Technique Used

0.) ~~Effect of substrate on Xdepl.~~

1.) Determine Dt.

2.) From data, determine total Q available for depletion.

3.) Since Phos. in Depl. must compensate substrate, any variation in N_{SUB} must compensate part of Q put in to set V_T depl. So Assume we can live with 10% or 15% (or 18.75%) variation in Q & determine what kind of N_{SUB} variation this translate to where

$$N_{SUB} = \frac{Q}{X_j}$$ when X_j is a $X_{1/100}$ point (all of range).

4.) Knowing various N_{SUB}s one can calculate effect on V_T from $\frac{Q_B}{C_o} + 2\phi_F$. What is then determined is the ΔV_T relative to $N_{SUB} \times 1.20$ and $N_{SUB} \times .80$, also from ± 30%.

5.) Since we need to get to 10^{16} for enhancement V_T, we start with N_{SUB} of 2.5×10^{15} ± 30% and 7.5 E15 implant.

6.) New V_T's, due to $\frac{Q_B}{C_o} + 2\phi_F$ are calculated from ΔV_T.

7.) Then split ΔV_T by 2 and calculate current deviation as a function of N_{SUB} variation. $I = K(V_G - V_T)^2$

8.) Then check effect of N_{SUB} variation on junction capacitance.

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Bottom Line

1.) We need ~10^{16} surface concentration to hit proper thresholds on enhancement devices.

2.) We need considerably less doping than this (2.5E15 → 6Ω-cm) to be safe from a depletion spread point of view. However we also play a tradeoff game with junction capacitance here as well.

E.G.

	$X_{j\,depl}$ @ 6V.	Cap. @ 0V.
6Ω-cm (2.5E15)	~2μ	>.11 pf/mil^2
22Ω-cm (6.0E14)	~4μ	.055 pf/mil^2

3.) Assumption is that $X_{j\,depl.}$ is critical and that add'l cap. introduced will be charged faster w/ depl. loads anyway.

∴ Go with 2.5E15 starting (for $X_{j\,depl}$) and implant another 7.5E15 ~~to~~ set V_{TE} @ N = 10^{16} level.

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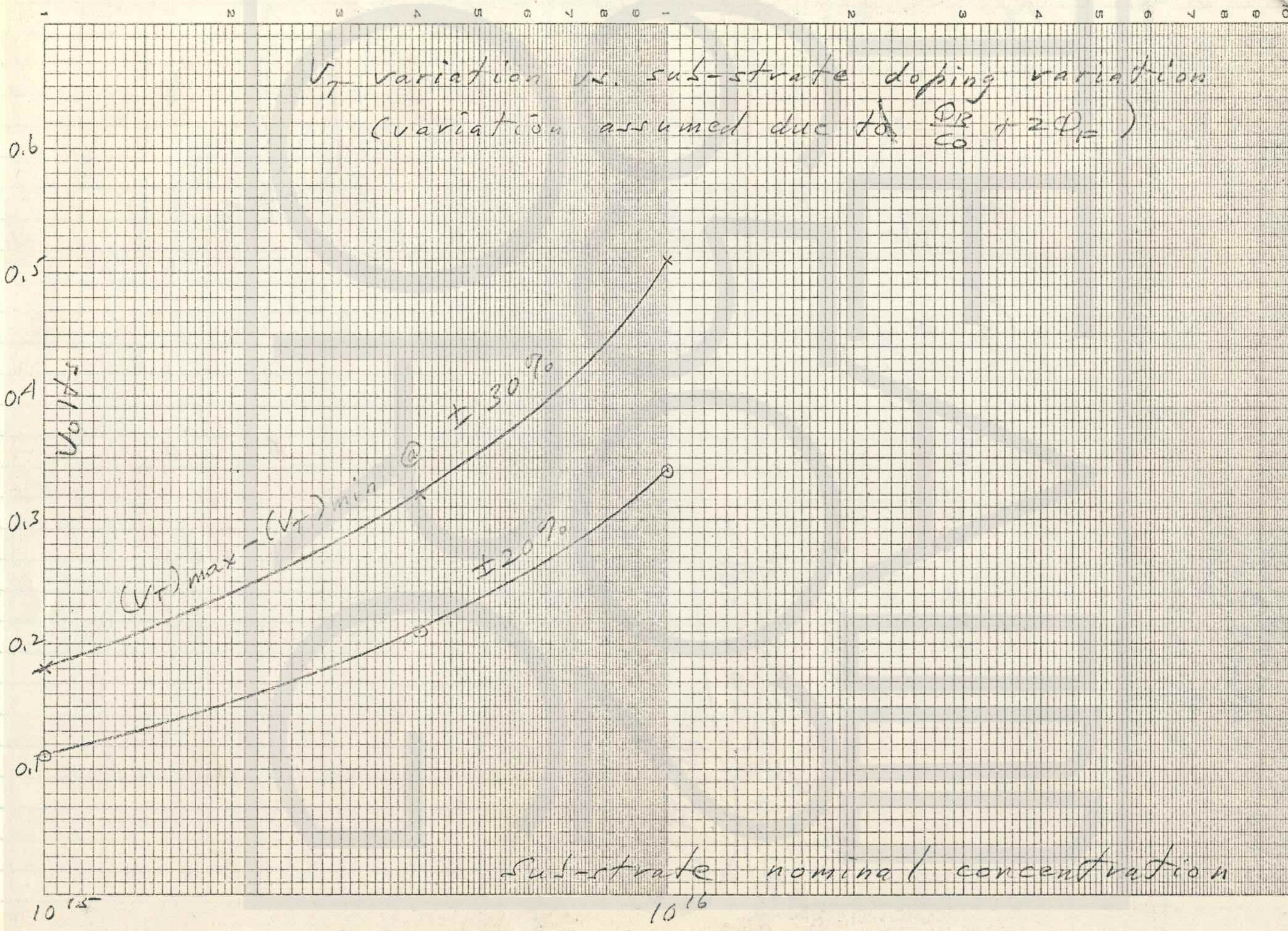
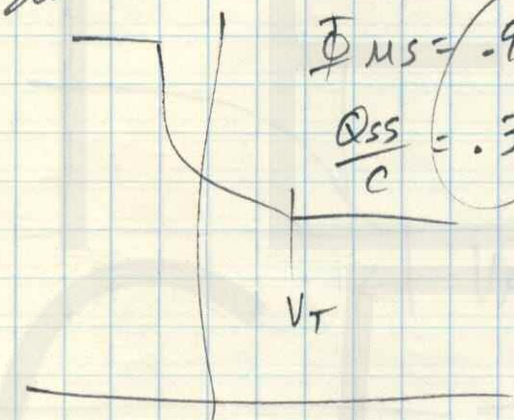

V_T variation vs. sub-strate doping variation
(variation assumed due to $\frac{Q_B}{C_O} + 2\phi_F$)
V_0 / V_T
0.6
0.5
0.4
0.3
0.2
0.1
± 30 %
± 20 %
$(V_T)_{max} - (V_T)_{min}$ @
Sub-strate nominal concentration
10^{15}
10^{16}

Meeting 10/4/74

John Pajunen
Steve Sherman
Walt Eisenhower
Self
Ernie Helfrich

Non-related N^+-N^+ interconnects

Eul



$\Phi_{MS} = .9V$

$\frac{Q_{SS}}{C} = .3$

$\frac{Q_B}{C_0} + 2\phi_F = 2.1V.$

$1.2 + .9 = 2.157$

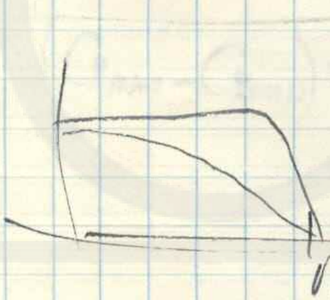
$V_B = 2.157 - .7$ ($\nearrow 2\phi_F$) $= K\sqrt{2\phi_F}$

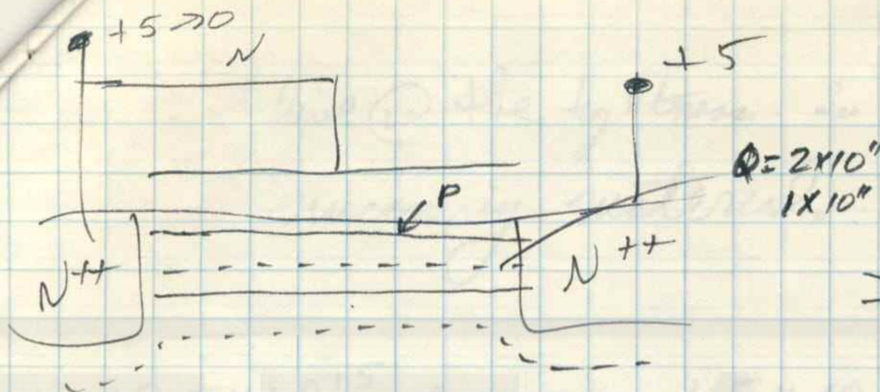
$V_B = 1.46$ $\rightarrow 10^{16}$ at./cm^3

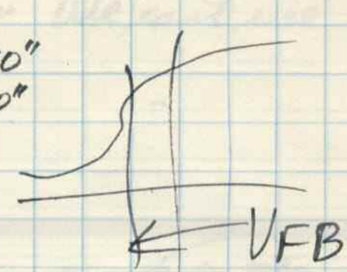
$I = K' W/_L \frac{(V_G - V_T)^2}{2}$ (4.75; 1.2 V, .6 V.)

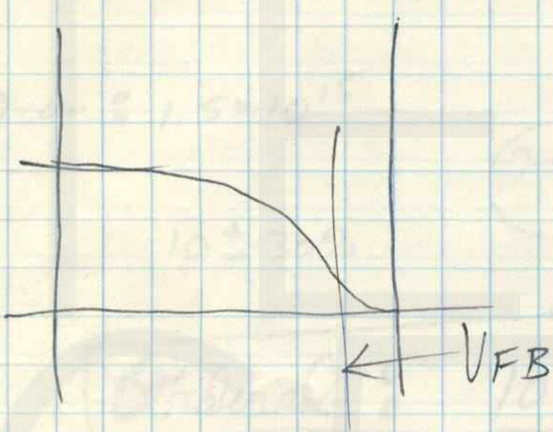
$\left(\frac{4.15}{3.55}\right)^2 = 1.37$

$K = \alpha\sqrt{N}$



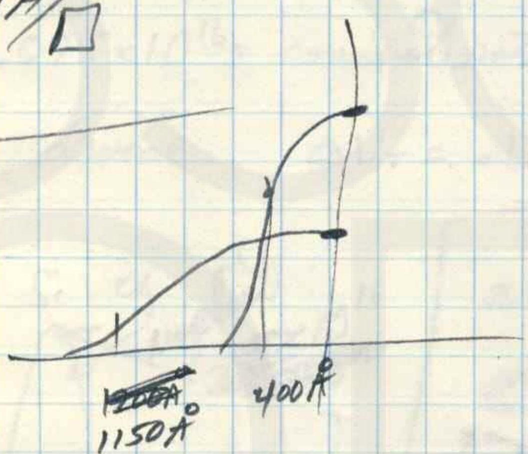






100uA/□

1050 Å

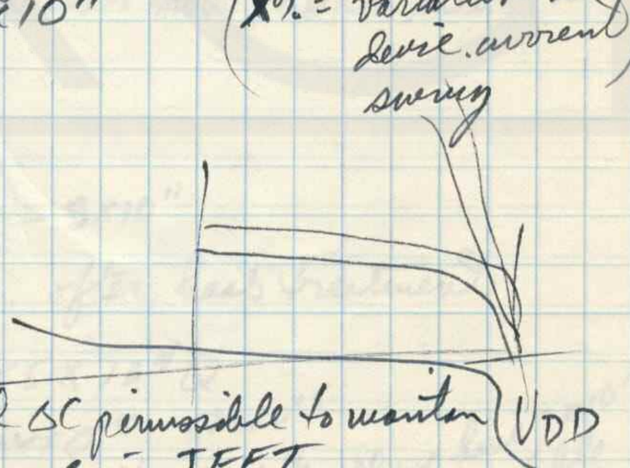


$\sigma_{1/2 \text{ before } Dt} = 400Å$

$\sigma_{1/2 \text{ after } Dt} = 1150Å$ — 1500Å = both side metallurgical junction

$\sigma_{1/10} = 2032Å$

$(C_{B_{MAX}} - C_{B_{MIN}}) \times 2500Å$ = total charge variation
$= X\% \times 2 \times 10''$ ($X\%$ = variation in device current swing)



~~X% = ΔC_B~~

X%	ΔC
10% (±5%)	$.8 \times 10^{15}$
15%	1.2×10^{15}
18.75%	1.5×10^{15}

→ Total ΔC permissible to maintain ± % change in JFET.

Can't live with the tightness ∴ We can't use 10^{16} for incoming material.

6Ω-cm : 2.5×10^{15} $\pm 30\%$ = 1.5×10^{15} = Δ Swing

10Ω-cm : 1.5×10^{15}

ρ – 10Ω-cm

10 ± 30%

Approx : $\left(\frac{14.5\times10^{15}}{\rho} = C_B\right)$

Ordered : 10Ω-cm ± 30%

$10^{16} \pm .075\times10^{16}$ = concentration in enhancement mode device. $\Delta V_T = .13$.

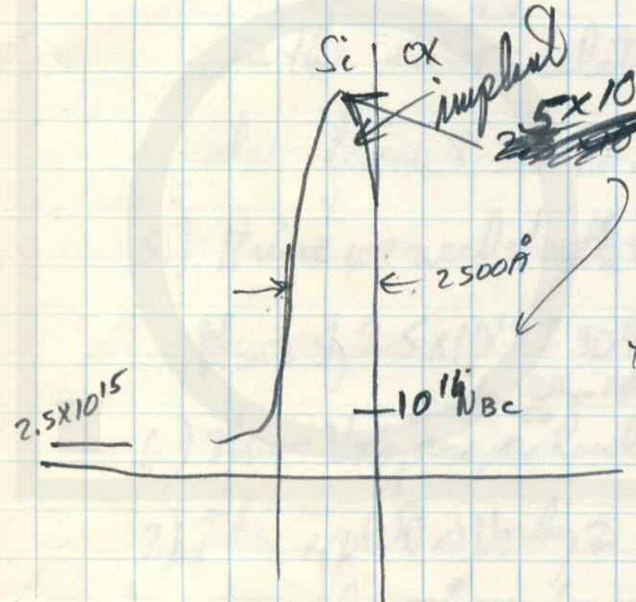
$Q = 3E11$

$2.5E15 = \frac{3E11}{\sqrt{\pi Dt}} e^{-x^2/4Dt}$ $Dt = .00435\mu^2$, $1\mu^2 = 10^{-8}\,cm^2$

$2.5E15 = \frac{3E11}{.117E{-8}} e^{-x^2/.017}$

$e^{x^2/.017\mu^2}$ E5 ; $x^2 = 13.8\times.017\mu^2 = .234\mu^2$

$x = .484\mu \approx 5000Å \sim 6000Å$.



the 10^{16} implant has to move ~ 6KÅ into the field.

$Q_{implant} = 3\times10^{11}$

Peak conc. after heat treatment

$C_S = 8.55\times10^4 Q$

$= ~~25\times10^{15}~~$ 50×10^{15}

$= ~~2.5\times10^{16}~~$ 5×10^{16} If we have $2\times10^{11}Q$ available.