Analysis of CNT based vacuum transistor

-Modeling of 3 terminal device

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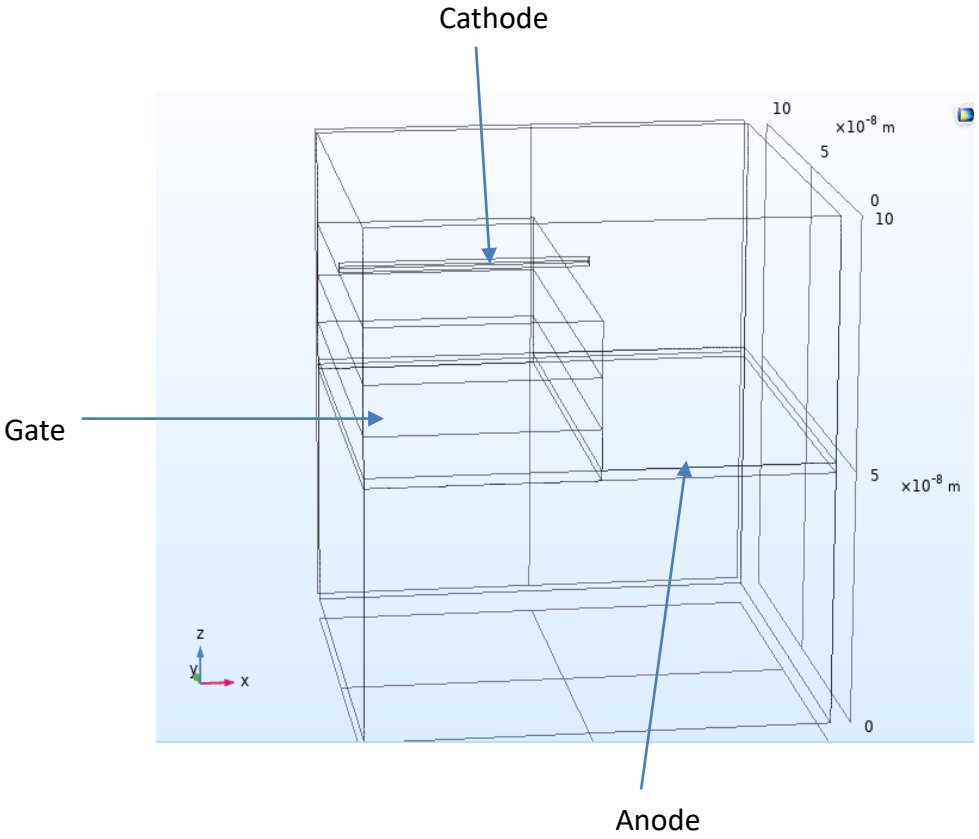
3 Terminal Model



- Gate terminal is between the anode and cathode terminal.
- Al is used as Gate terminal as well as Anode material.
- Cathode is made of CNT.
- Maximum electric Field is extracted from the Cathode terminal and by using F-N equation, current density is obtained.
- Anode to Gate terminal distance is 26 nm.

Calculations

- Fowler Nordheim equation to extract the current density:

$$J = \frac{K1 \times \beta^2 \times E^2}{\emptyset} \exp\left(\frac{-K2 \times \emptyset^{1.5}}{\beta \times E}\right)$$

$$Where\ J = Emitted\ Current\ density\ from\ the\ cathode$$

$$K1 = 2.73 \times 10^{-7}\ AV^{-2}eV$$

$$K2 = 6.83 \times 10^{9}\ VeV^{-1.5}Vm^{-1}$$

$$\beta = Field\ Enhancement\ Factor = 15$$

$$\emptyset = Work\ Function\ of\ Cathode\ material = 5\ eV$$

- Current Density is multiplied by the area of the cathode terminal to get the emitted current.

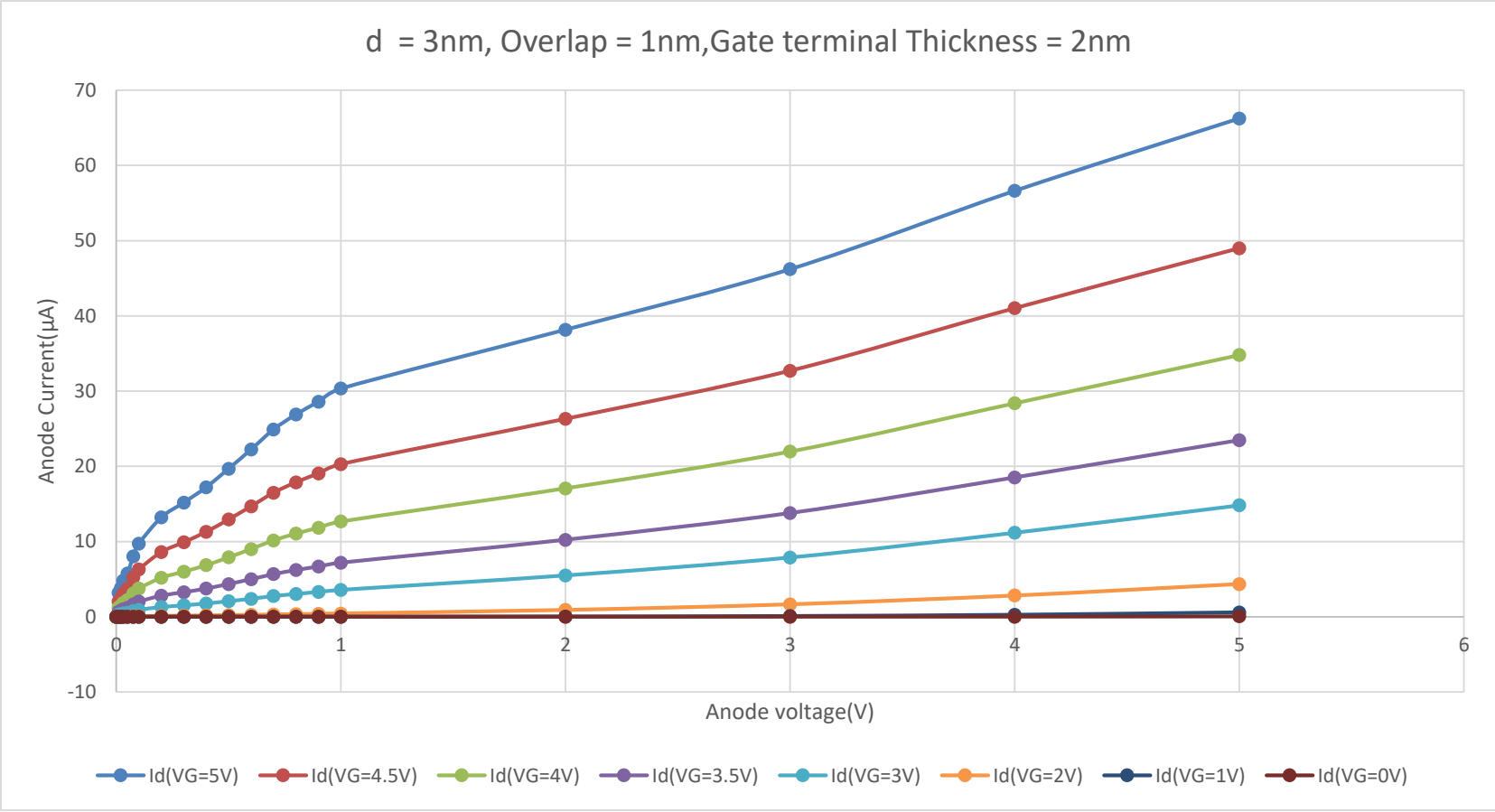
Procedure

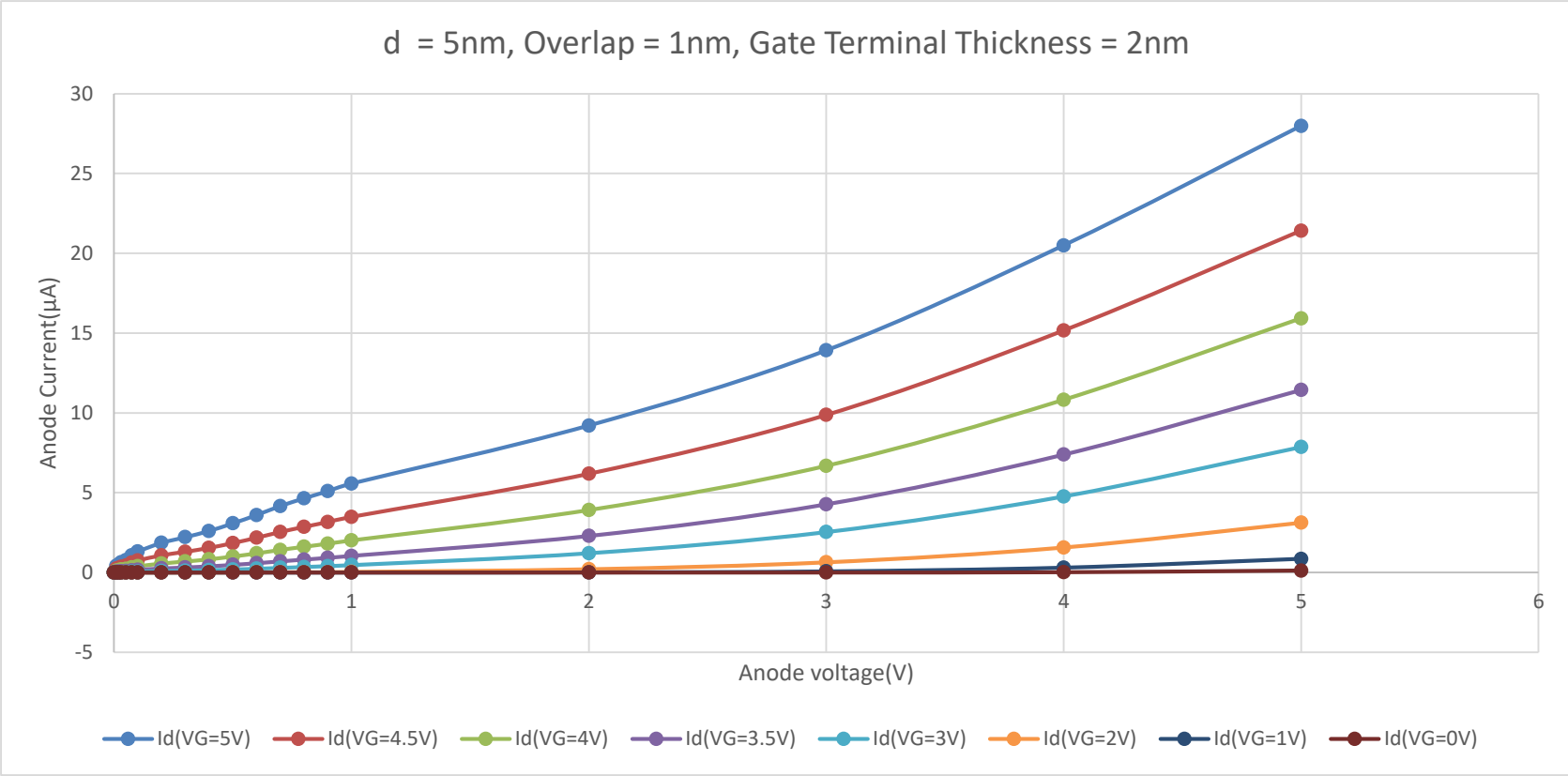
- All emitted electrons will not reach the anode terminal due to the gate leakage current.

$$Anode\ Current = Collection\ Efficiency \times Emitted\ Current$$

- Family of Curves are plotted for the different gate voltages.
- Different cases are considered for family of curves and best case is considered.
- For the 2 best cases, threshold voltage is measured and Compared.

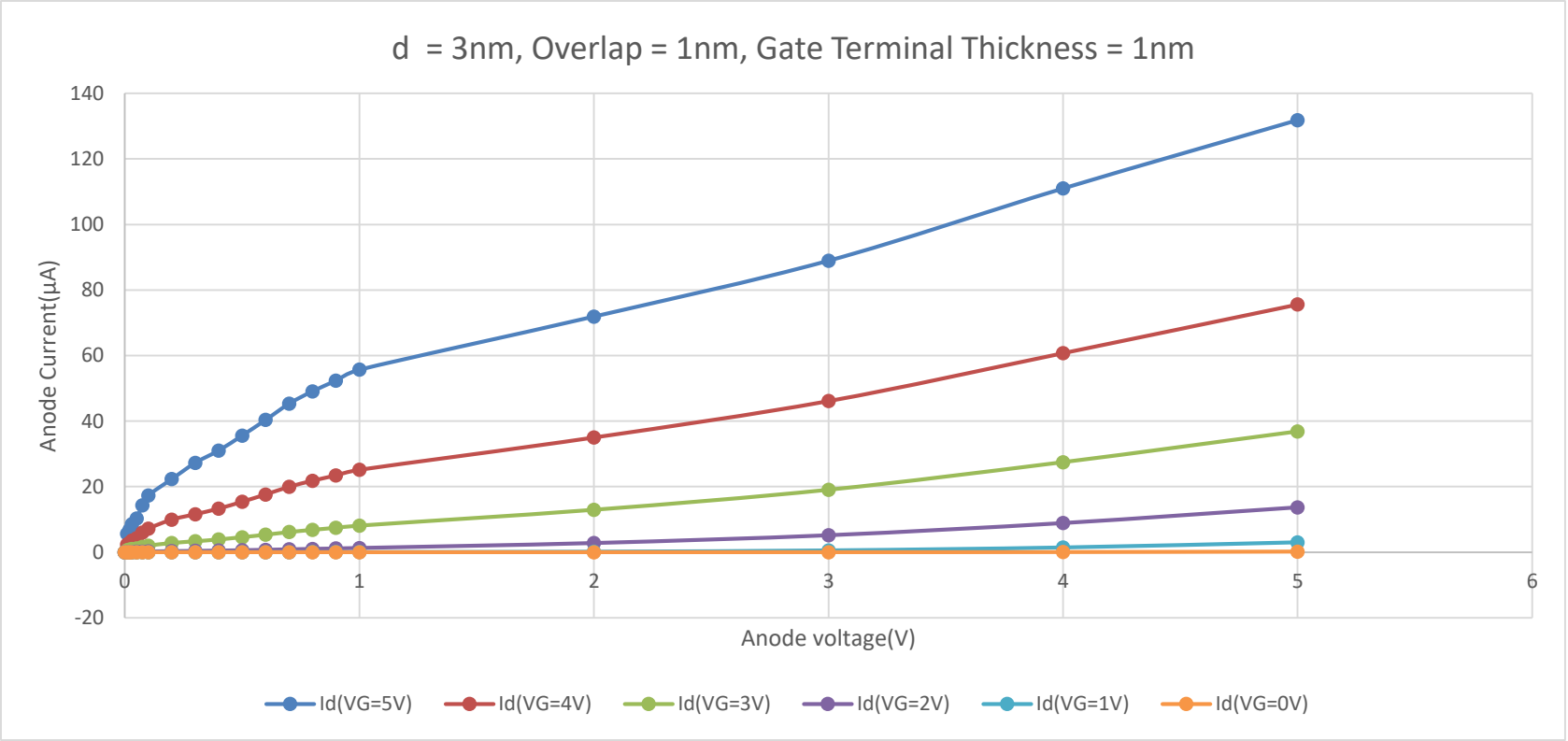
Case Study : 1 Changing the Distance between Cathode and Gate Terminal(d) and Overlap





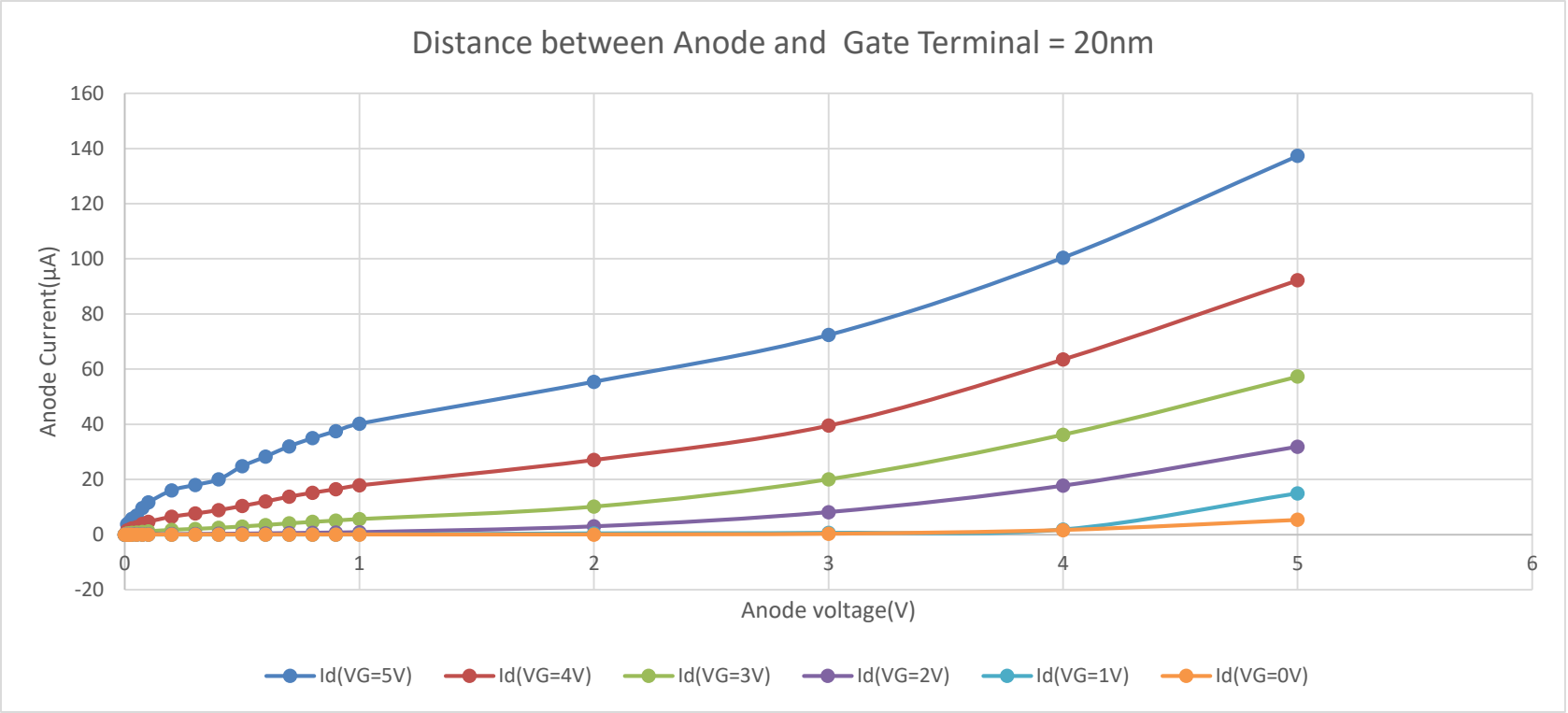
❑As the distance between cathode and gate terminal increases, Anode current decreases.

Case Study : 2 Varying thickness of Gate Terminal



❑As the thickness of Gate Terminal decreases, Anode current increases.

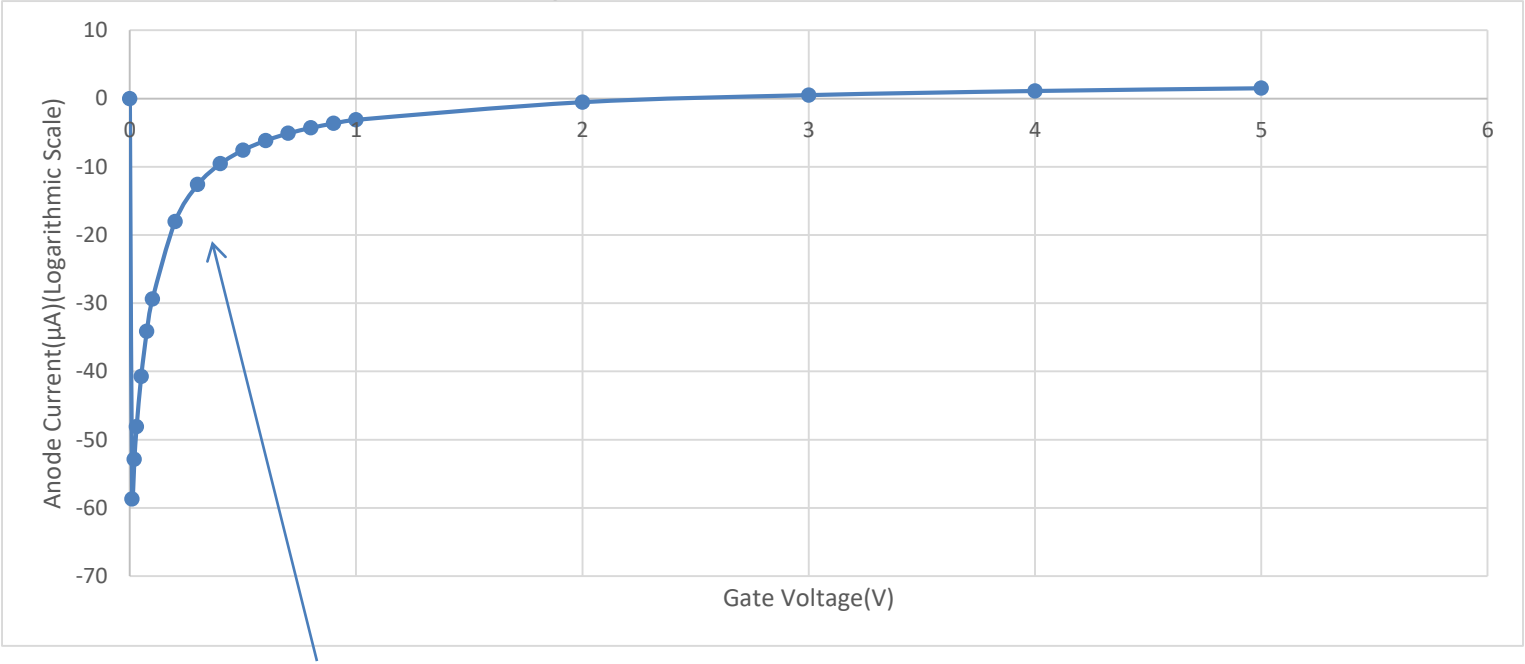
Case Study : 3 Changing the distance between Anode and Gate Terminal



❑As the distance between Anode and Gate terminal decreases, Anode current increases.

Results-Conclusion

- For the best case possible, d = 3 nm (Cathode to Gate distance)
  Gate terminal Thickness = 1 nm
  Distance between Anode and Gate terminal = 20nm



VT = 0.4 V