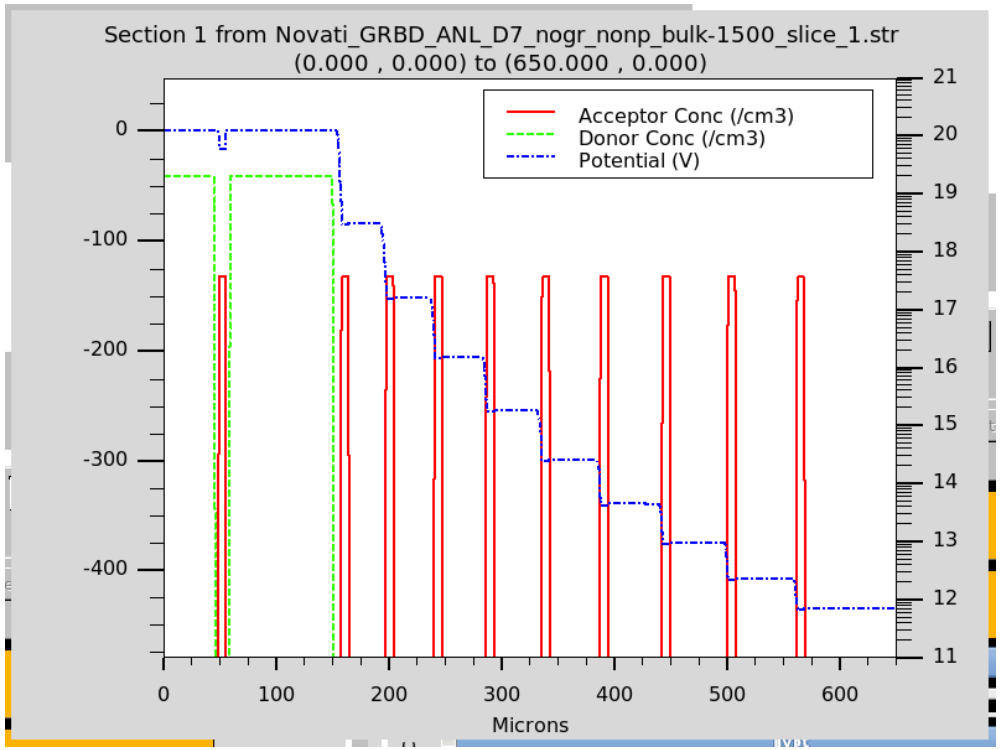
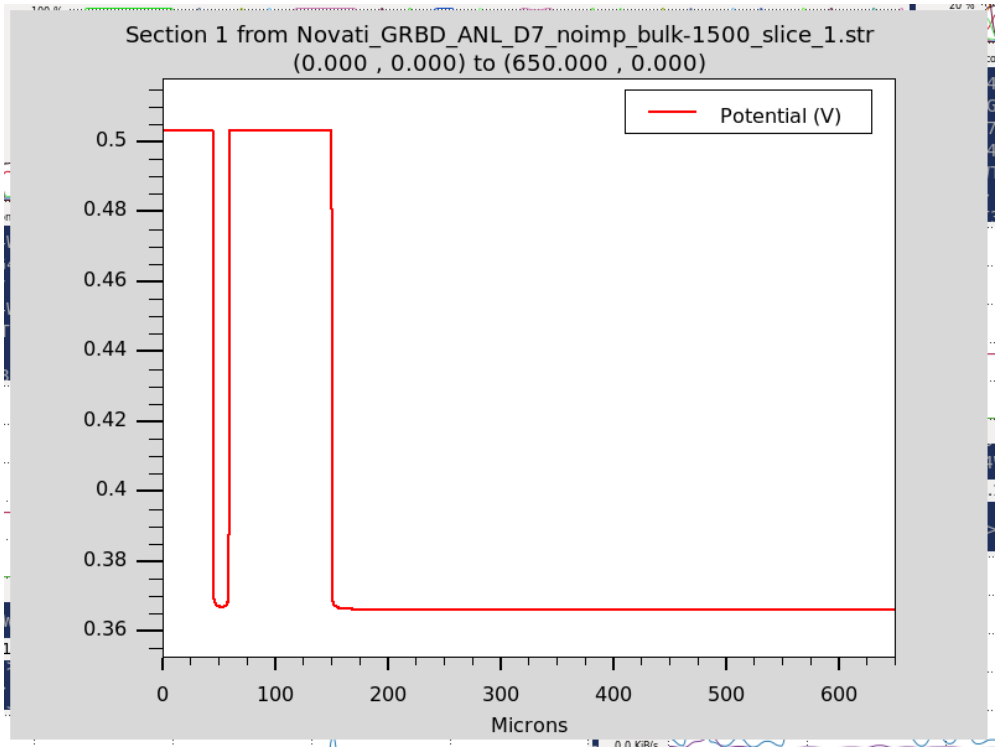
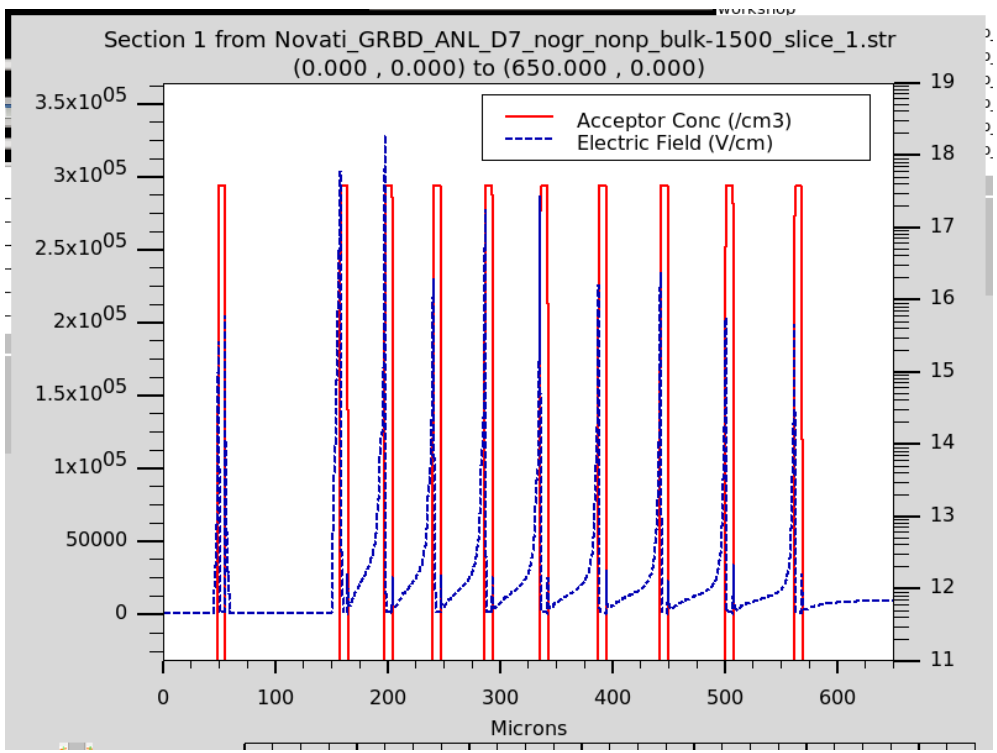
Surface Potential

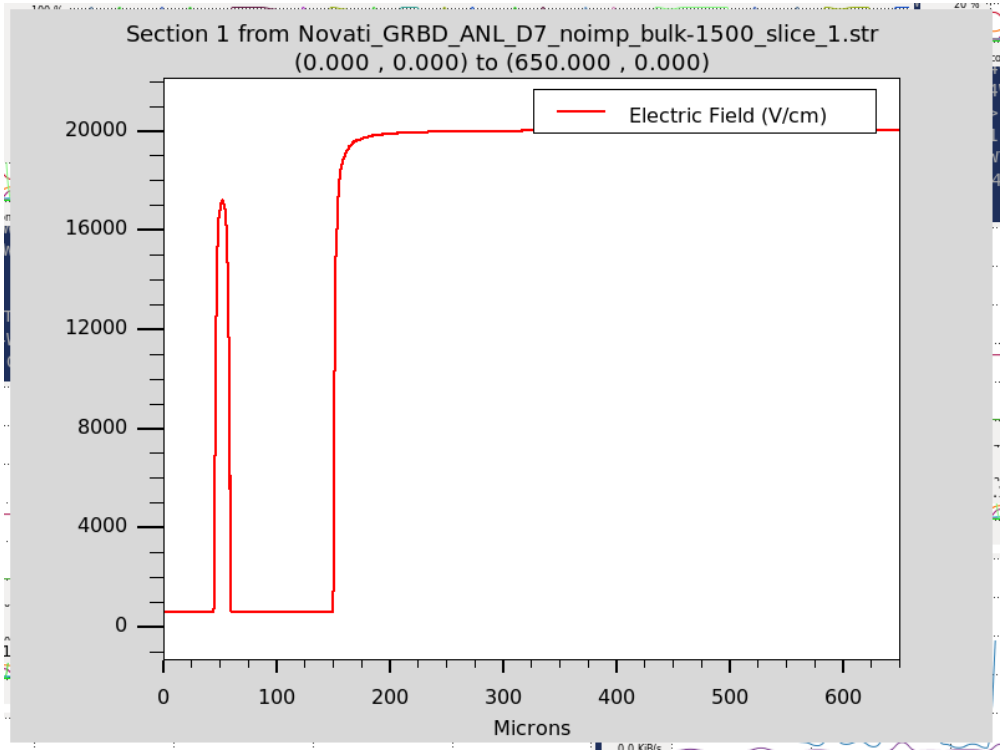




- Left: P-stop implants Only
- Right: No implants
- The guard ring provides lateral blocking junctions (which N-P junction) to drop potential across the device.
- We must drop potential → N-P junction with reverse bias is required!! → **P-Stop actually provides the potential drop!!!**

Surface Electric Field

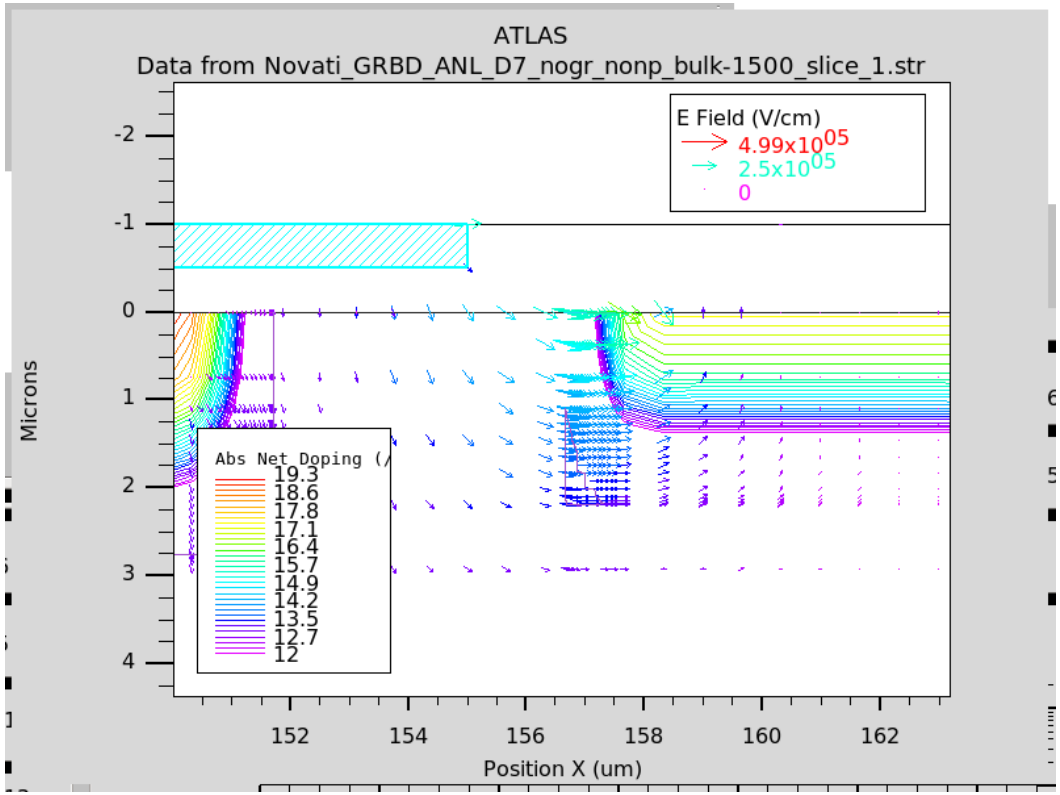




- As expected, the electric field at N-P junction is much higher (at leatst an order of magnitude) than vanilla device case.
- As seen in the E-field between CCR and GR1, the depletion region was suppressed by n+ CCR contact.
- The peak E-field decreases as the distance between p-stops increase at outer guard rings(GR4 to 8.)
- We can decrease E-field intensity by decreasing the doping concentration of p-stop.
- In other words, we need heavier doped p+ to reduce potential further but the doping concentration is limited by breakdown characteristic.

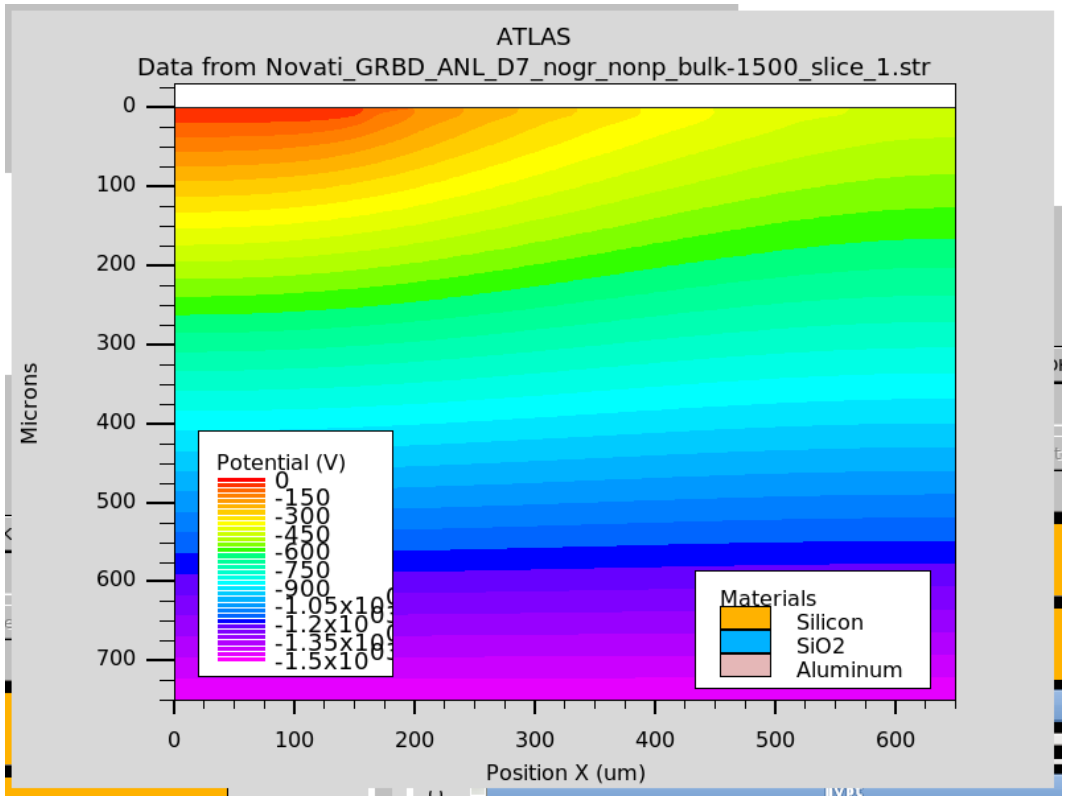
$$\mathcal{E}(x) = \frac{qN_d\,(x - x_n)}{\varepsilon_s}$$

Electric Field (Vector 2D Plot)



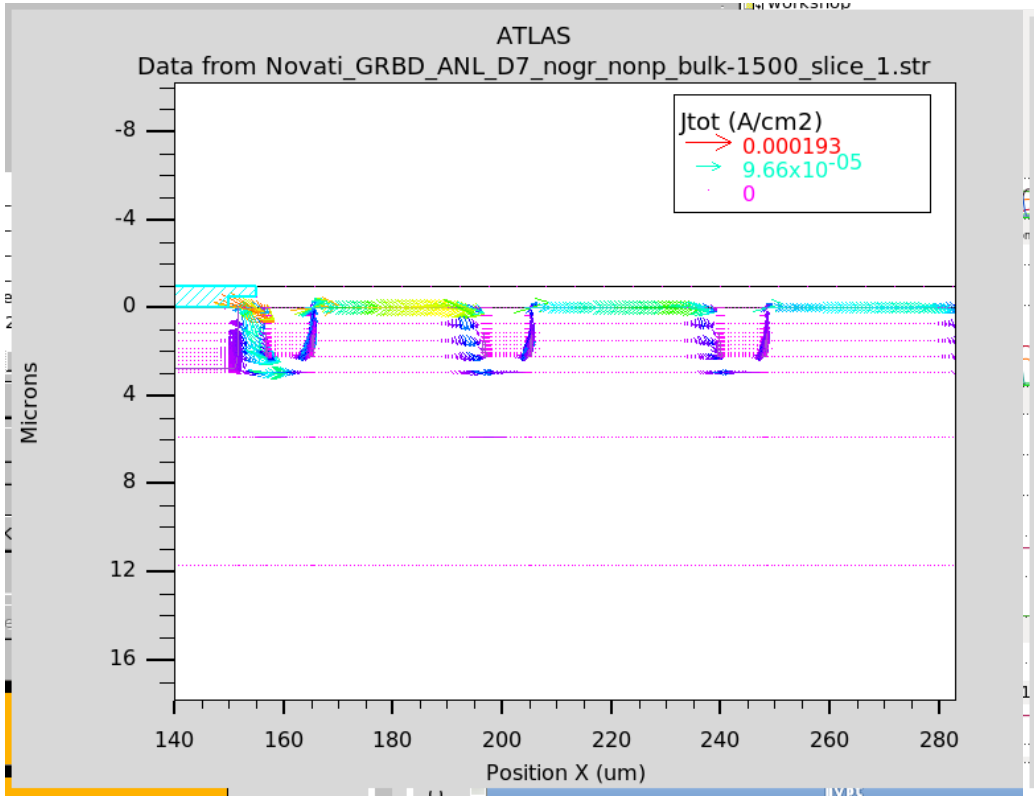
- The CCR overhang electrode amplifies electric field intensity.
- Reducing the CCR right side overhang can be another way to reduce GR1 p-stop electric field.
- However, we cannot entirely remove the overhang since right side of CCR n+contact overhang is also reverse biased.
- IMO, we can reduce the right overhang of CCR to barely cover the lateral diffusion length of n+ implant.

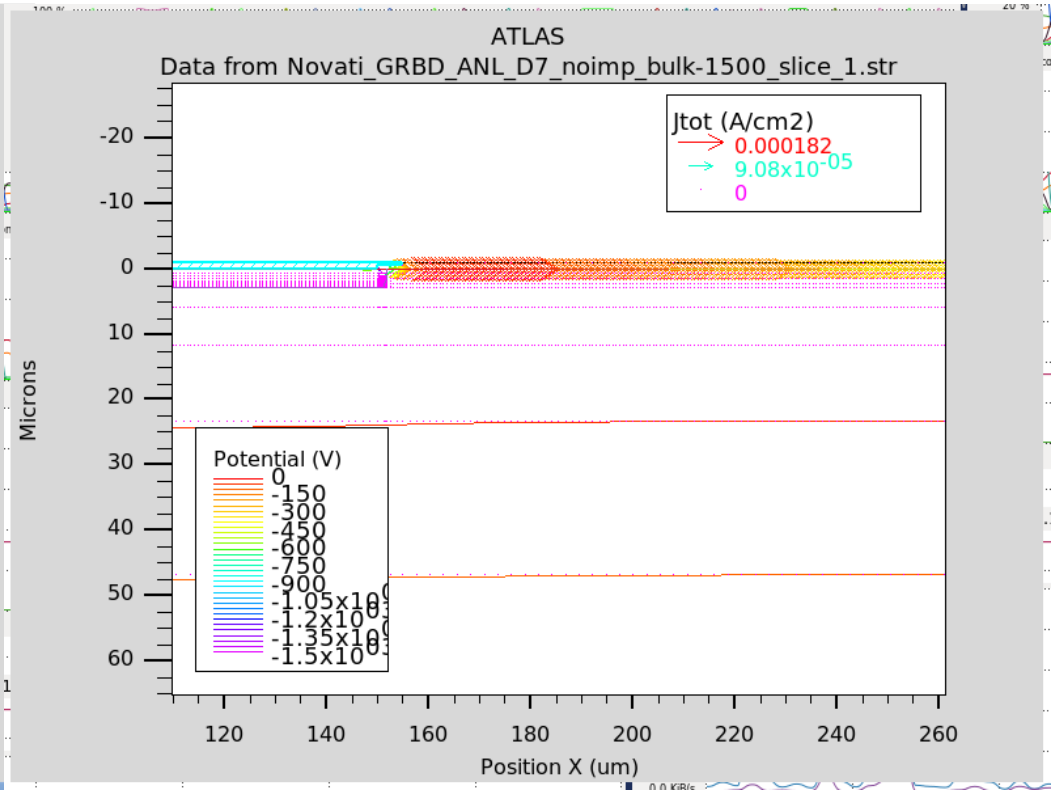
Potential (2D Plot)



- Current device has 600 um of space from pixel edge.
- The potential at the wafer edge is still sitting at -500 V range while the bulk bias is at -1000 V.
- Since the potential drop at the outer guard rings (GR4 ~ 8) are not as high as inner guard rings, we may implement a biased GR design policy to minimize the edge potential.
- Alternatively, we can install more p-stops, or more guard rings, to even reduce the potential difference at the wafer cut.

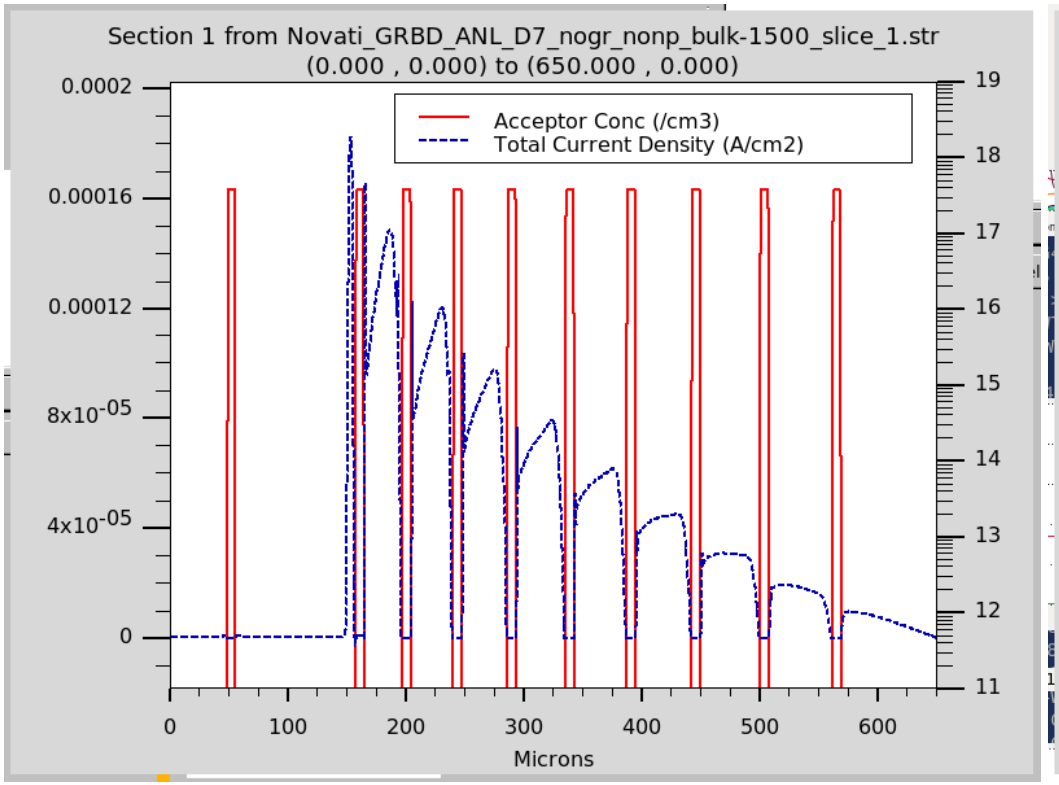
Current Density (Vector 2D Plot)

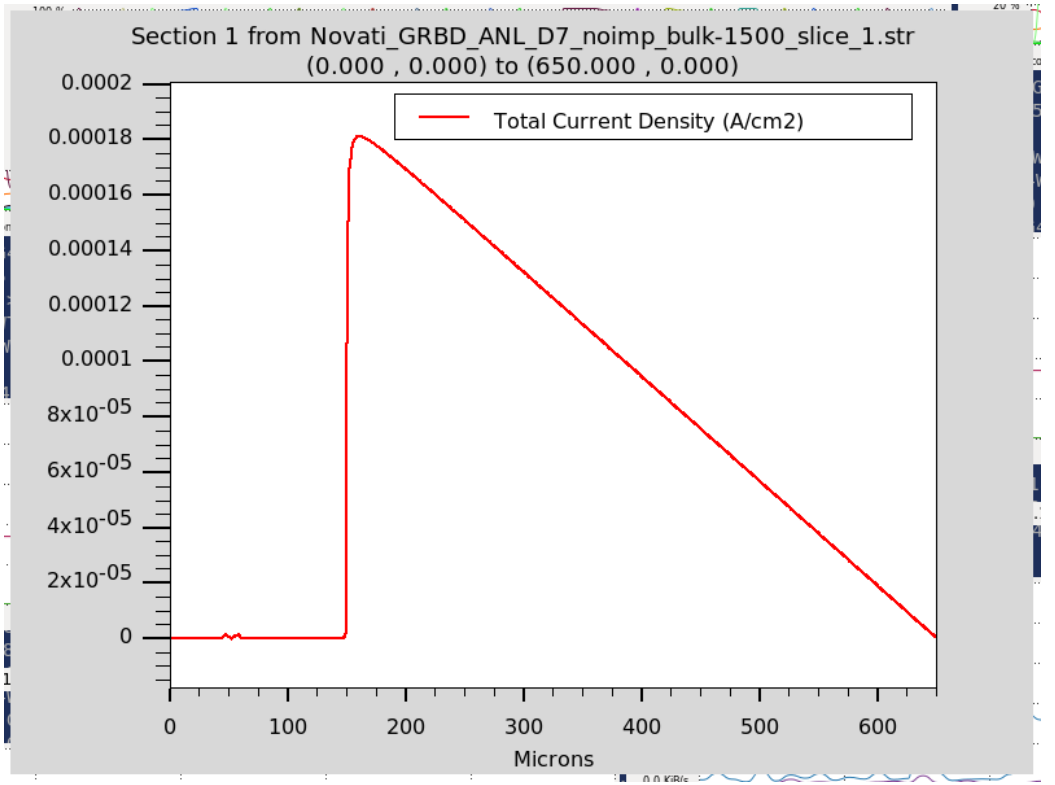




- Of course, the reverse biased junctions reduce the surface leakage current → Much less noise.
- Implementing n+ also provides more reverse biased contacts: even less noise as well as GR metal overhangs to even reduce the steep electric field at p-stop contacts.

Surface Current Density





Summary

- P-stop is actually important in the n-in-p structure!!
- Unnecessary overhang extension may cause early breakdown.
- N+ guard ring contacts may prove useful with metal overhang provider.
- Also, the n+ contacts suppress the electric field between guard rings: reduces leakage current even further.
- Since our design parameters are limited, overhang length manipulation can be the start.