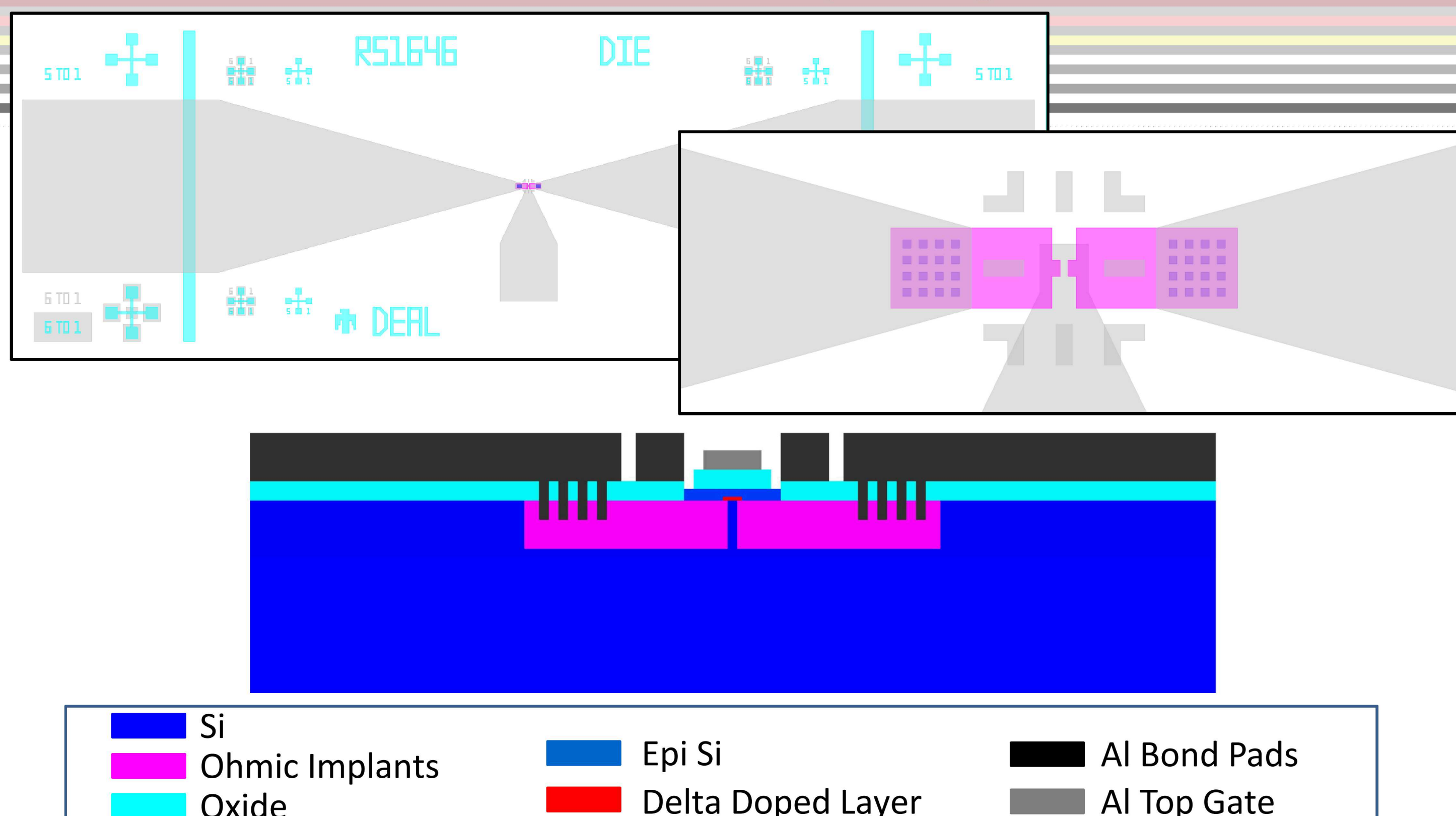
Measurements: Mobility, Leakage, Gating



### In-Situ Electrical Test Die

APAM diagnostic to electrically characterize device throughout the APAM process

Measurements: APAM conductivity during APAM fabrication



- Si
- Ohmic Implants
- Oxide
- Epi Si
- Delta Doped Layer
- ALD gate dielectric
- Al Bond Pads
- Al Top Gate



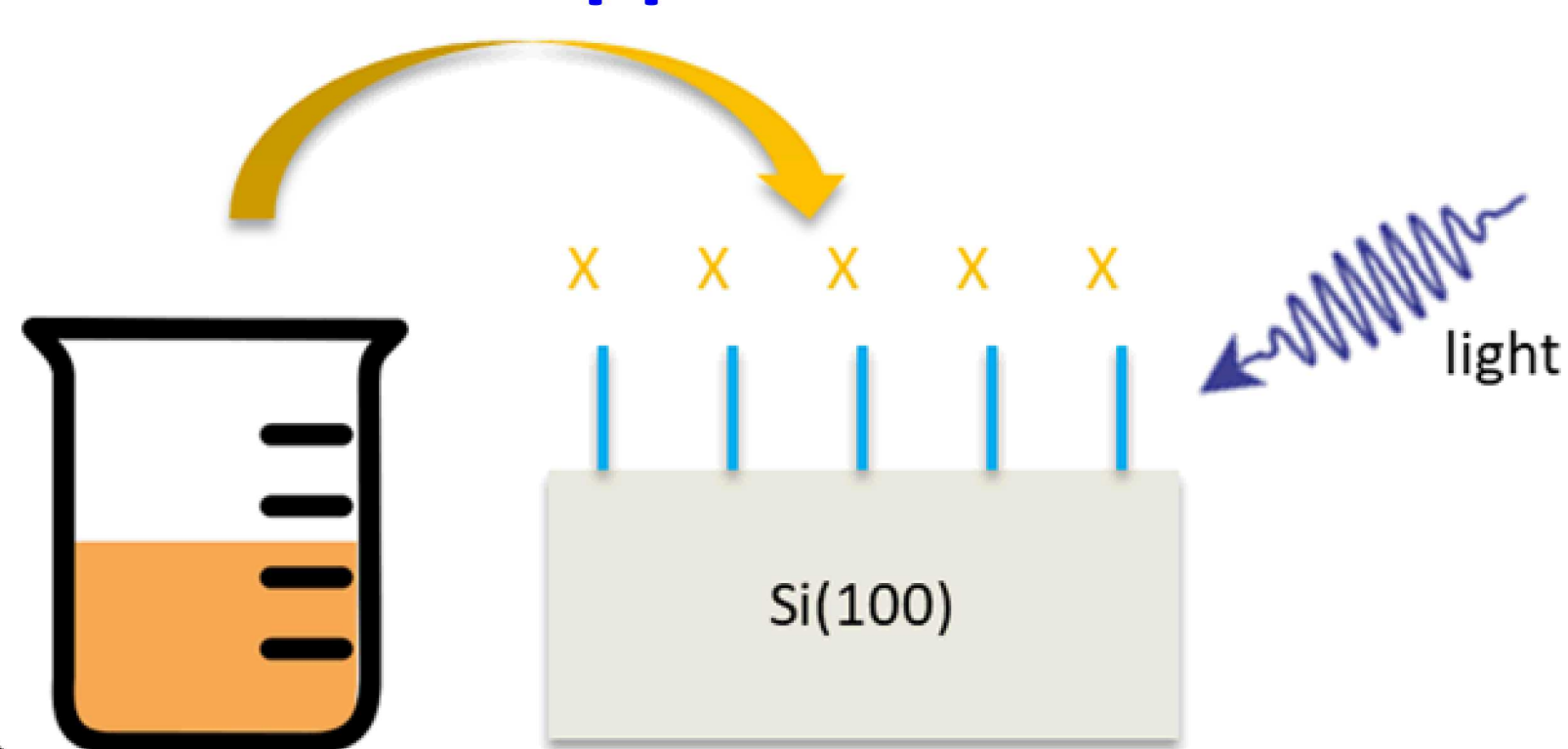
# Fabrication

## fabrication of diagnostic devices to evaluate APAM process.

Phillip Gamache, Sean Smith, Dan Ward

Surface Chemistry  
Electronics

### Thrust 4: Application Platform



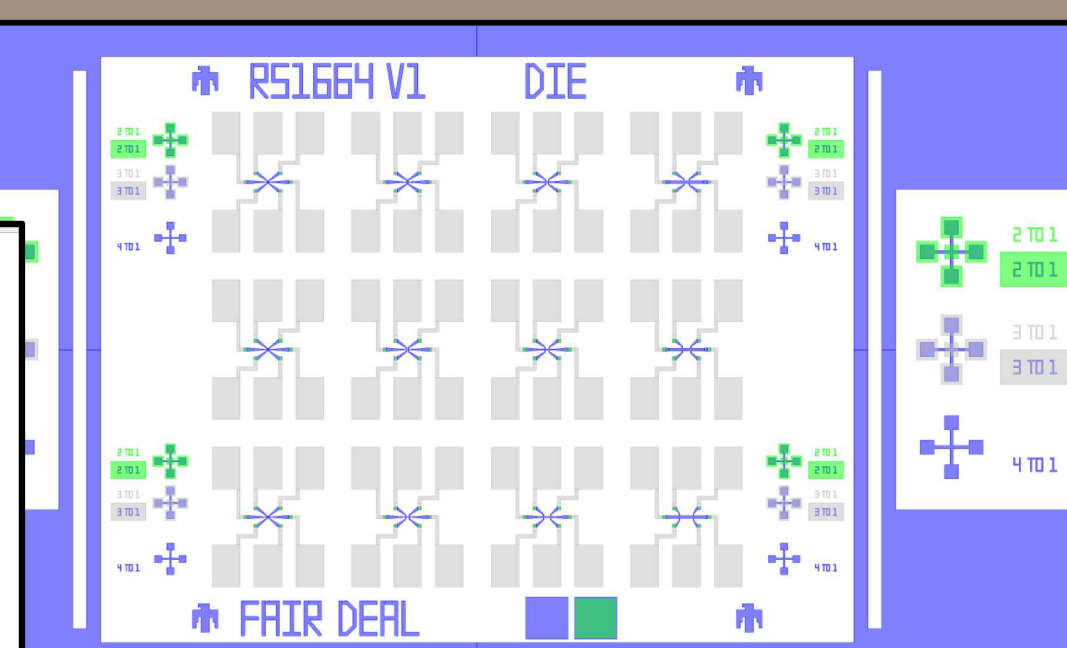
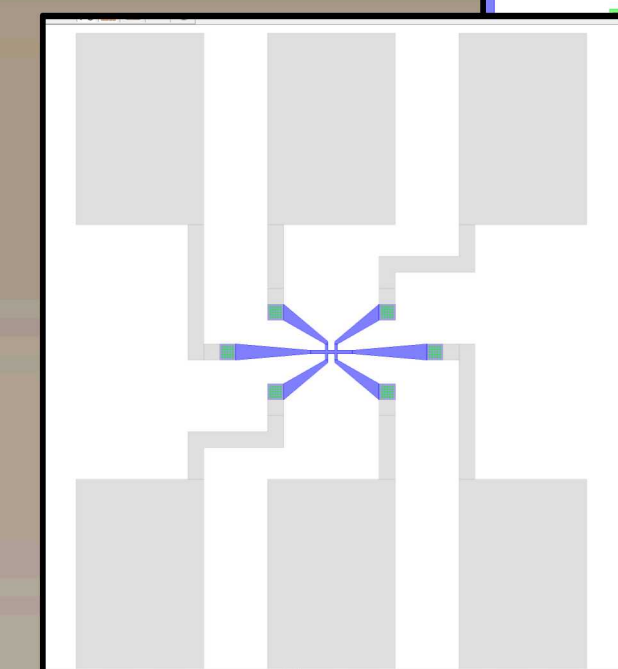
### Oxide APAM Masking

Test donor/acceptor doping quickly without APAM pattern. Possible to extend to <100 nm length scales.

Measurements: Mobility, Conductivity



Si Epi Si  
Oxide Delta Doped Layer  
Al Top Gate

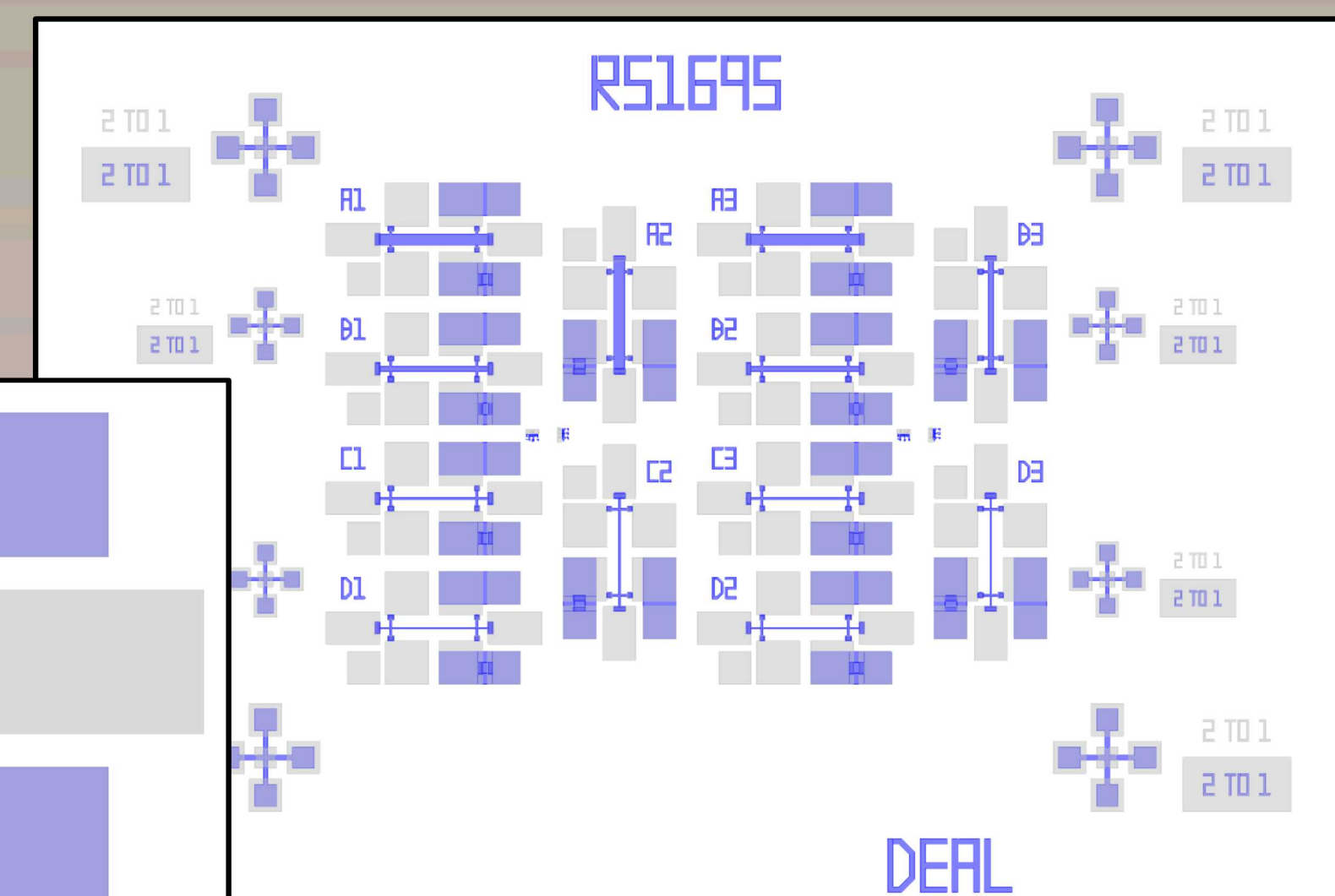
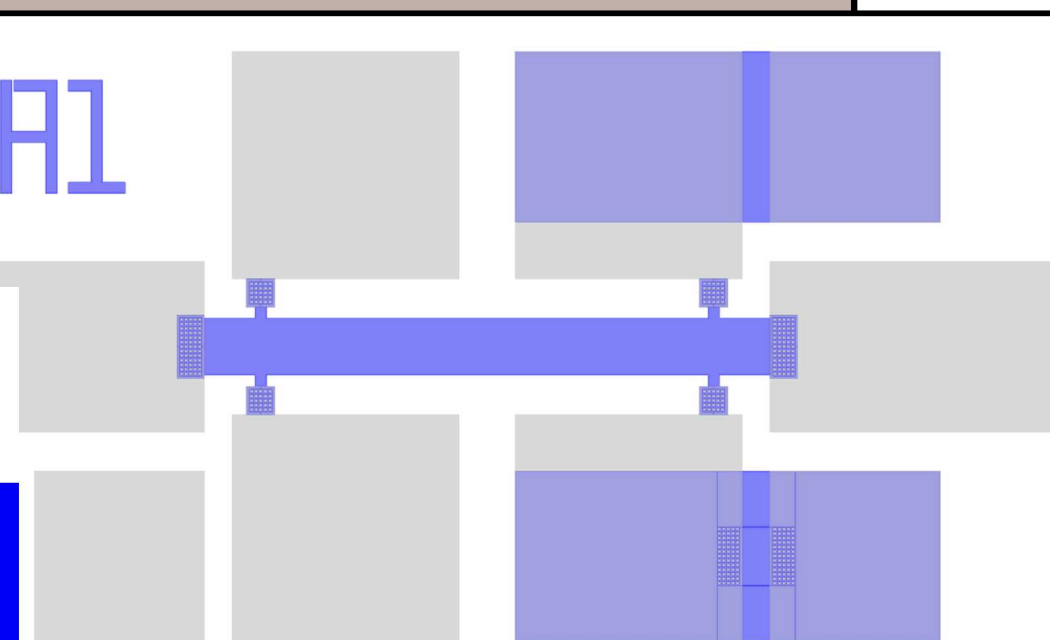
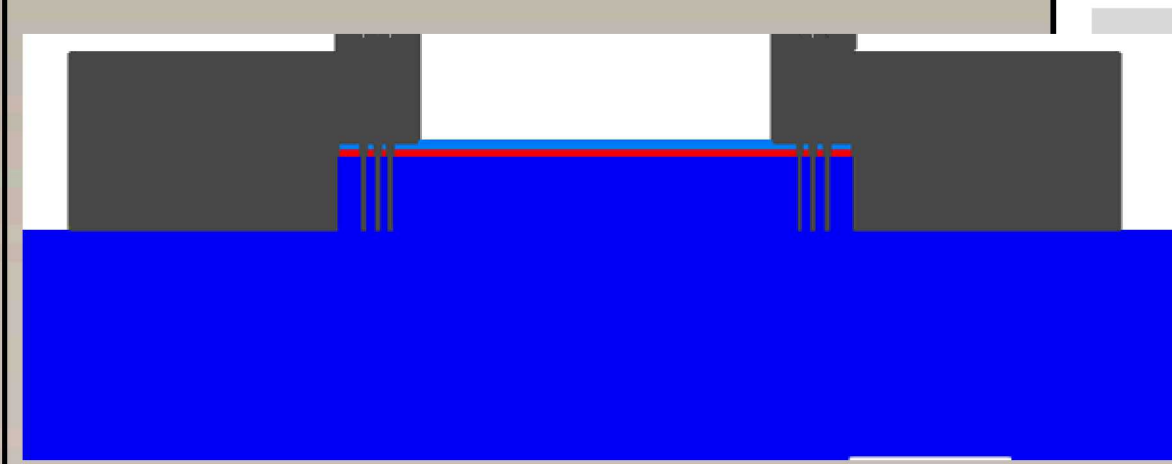


### Hall Bars

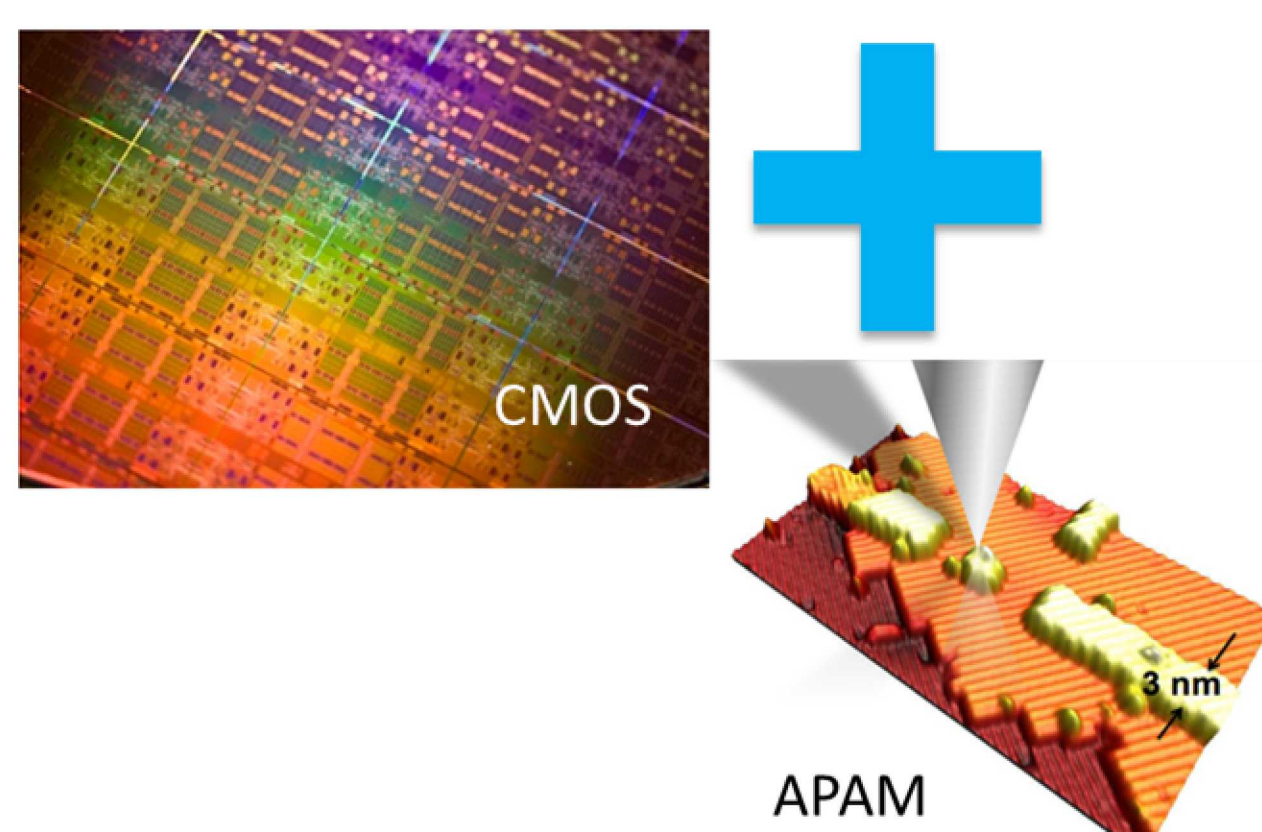
Basic performance diagnostic for delta doped layer performance

Measurements: Mobility, Conductivity

Si  
Oxide  
Epi Si  
Delta Doped Layer  
Al Top Gate



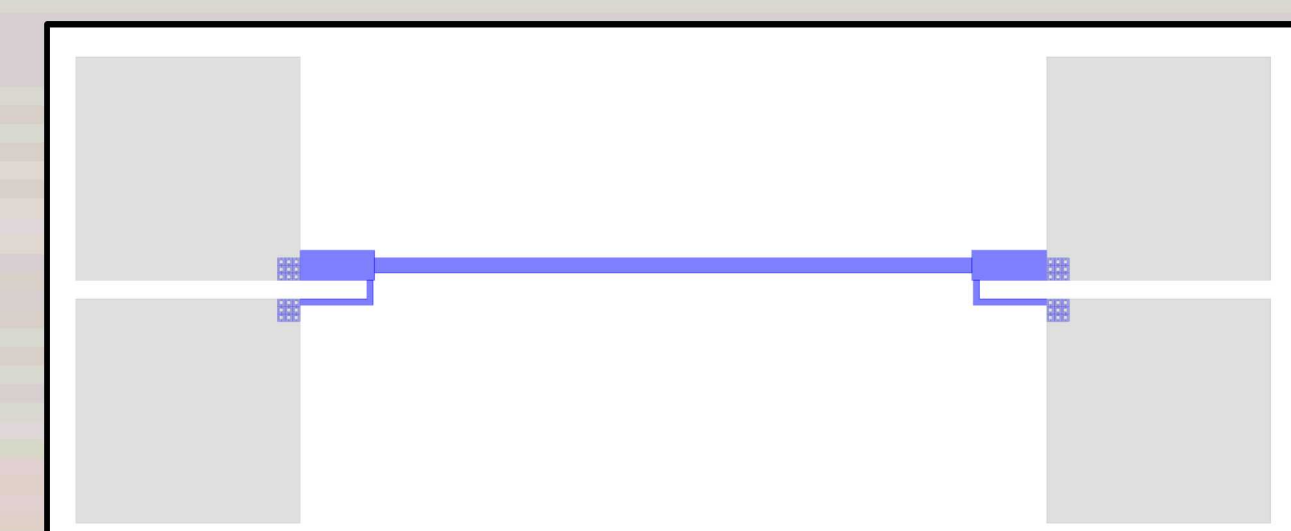
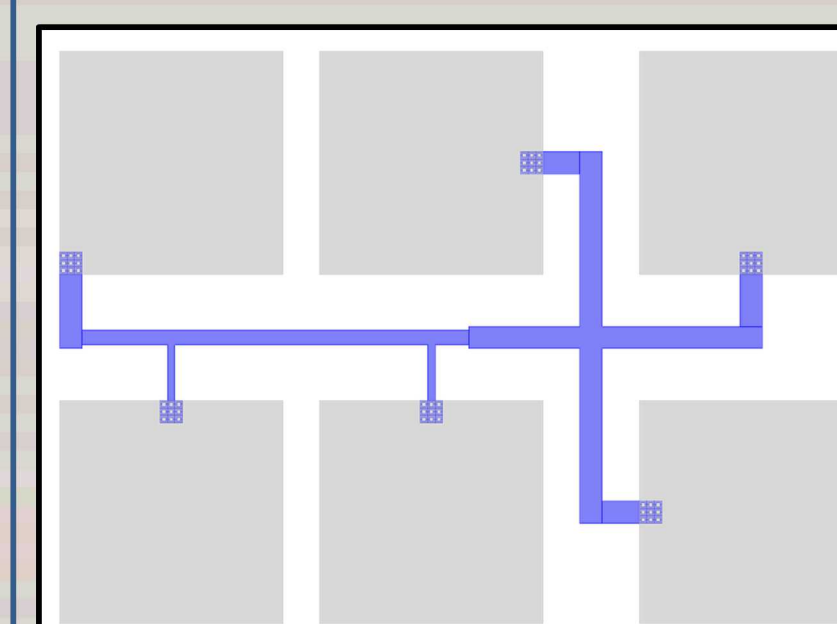
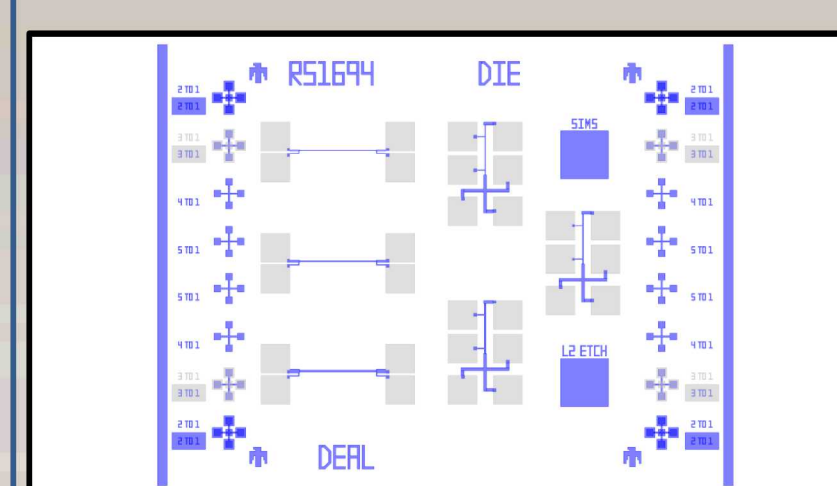
### Thrust 3: CMOS Integration



### APAM Robustness

Assess when APAM fails

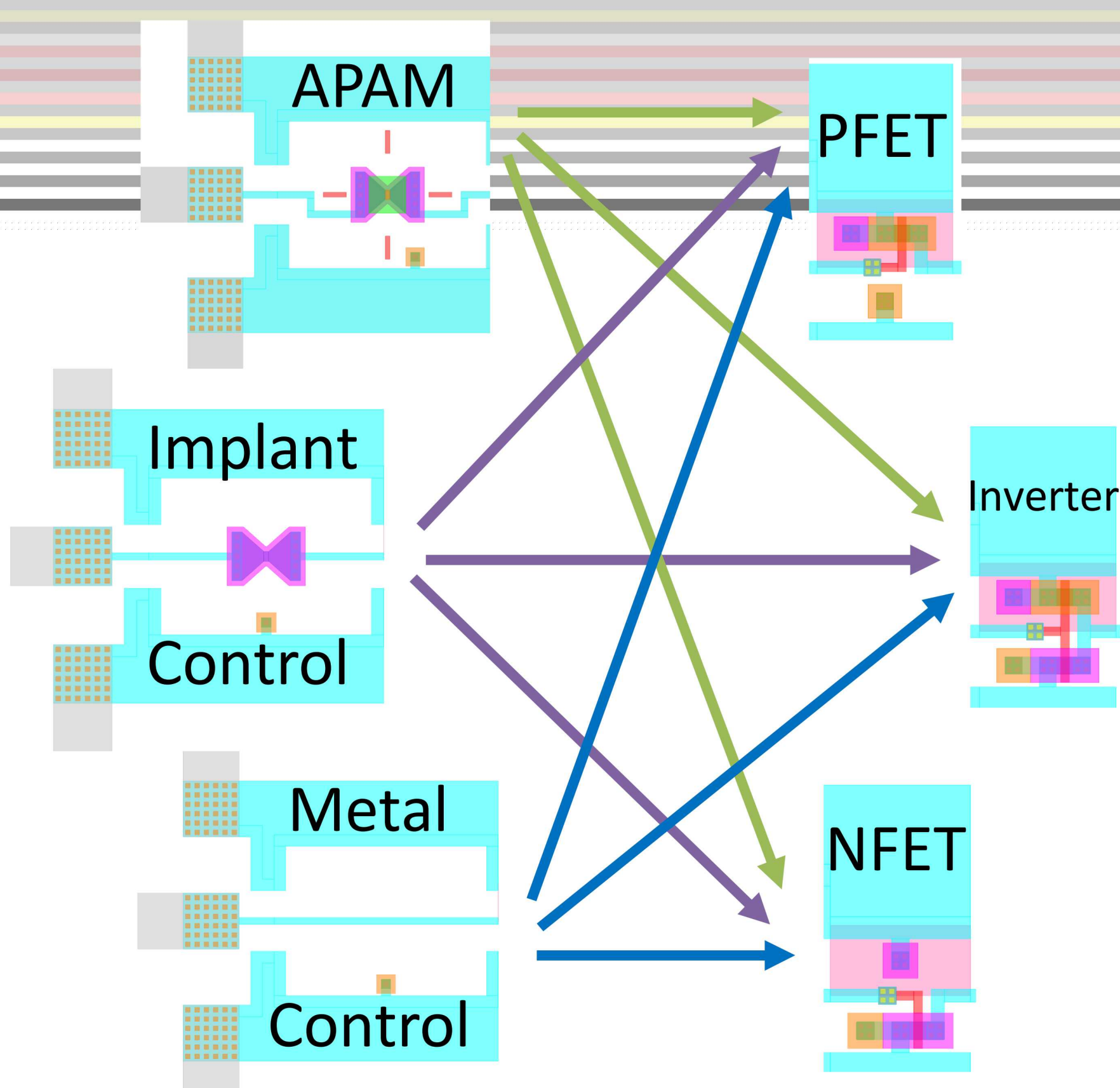
Measurements: Conductivity as function of time and temperature



## Going Forward.....

### Direct CMOS Integration

Measurements: CMOS/APAM functionality



### APAM/CMOS Integration Die

