Edge structure optimization for N-type MAPS toward a high-performance medical imaging system

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Gian-Franco Dalla Betta
Manuel Da Rocha Rolo
Lucio Pancheri

On behalf of the
1MICRON Collaboration

Outline

1. Introduction
2. Simulation Validation
3. Ultra-thick Fully Depleted MAPS
4. Modeling of the dicing edge
5. Conclusion & Future Work

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Bottlenecks

1. Poor contrast for soft tissues;
2. Spatial resolution not high enough (typically a few tens of μm);
3. Sensitivity to subtle structural variations is limited.

Goal of ***1MICRON*** (EIC Pathfinder Project)

1. Spatial resolution down to ~1 μm (comparable to pathology laboratories);

2. High contrast for soft tissues;

3. Real-time imaging.

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1. Edge-on geometry to improve detection efficiency over a wide energy range 10.1016/S0168-9002(96)01076-5 (F. Arfelli, et al);
2. Grating based phase contrast imaging;
3. Fully depleted thick MPAS (≥ 650 μm) with minimized dead area;
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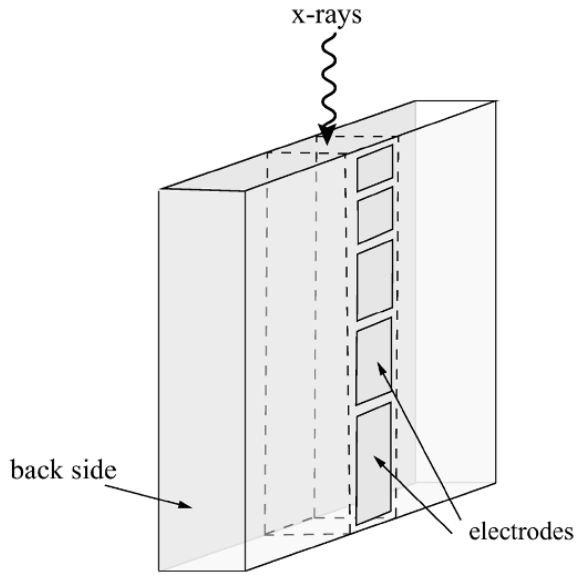

(b) Edge-on geometry

Plot from [10.1088/1361-6560/abc5a5](10.1088/1361-6560/abc5a5)
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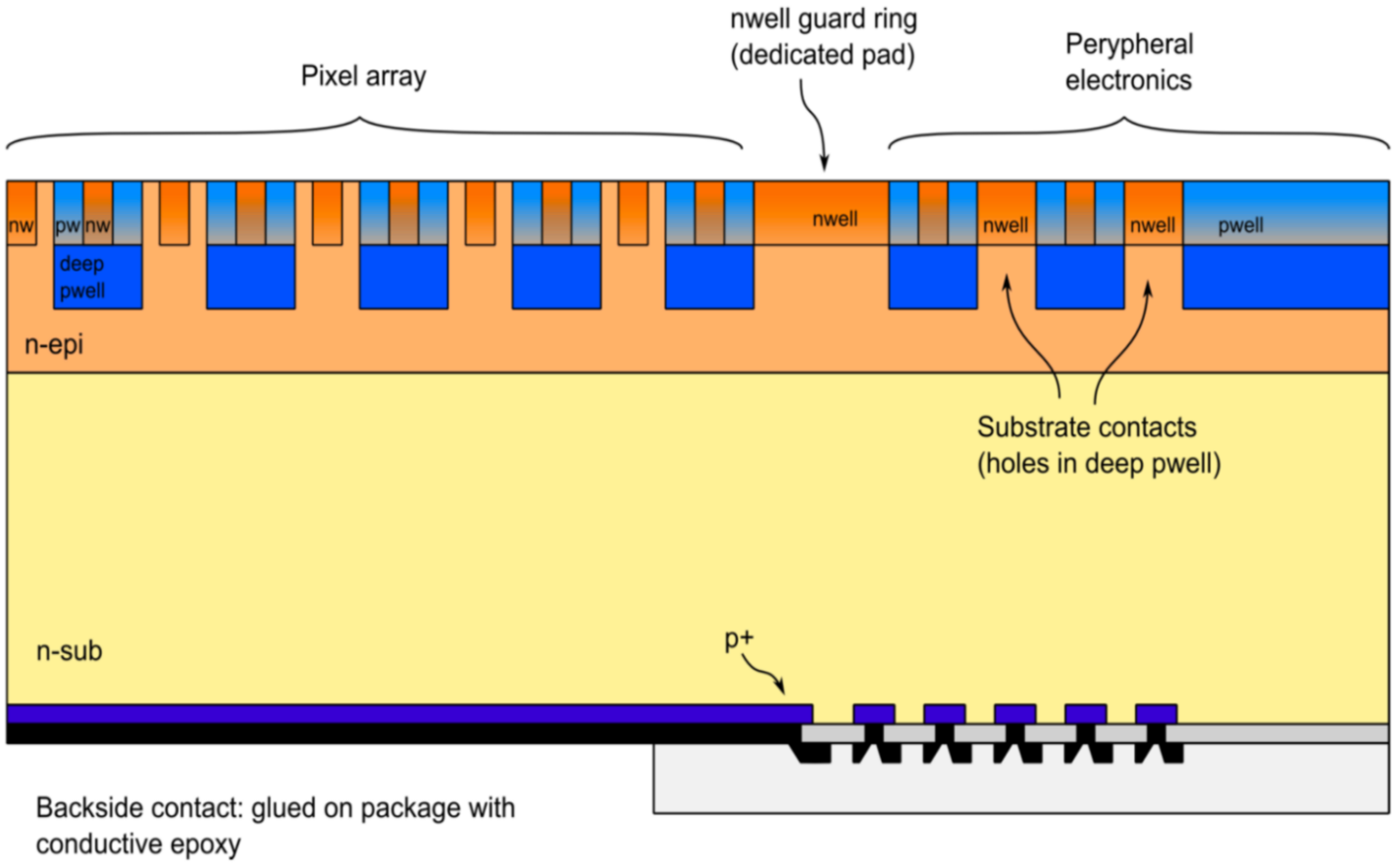

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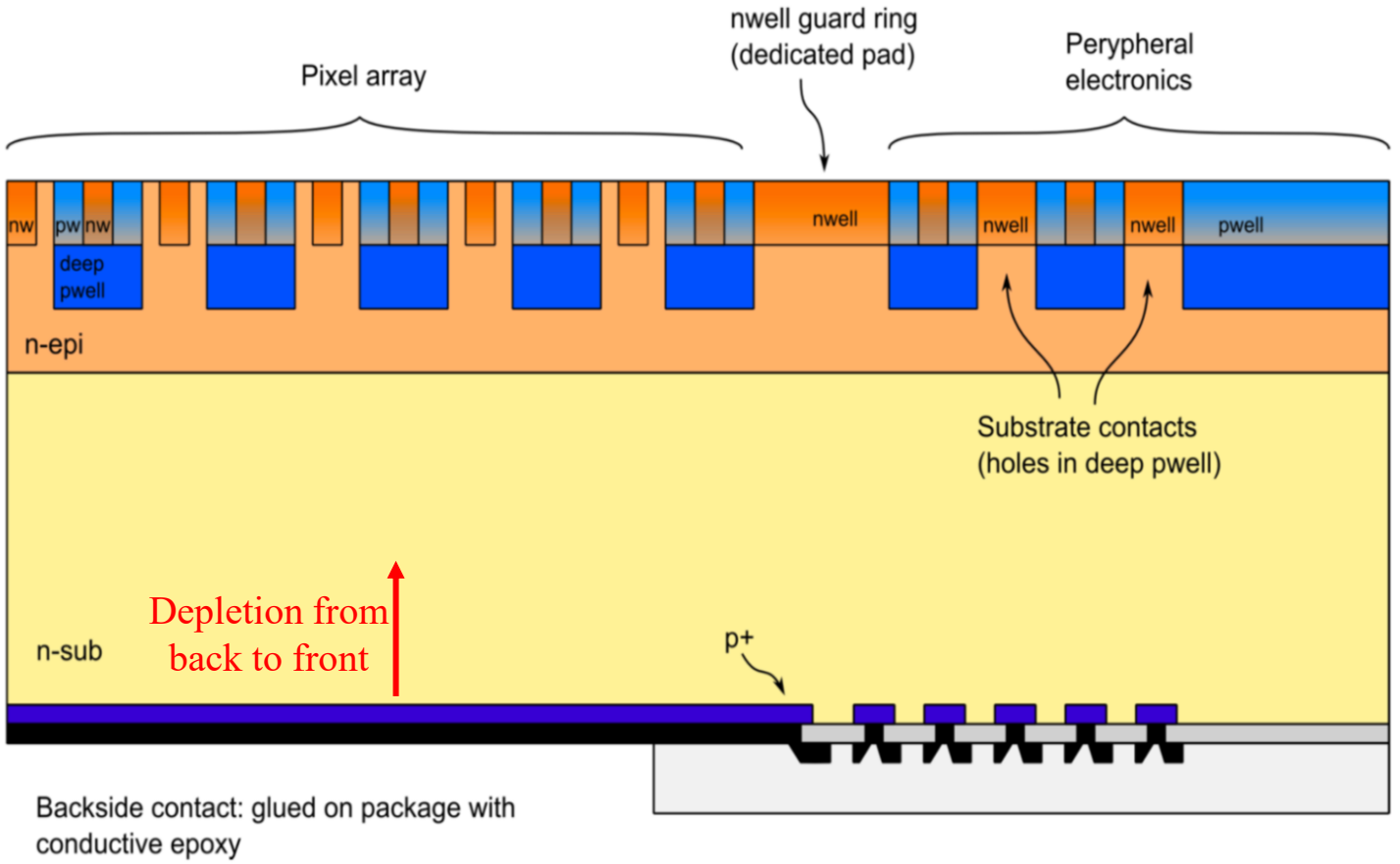

Simulation Validation

Bias scheme to measure V_{FD}, V_{PT}:

$V_{NGR} = 0.9$ V

$V_{Pix} = 0.8$ V

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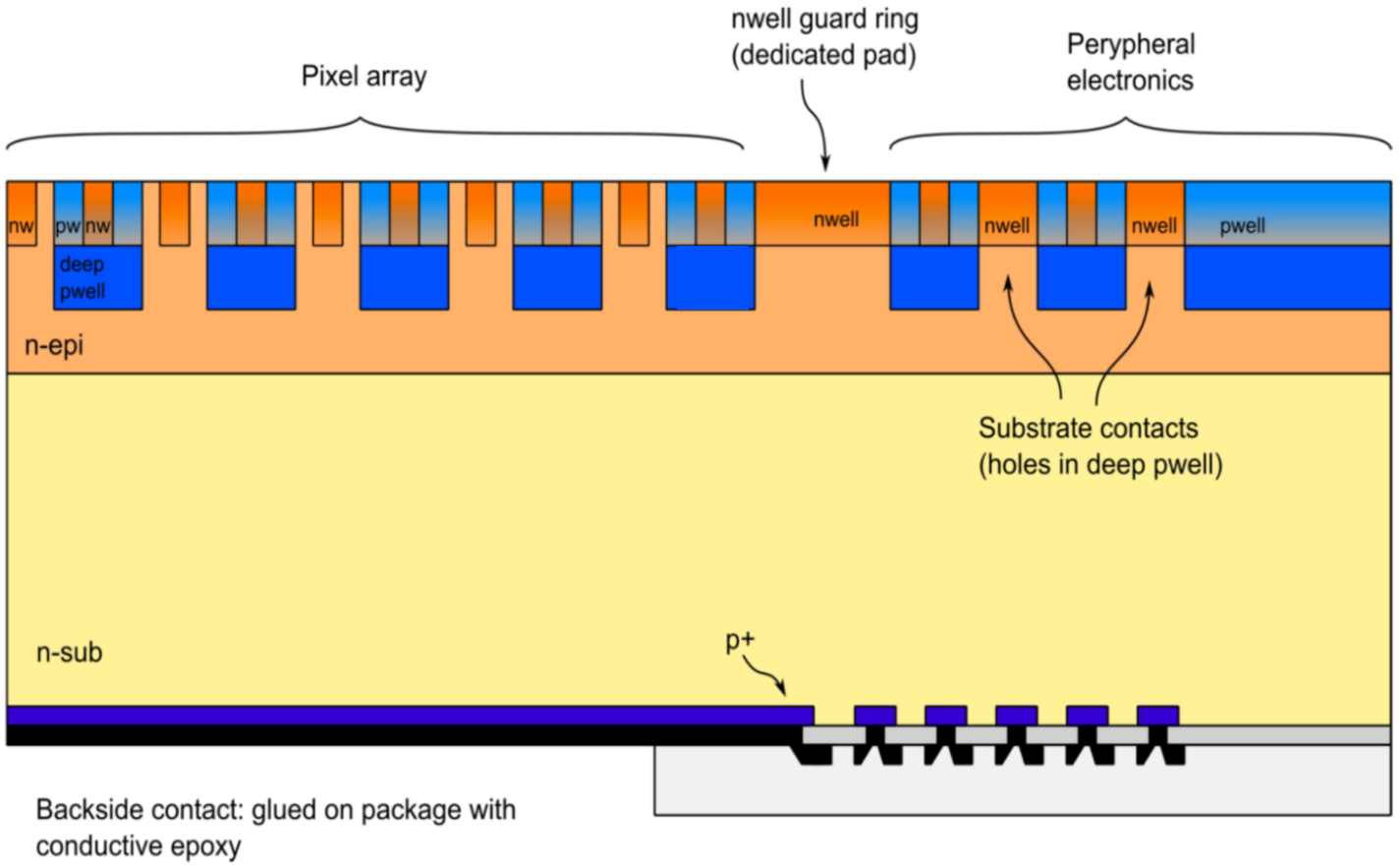

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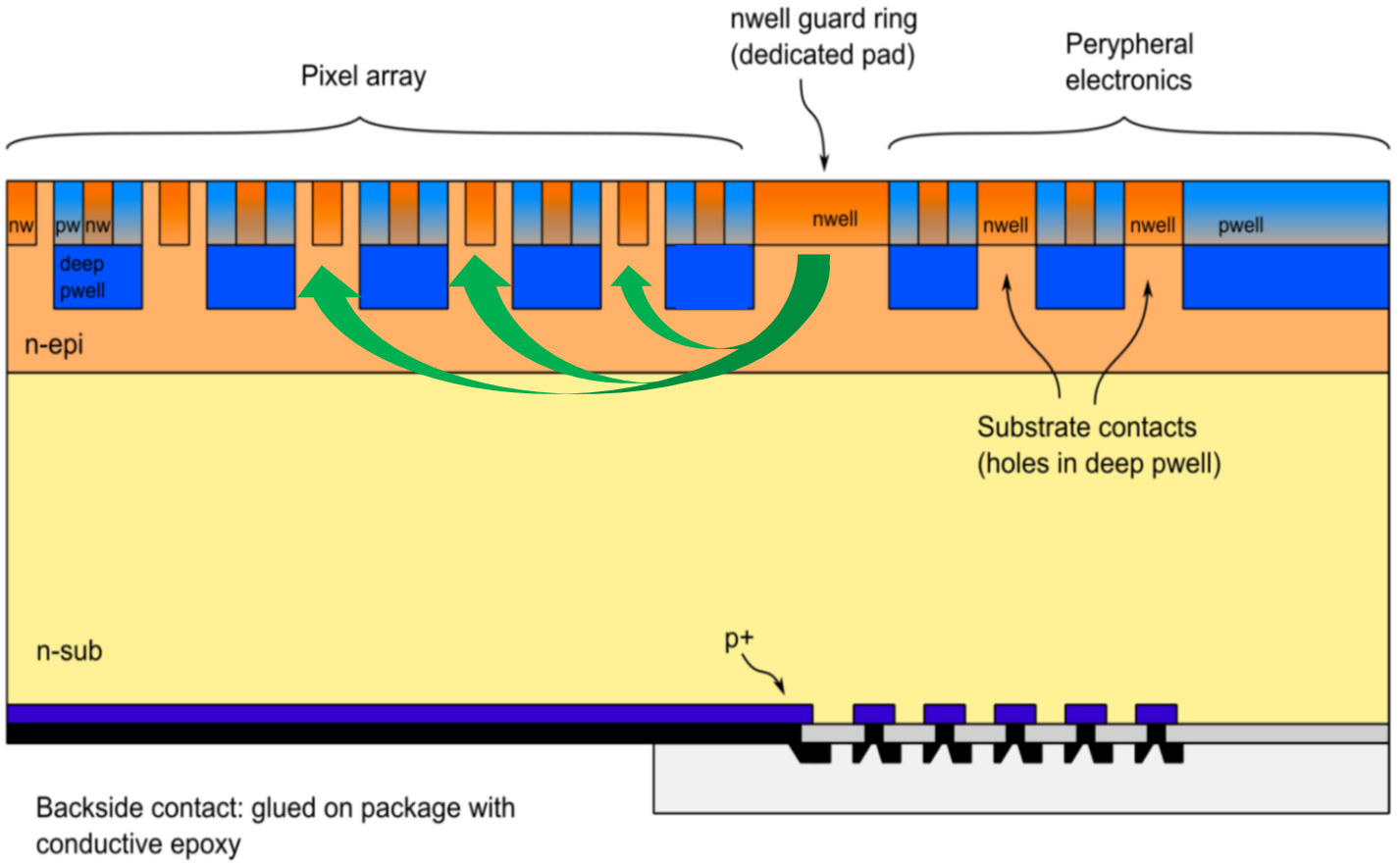

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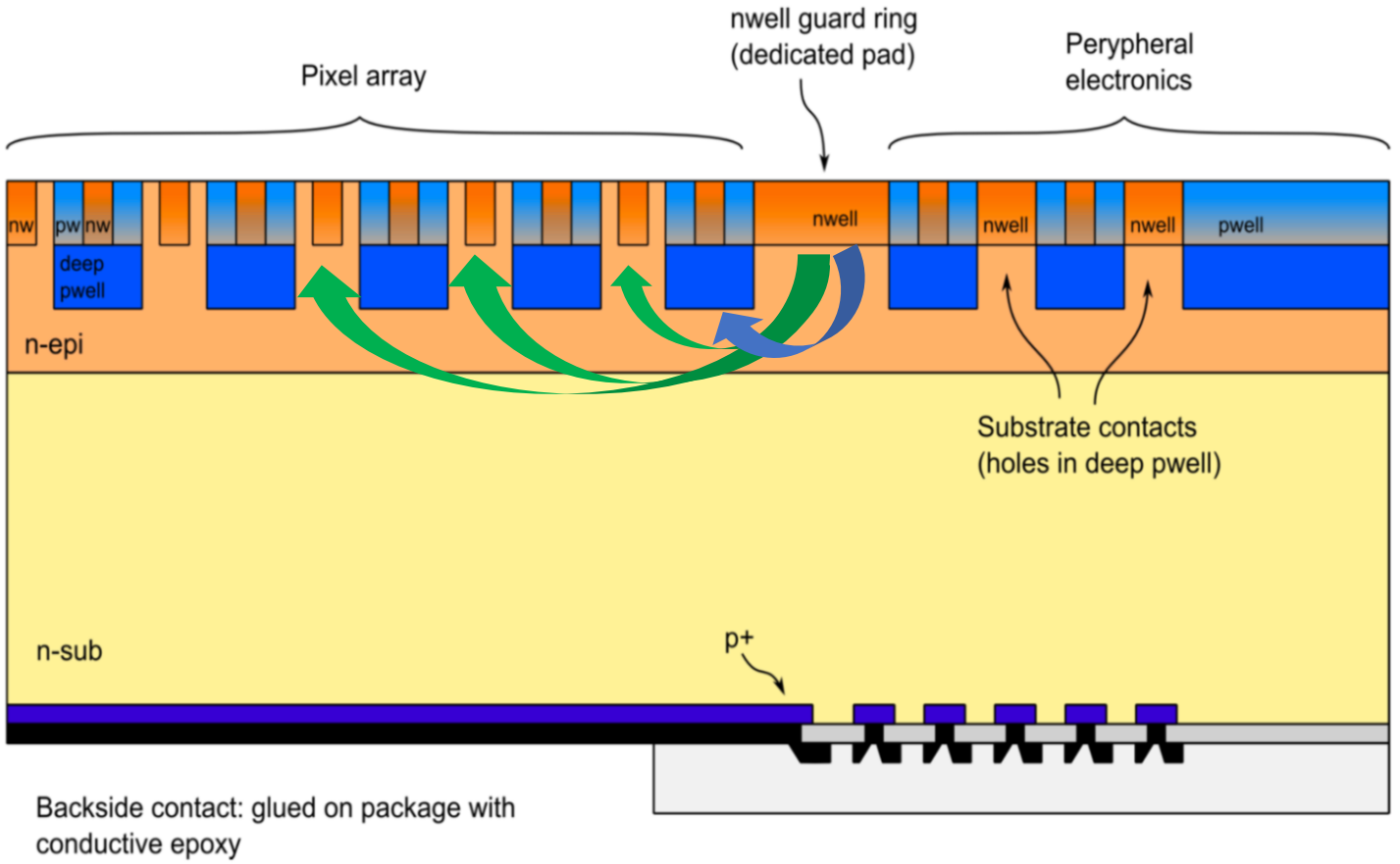

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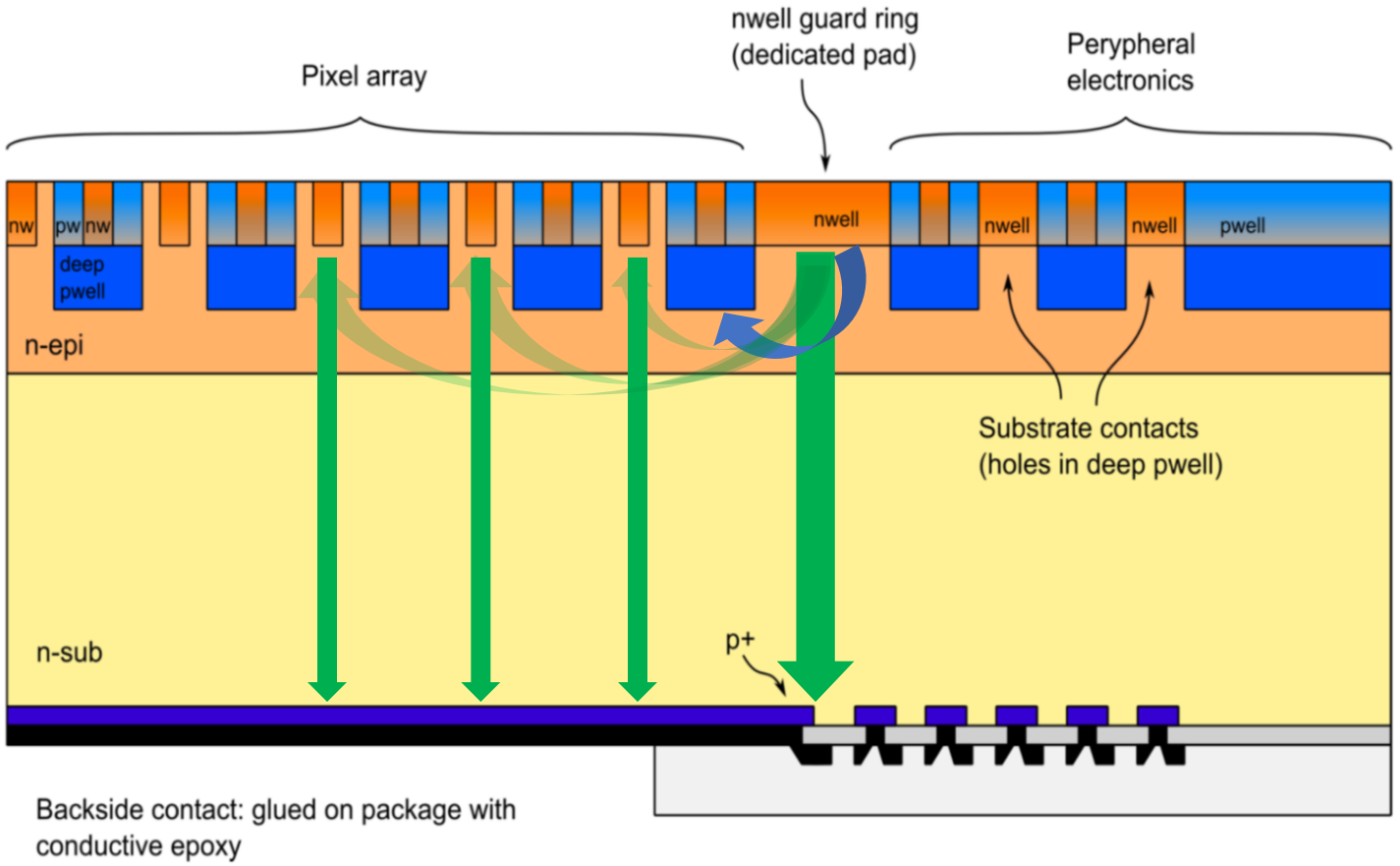

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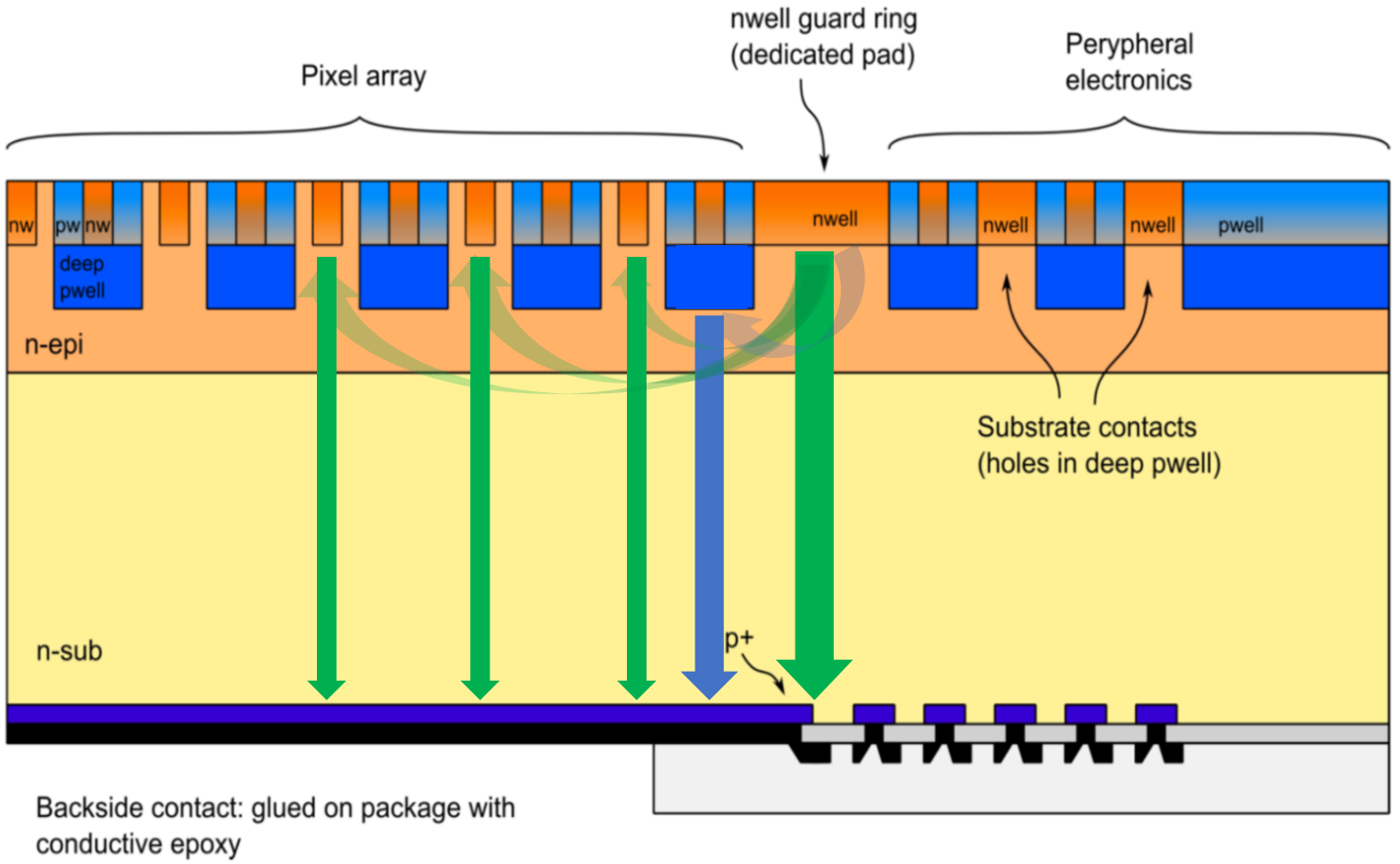

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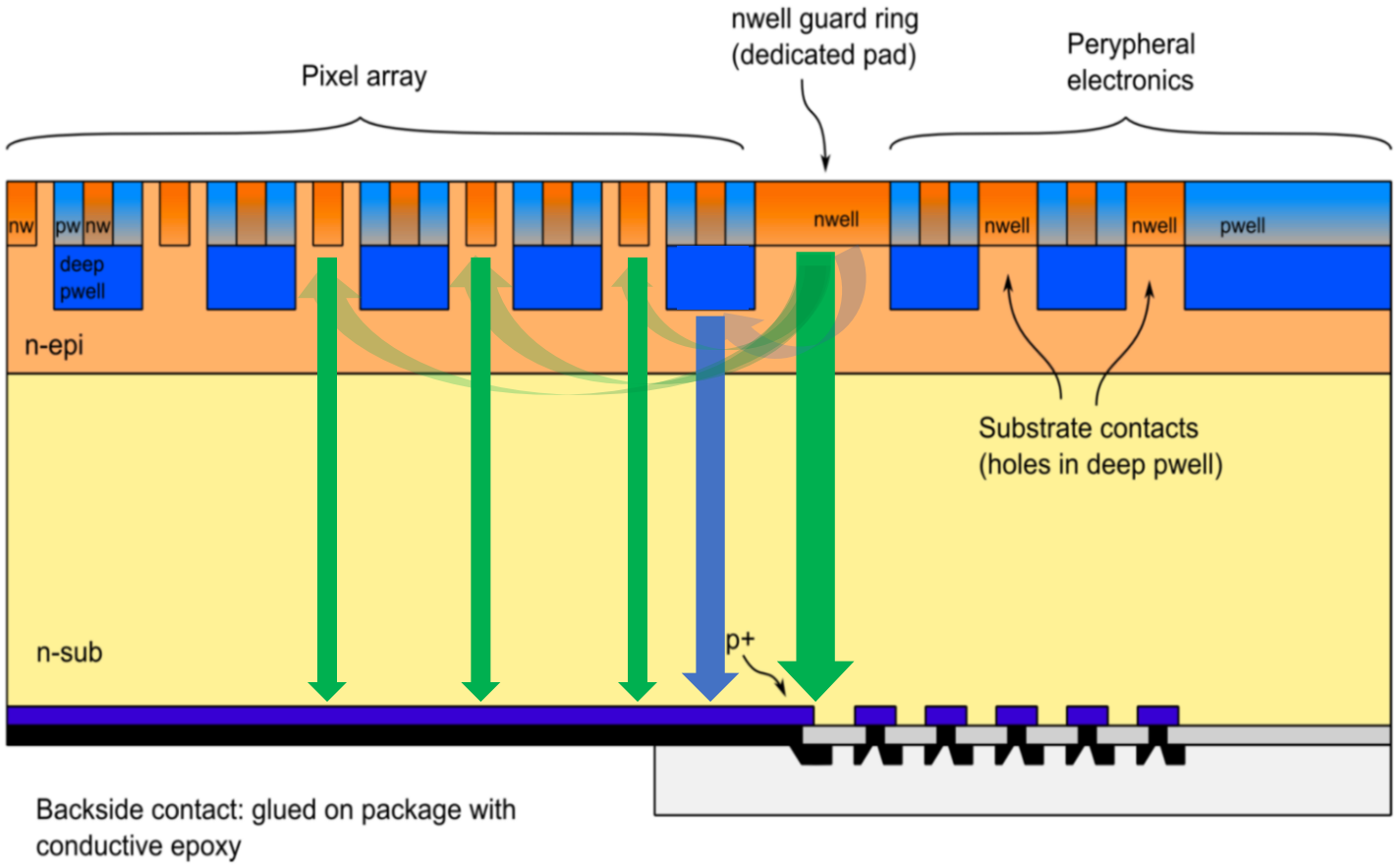
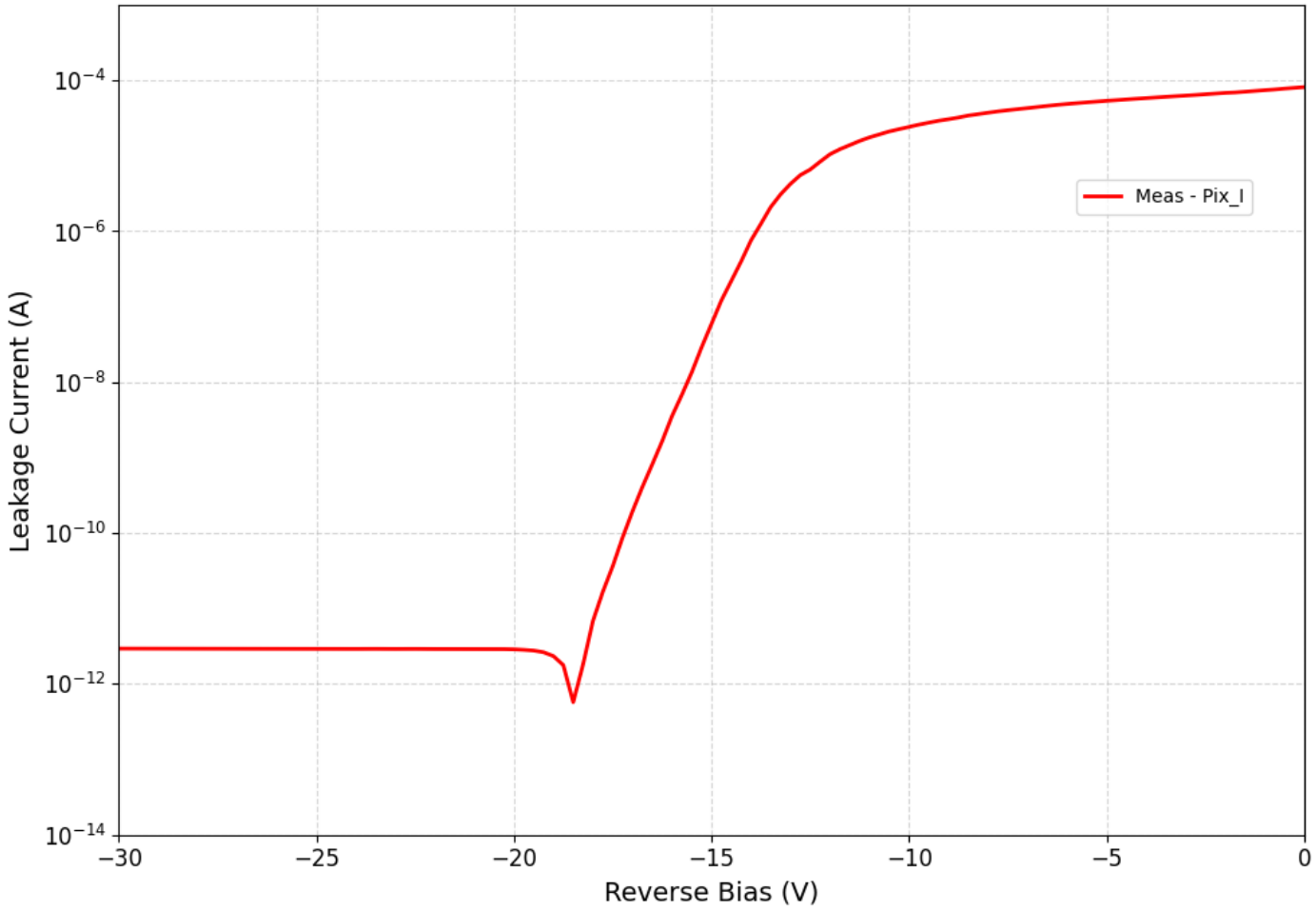


Ideal Condition

1. $V_{FD} < V_{PT}$ (wide operation range)
2. $V_{BD} > V_{PT}$ (no electrical breakdown)

Simulation Validation

Results from ARCADIA test structures
(thickness = 48 µm)



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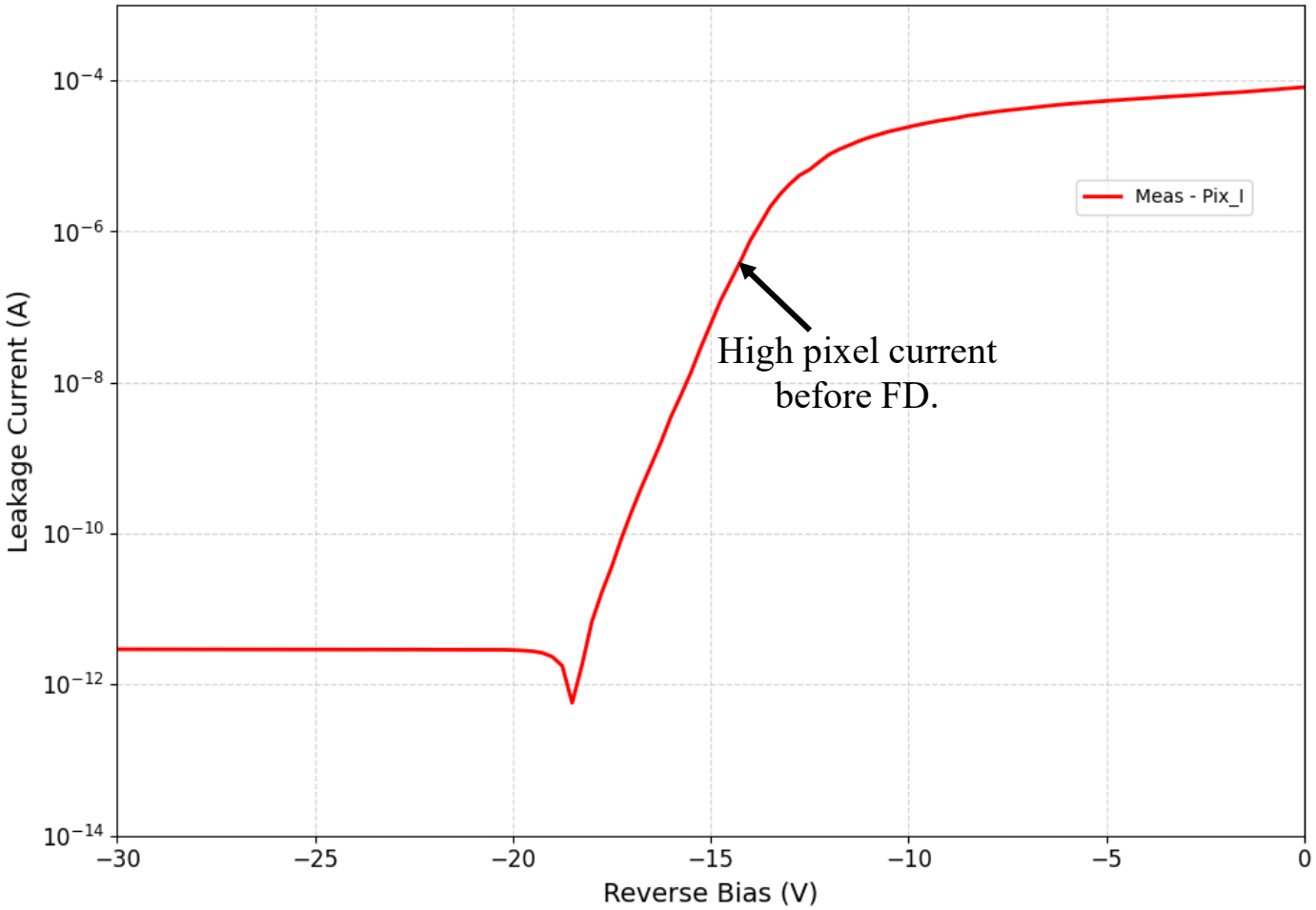

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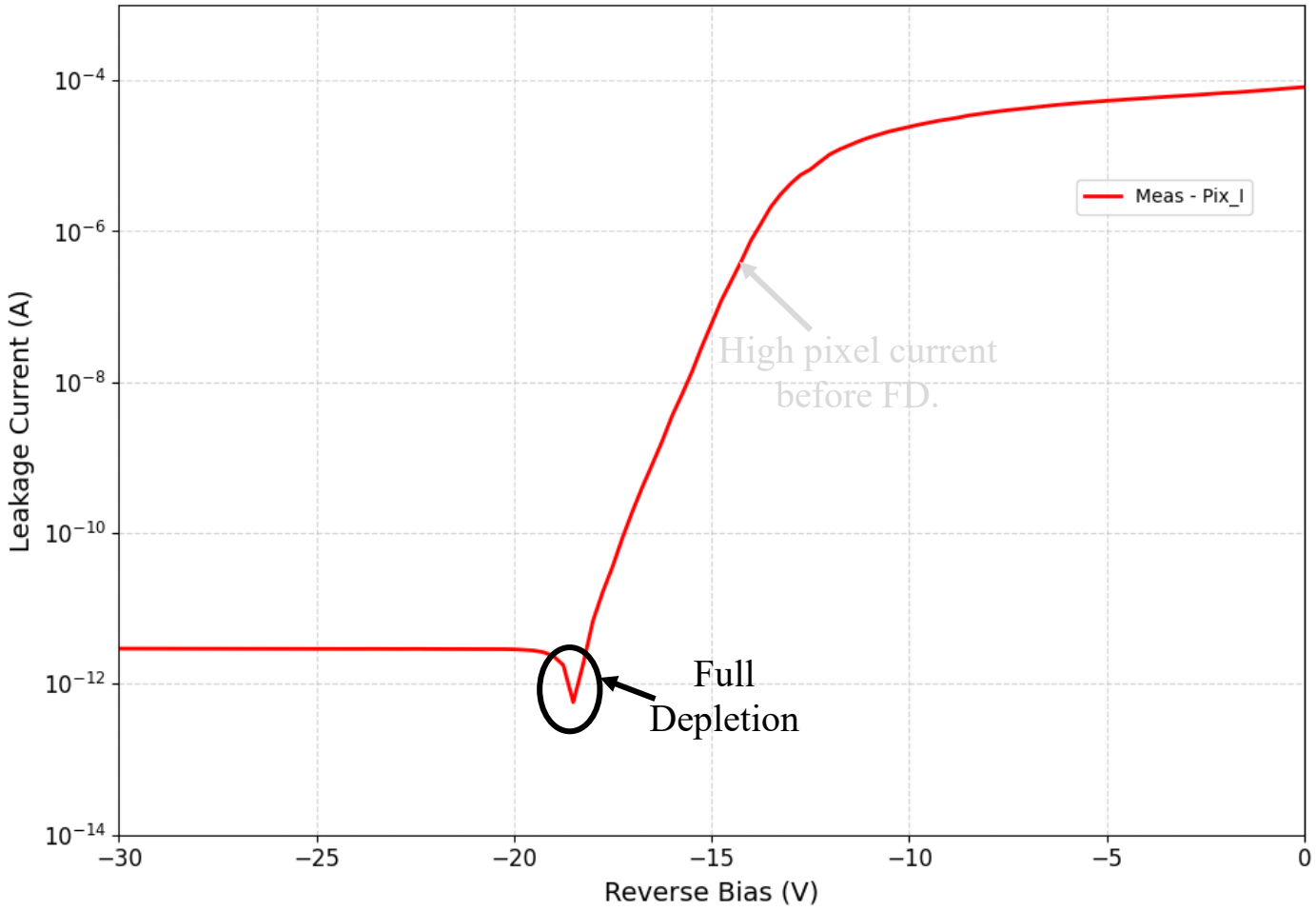

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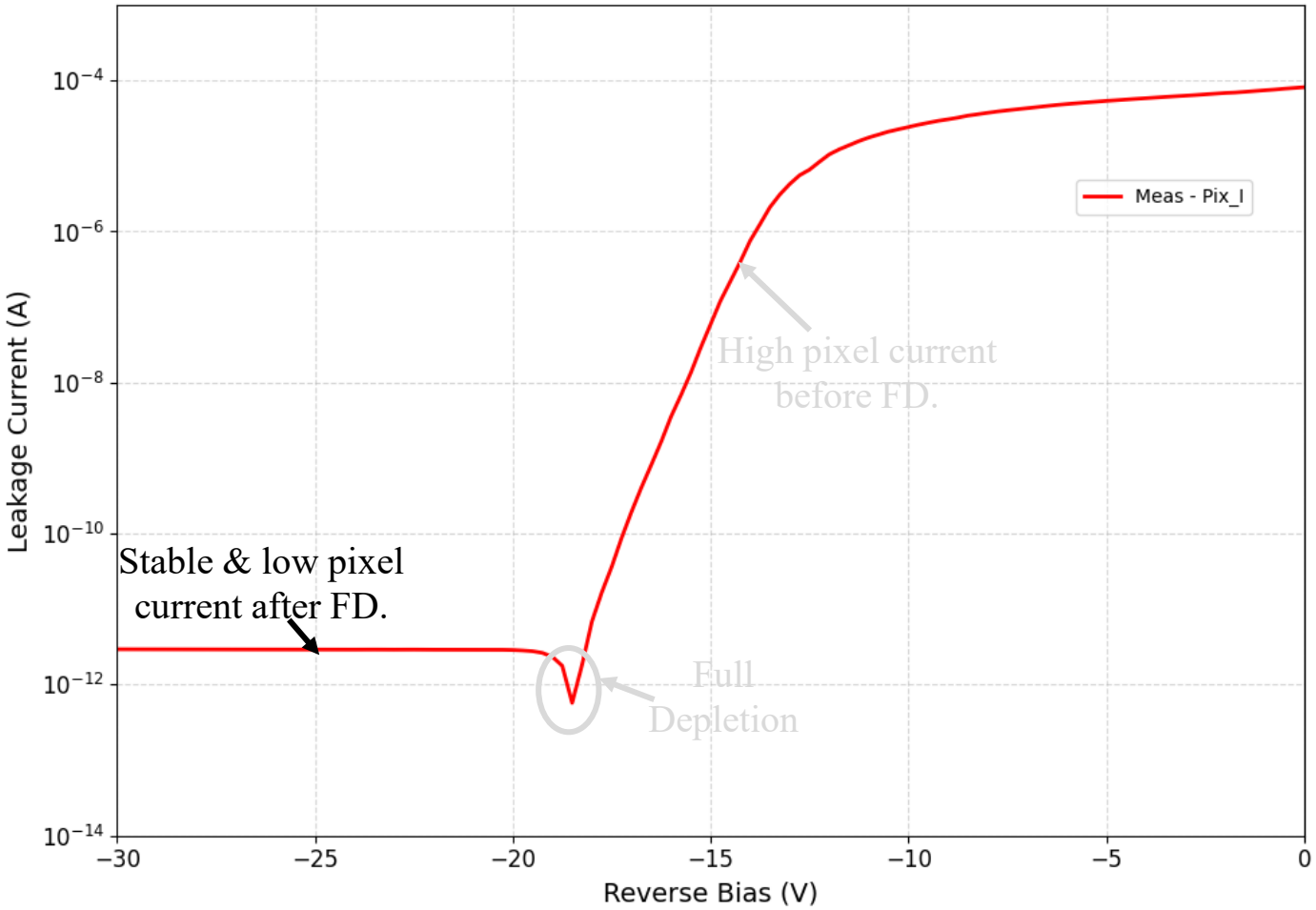

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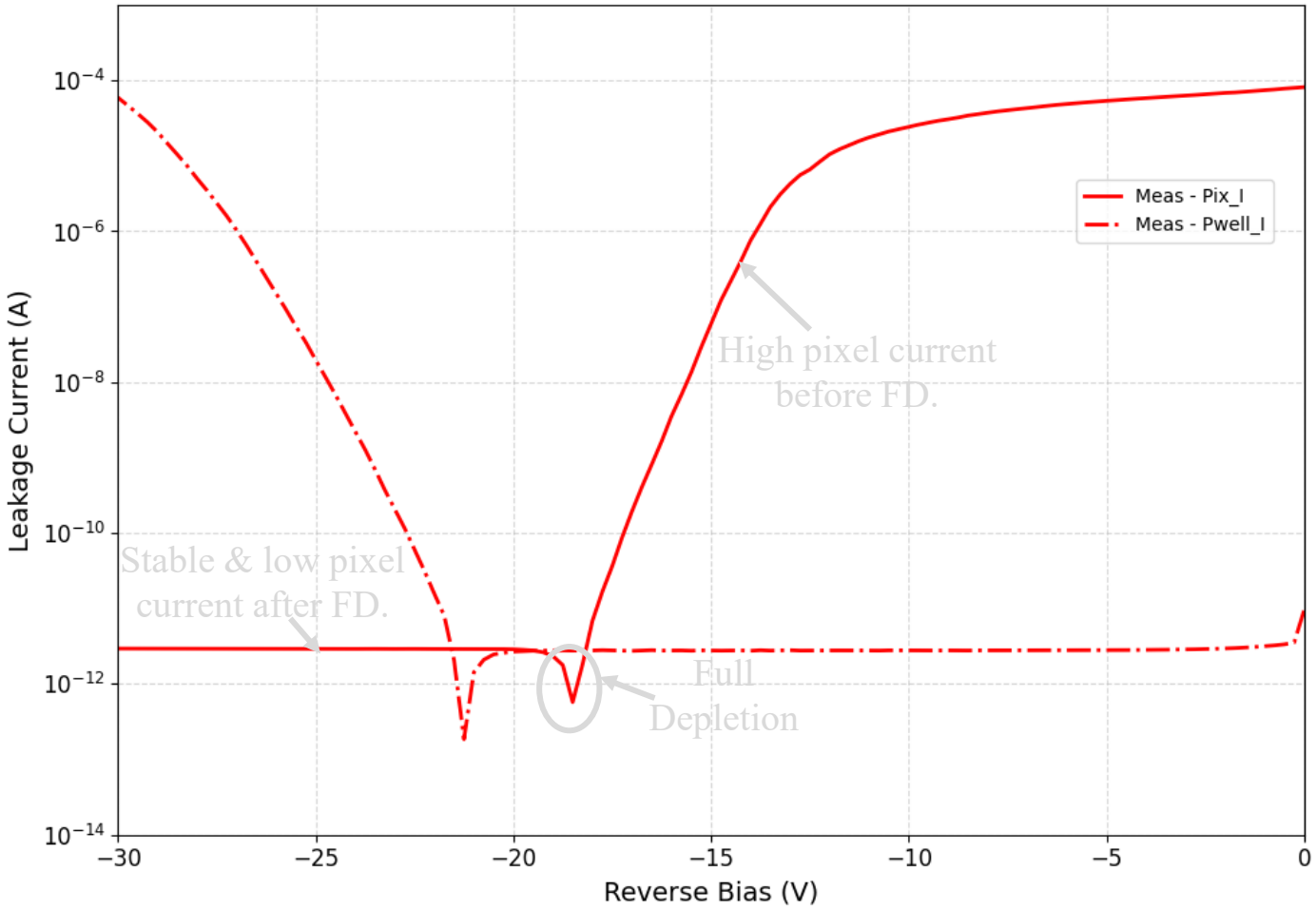

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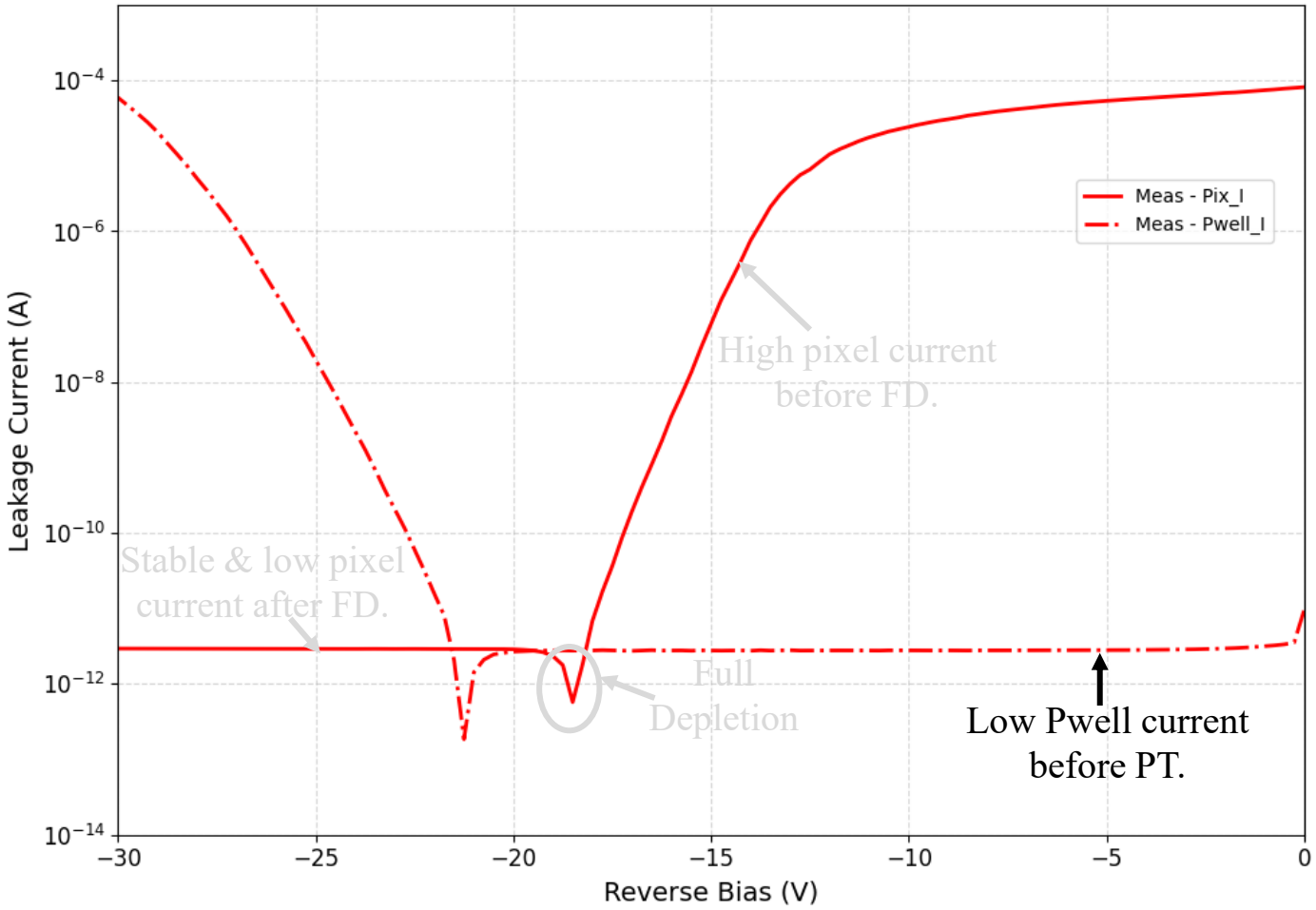

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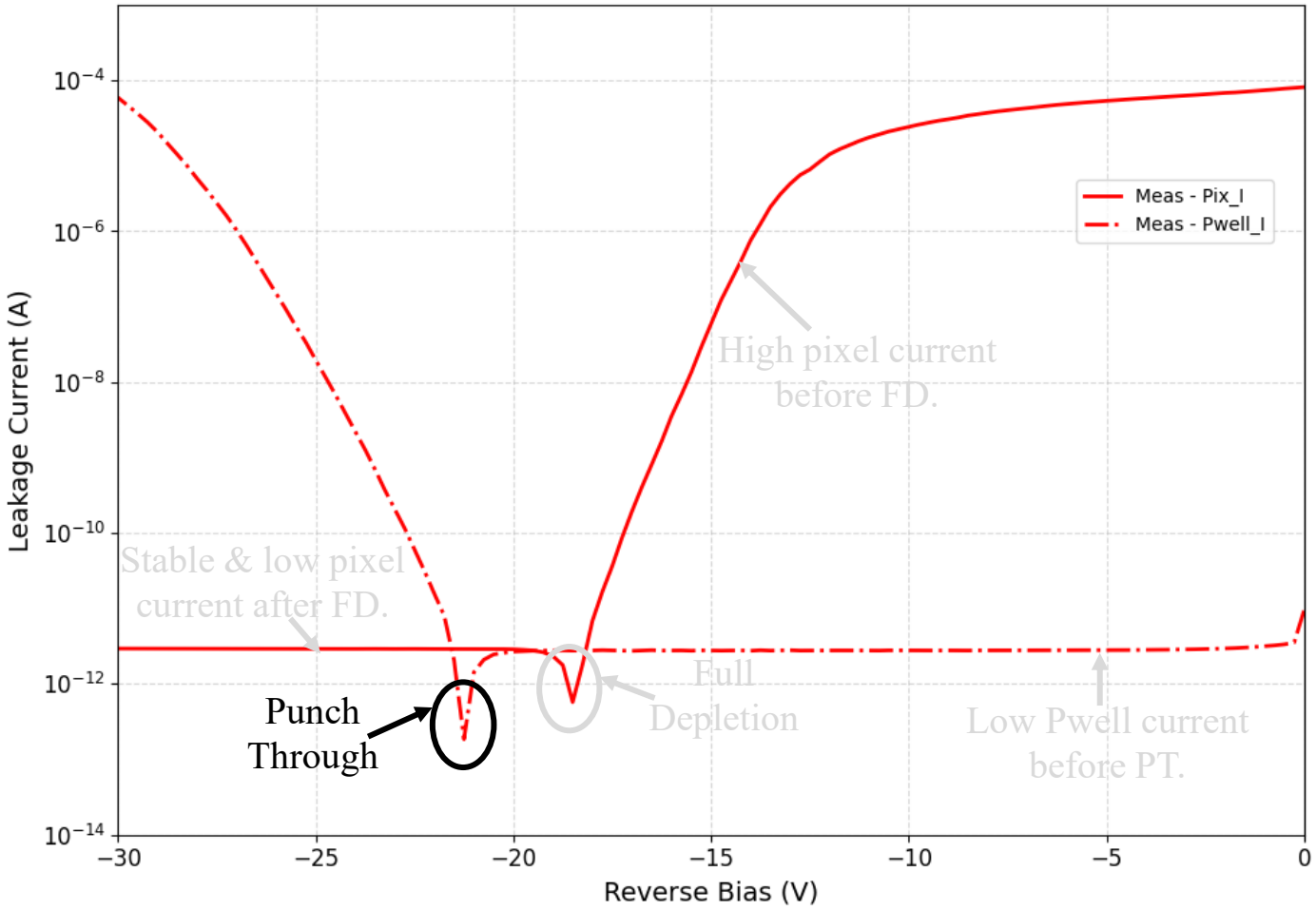

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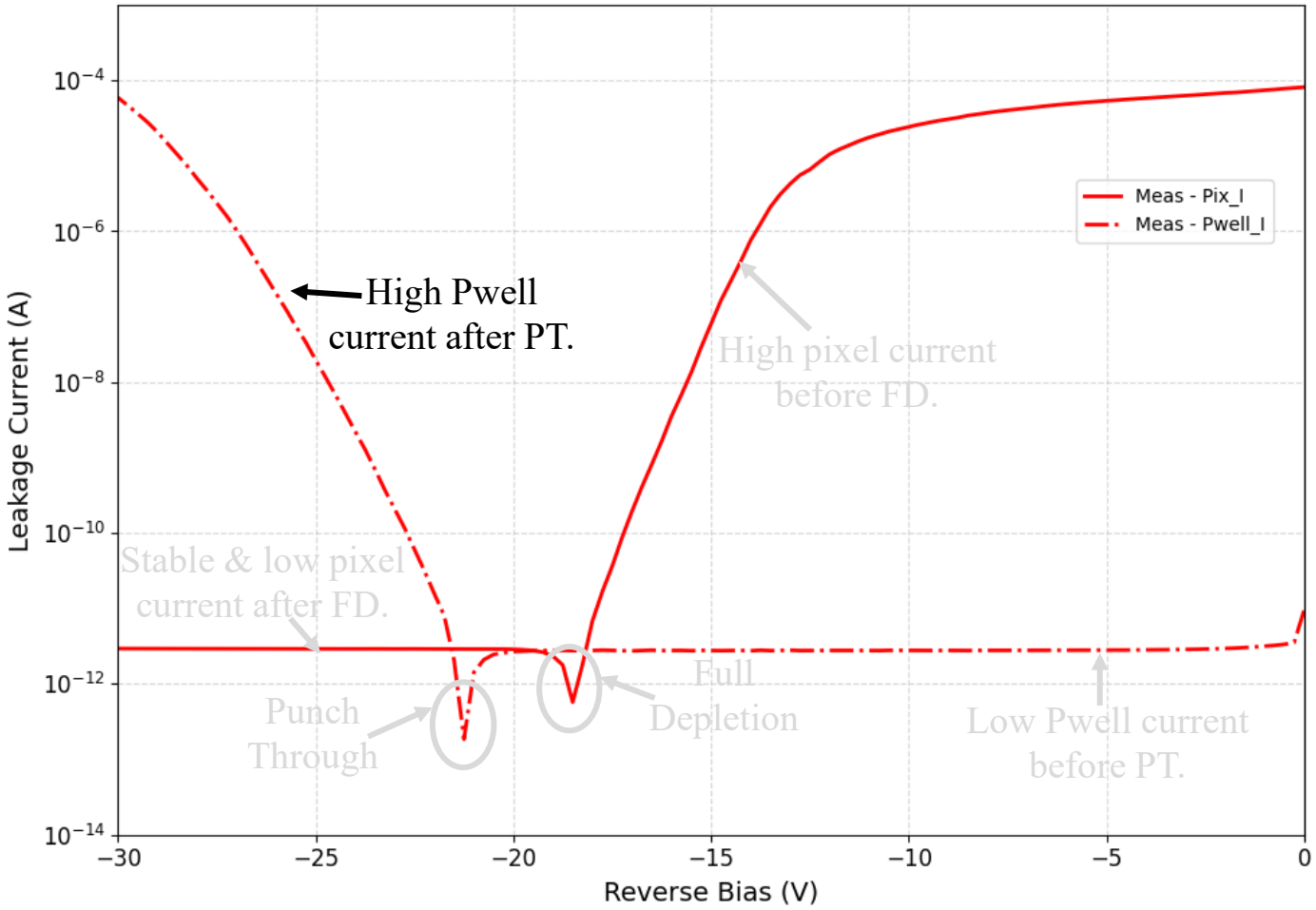

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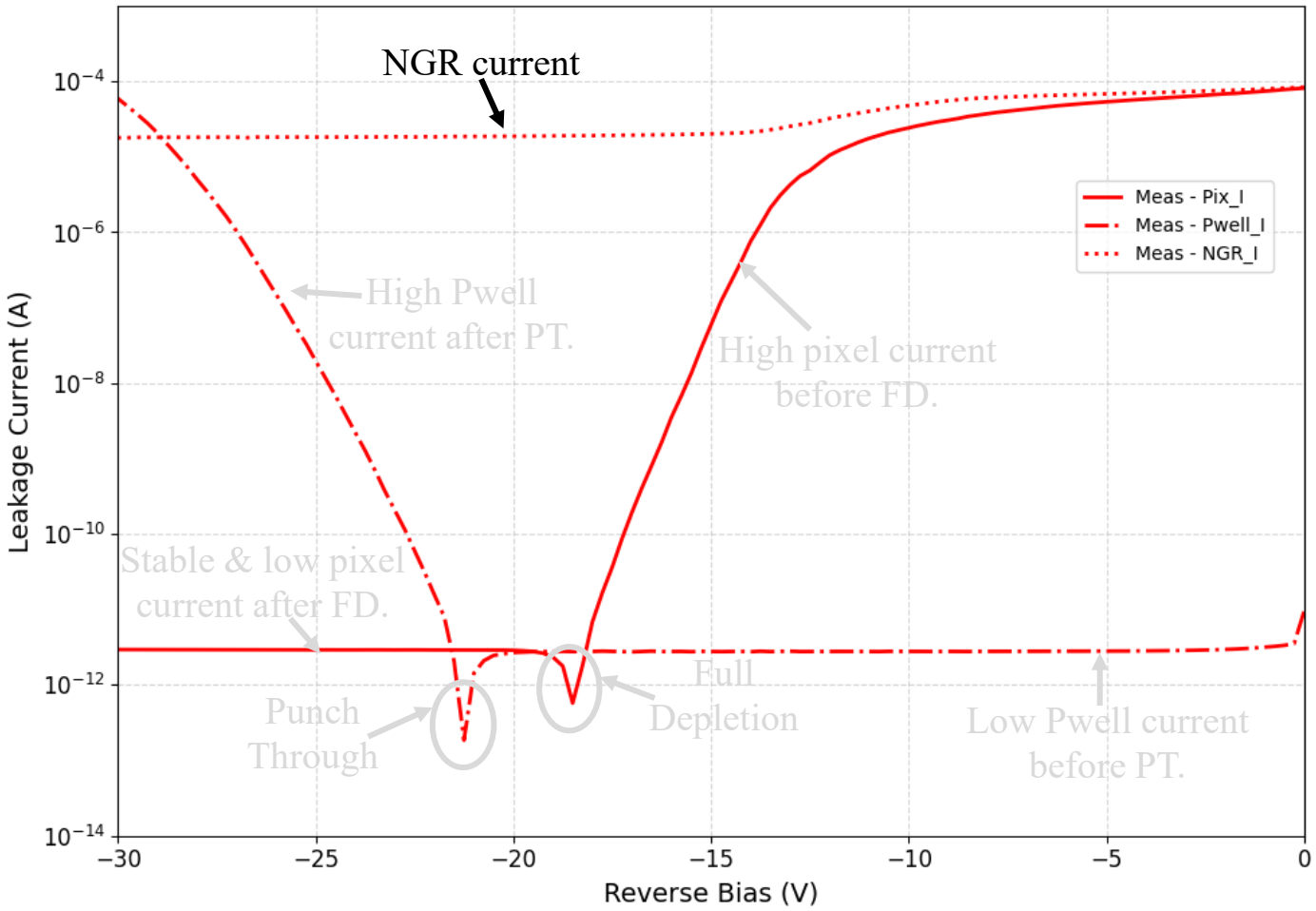

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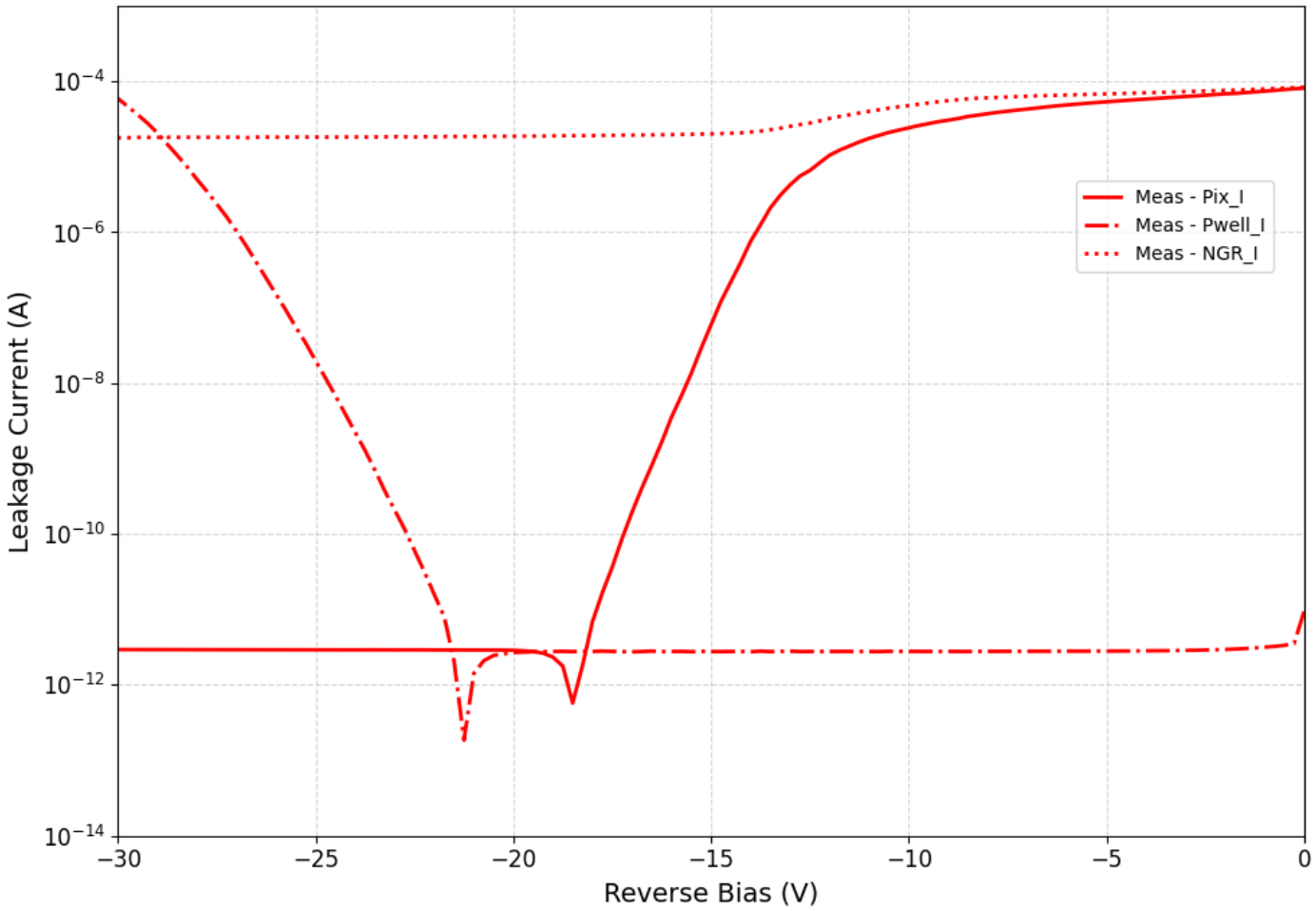

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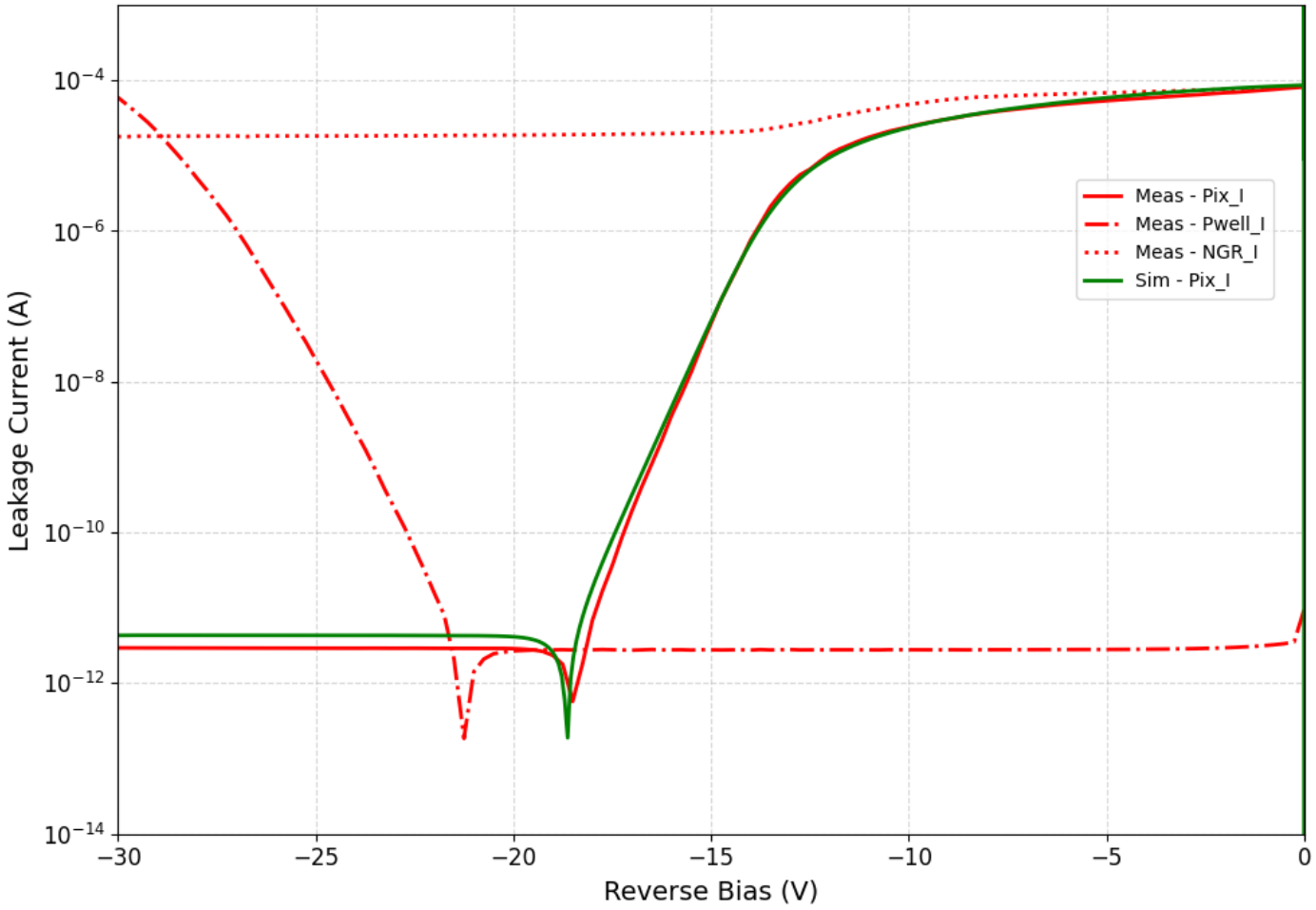

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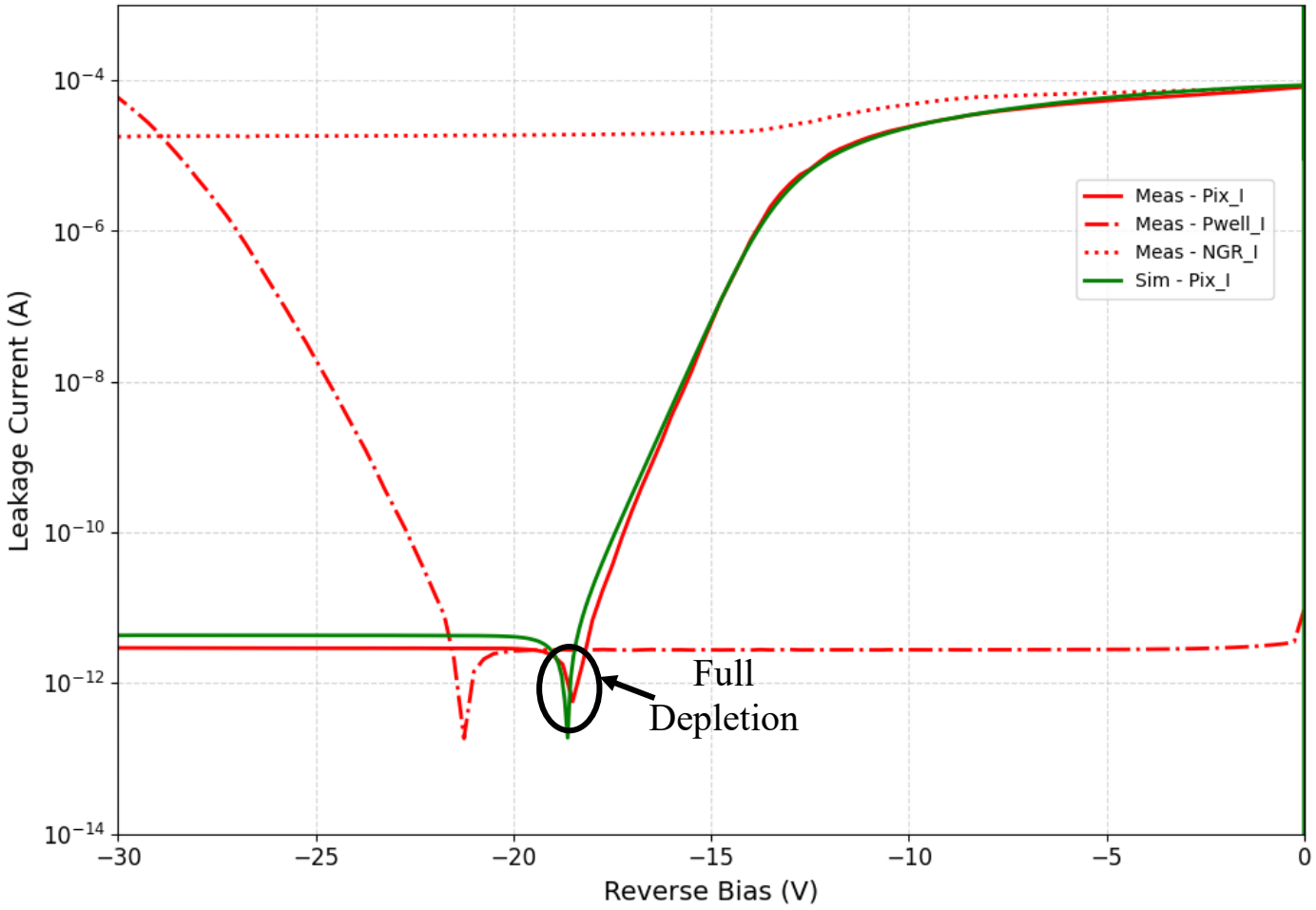

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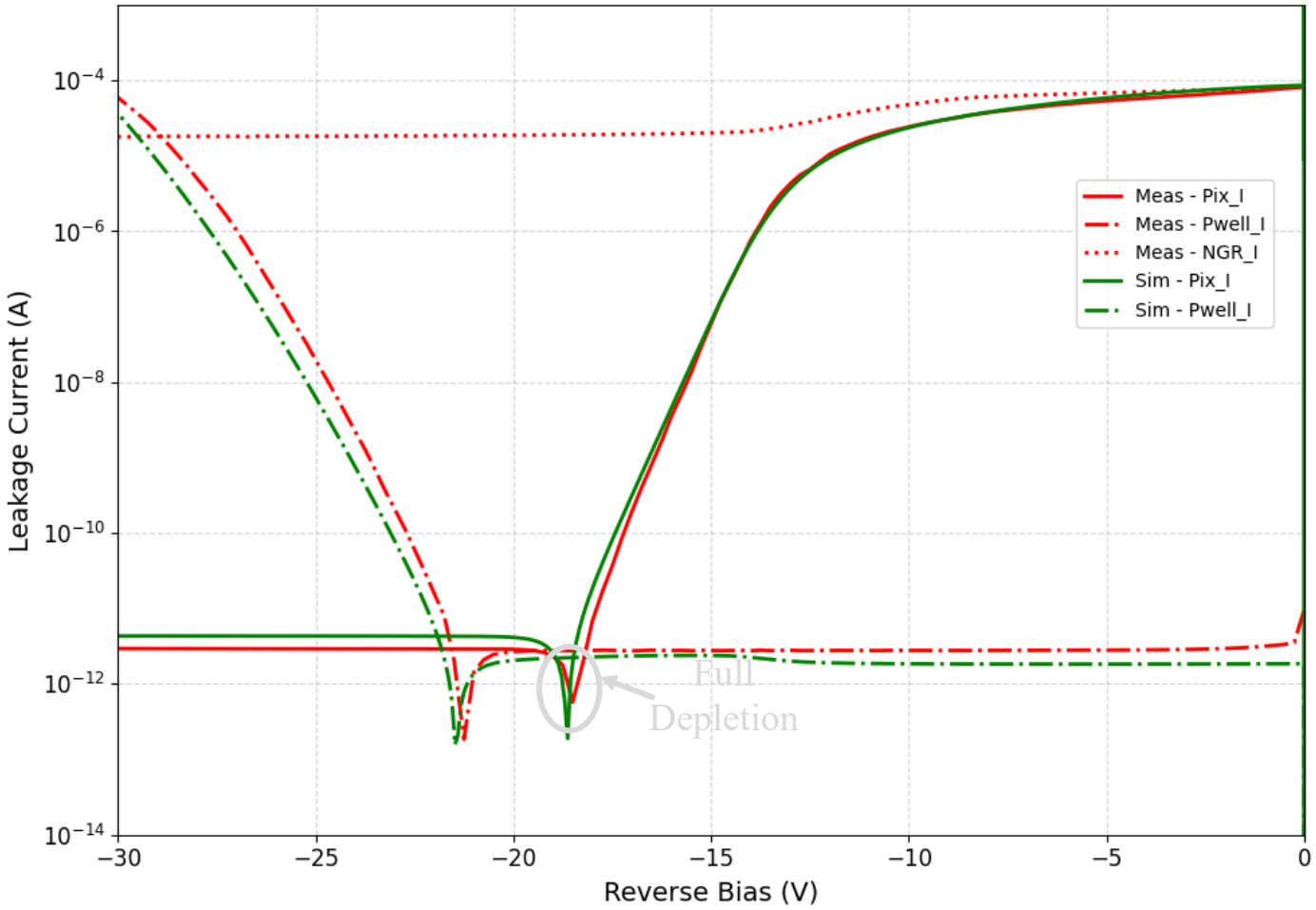

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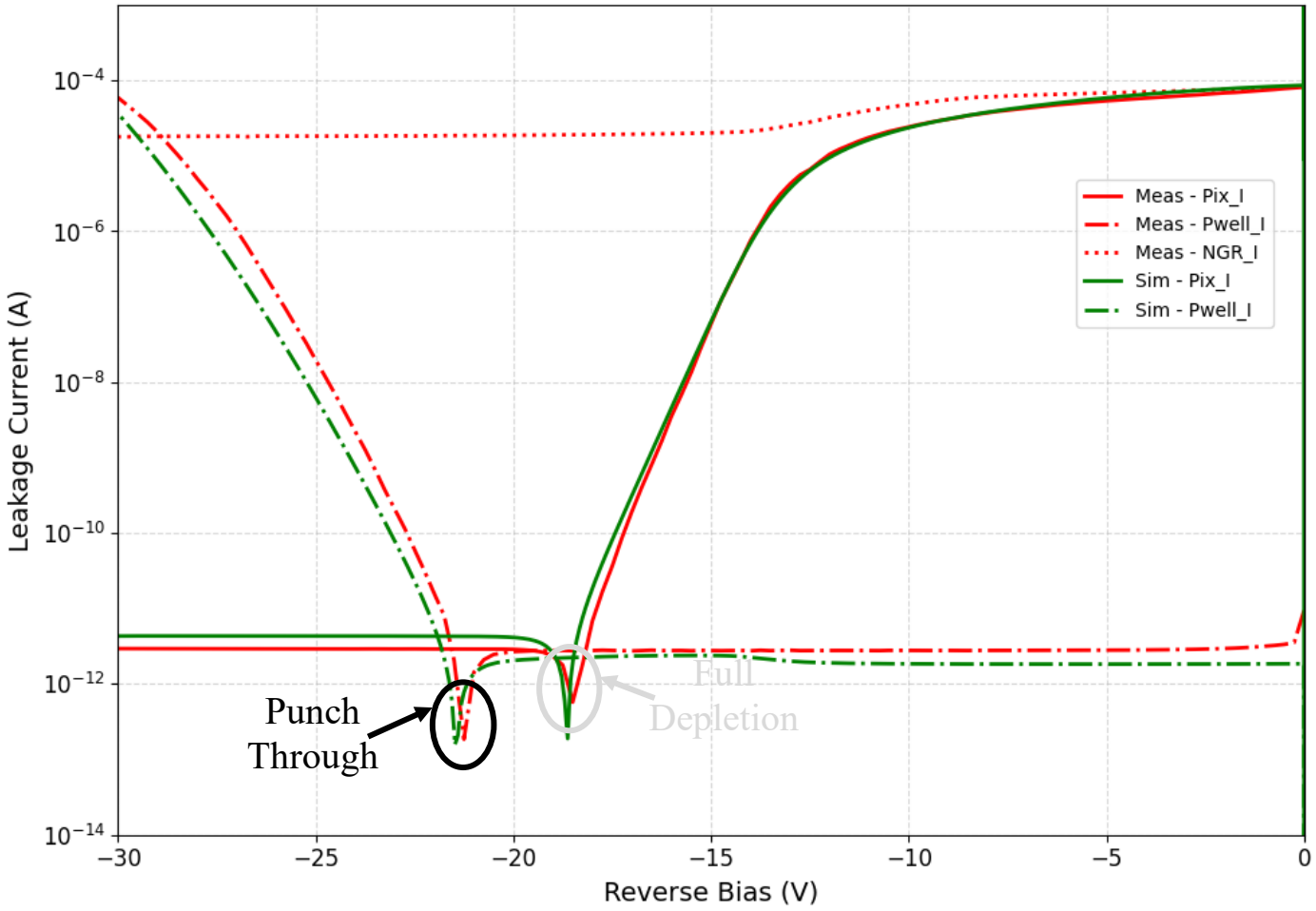

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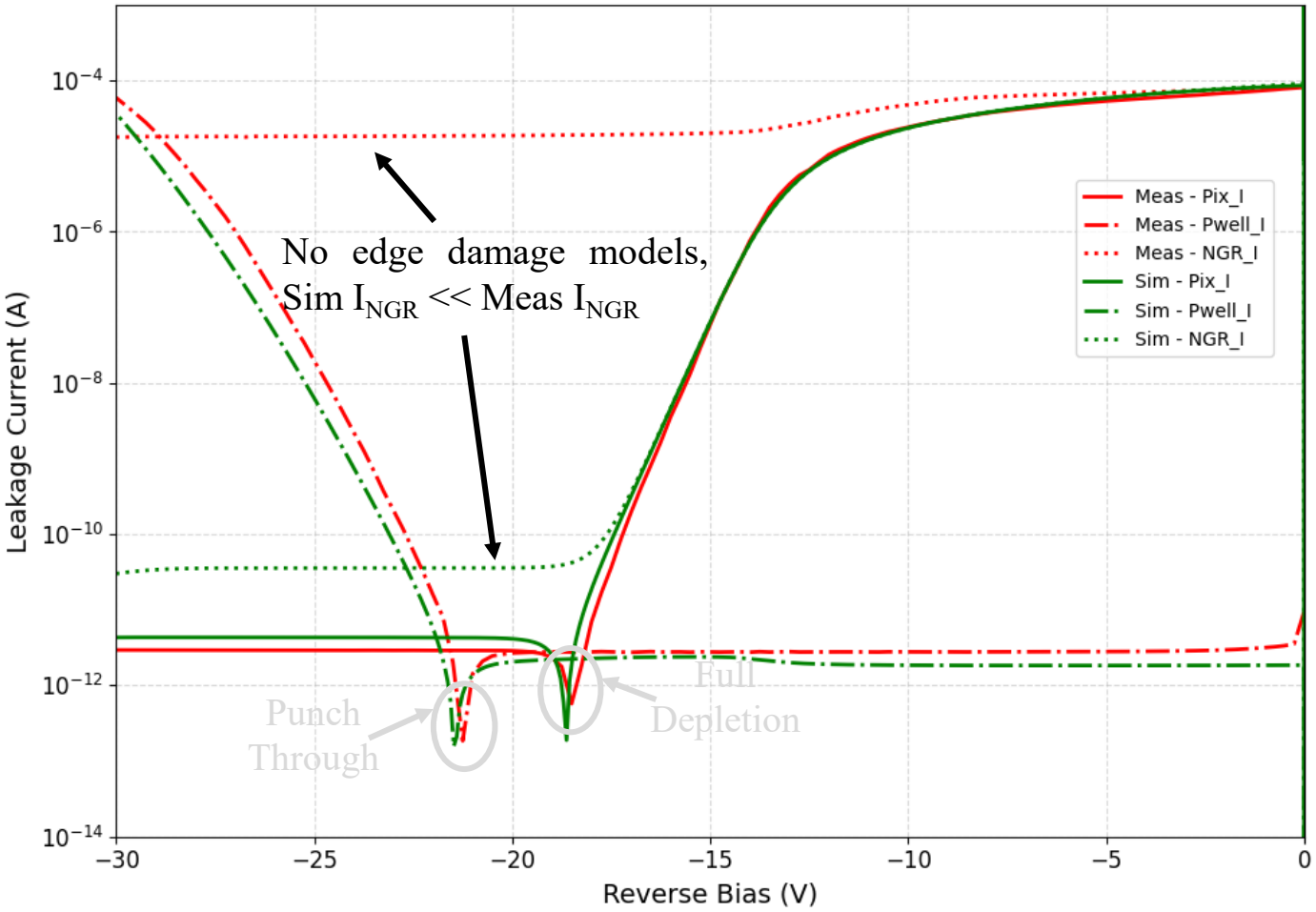

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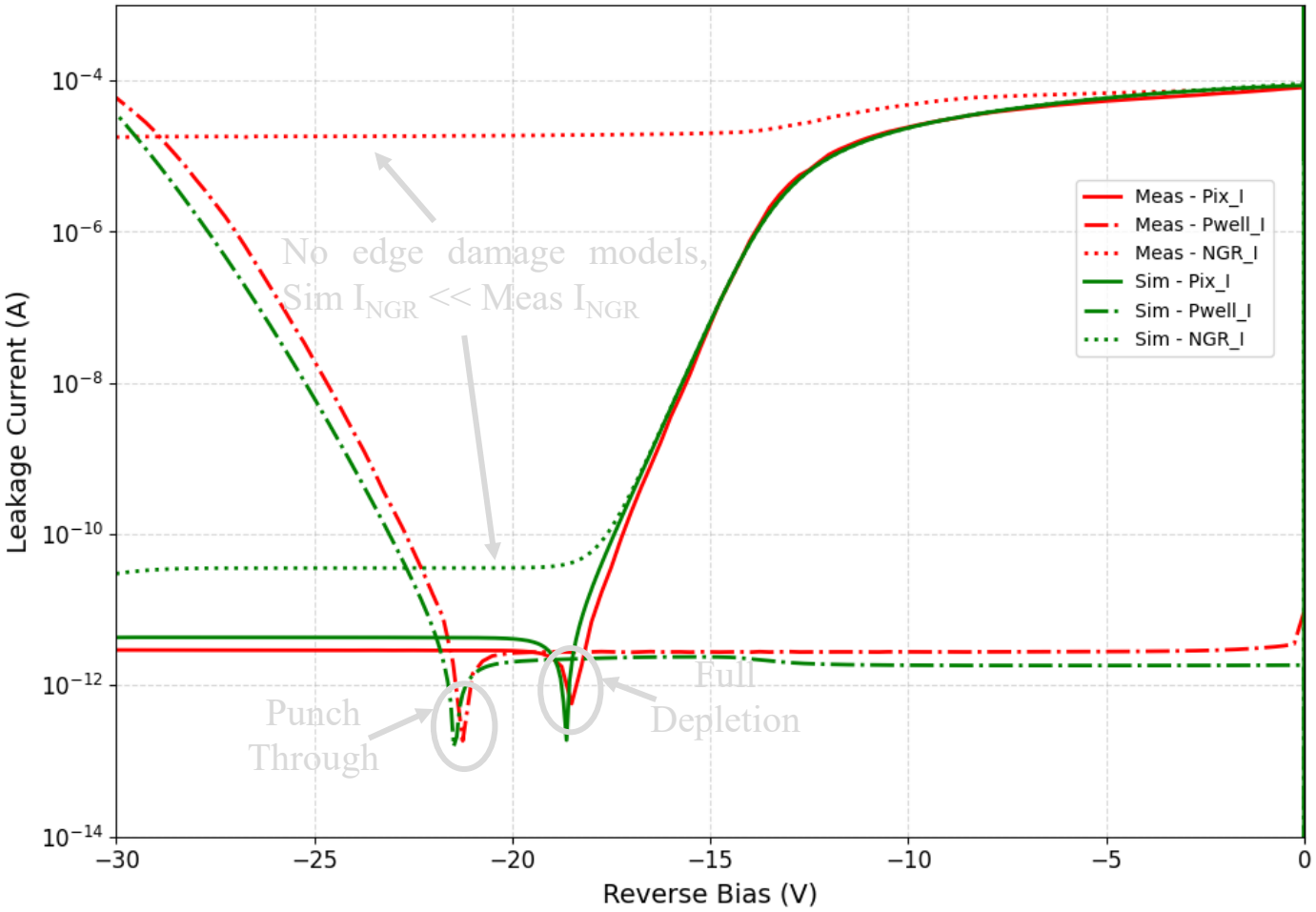

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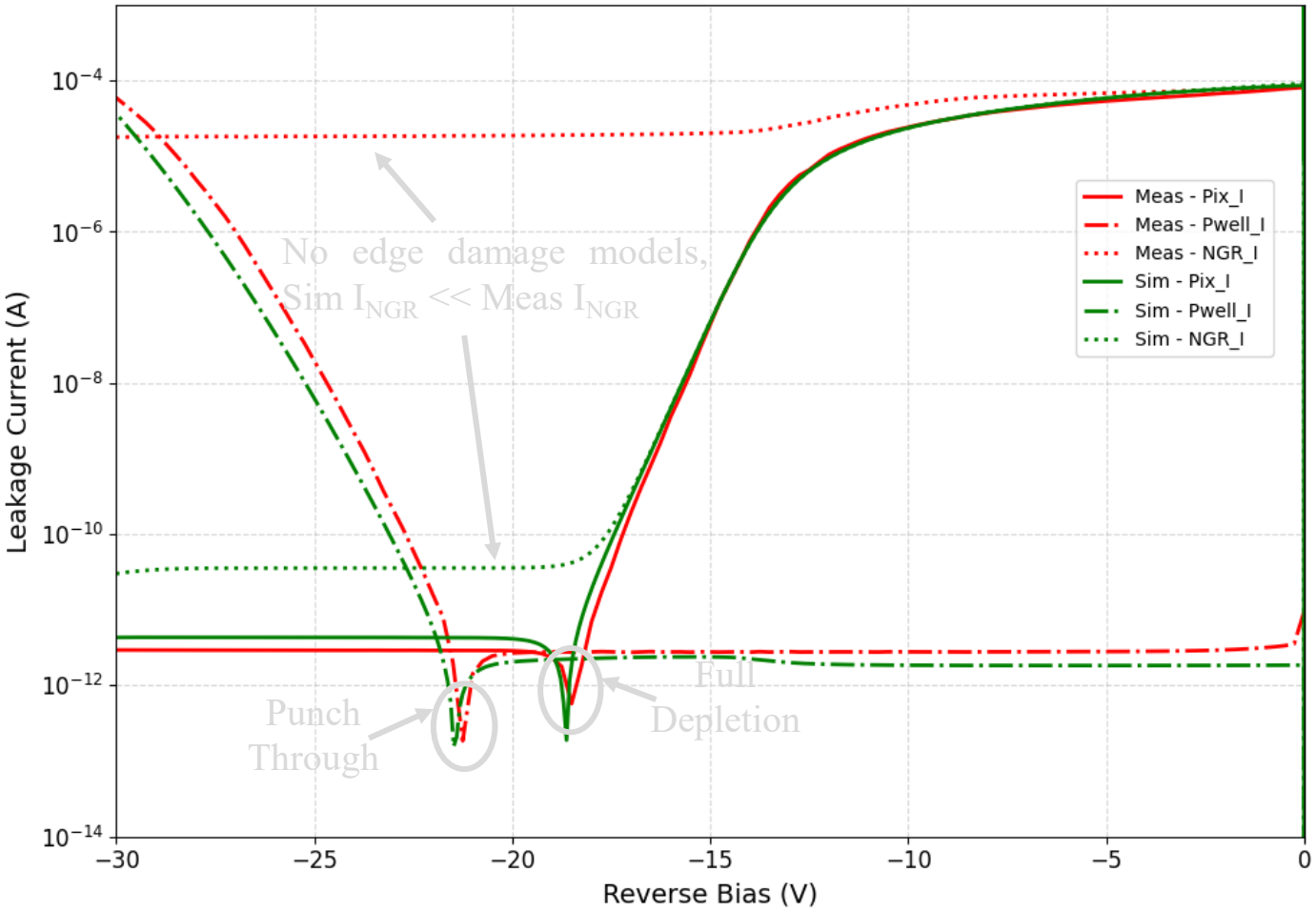

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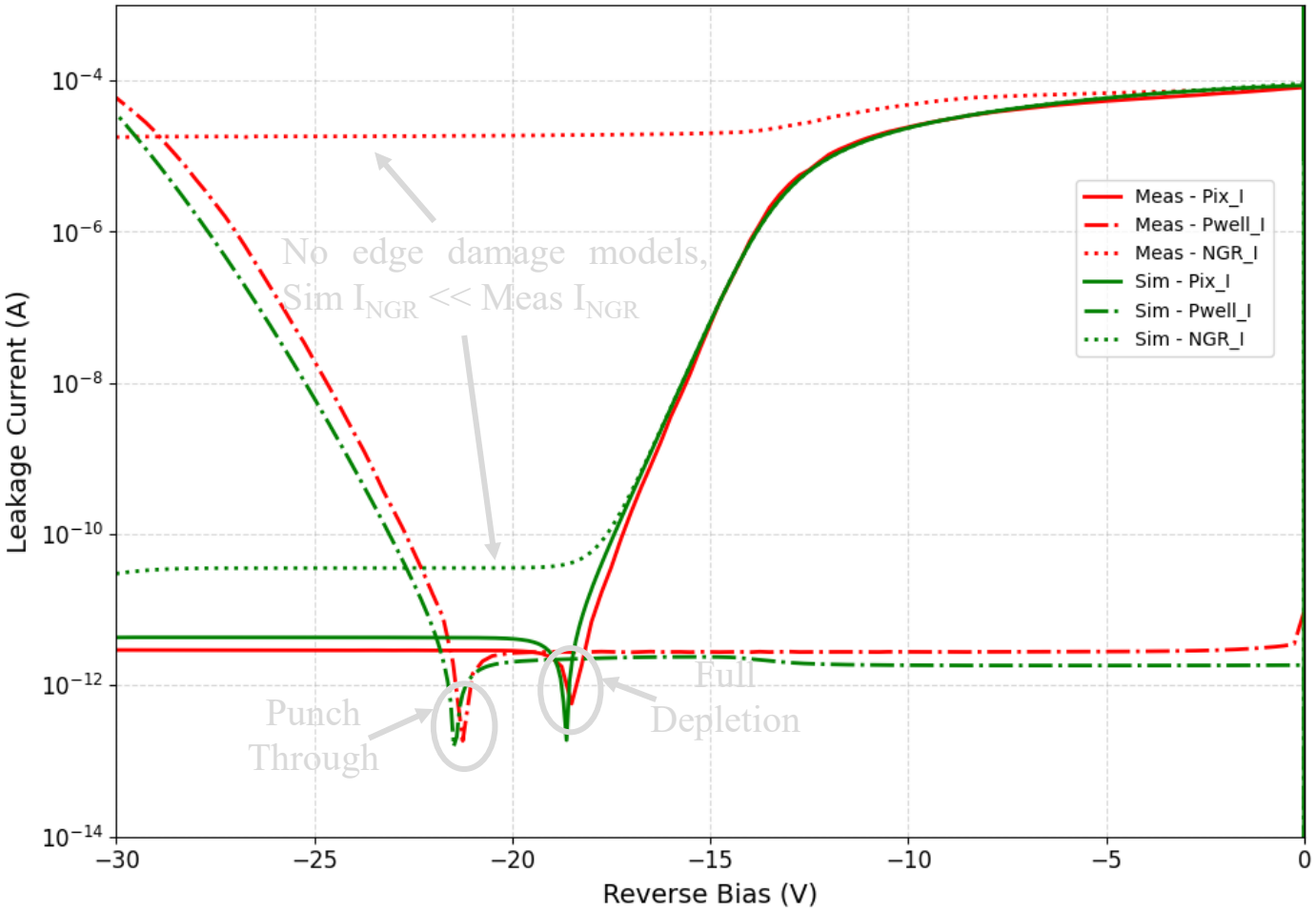

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Ultra-thick Fully Depleted MAPS

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2. Significantly increased substrate thickness (≥ 650 μm);
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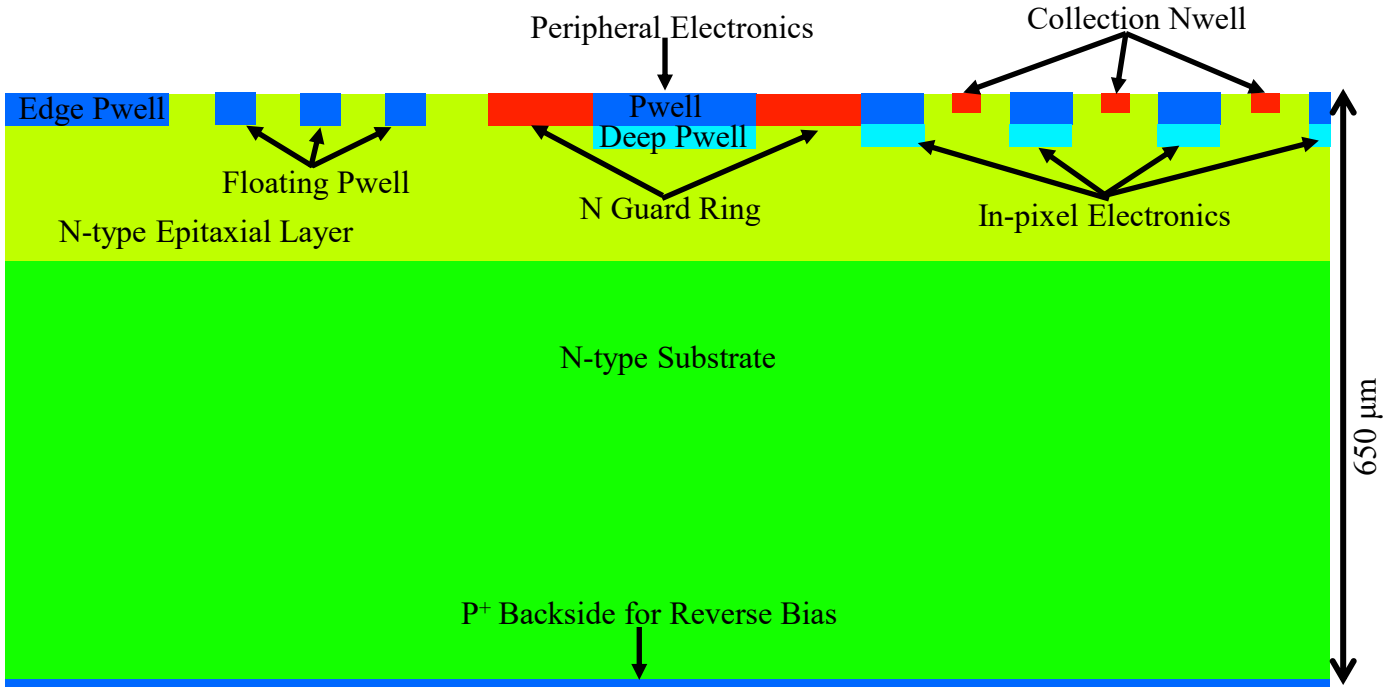

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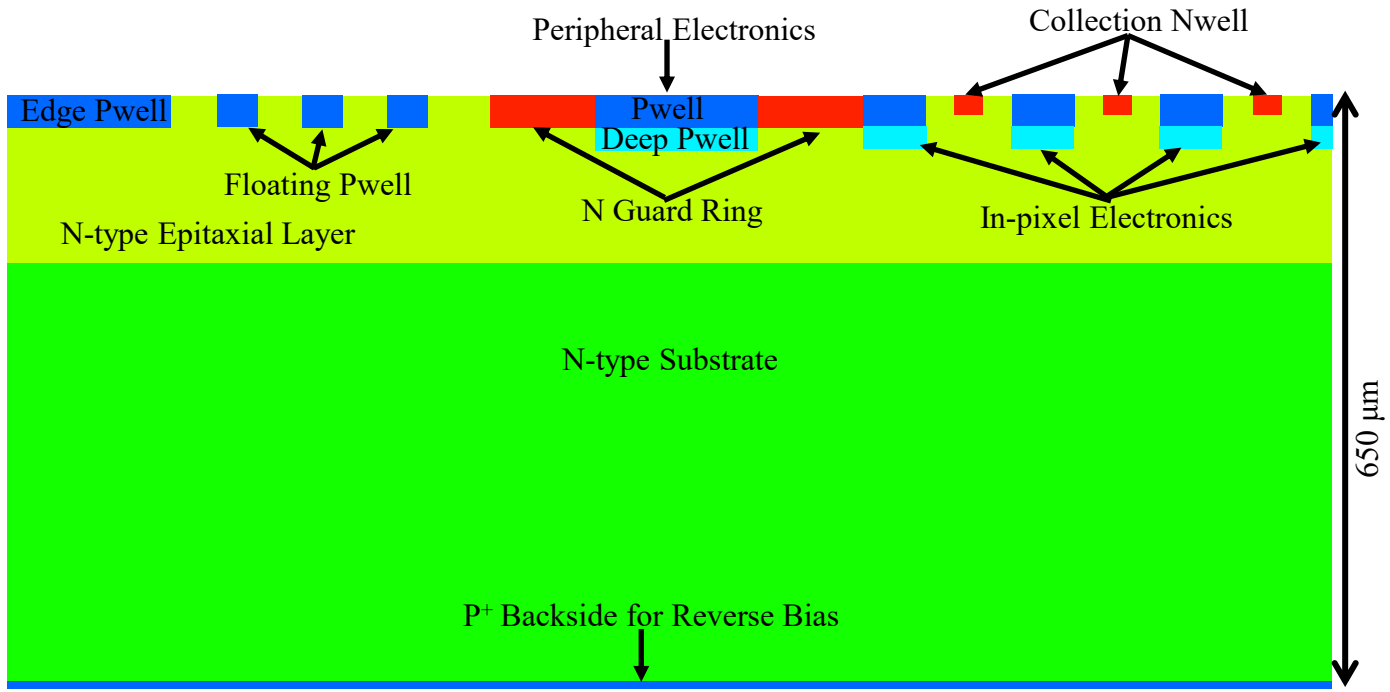

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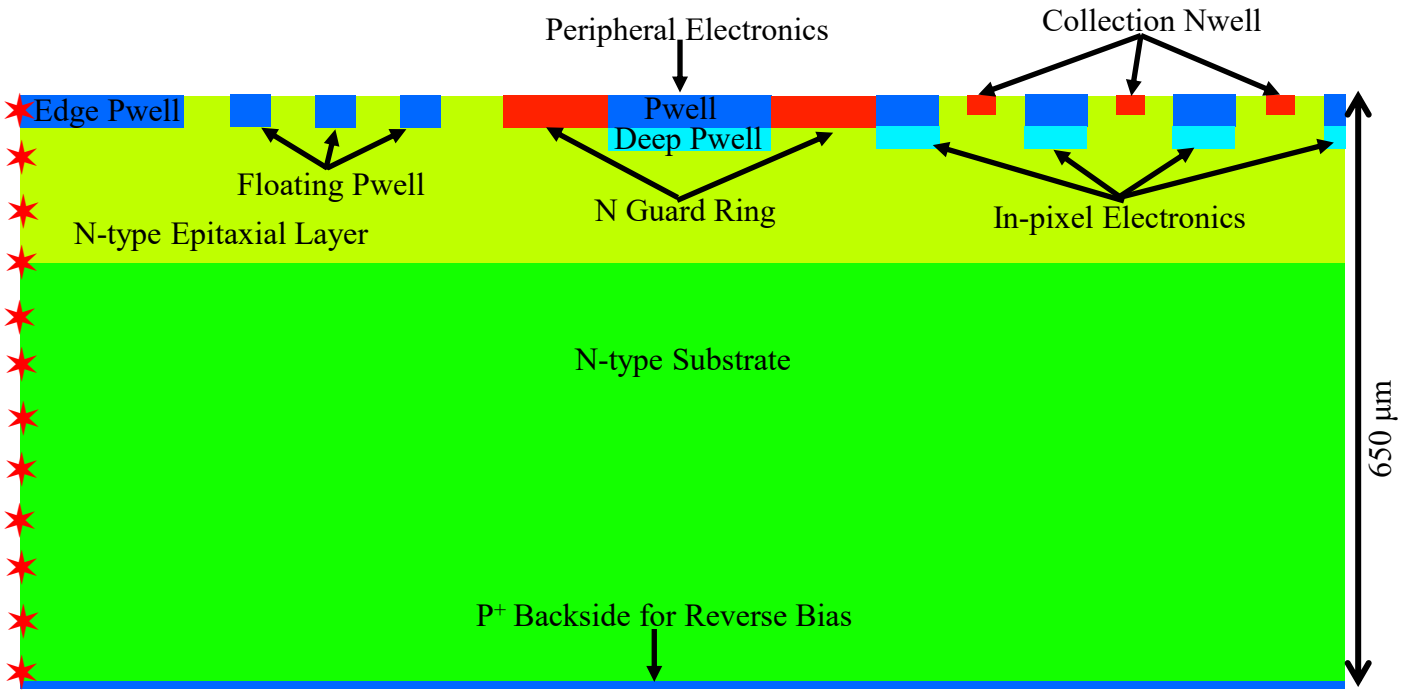

Edge Pwell potential closely follows back bias after dicing; shorted to the back bias in TCAD simulations to represent the worst scenario.

Shorting Edge Pwell to the back bias raise concerns such as:

Lateral punch-through ;

Early breakdown.

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Influence of Floating Pwell configuration.

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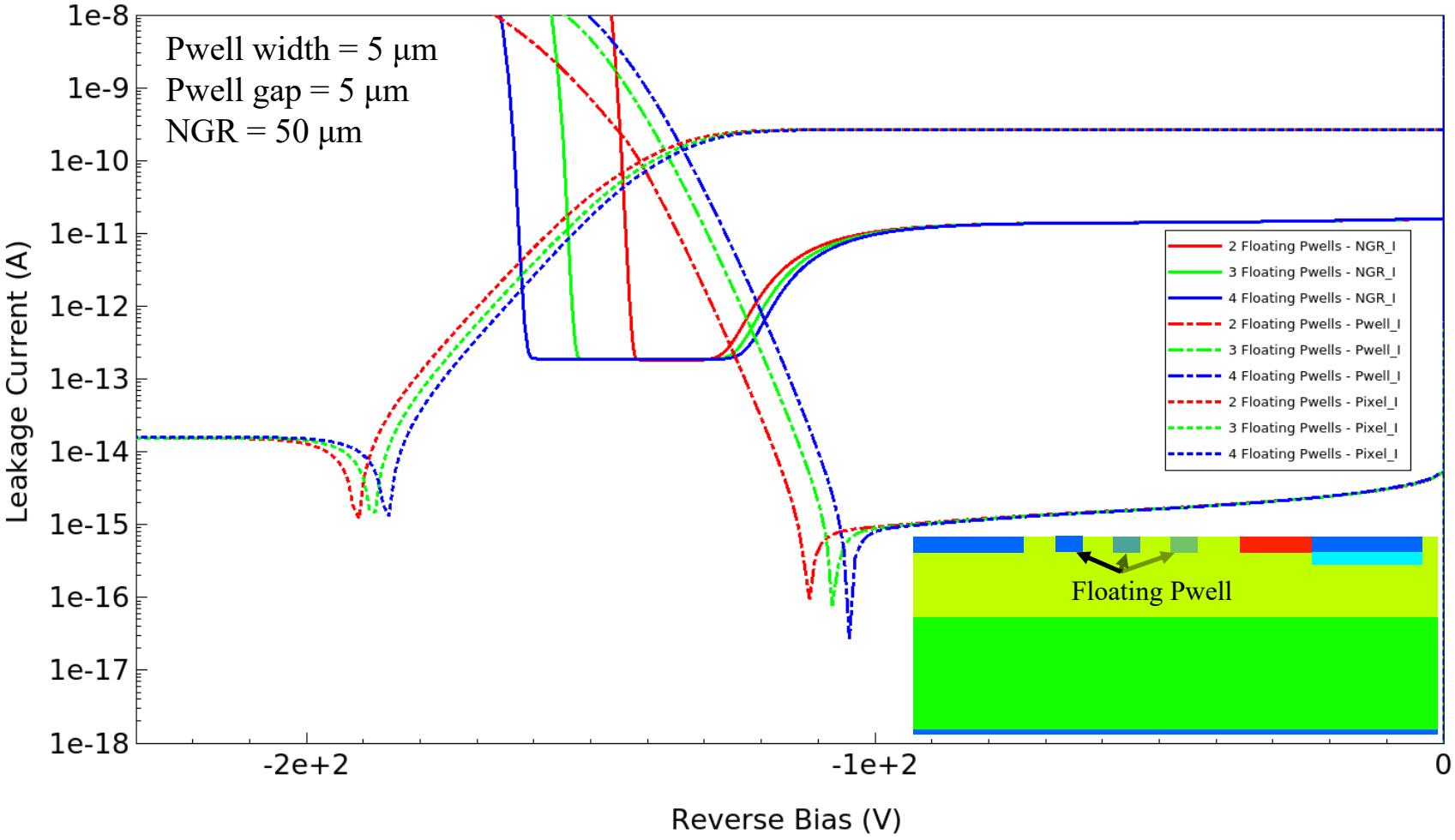
Thickness = 650 µm, Substrate Resistivity ≈ 10 kΩ • cm



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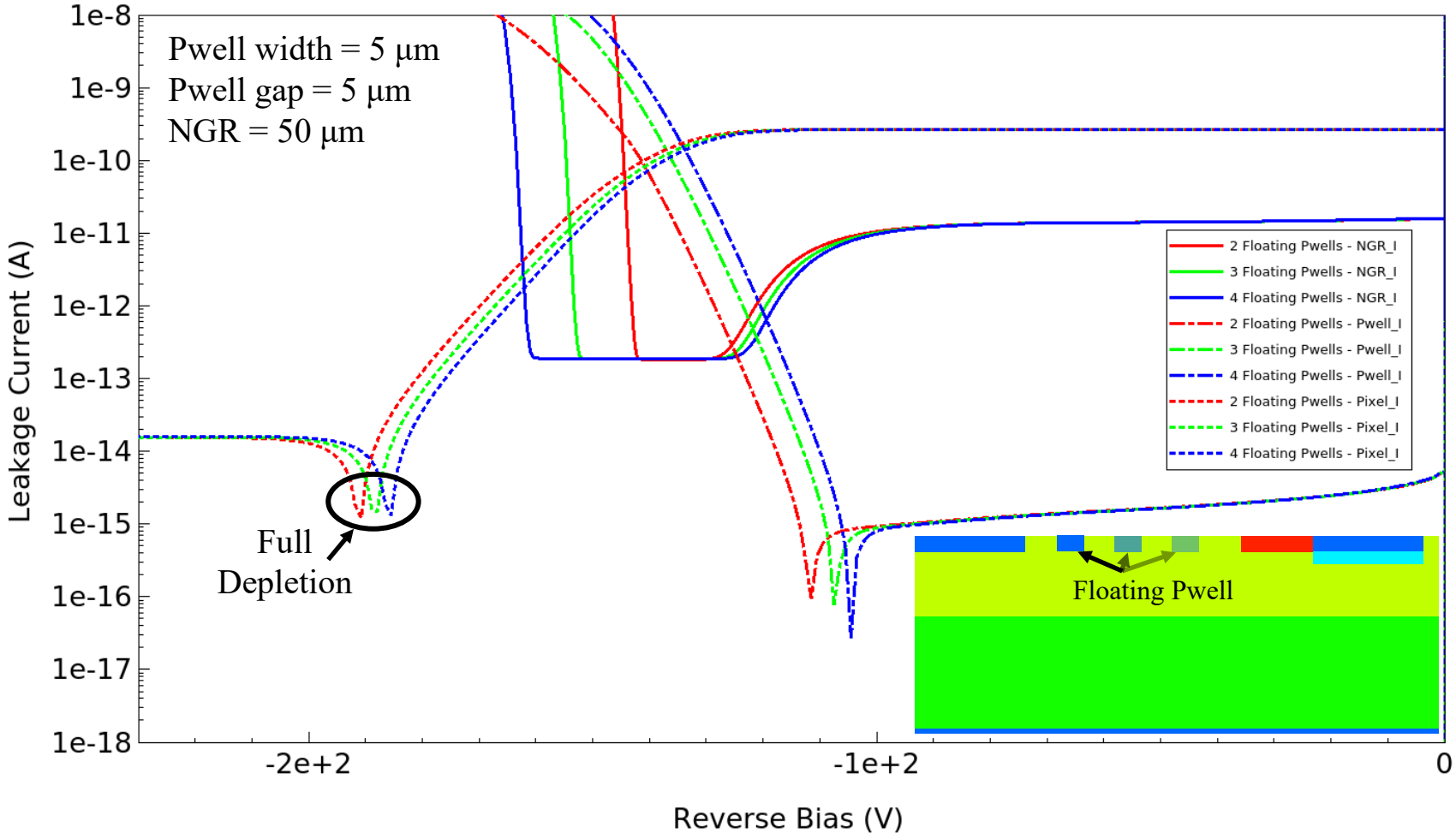

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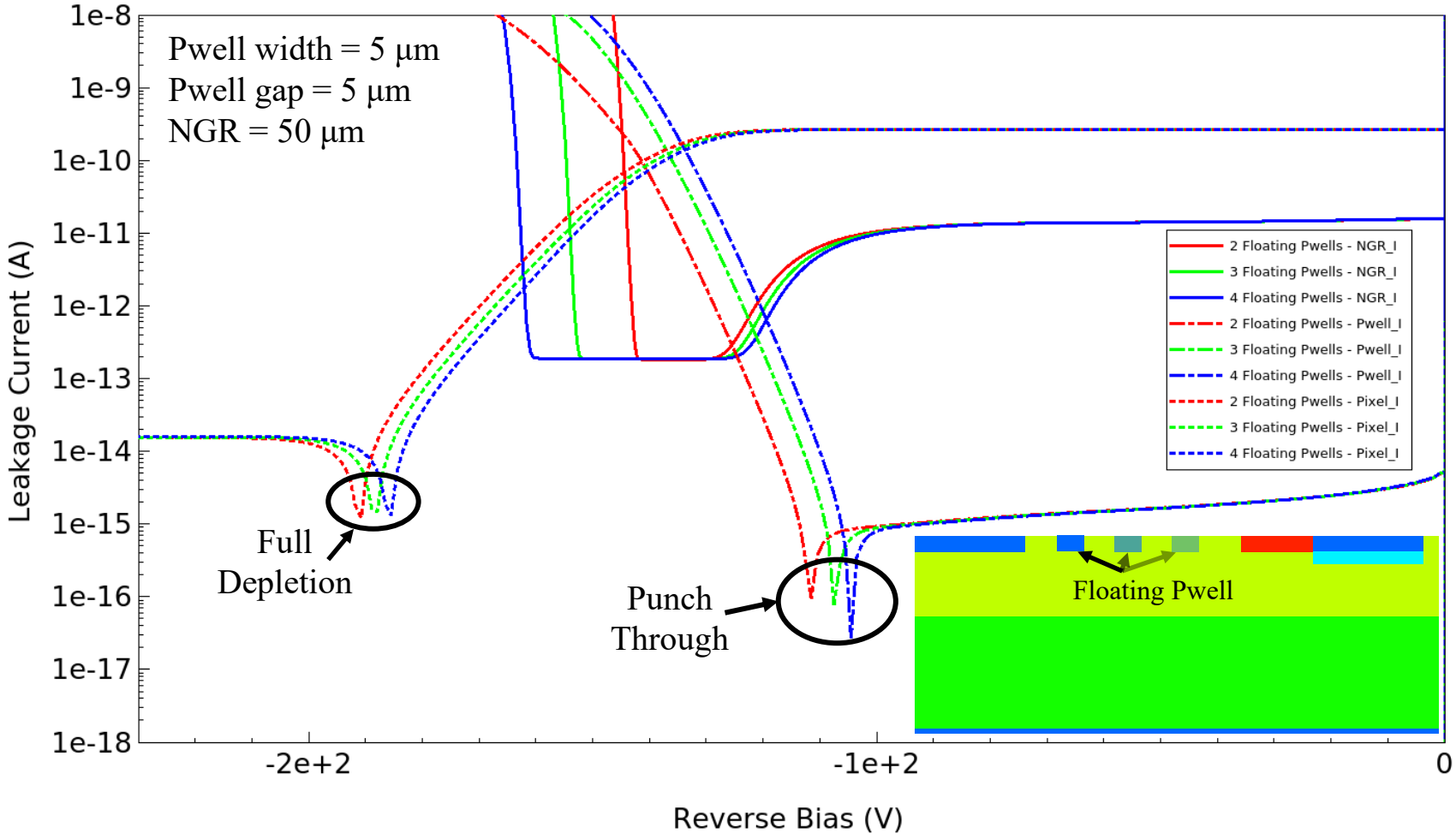

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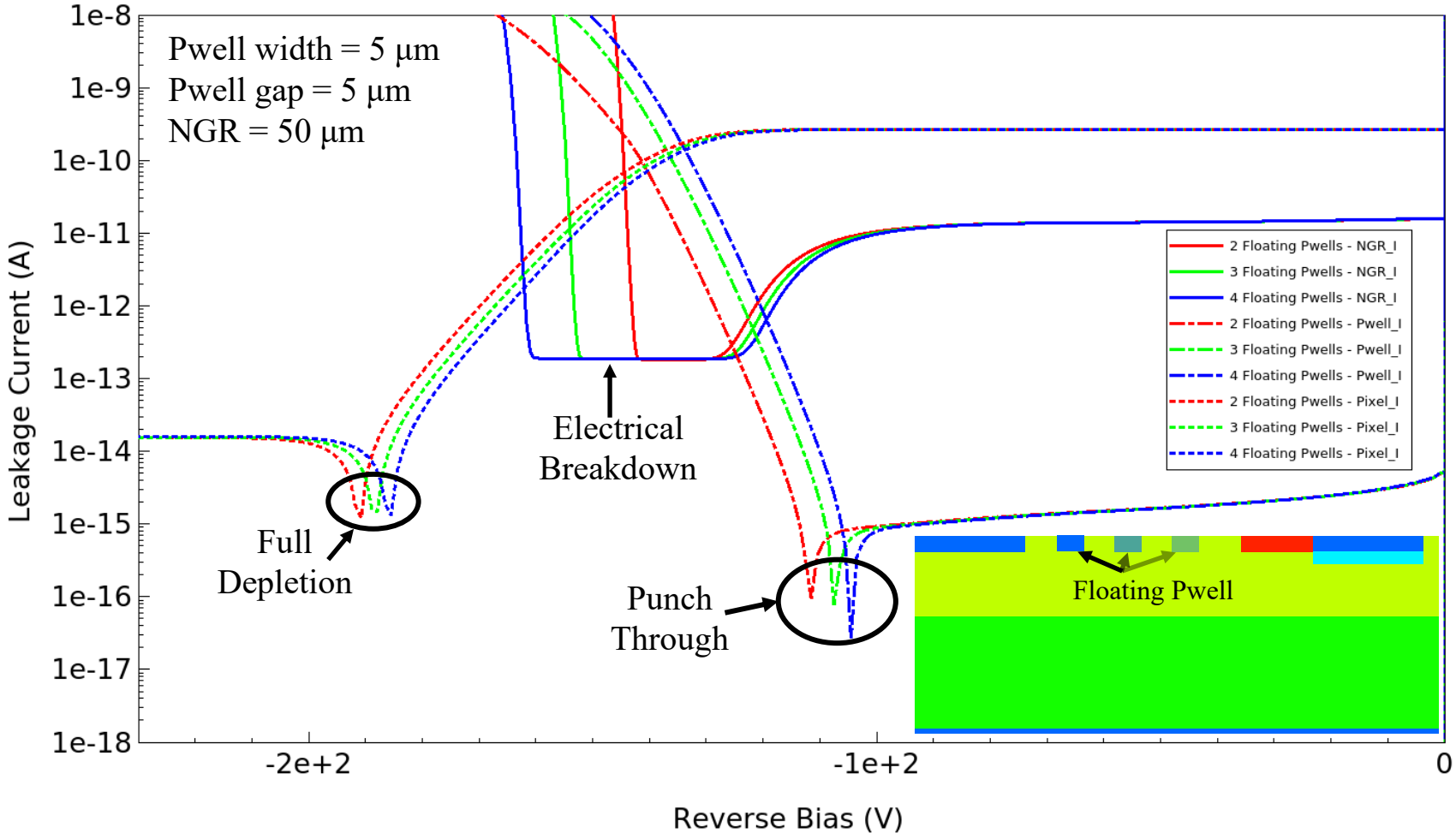

Shorting Edge Pwell to the back bias raise concerns such as:
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Influence of Floating Pwell configuration.

Conclusion
Extra Floating Pwells increase V_{BD}, while the influence on V_{FD} and V_{PT} is limited.

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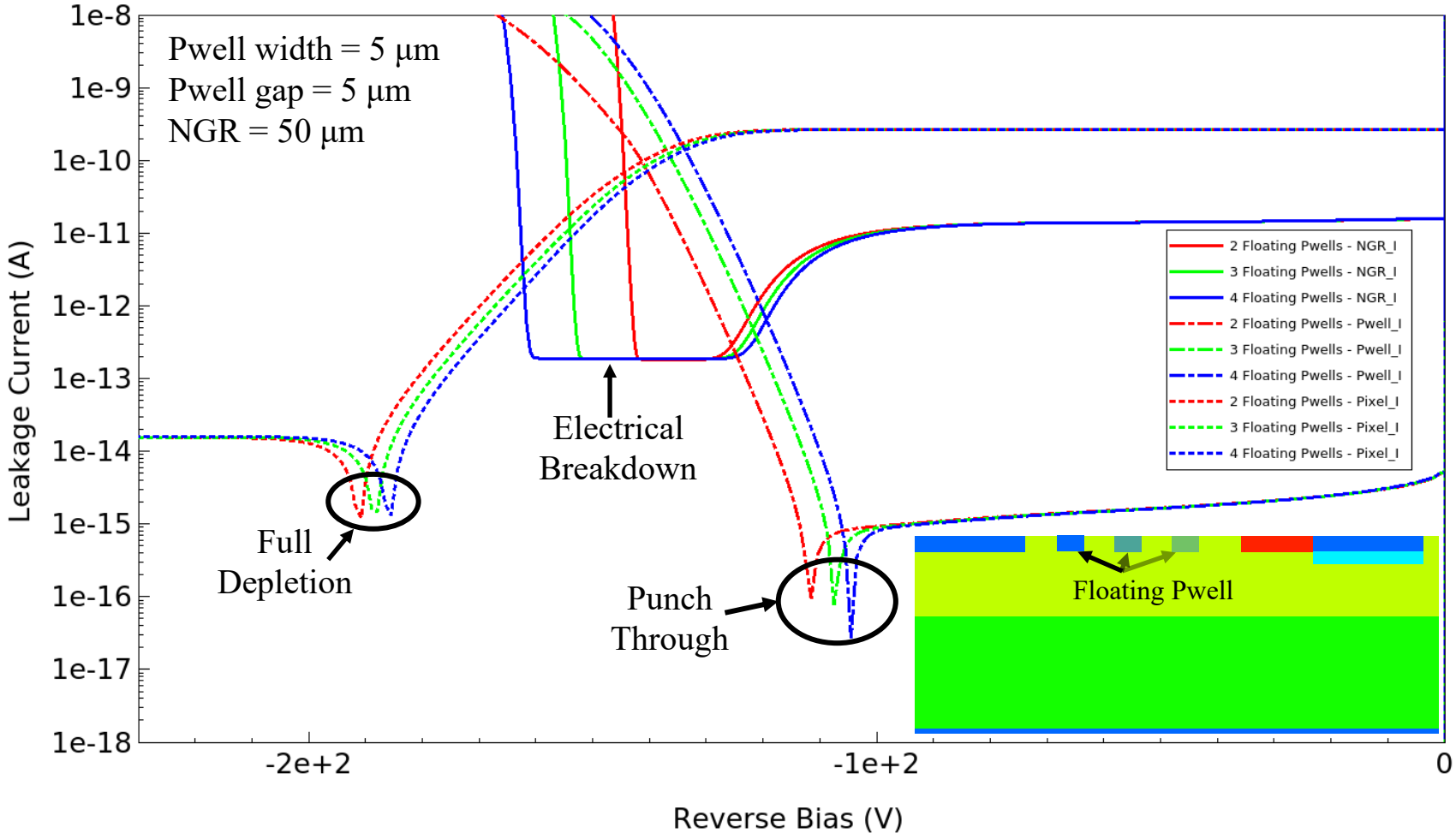

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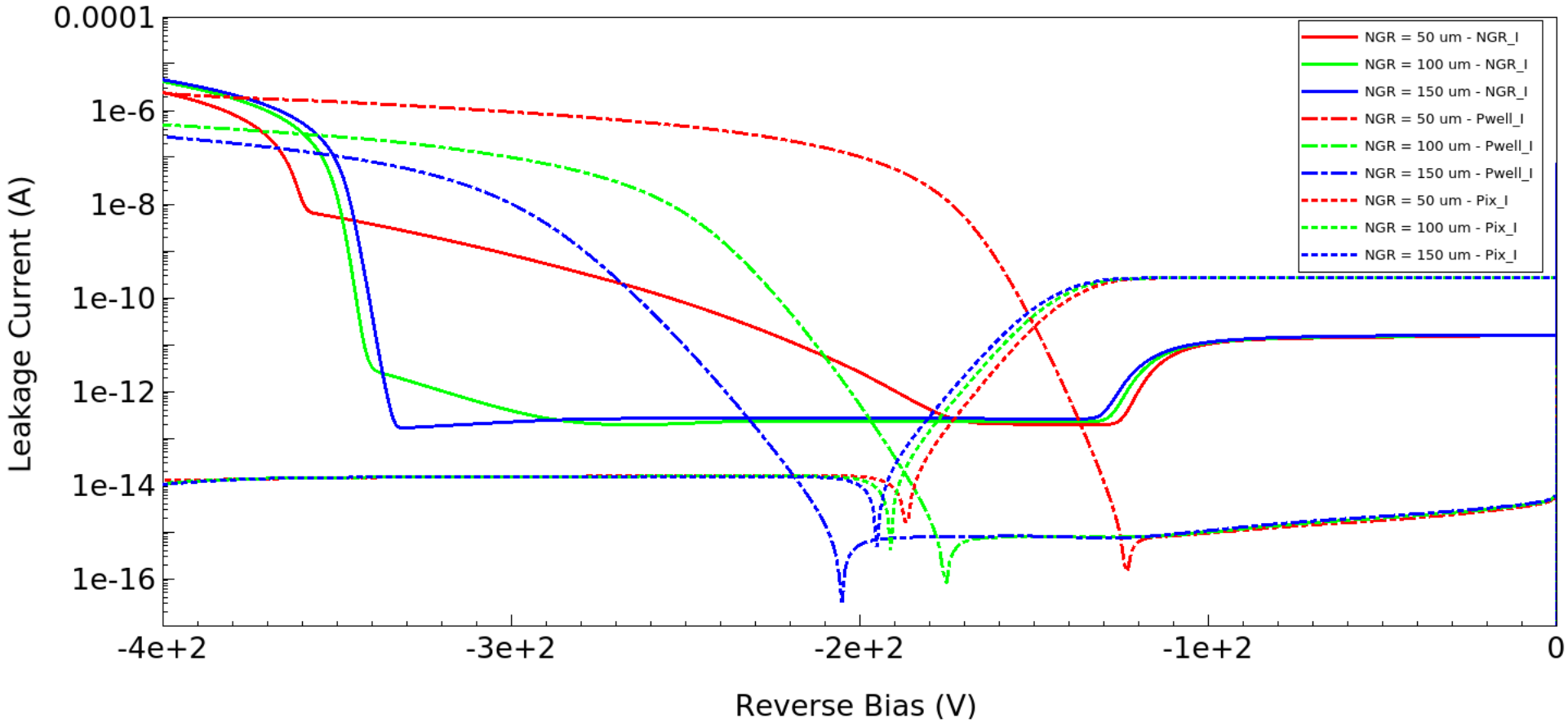

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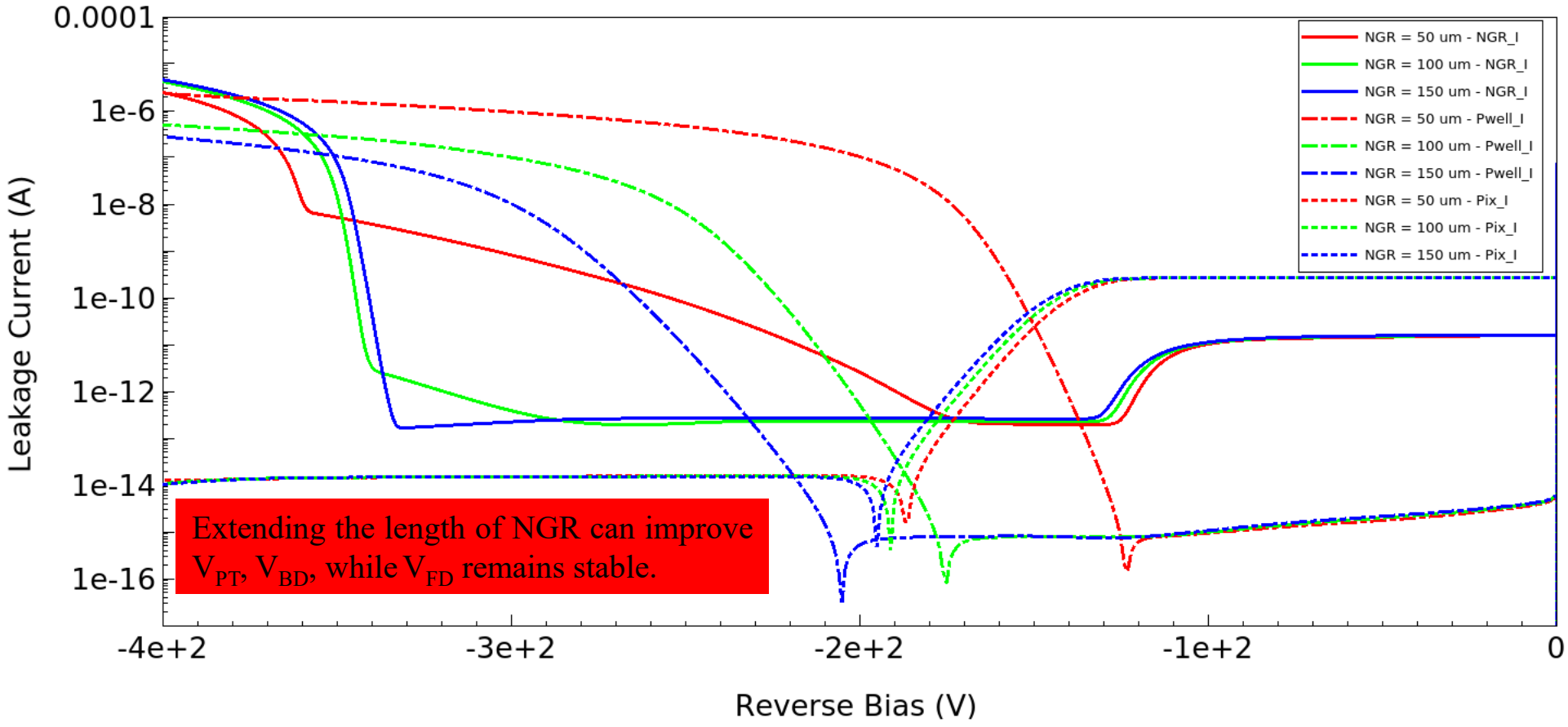

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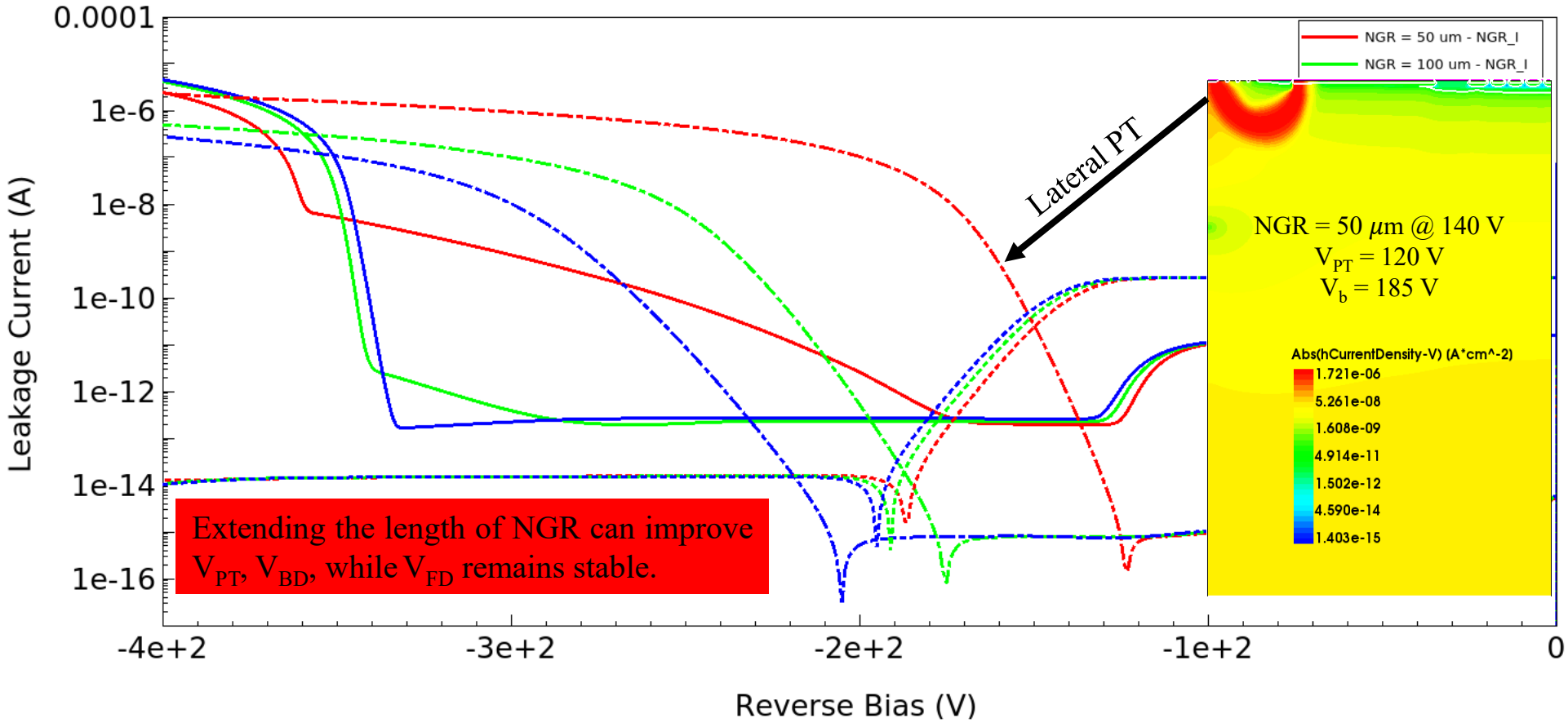

Example
Influence of NGR length.

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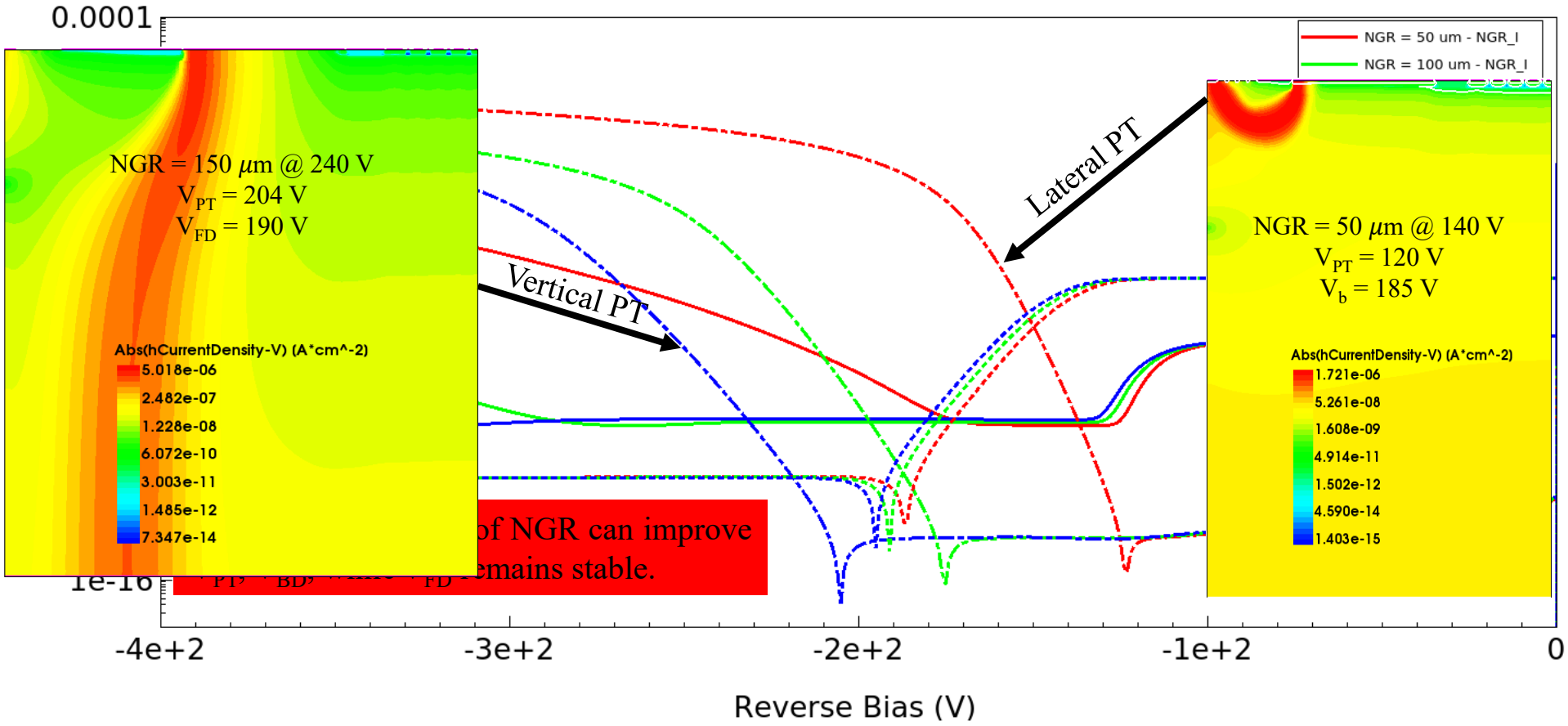

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Does the conclusion still hold after radiation damage which introduces:

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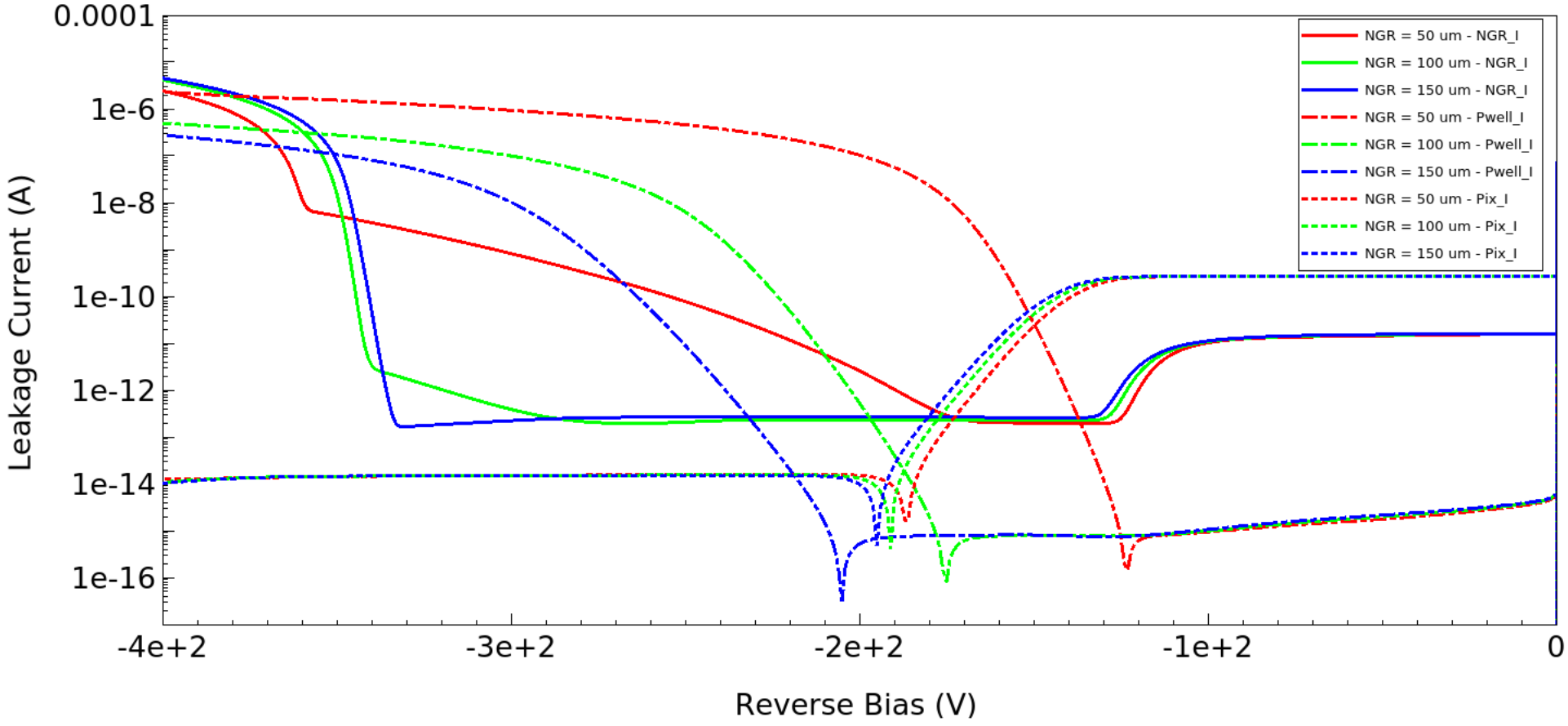

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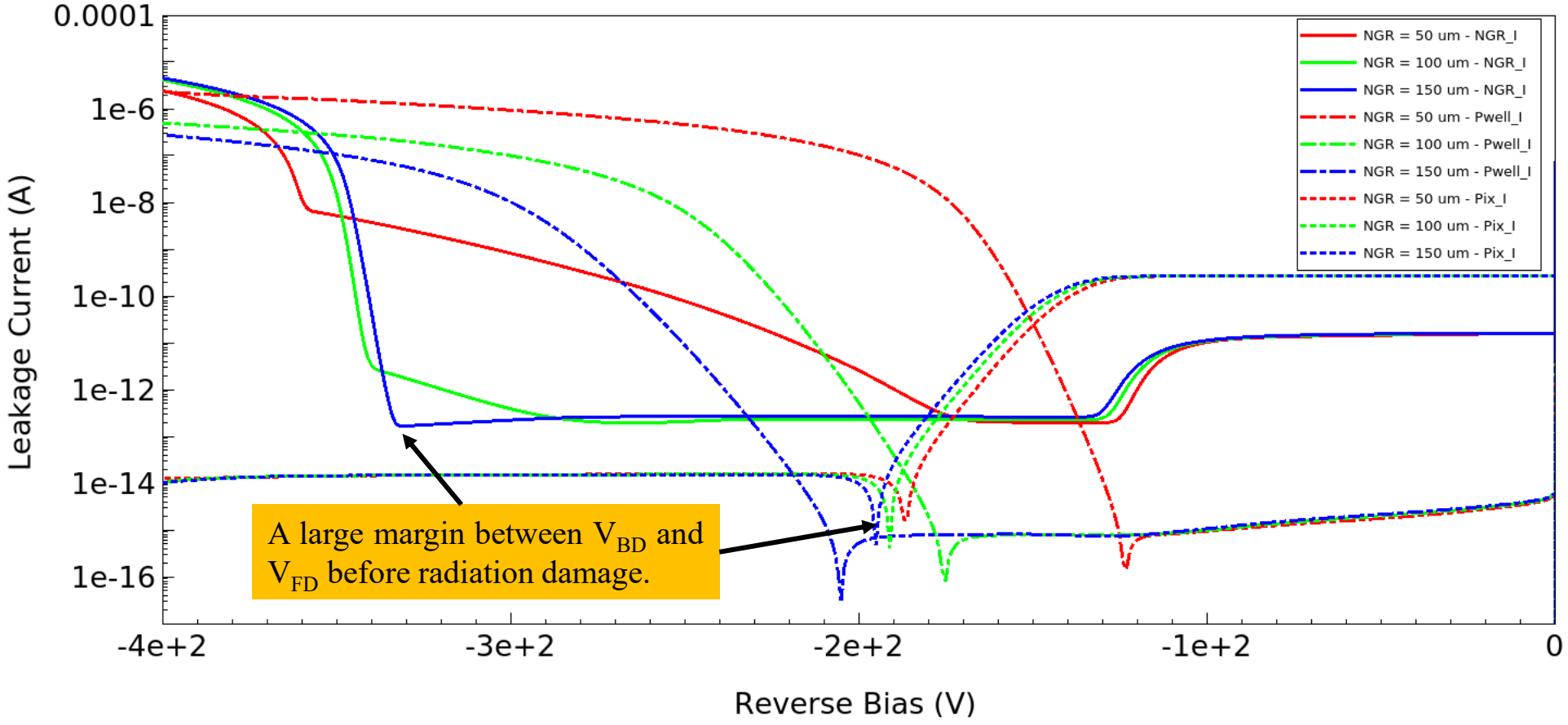
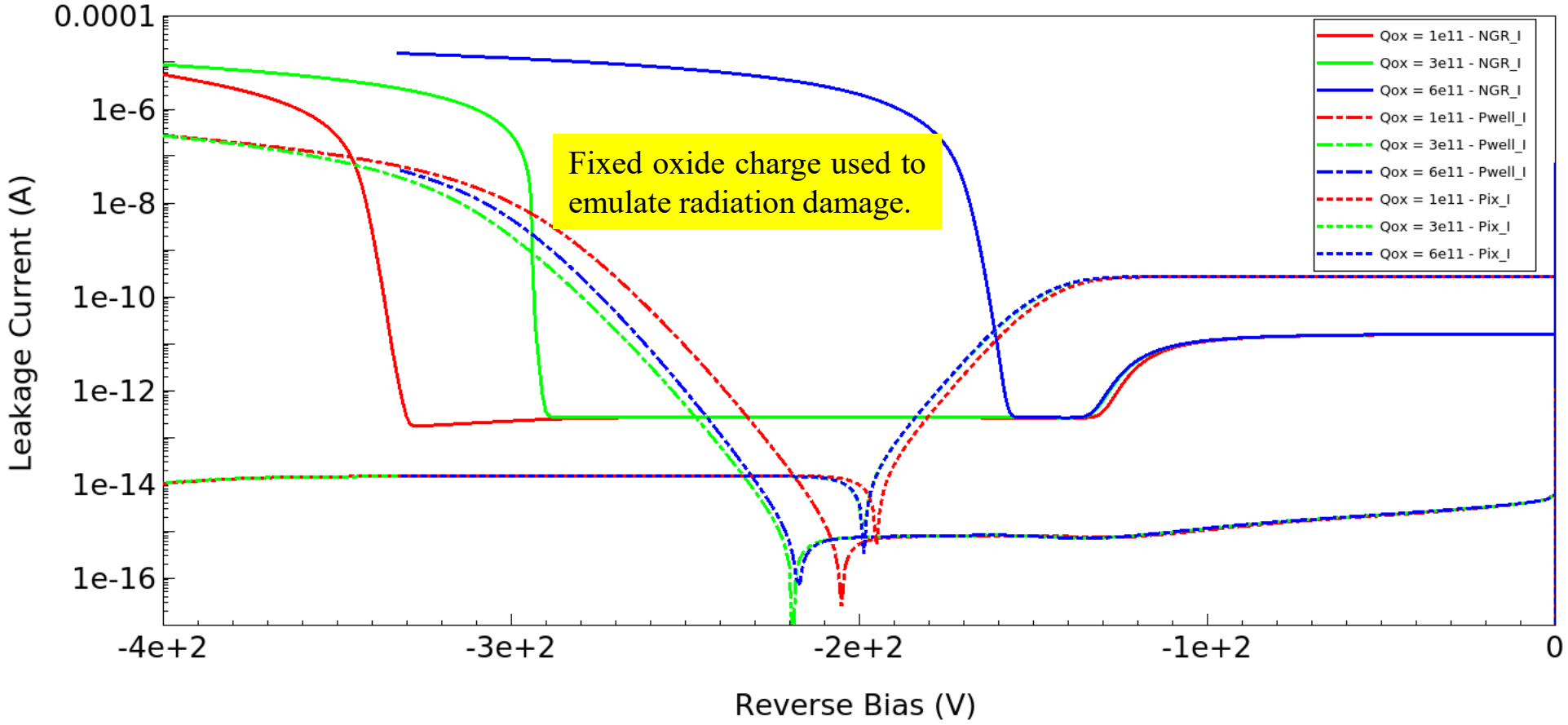


Fixed oxide charge used to emulate radiation damage.

3 Floating Pwells, NGR = 150 µm



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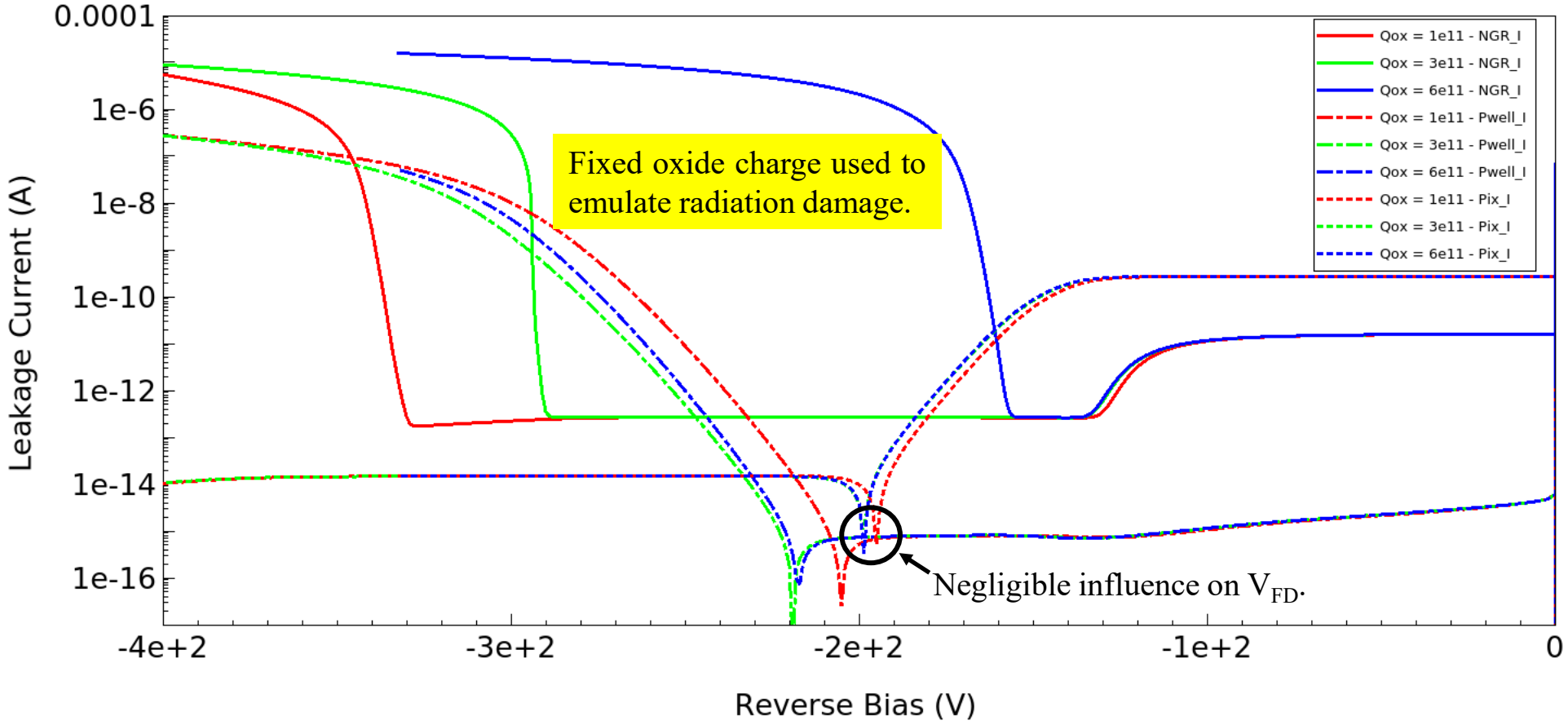

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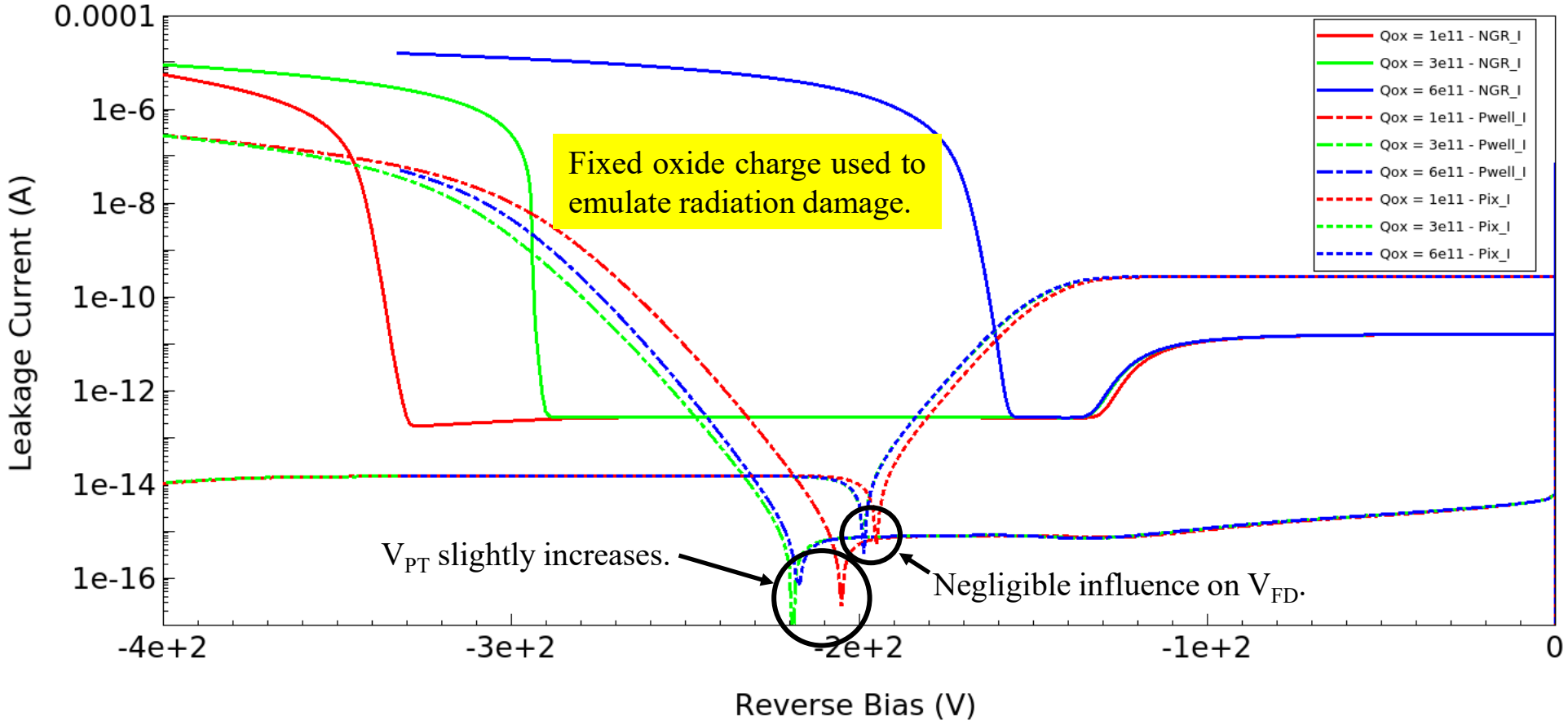

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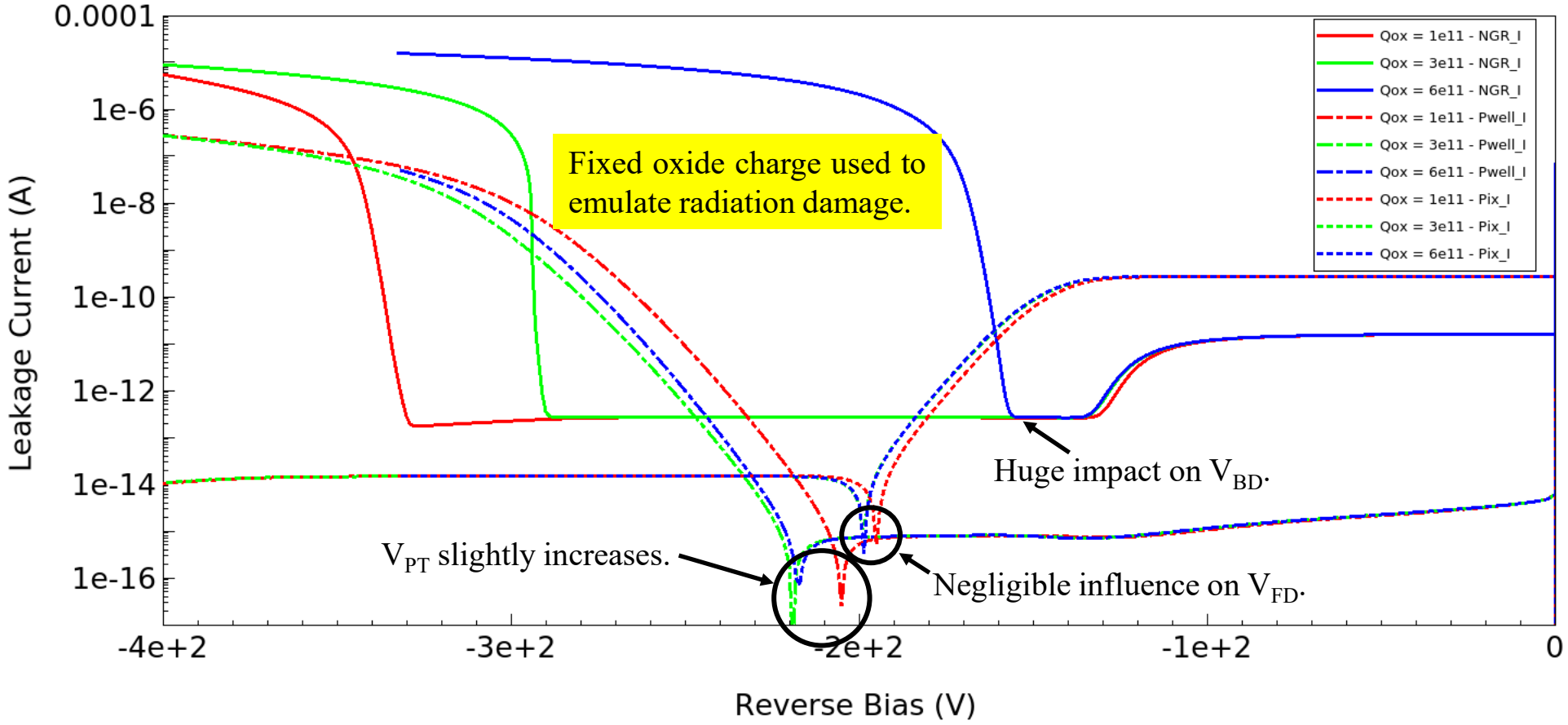
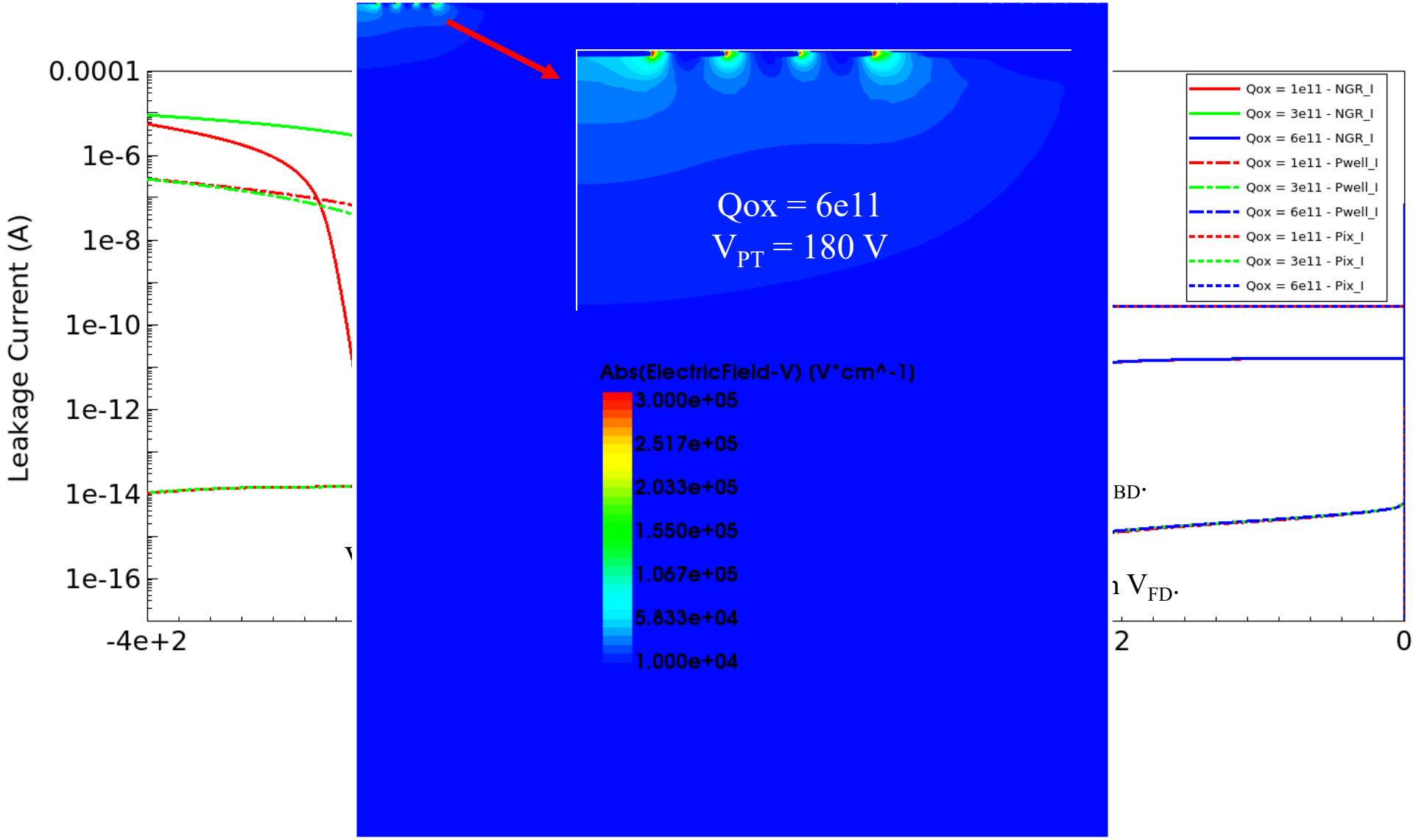


Ultra-thick Fully Depleted MAPS



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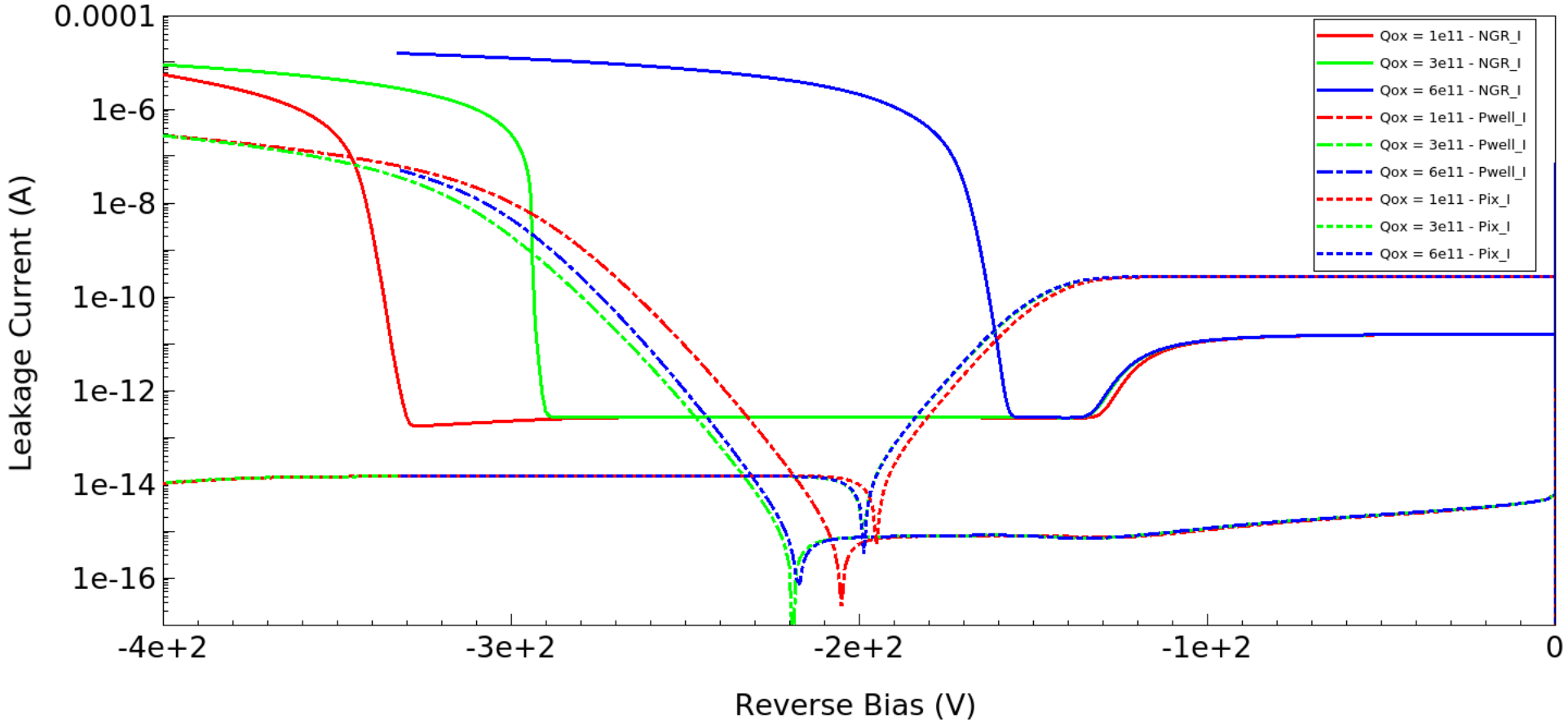
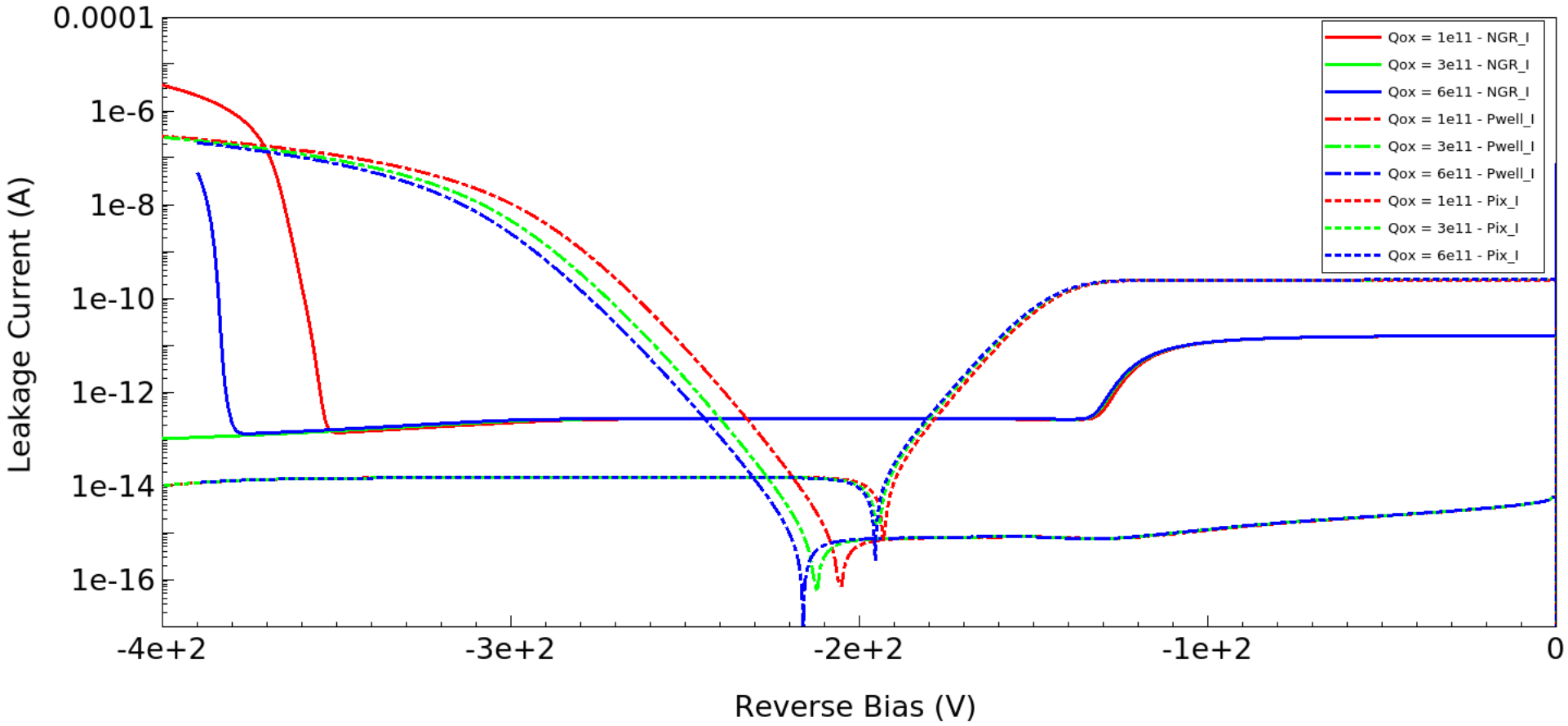


3 Floating Pwells, NGR = 150 μm (with ***Field Plate***)



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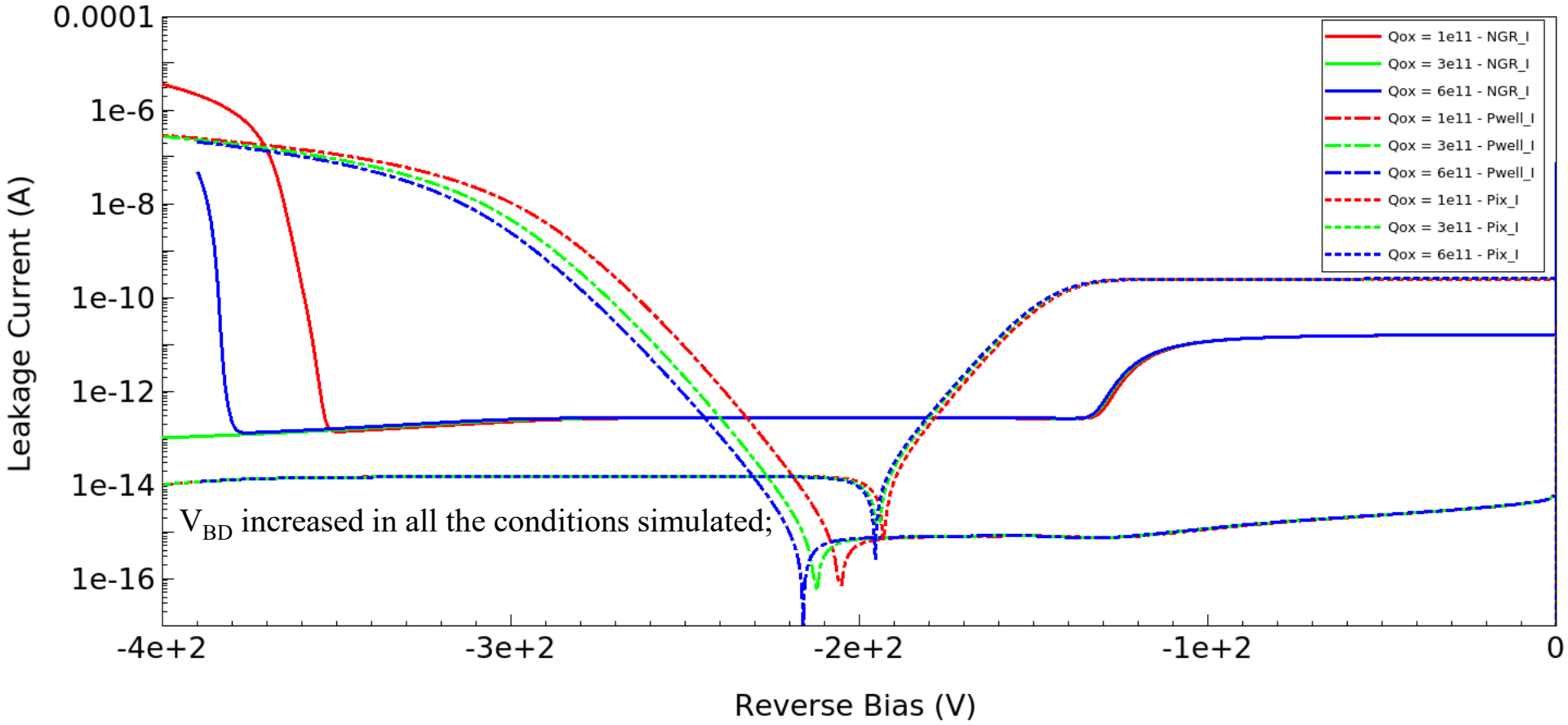

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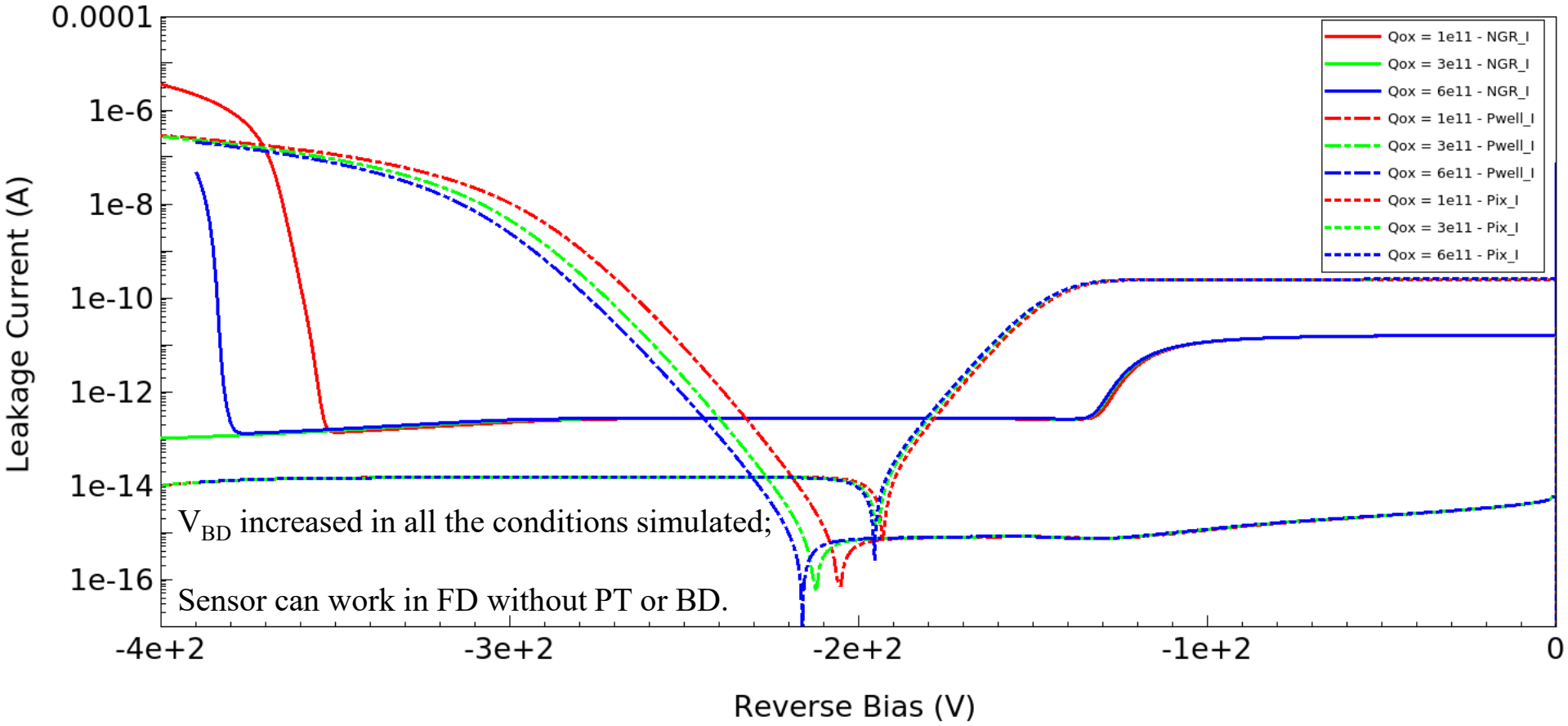

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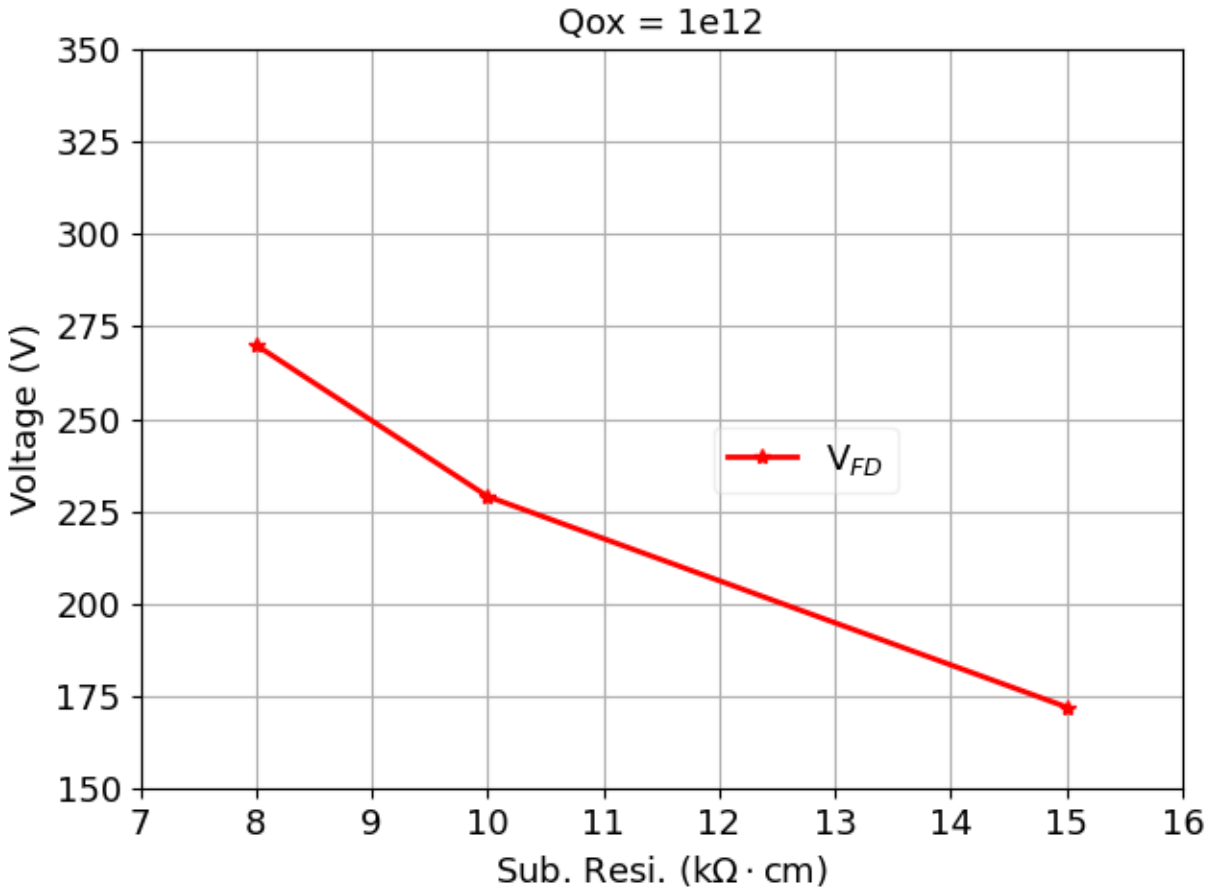

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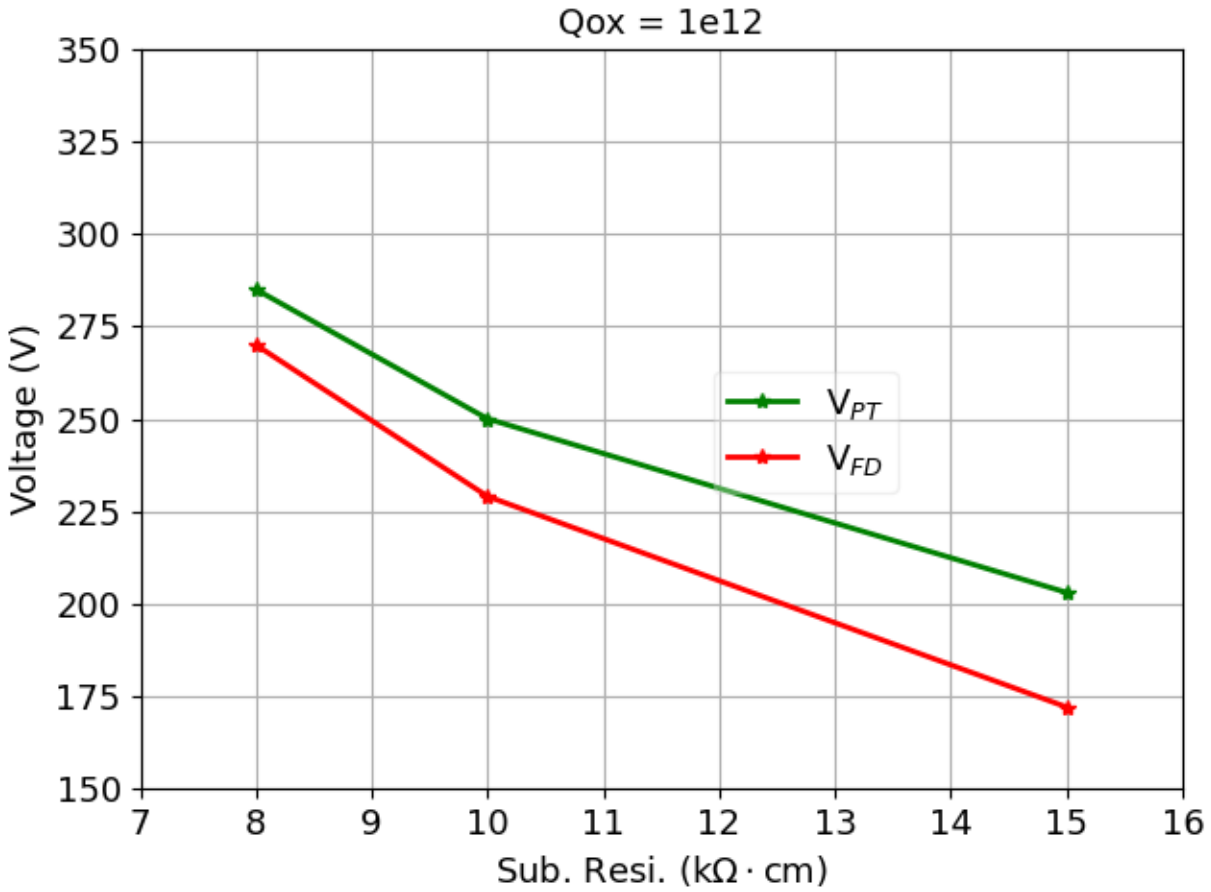

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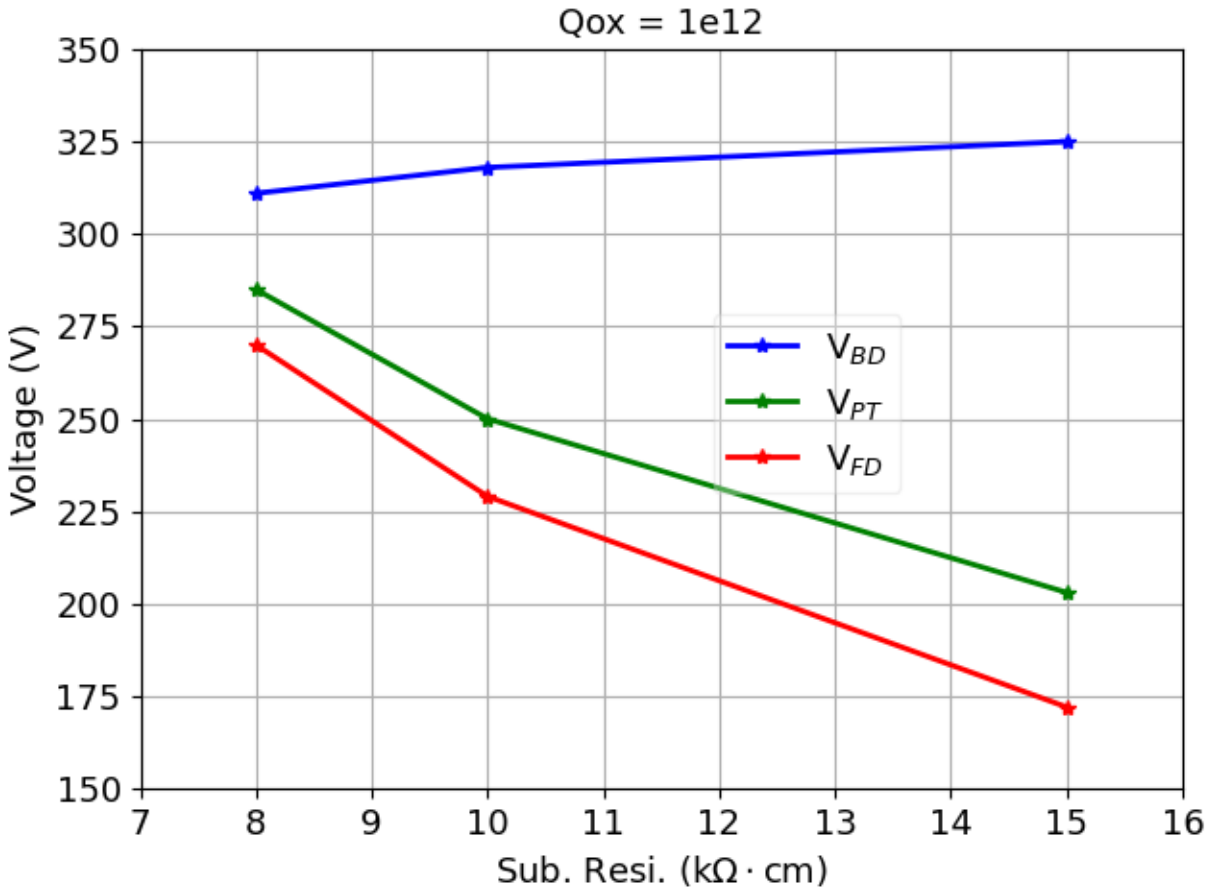

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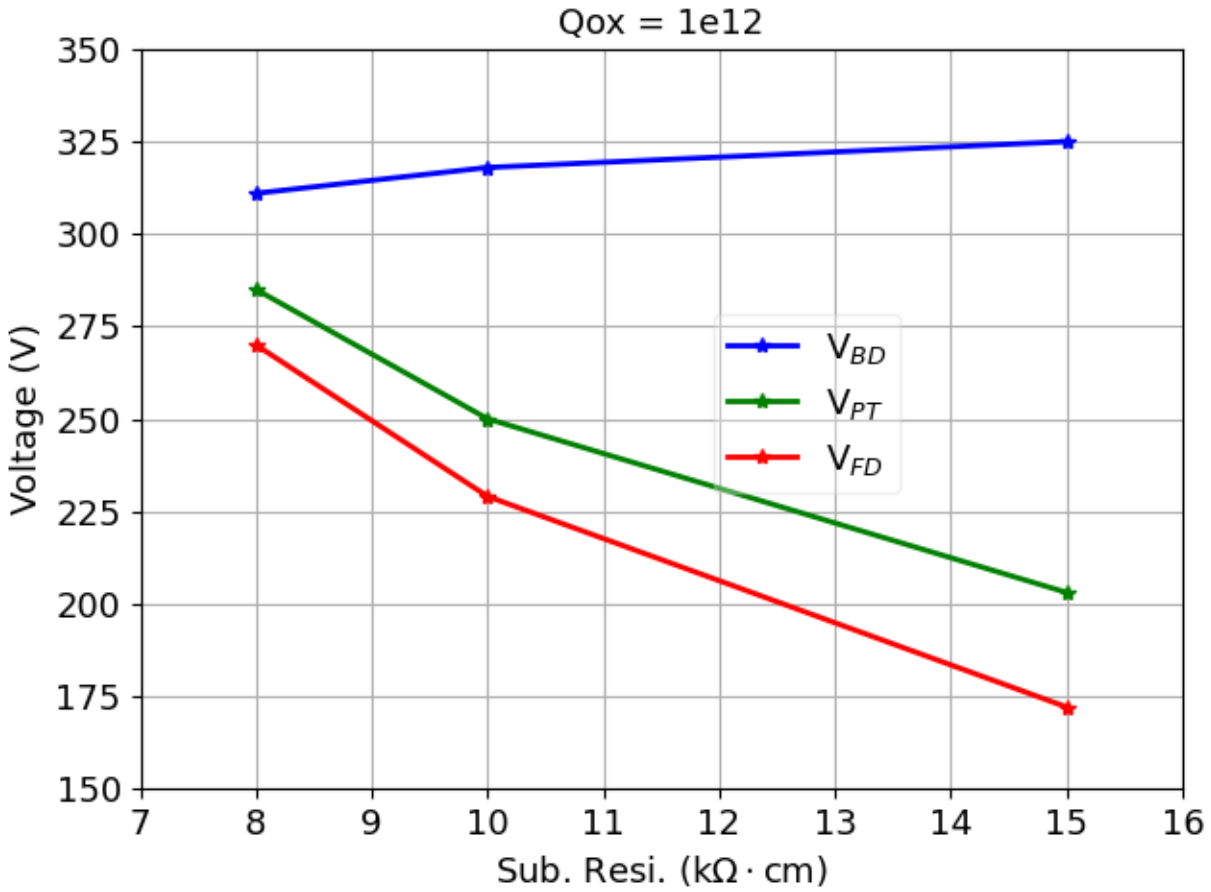

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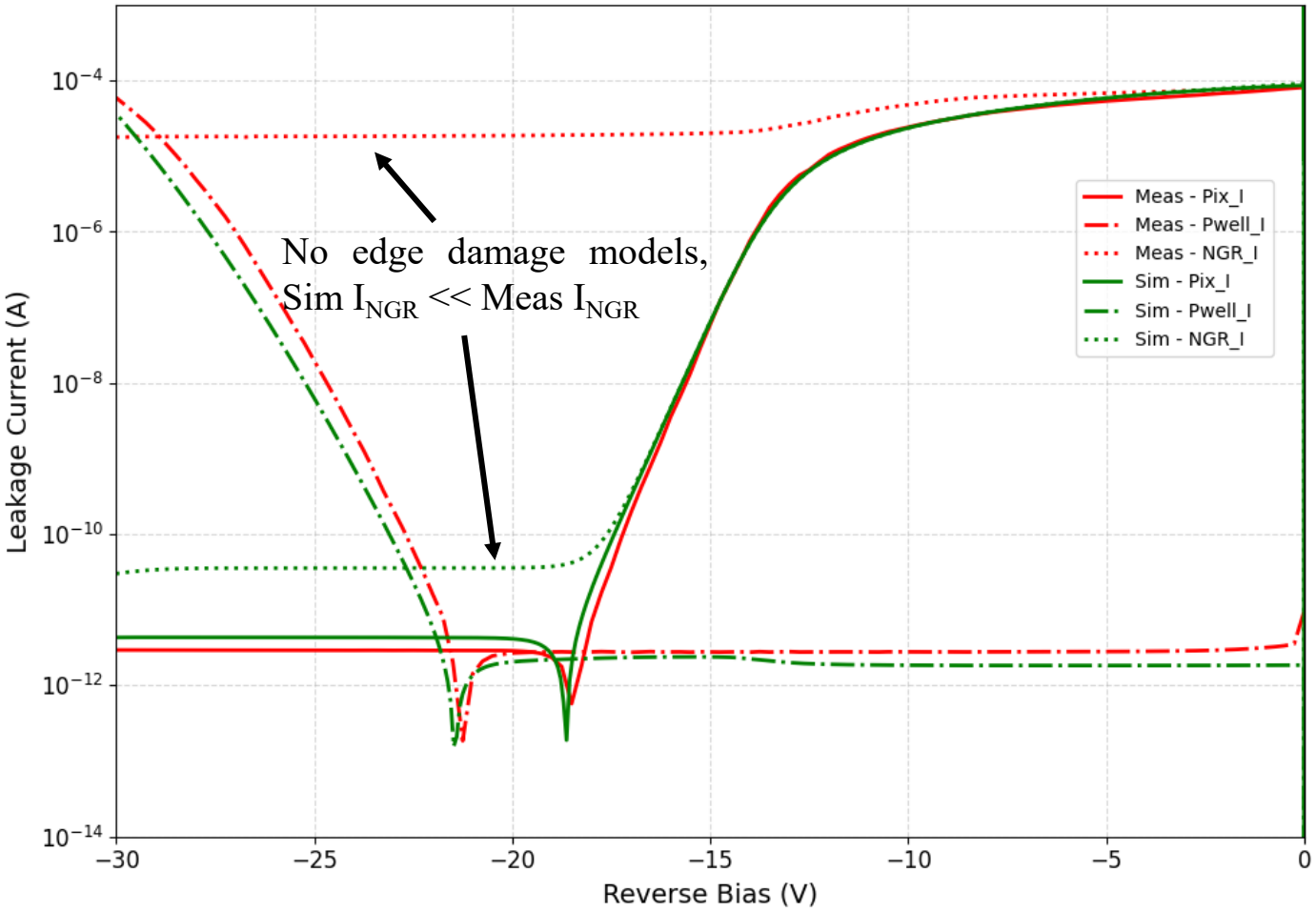
Modeling of the dicing edge

The measured high NGR current suggests contribution from the dicing edge.



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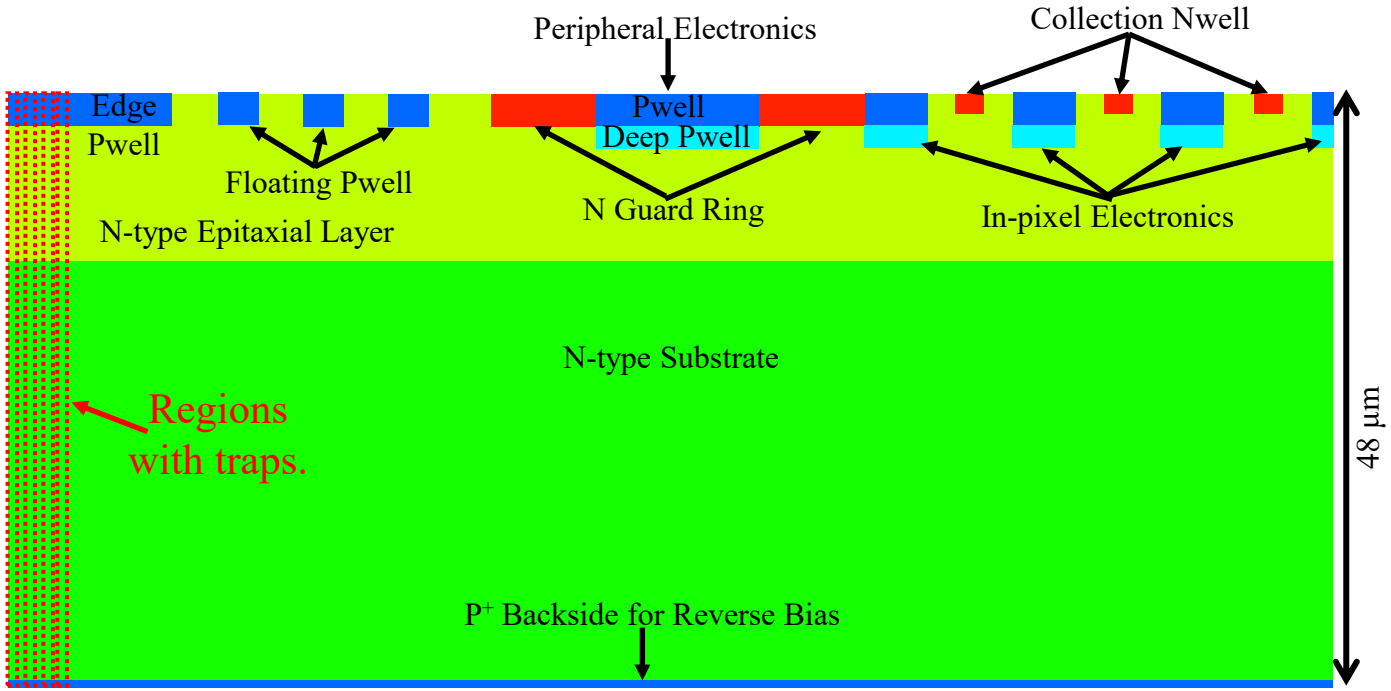

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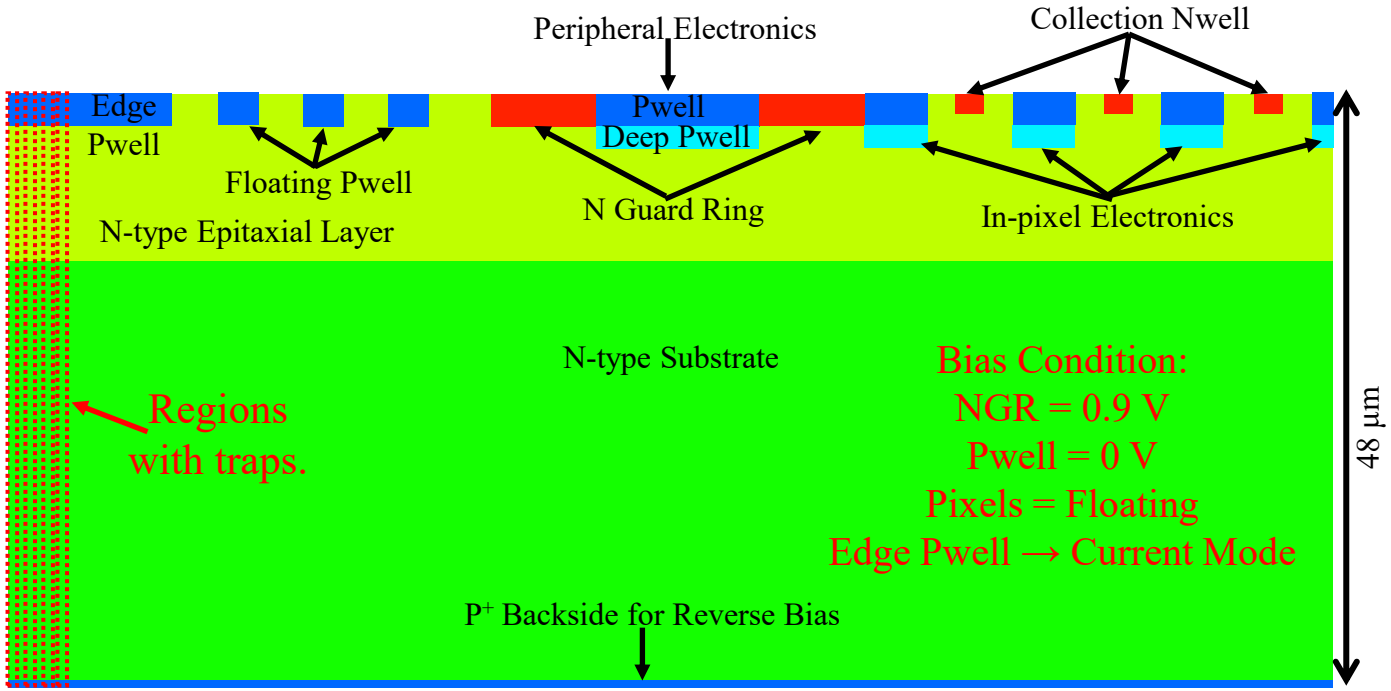

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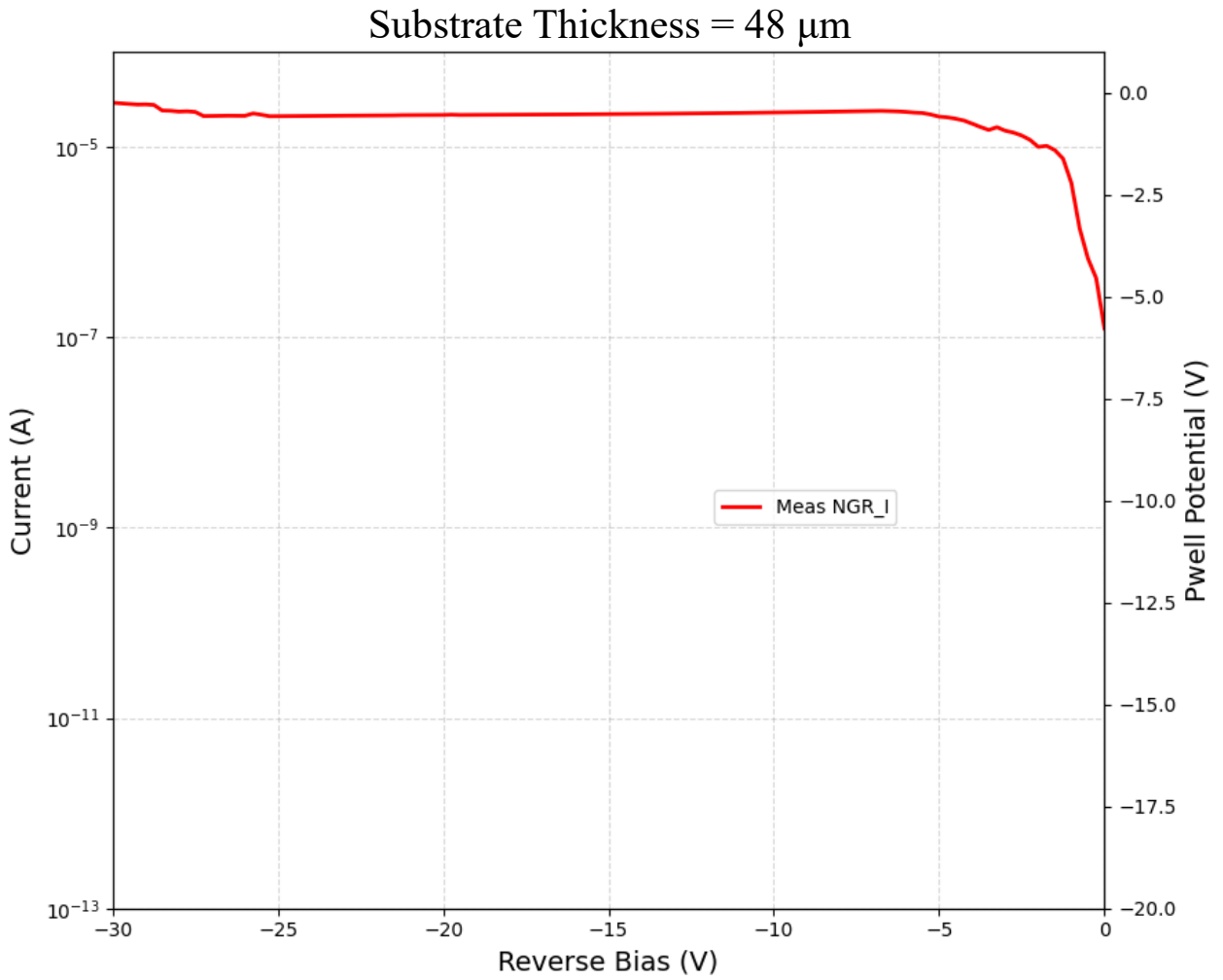

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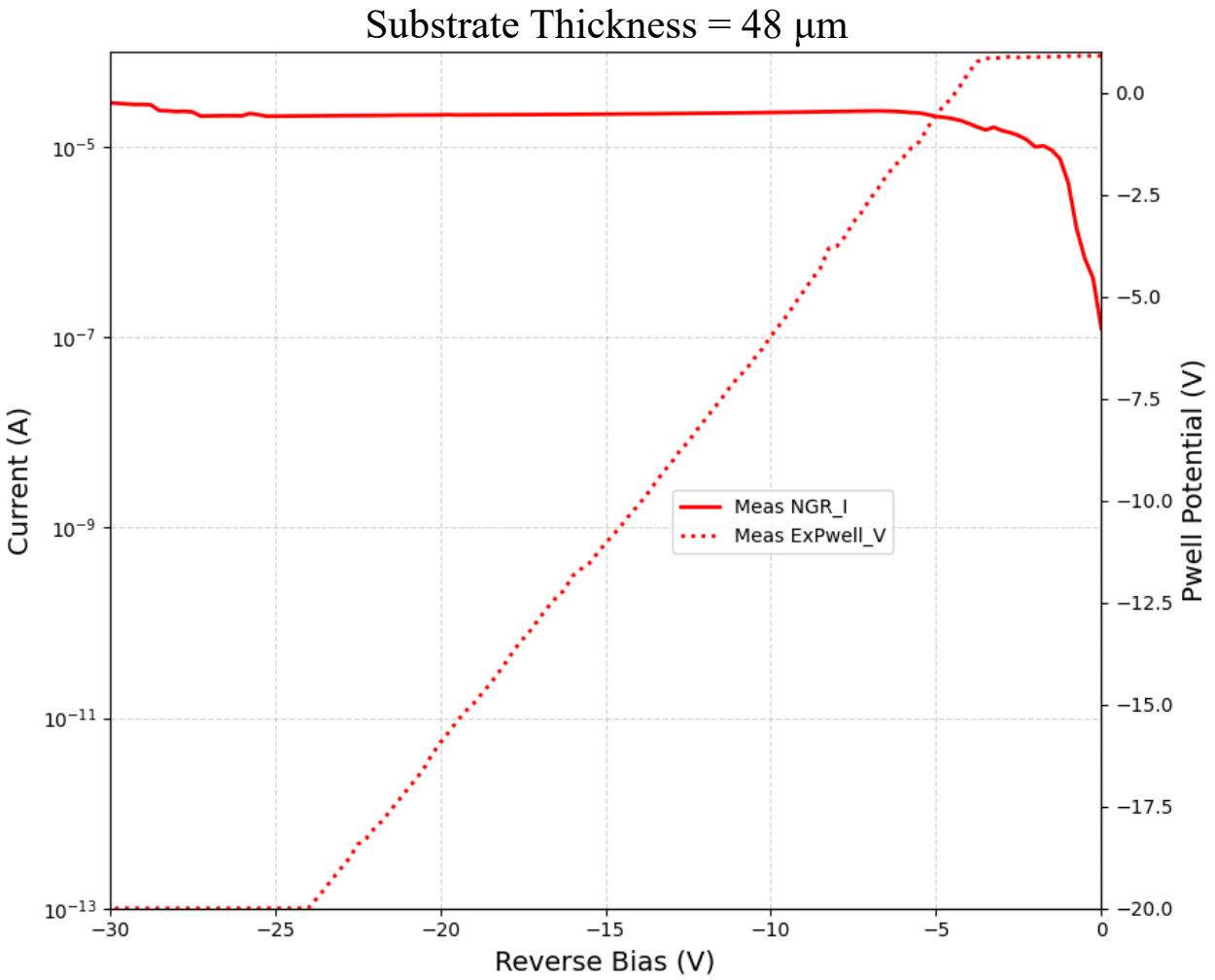

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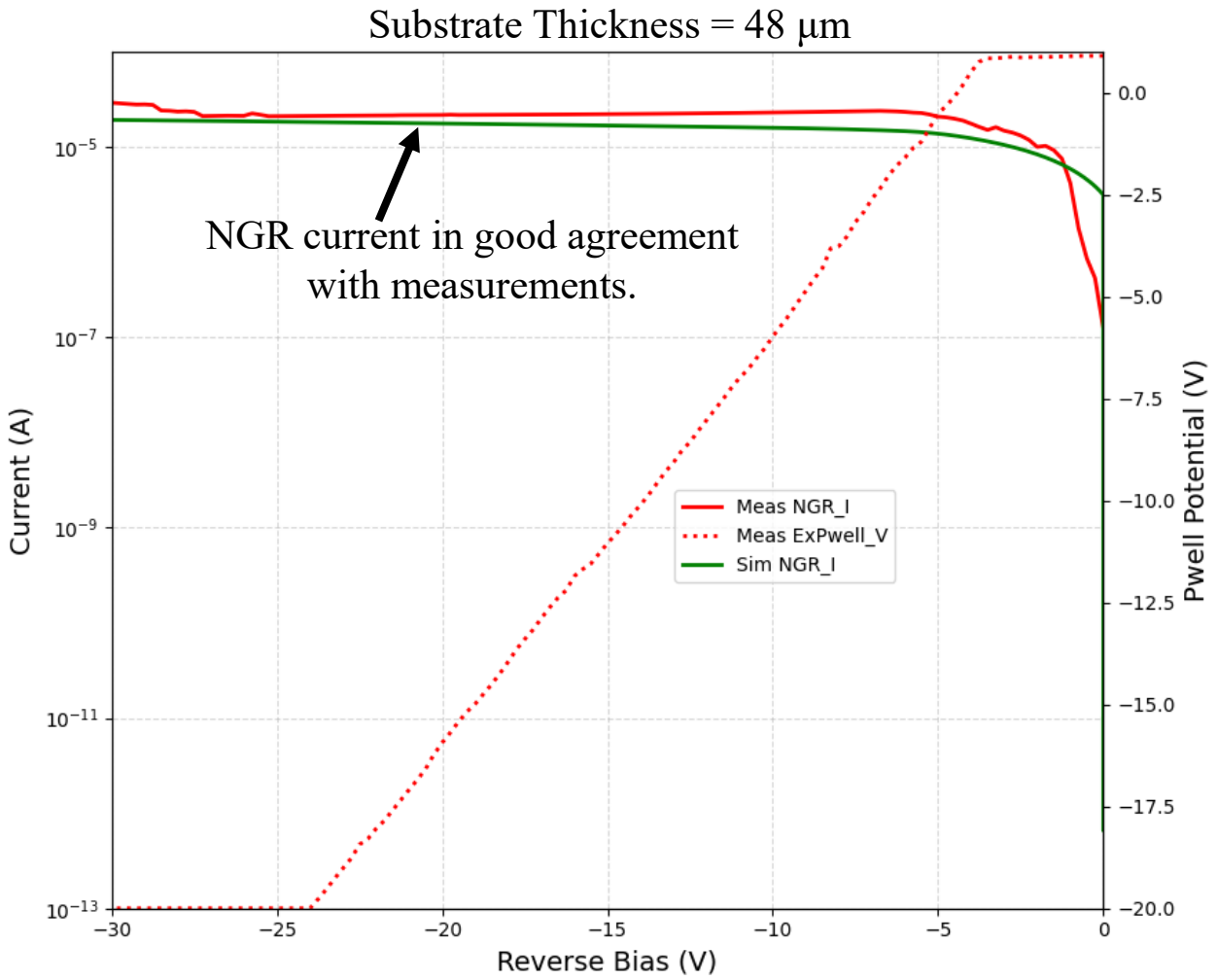

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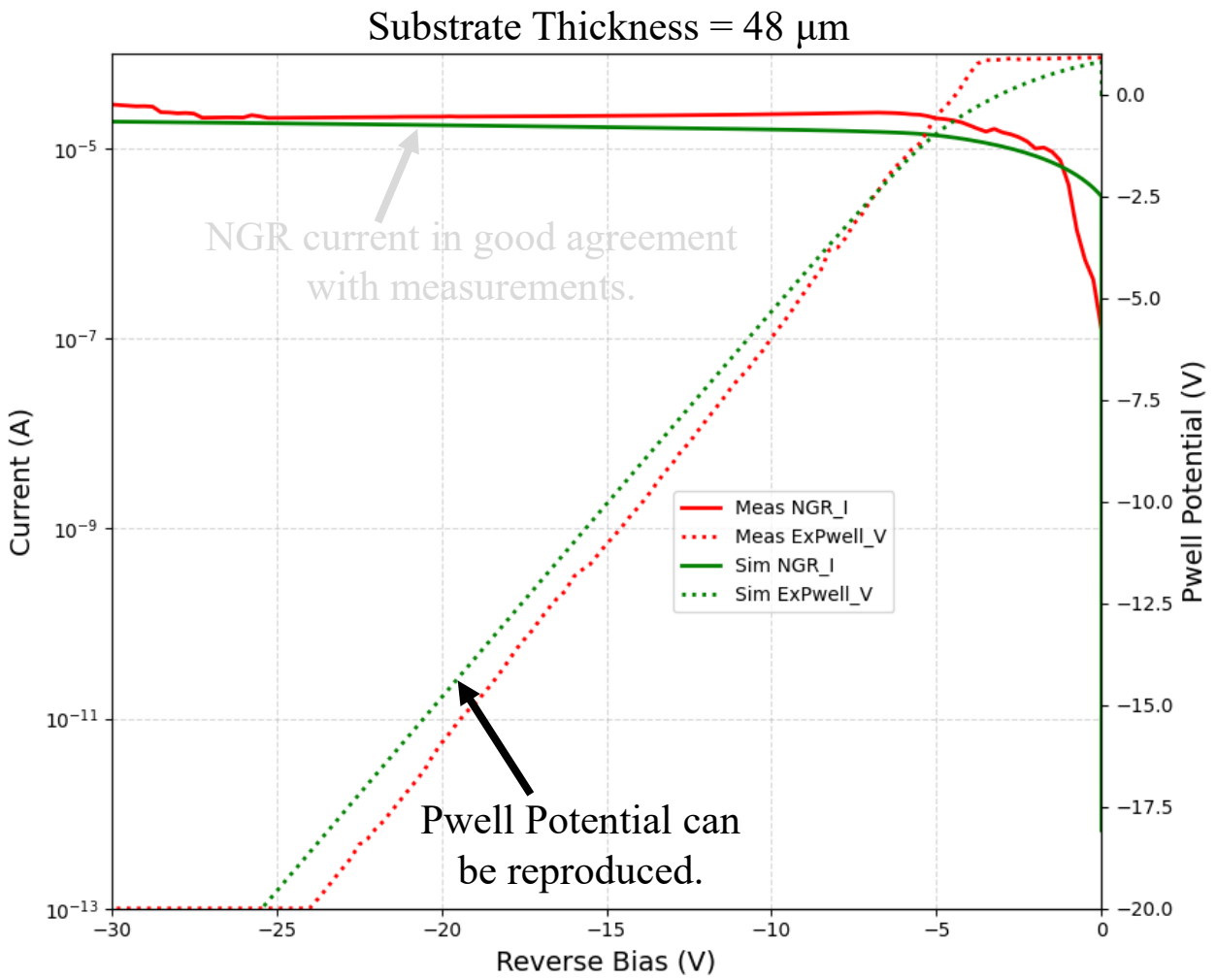

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5. Radiation campaign…

This work was supported by the European Union's Horizon Europe research and innovation programme under the 1MICRON project – "New Technology for 1 MICRON Resolution Biomedical Imaging" (grant agreement No. 101186826)."

Karolinska Institutet

TECHNISCHE UNIVERSITÄT MÜNCHEN

Istituto Nazionale di Fisica Nucleare

Thank you!

1. Thickness = ***715 µm***
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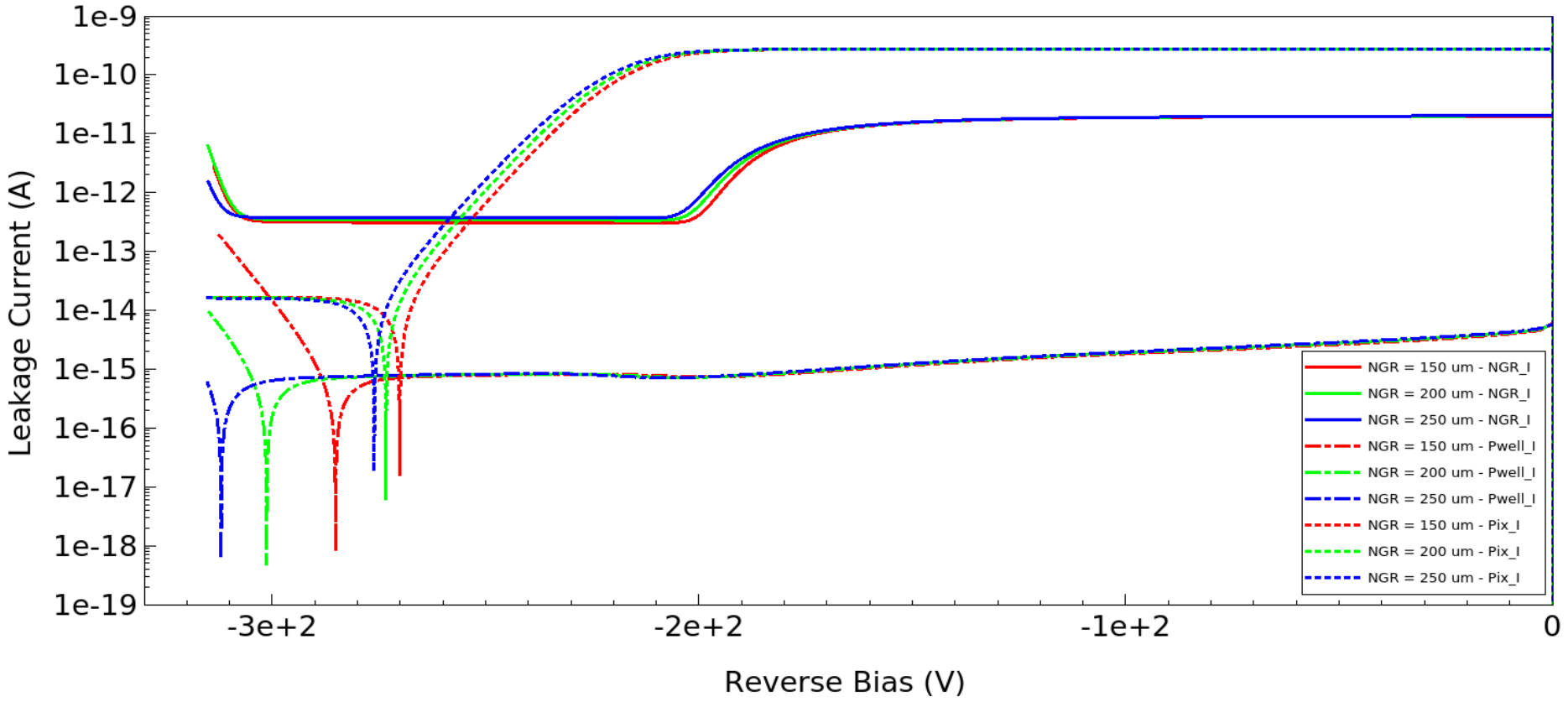
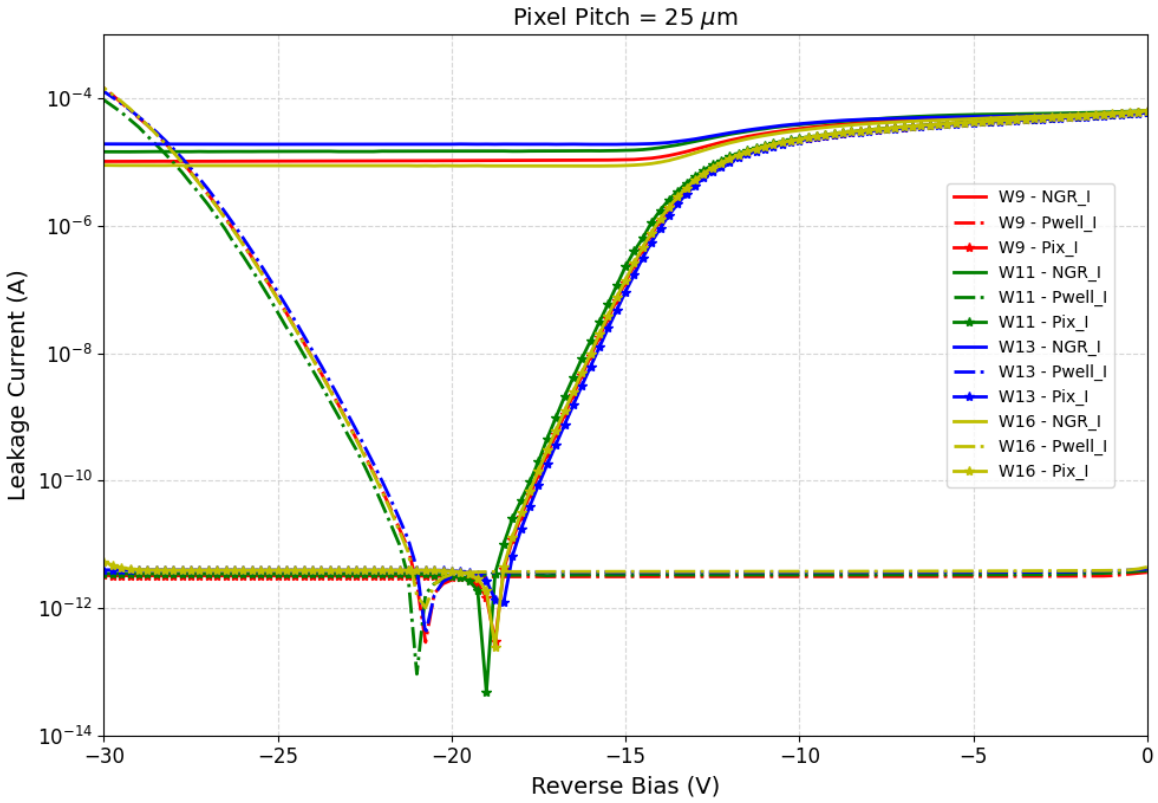
5 Floating Pwells (with Field Plate)




Pixel Pitch = 25 μm
Leakage Current (A)
Reverse Bias (V)
W9 - NGR_I
W9 - Pwell_I
W9 - Pix_I
W11 - NGR_I
W11 - Pwell_I
W11 - Pix_I
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W13 - Pwell_I
W13 - Pix_I
W16 - NGR_I
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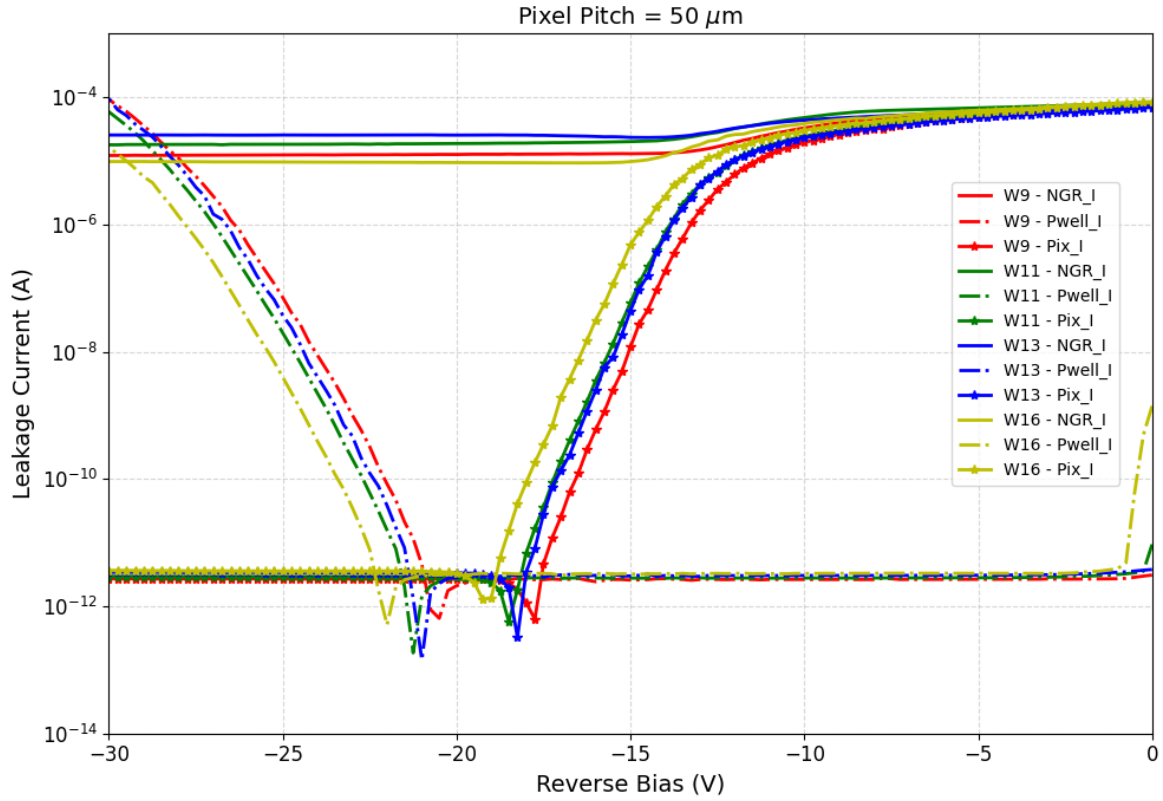
Pixel Pitch = 50 μm
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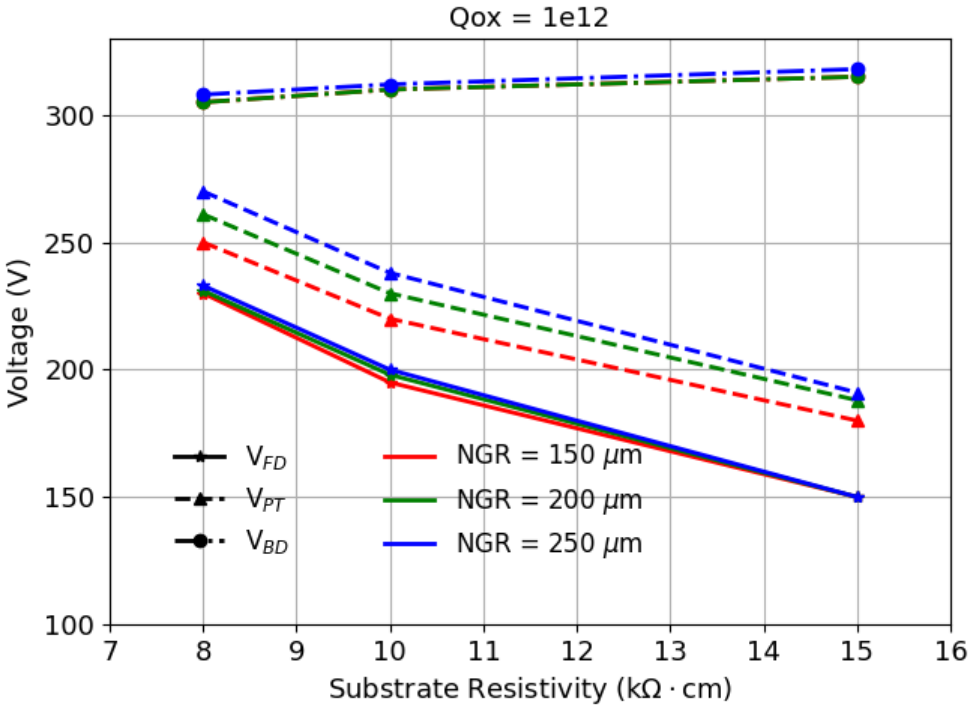
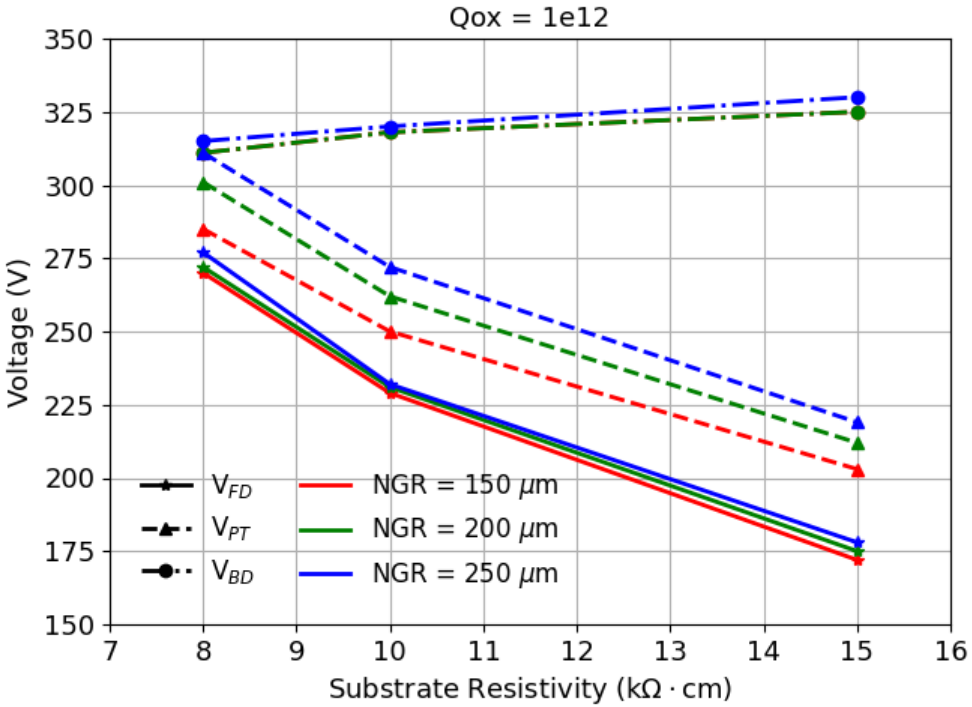
Reverse Bias (V)
W9 - NGR_I
W9 - Pwell_I
W9 - Pix_I
W11 - NGR_I
W11 - Pwell_I
W11 - Pix_I
W13 - NGR_I
W13 - Pwell_I
W13 - Pix_I
W16 - NGR_I
W16 - Pwell_I
W16 - Pix_I

5 Floating Pwells, Substrate Thickness = 650 µm



5 Floating Pwells, Substrate Thickness = 715 µm



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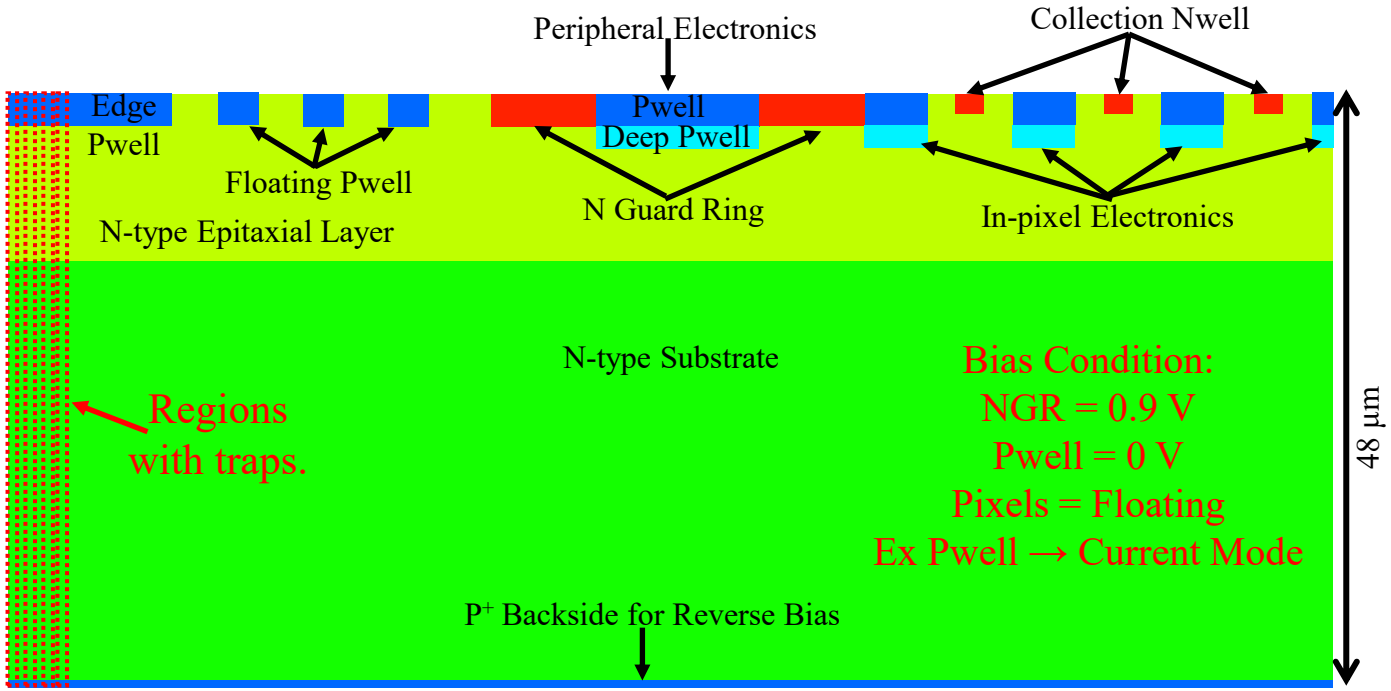
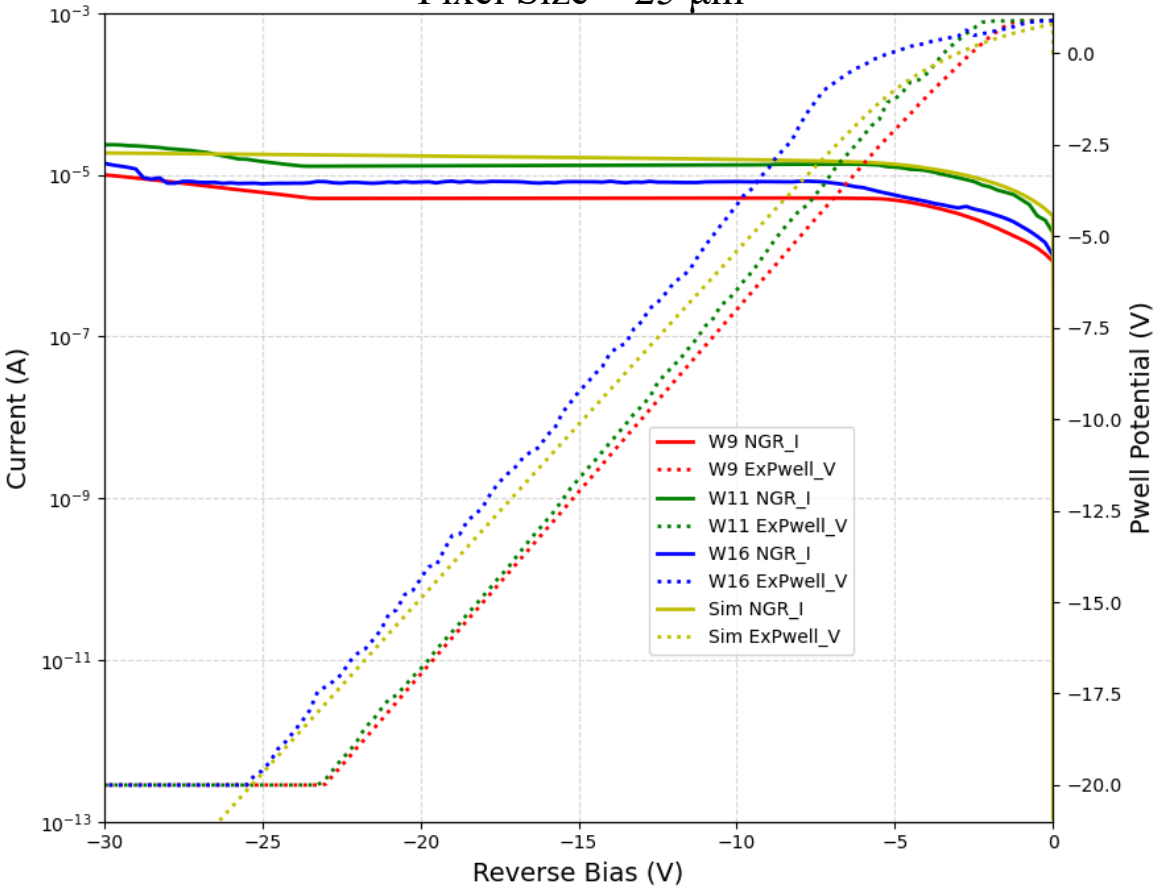
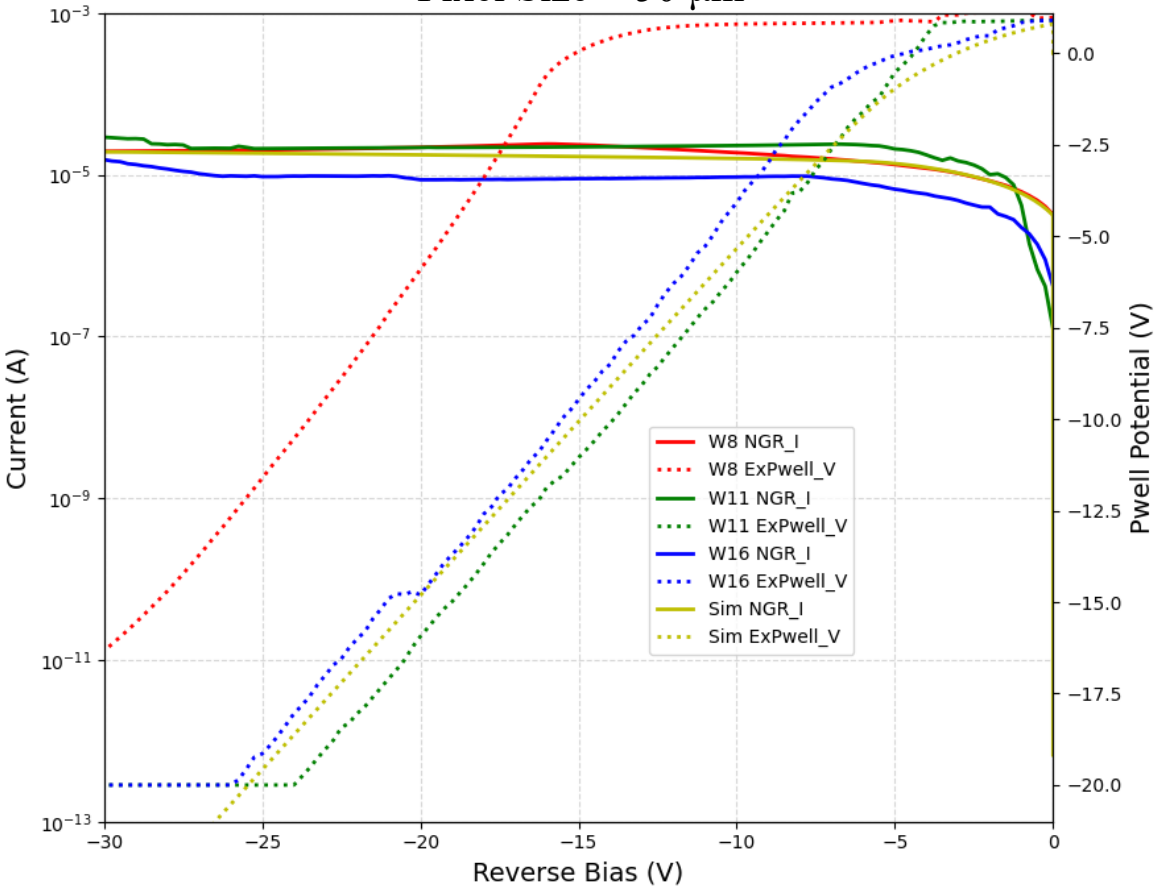


Substrate Thickness = 48 µm
Pixel Size = 25 µm



Substrate Thickness = 48 µm
Pixel Size = 50 µm