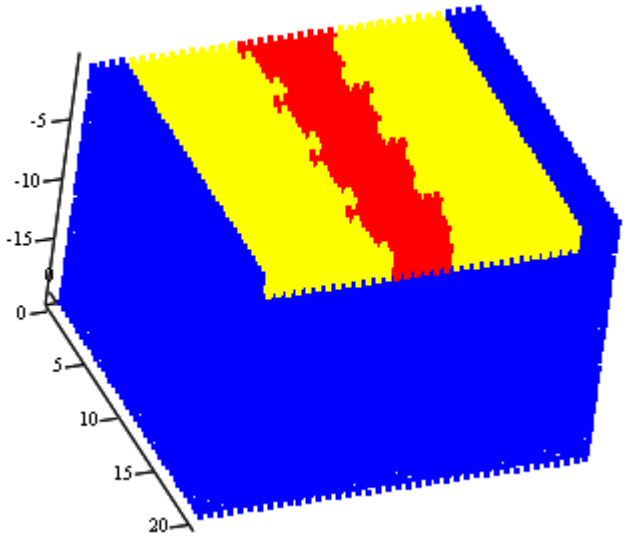
Progress with CPC-T Potential Studies

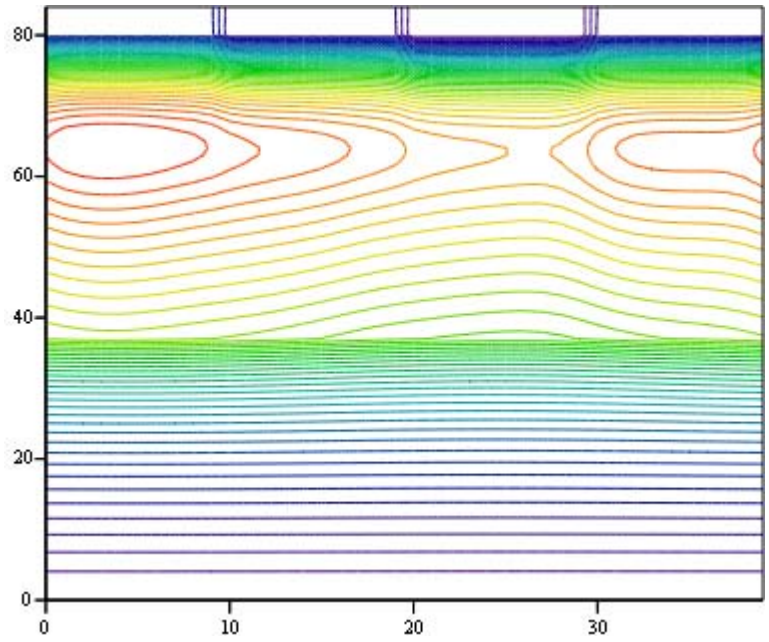
- Look at:
  - Changing width of Christmas Tree.
  - Changing depth of supplementary channel in various ways.
  - “Double” Christmas Tree.
  - Effects of alignment errors.

Christmas Tree

- Dopant concentrations.
- Red, at surface 3.6 x 10^{22} m^{-3}.
- Yellow, at surface 1.2 x 10^{22} m^{-3}.
- Distributions half Gaussian with $\sigma = 0.41$ μm.
- Blue, 1 x 10^{19} m^{-3}, uniform.
- "Trees", 5 μm decreasing to 3 μm.



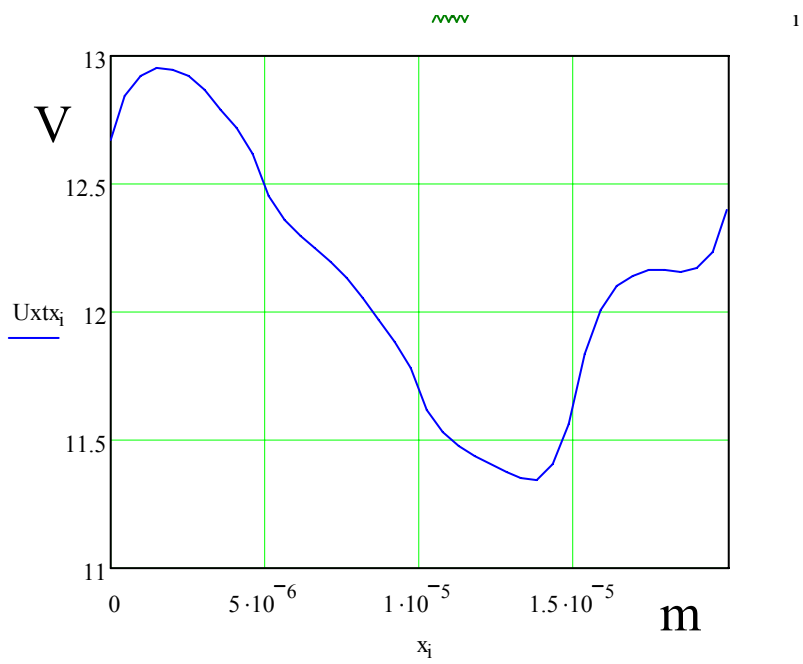
- Cross section through gates.
- Upper section "expanded" due to varying vertical step size.



Upfxy

Narrow Christmas Tree

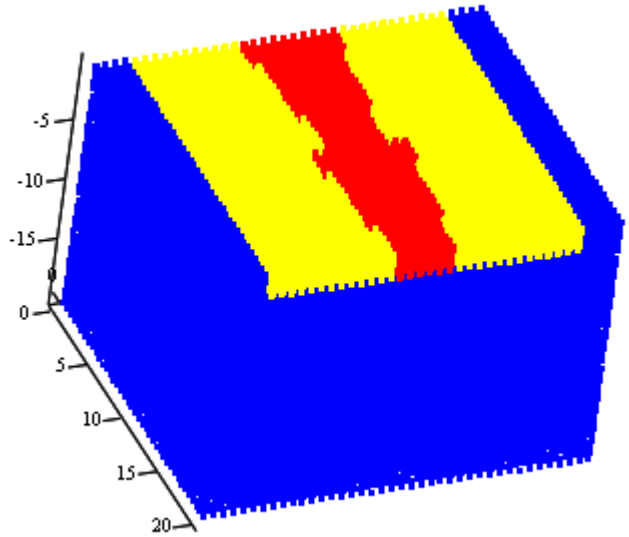
- Potential along Christmas tree:



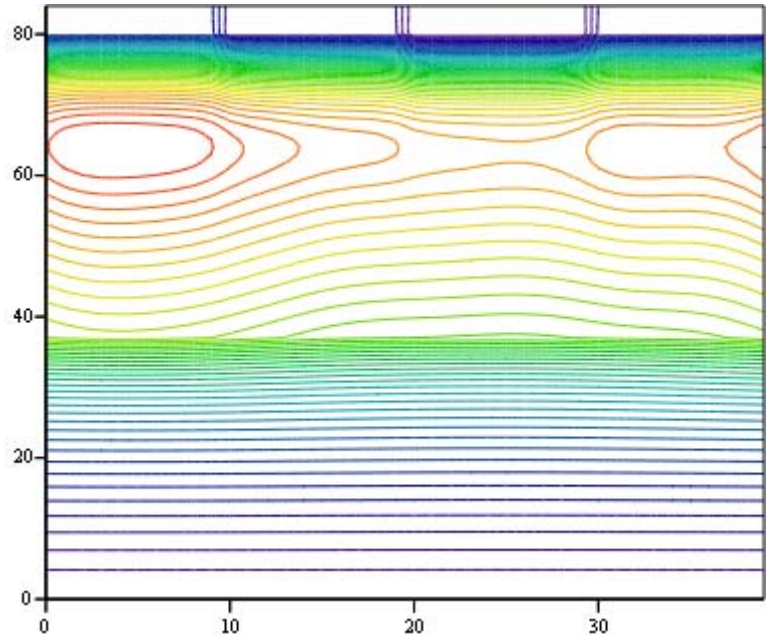
- $\Delta V \sim 1.61$ V.
- Asymmetry of potential under gates apparent.
- Depth of buried channel 0.61 μm.

Double Christmas Tree

- Dopant concentrations.
- Red, 3.6 x 10^{22} m^{-3}.
- Yellow, 1.2 x 10^{22} m^{-3}.
- Blue, 1 x 10^{19} m^{-3}.
- Width of supplementary channel 5 μm decreasing to 3 μm.



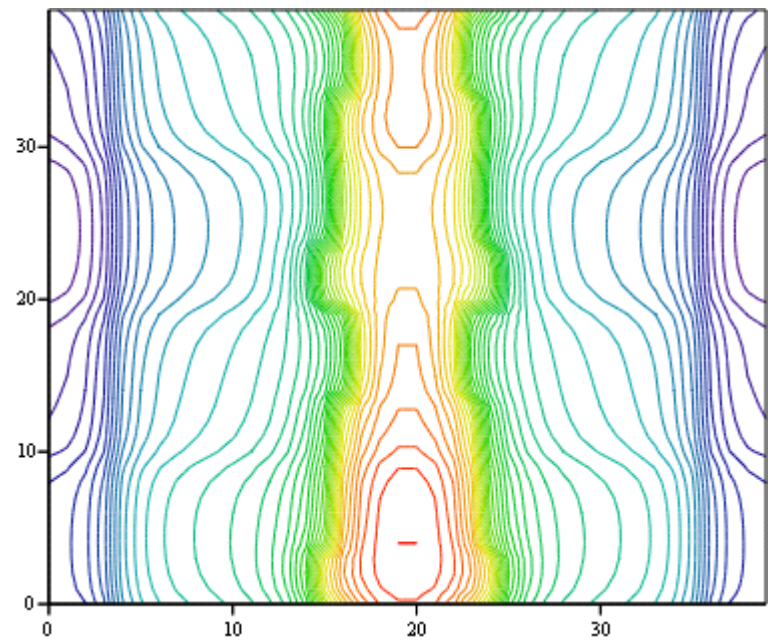
- Cross section through gates.



Upfxy

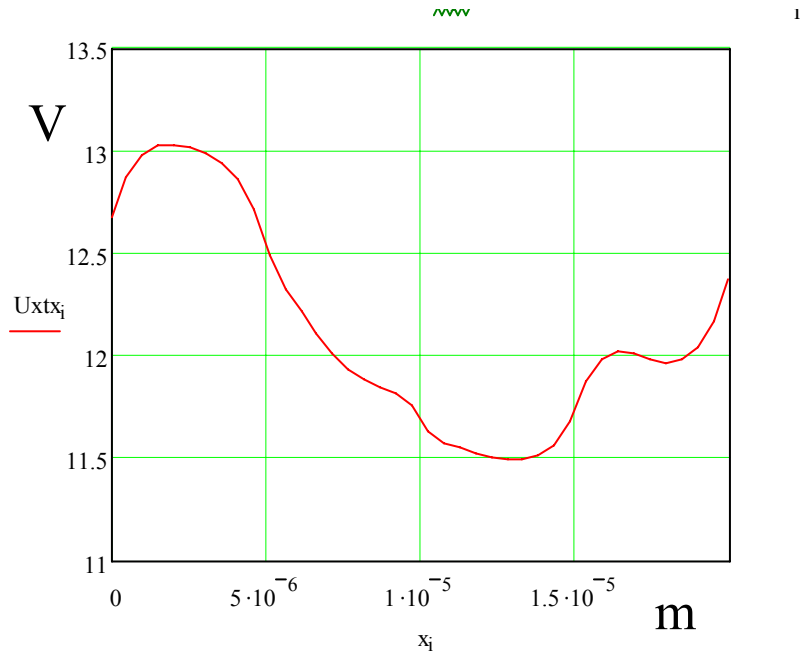
Double Christmas Tree

- Horizontal section at depth of buried channel, 0.61 μm.



Upfxz

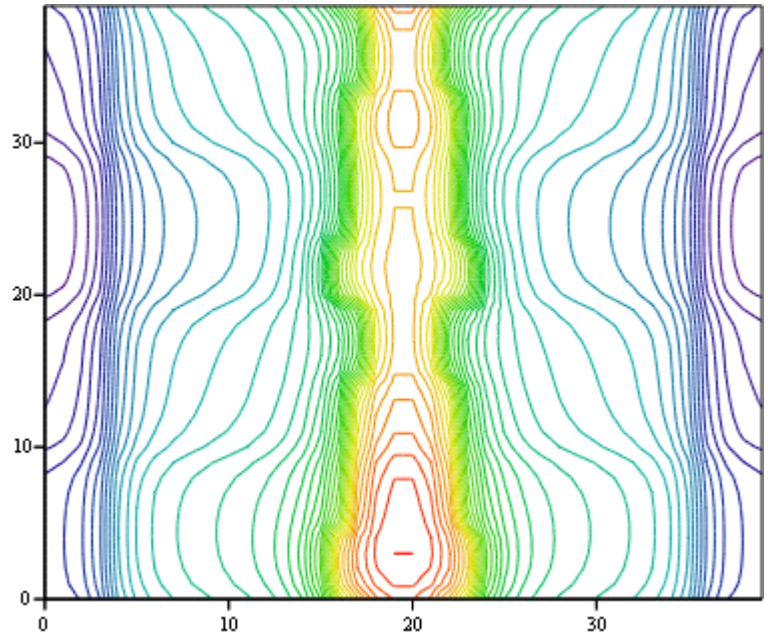
- Potential along Christmas tree:



- ΔV ~ 1.54 V
- Asymmetry under gates small.

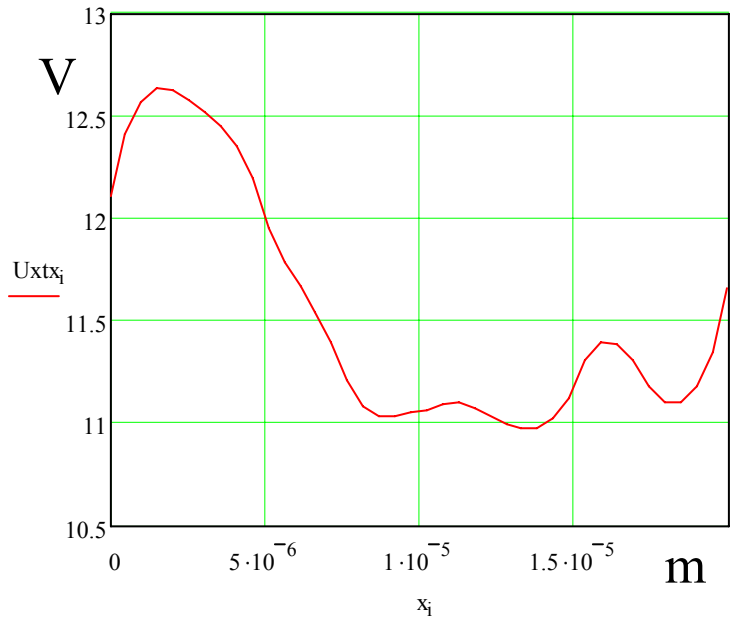
Narrow Double Christmas Tree

- Horizontal section at depth of buried channel.
- Width of supplementary channel 4 μm decreasing to 2 μm



Upfxz

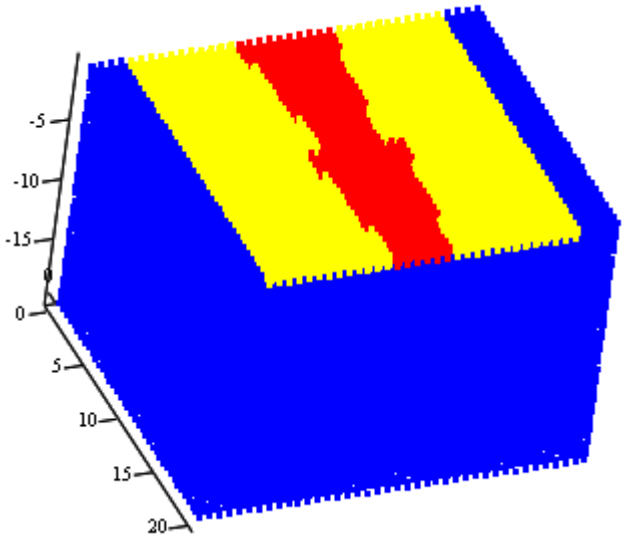
- Potential along Christmas tree:



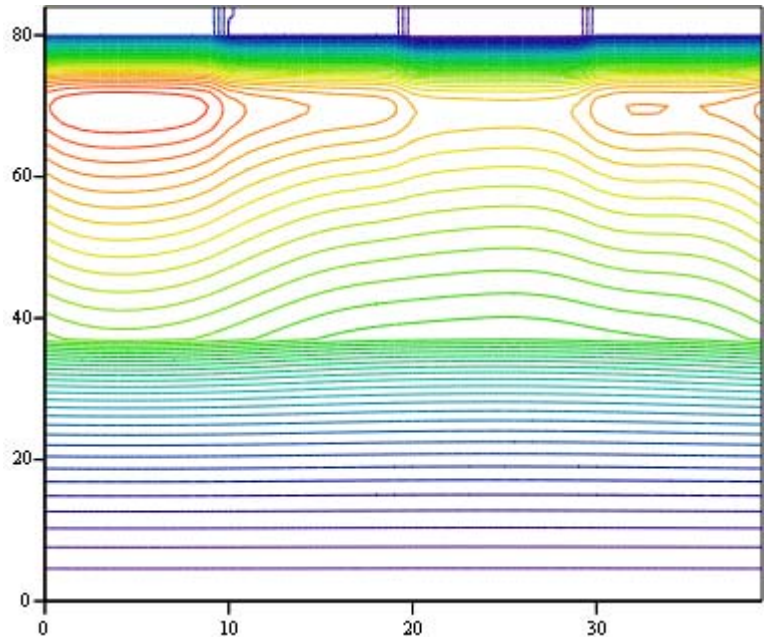
- ΔV ~ 1.66 V
- Asymmetry under gates increased.
- Potential “bump” where Christmas Tree structure underlies boundary between gate 2 and pedestal gate.

Shallow double Christmas Tree

- Dopant concentrations.
- Red, 7.2 x 10^{22} m^{-3}, σ = 0.2 μm.
- Yellow, 2.4 x 10^{22} m^{-3}, σ = 0.2 μm.
- Blue, 1 x 10^{19} m^{-3}.
- Width of supplementary channel 5 μm decreasing to 3 μm



- Cross section through gates.

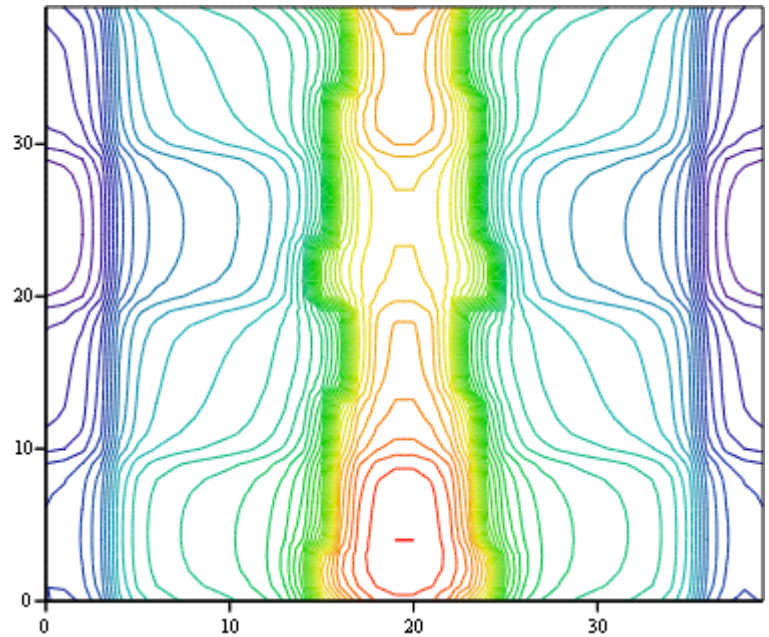


Upfxy

- Some decrease in depth of supplementary channel.

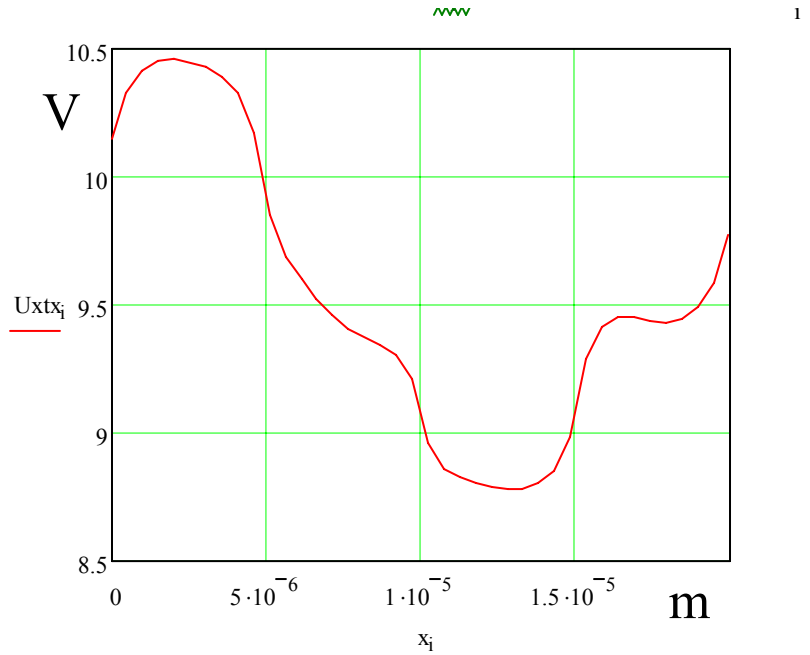
Shallow double Christmas Tree

- Horizontal section at depth of buried channel (0.34 μm).



Upfxz

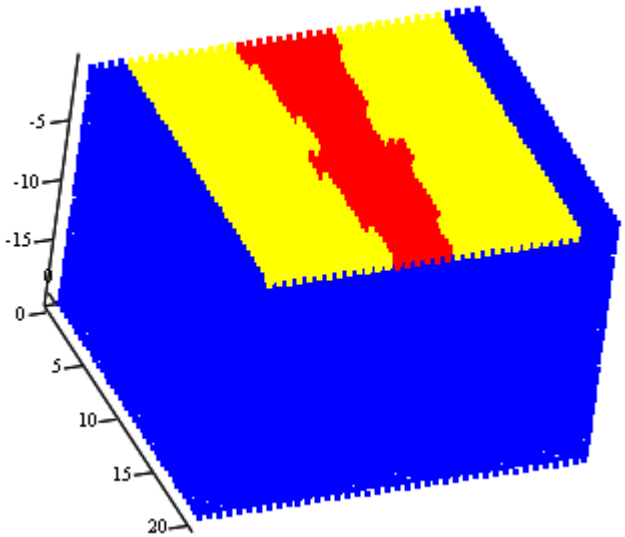
- Potential along Christmas tree:



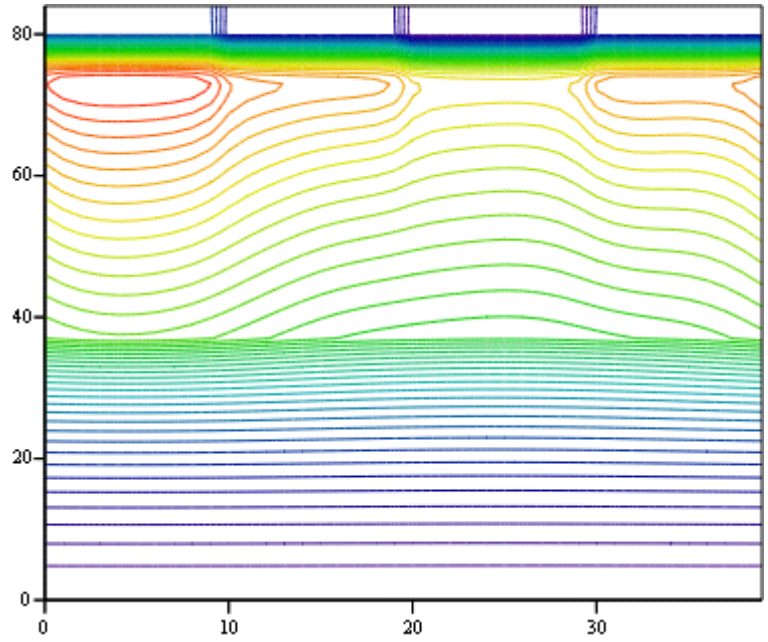
- ΔV ~ 1.67 V
- Decrease in depth causes increase in ΔV.

Very shallow double Christmas Tree

- Dopant concentrations.
- Red, 15 x 10^{22} m^{-3}, σ = 0.1 μm.
- Yellow, 5 x 10^{22} m^{-3}, σ = 0.1 μm.
- Blue, 1 x 10^{19} m^{-3}.
- Width of supplementary channel 5 μm decreasing to 3 μm.



- Cross section through gates.

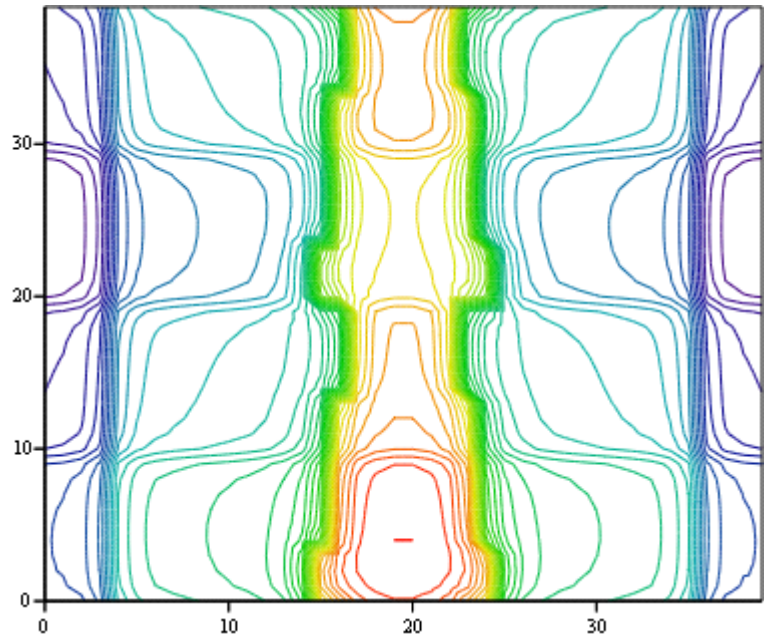


Upfxy

- Further decrease in depth of supplementary channel achieved.

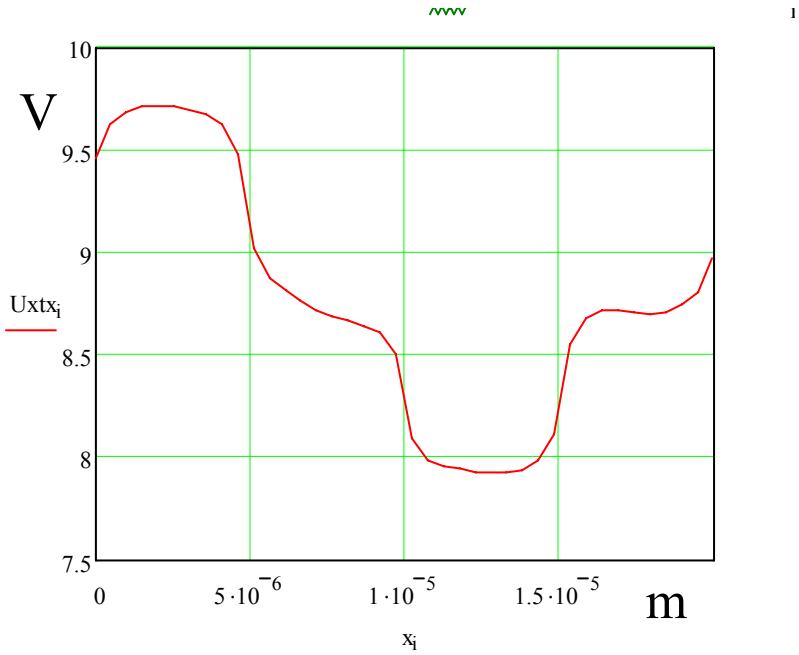
Very shallow double Christmas Tree

- Horizontal section at depth of buried channel (0.16 μm).



Upfxz

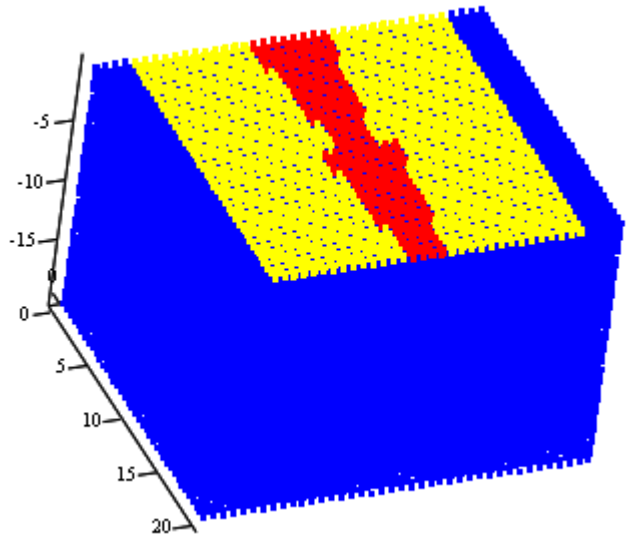
- Potential along Christmas tree:



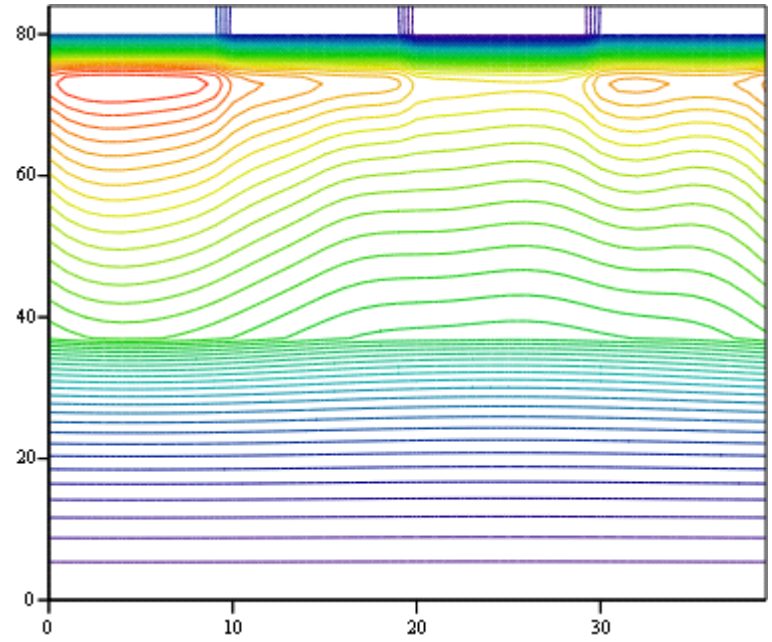
- ΔV ~ 1.79 V
- Further decrease in depth causes further increase in ΔV.

Very shallow narrow double Christmas Tree

- Dopant concentrations.
- Red, 15 x 10^{22} m^{-3}, σ = 0.1 μm.
- Yellow, 5 x 10^{22} m^{-3}, σ = 0.1 μm.
- Blue, 1 x 10^{19} m^{-3}.
- Width of supplementary channel 4 μm decreasing to 2 μm.



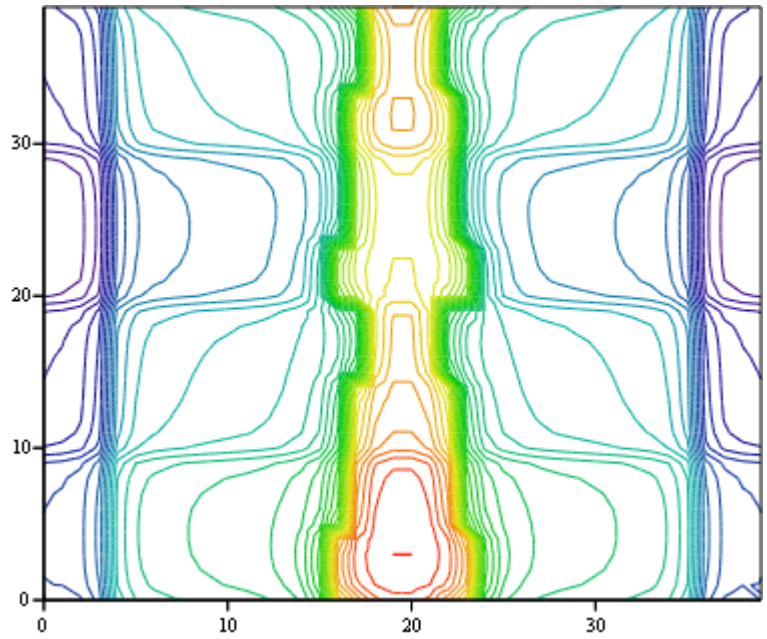
- Cross section through gates.



Upfxy

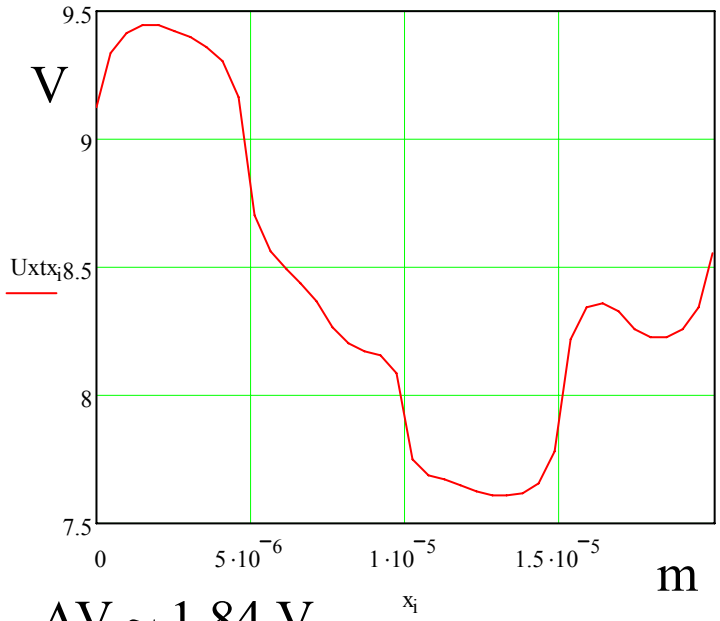
Very shallow narrow double Christmas Tree

- Horizontal section at depth of buried channel (0.16 μm).



Upfxz

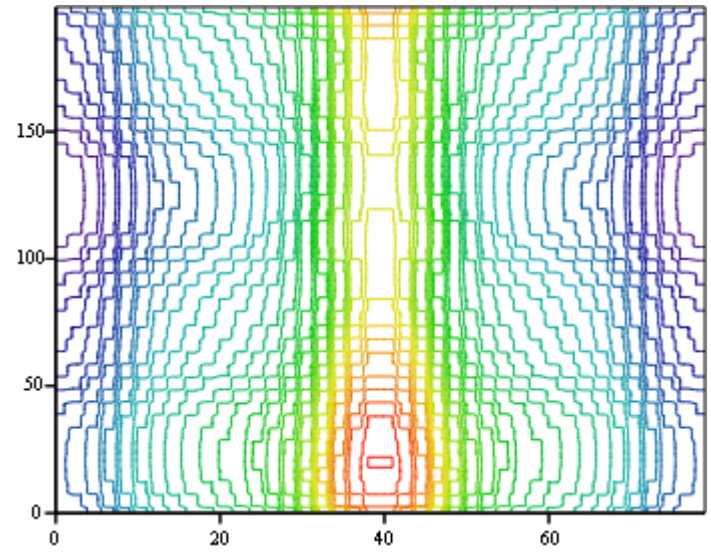
- Potential along Christmas tree:



- ΔV ~ 1.84 V
- Further increase in ΔV due to very narrow Christmas Tree structure, but size of potential bumps increased.
- Must check this is not just effect of grid resolution.

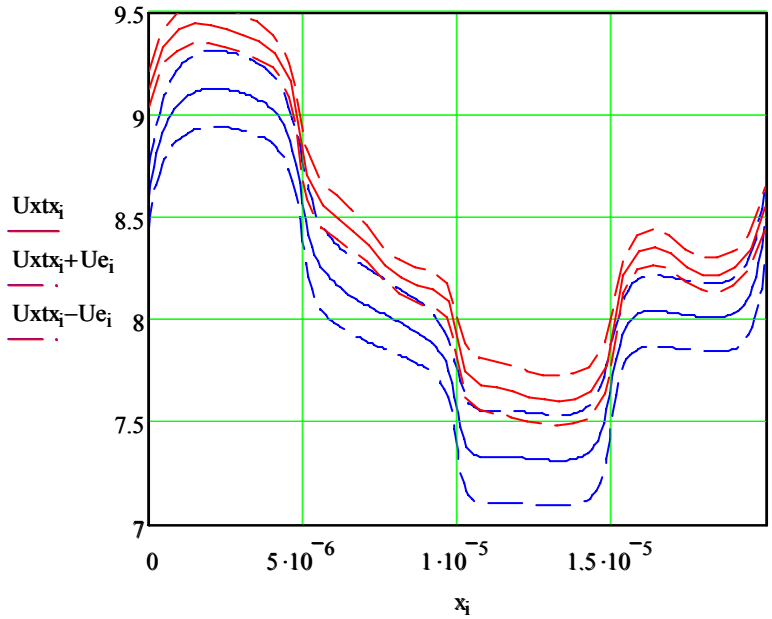
Higher resolution studies

- Look at only top 1.2 μm of CCD using fine grid with potential of lower plane determined from coarse grid:



$UGxz^{T}$

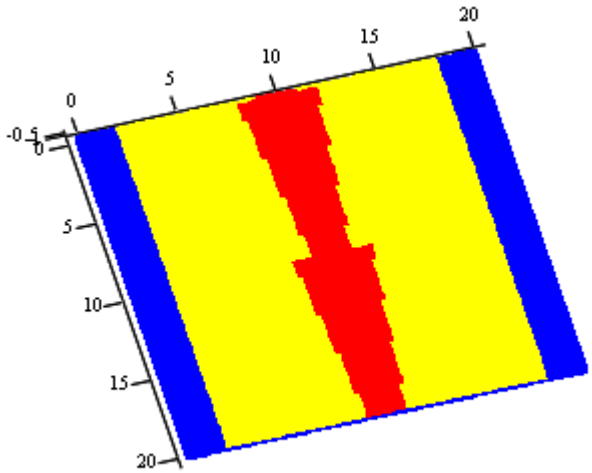
- Look at very shallow narrow double Christmas Tree.
- Check "higher resolution" against previous results:



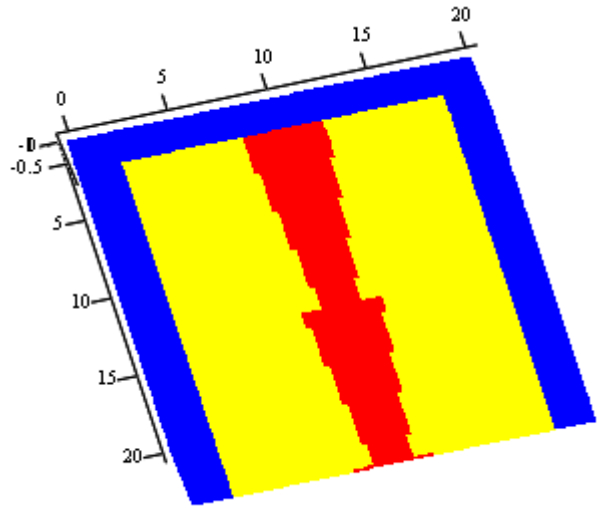
- Grid poorly chosen!
- ΔV = 1.821 V for

Higher resolution studies – errors in implant position

- Shift implants w.r.t. gates by $\delta = +200$ nm.

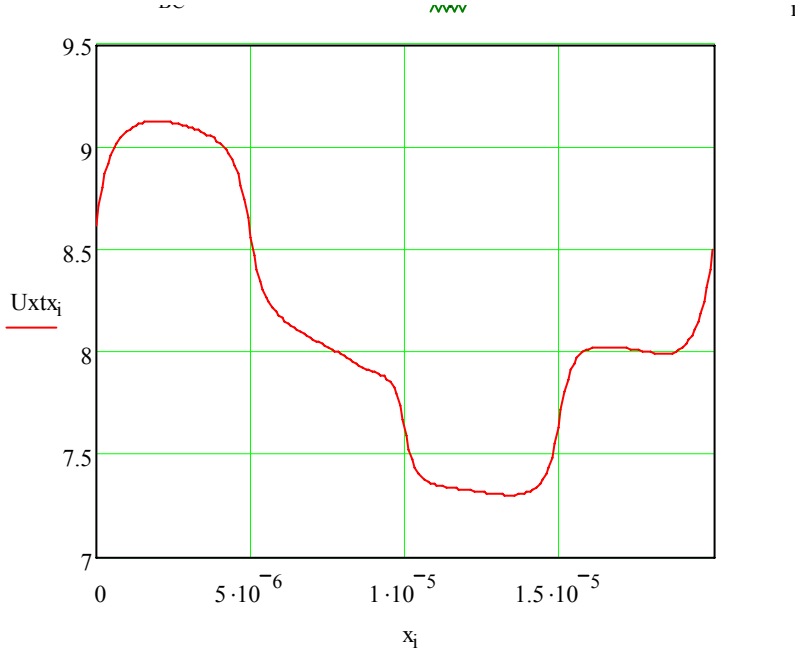


- Shift implants w.r.t. gates by $\delta = -200$ nm.

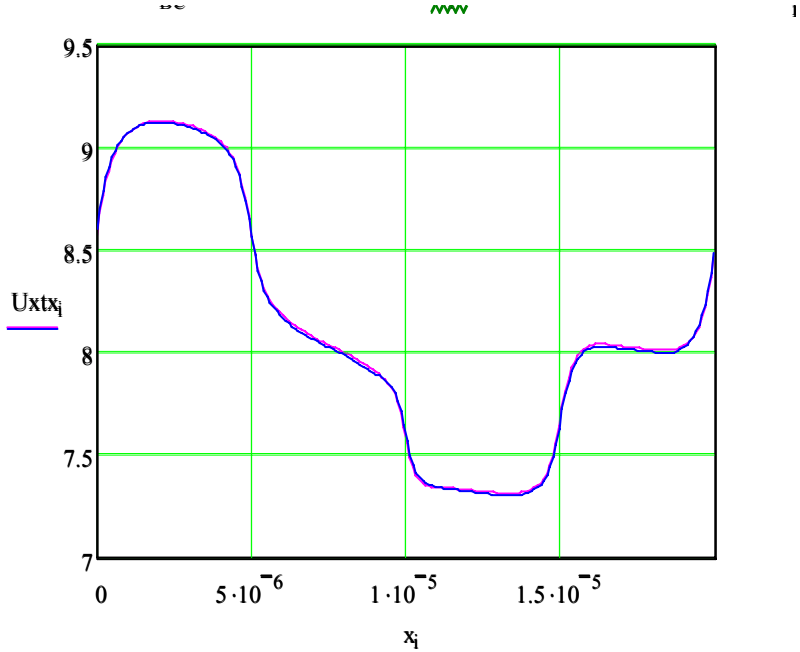


Effect of errors in implant position

- Red, nominal position.

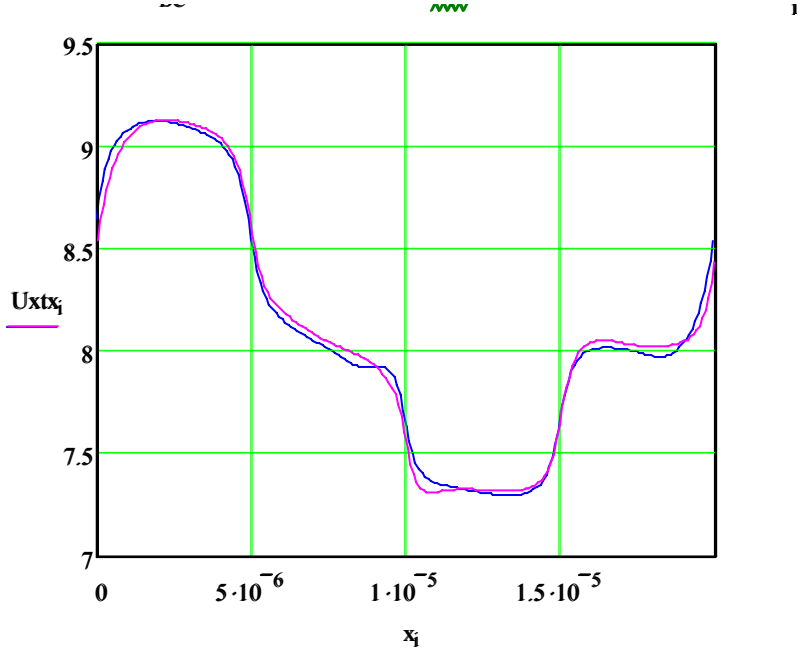


- Magenta, δ = + 200 nm.
- Blue, δ = – 200 nm.

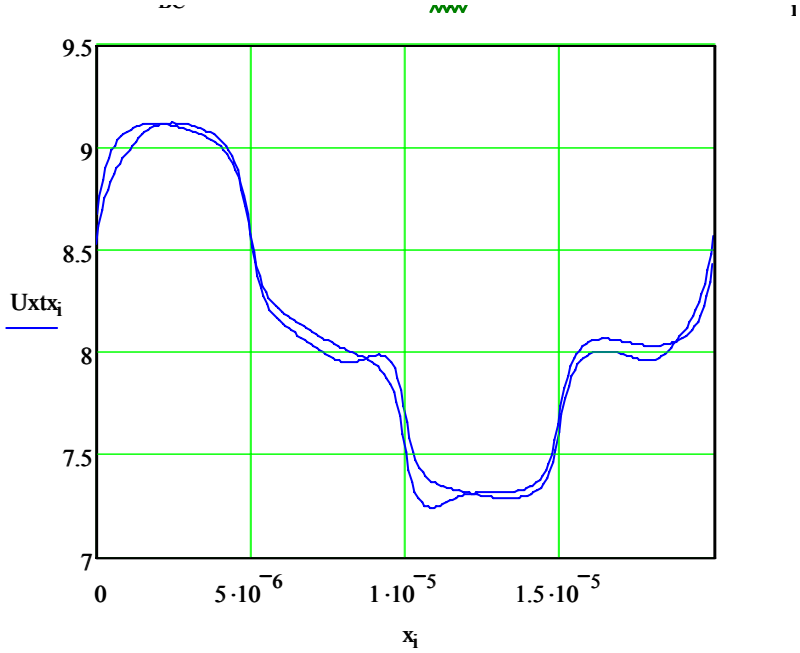


Effect of errors in implant position

- Magenta, $\delta = +\ 0.6\ \mu m.$
- Blue, $\delta = -\ 0.6\ \mu m.$



- Magenta, $\delta = +\ 1.2\ \mu m.$
- Blue, $\delta = -\ 1.2\ \mu m.$



Summary

- Change depth of buried channel by varying depth and concentration of dopants.
- For 2 V_{pp} clock swing, double Christmas Tree:
  - Depth ~ 0.61 μm, ΔV ~ 1.5 V.
  - Depth ~ 0.35 μm, ΔV ~ 1.7 V.
  - Depth ~ 0.16 μm, ΔV ~ 1.8 V.
- Increase ΔV by ~ 0.05...0.1 V when go to "narrow" structure.
- Increase ΔV by 0.05...0.1 V when use "single" structure.
- Larger asymmetry in potential obtained for narrower Christmas Tree.
- Larger asymmetry in potential obtained for single rather than double structure.
- Can steer gate potentials to avoid "bumps" with single Christmas Tree.
- Gate/implant alignment errors at 200 nm level do not look to cause significant potential bumps at a depth of 160 nm in double structure.
- Preliminary conclusion: Christmas Tree should be single, narrow and shallow.
- Now tune parameters and do some checks.