

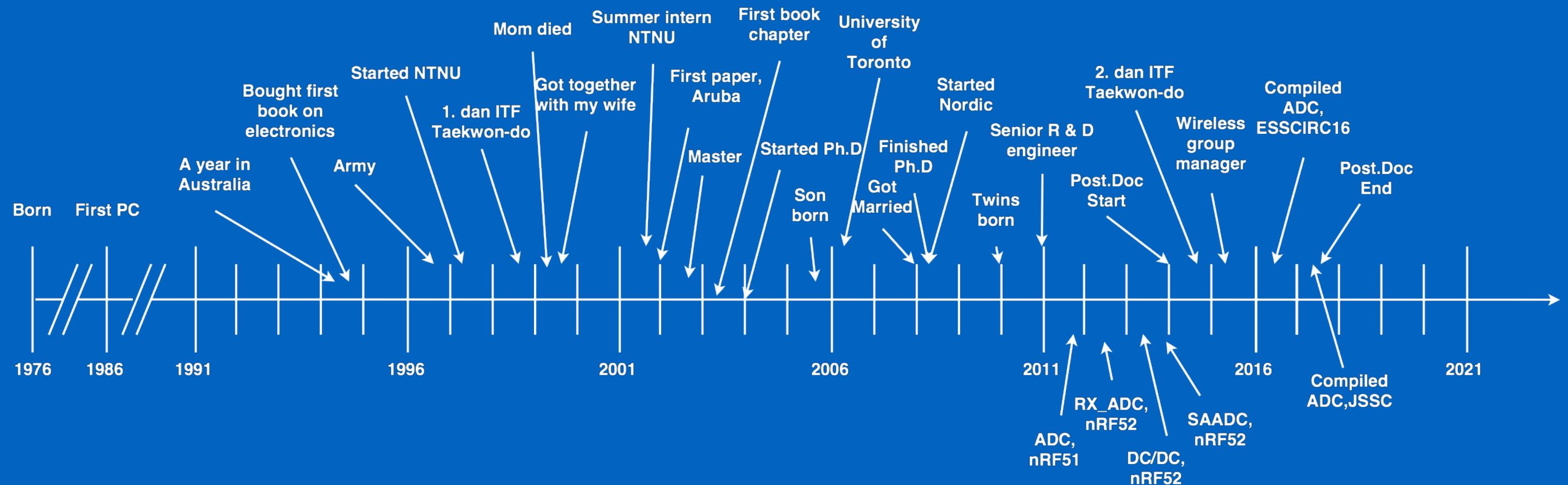


NORDIC
SEMICONDUCTOR

Smarter Things

Making integrated circuits

Carsten Wulff, Wireless Group Manager





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Smarter Things

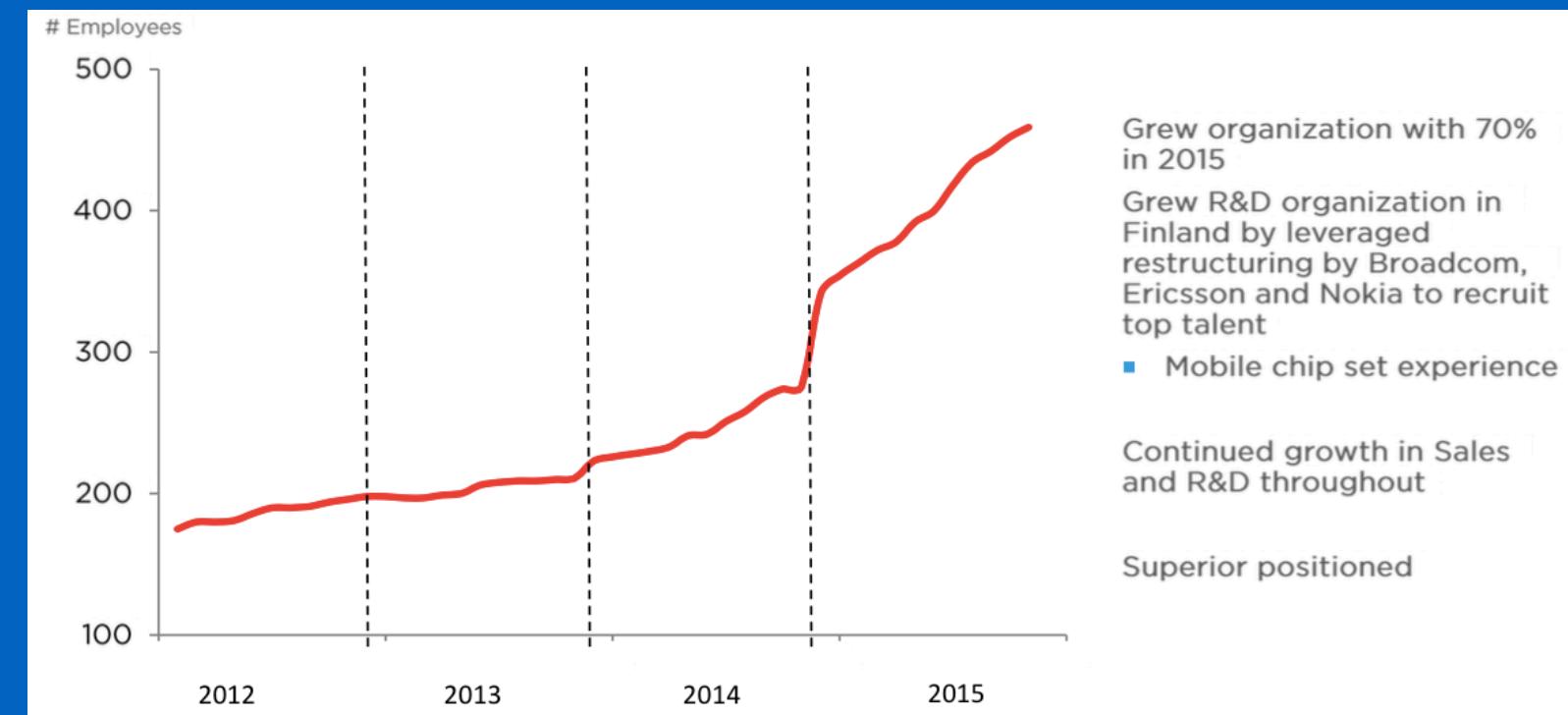
1983

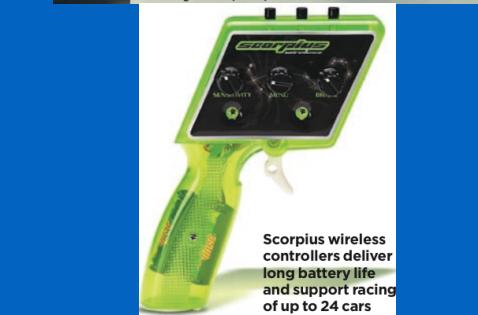
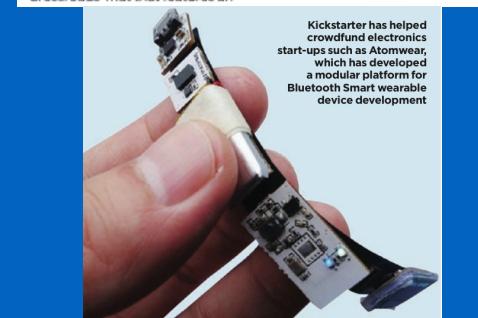
- Jan
- Trond
- Frank
- Oddvar

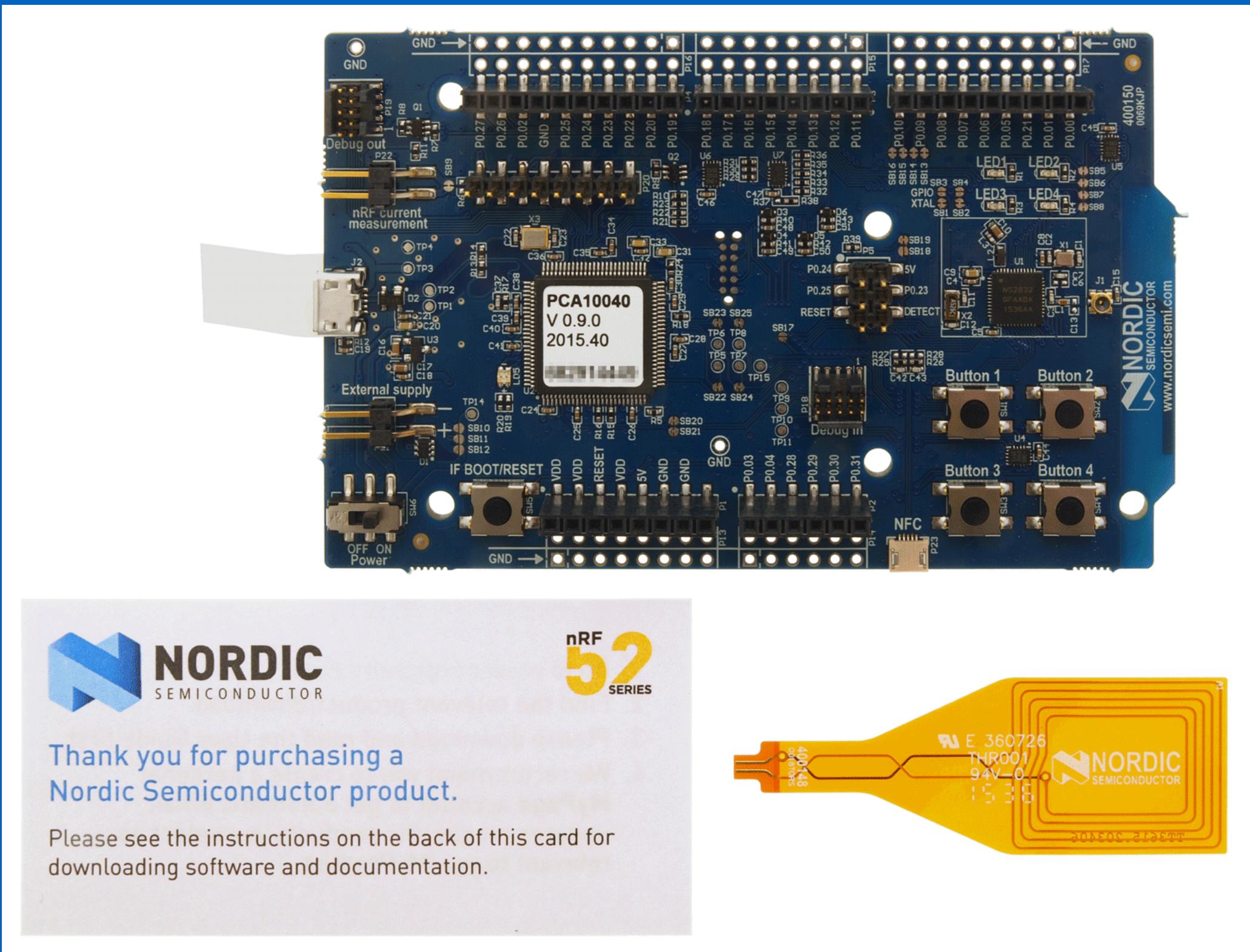


2017

570 people from 43 different nations *passionately committed to ultra-low-power wireless technology that will benefit the lives of billions worldwide*





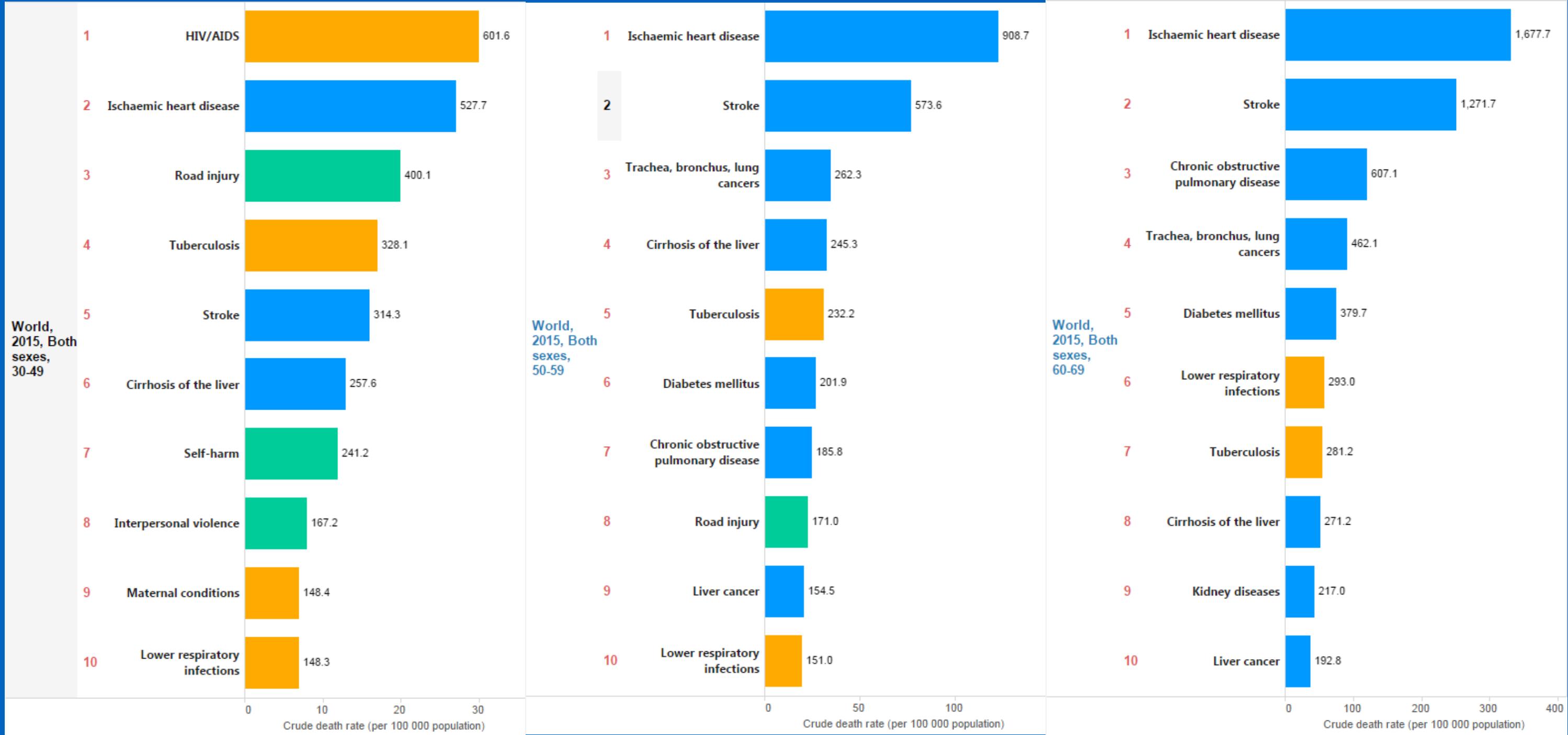


Wavy





Max: 2011 @ 122 Kg



... cardiovascular diseases killed
17.689 million people in 2015,
that's 31.3% of all deaths ... WHO

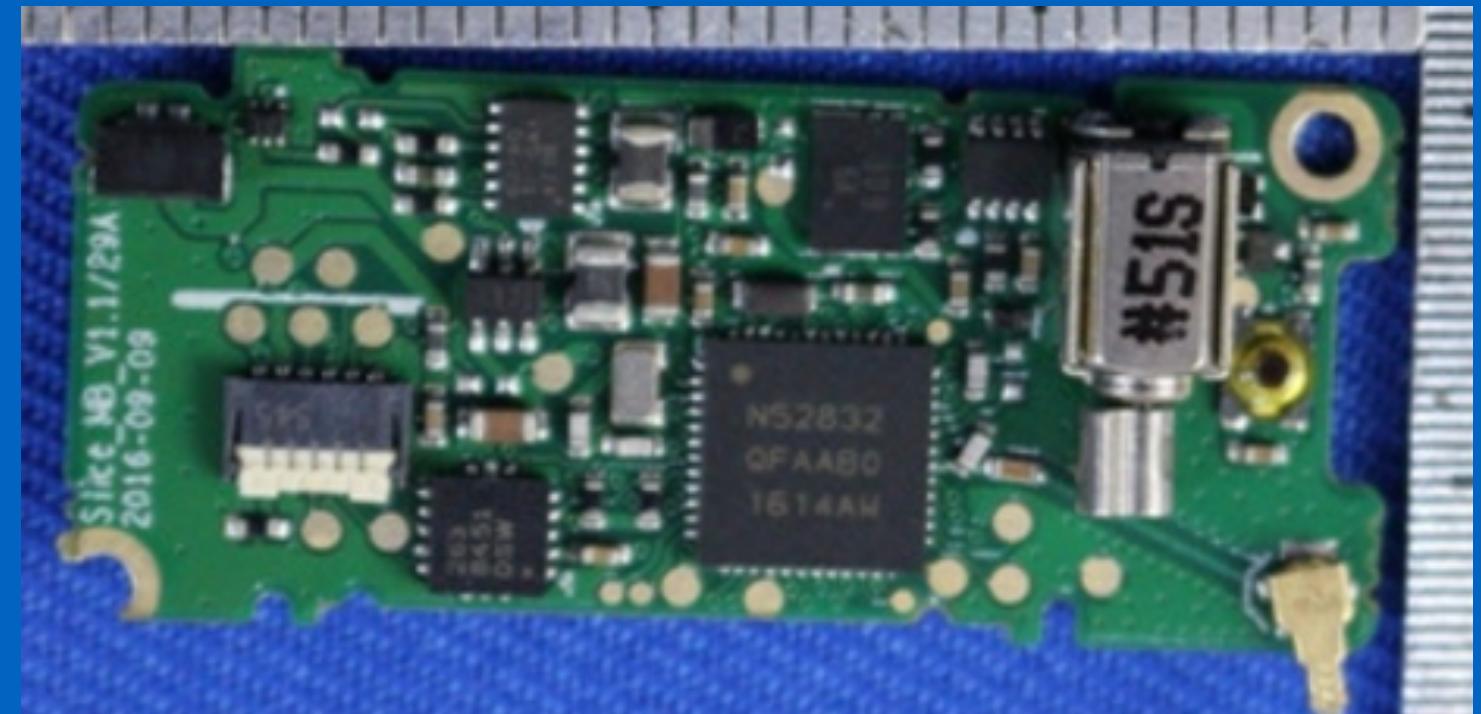


Carsten Wulff 2017

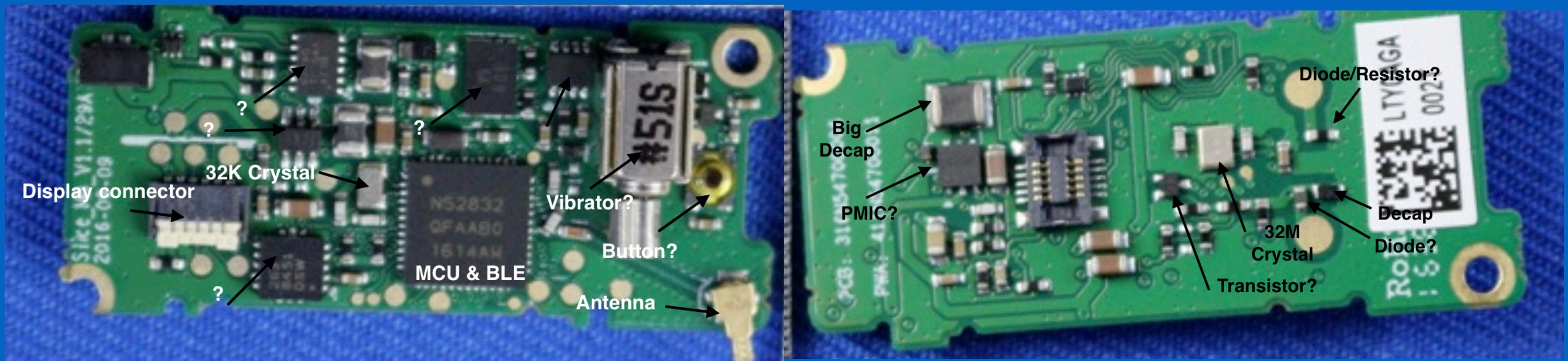


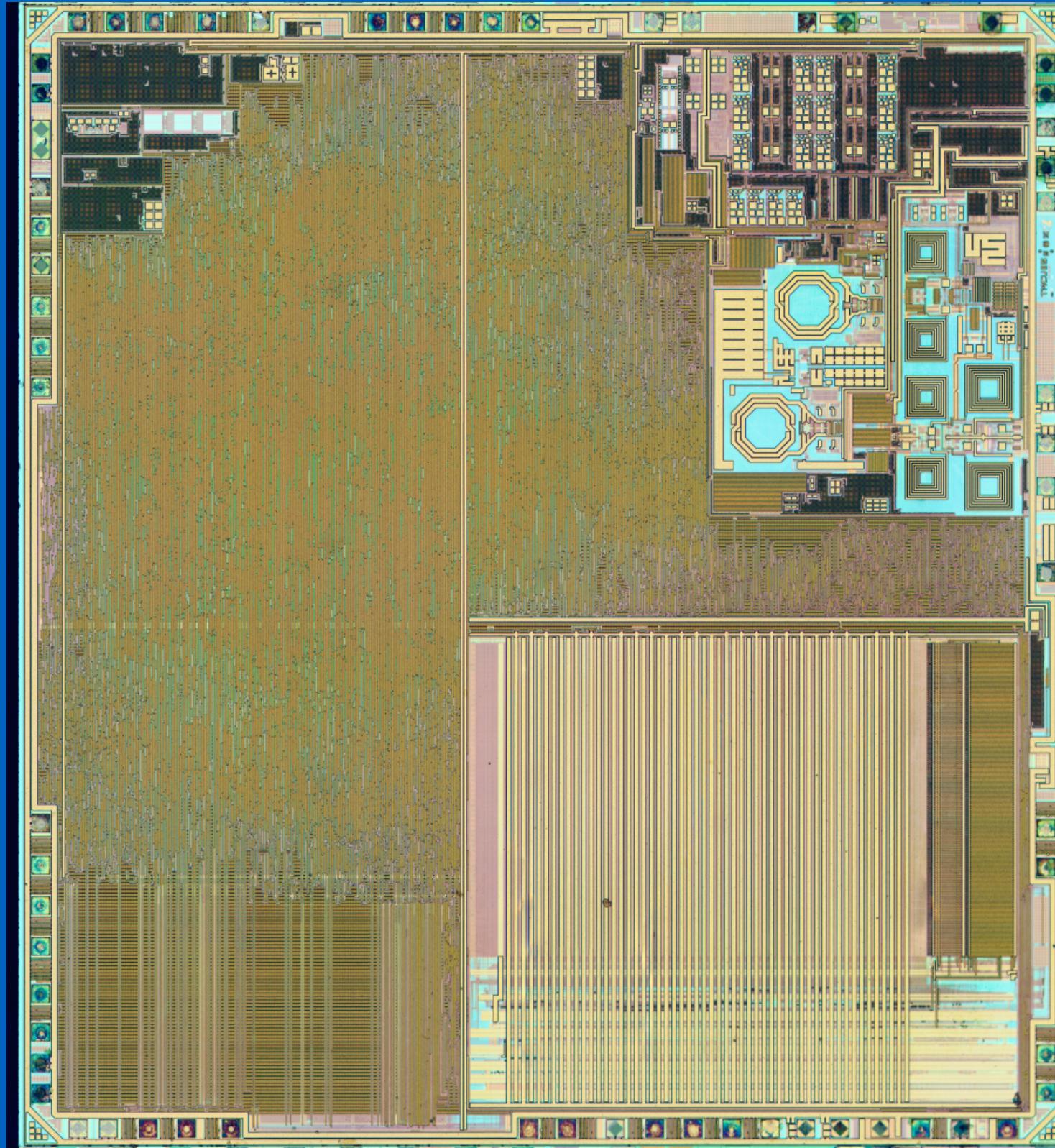
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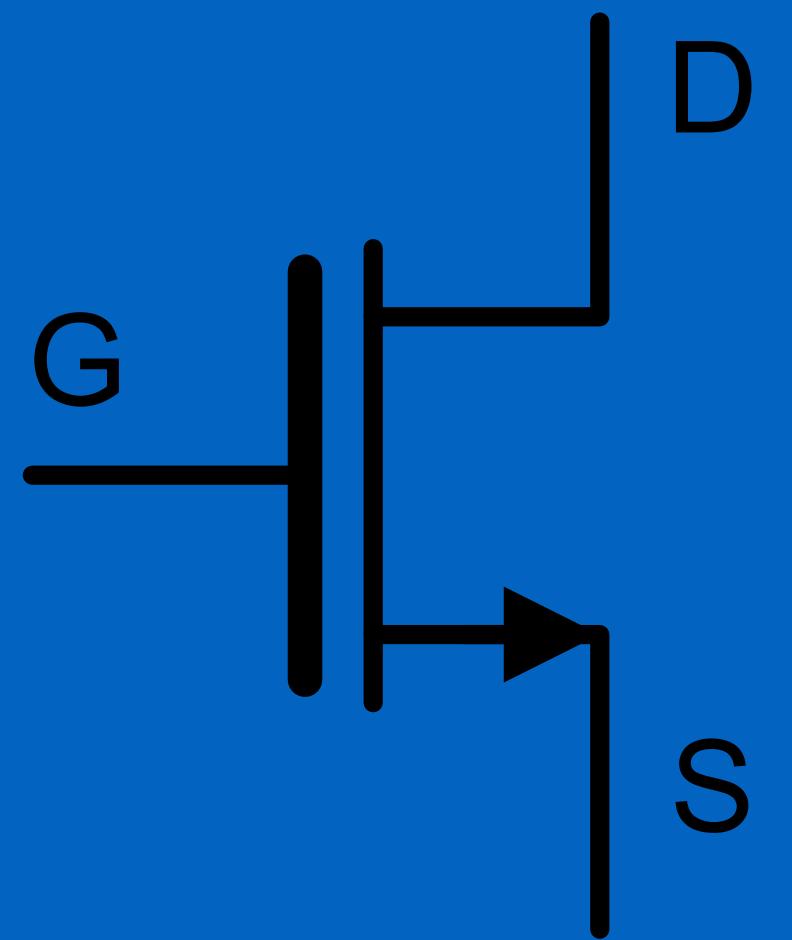


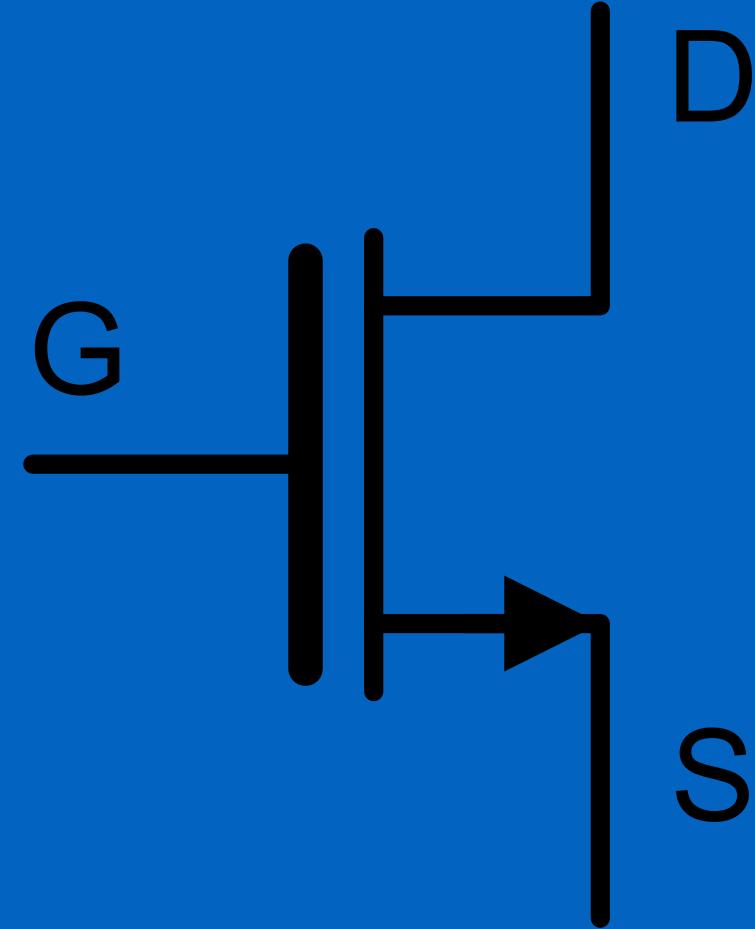


"PAI is NOT an exercise prescription. It does NOT tell you how to exercise in a specific way, but measures the physical activity that you already do and adds it up over a course of a week. **As long as you keep your weekly PAI score above 100, you are doing enough to protect yourself from disease and early death.**"









Simple model

$$I_D = \begin{cases} \text{high} & \text{if } V_{GS} > V_{TH} \\ 0 & \text{if } V_{GS} < V_{TH} \end{cases}$$

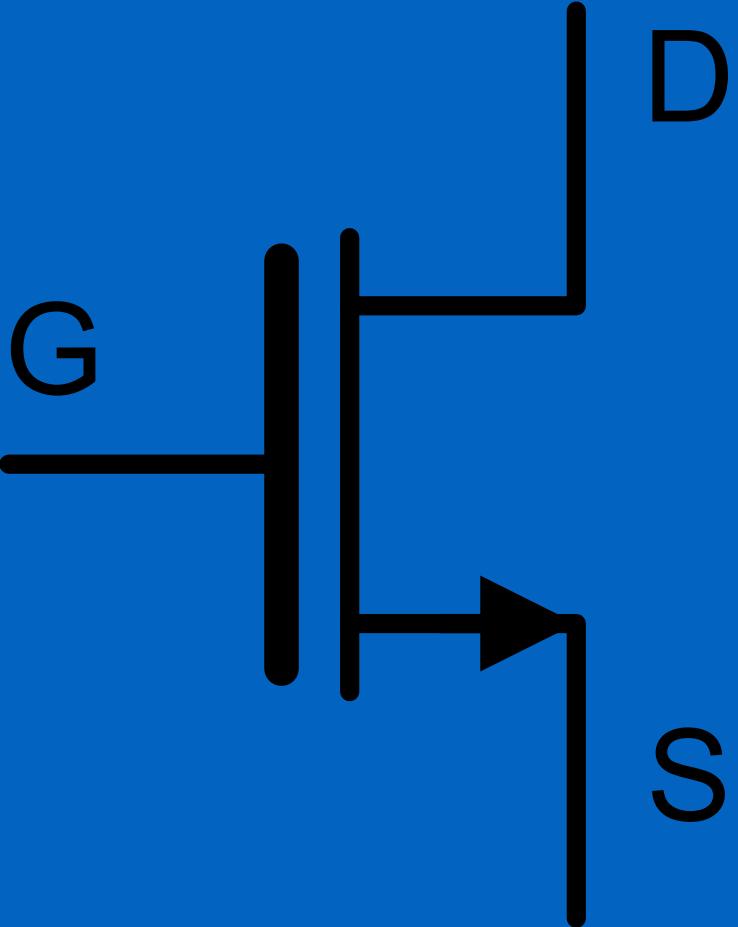
What you learn

$$I_D = \mu_n C_{ox} W/L (V_{GS} - V_{TH})^2$$

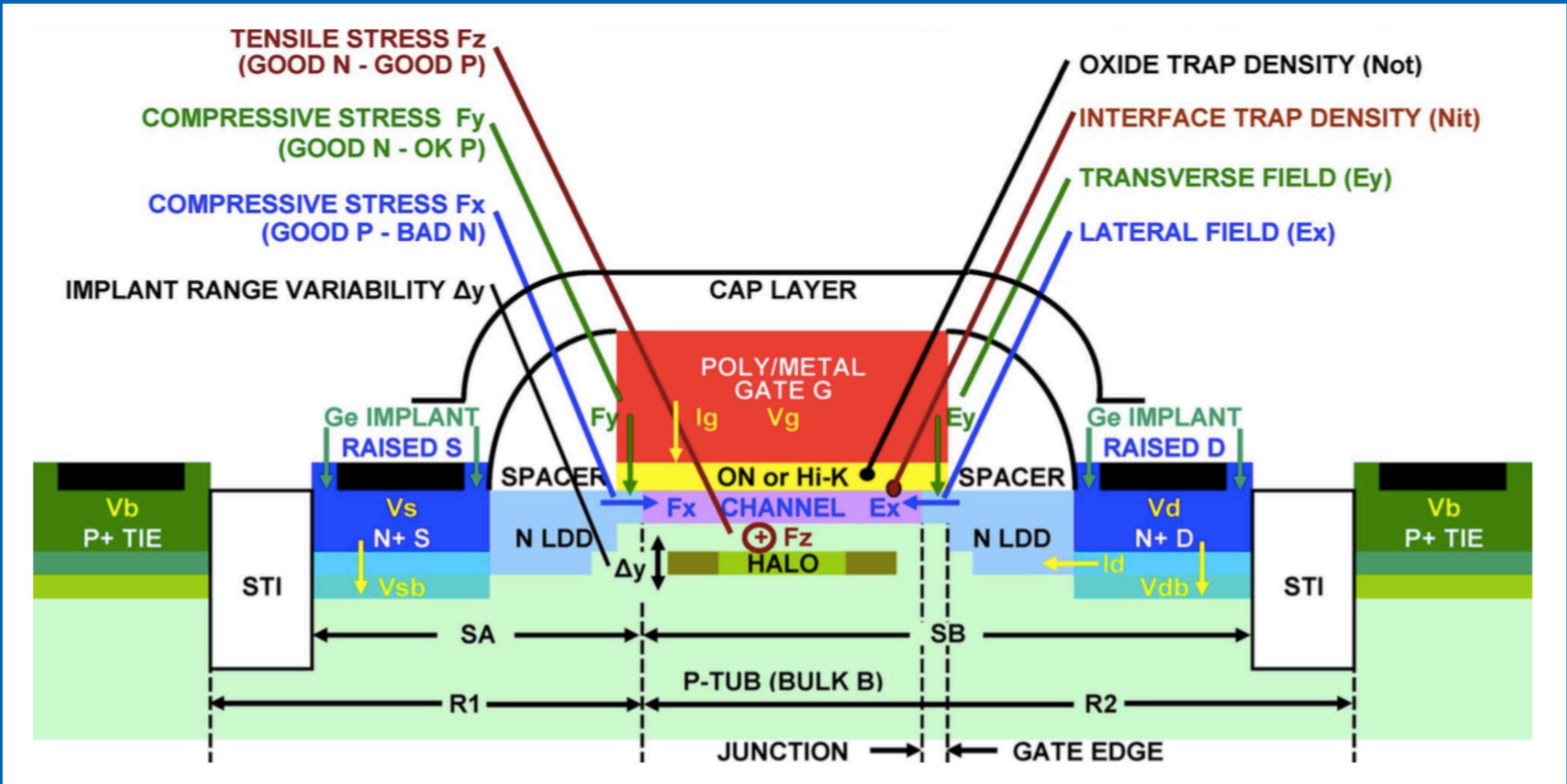
The truth

$$I_D = f(W, L, \mu_n, t_{ox}, sa, sb, sca, scb, scc, ad, as, pd, ps, \dots, V_{GS}, V_{DS})$$

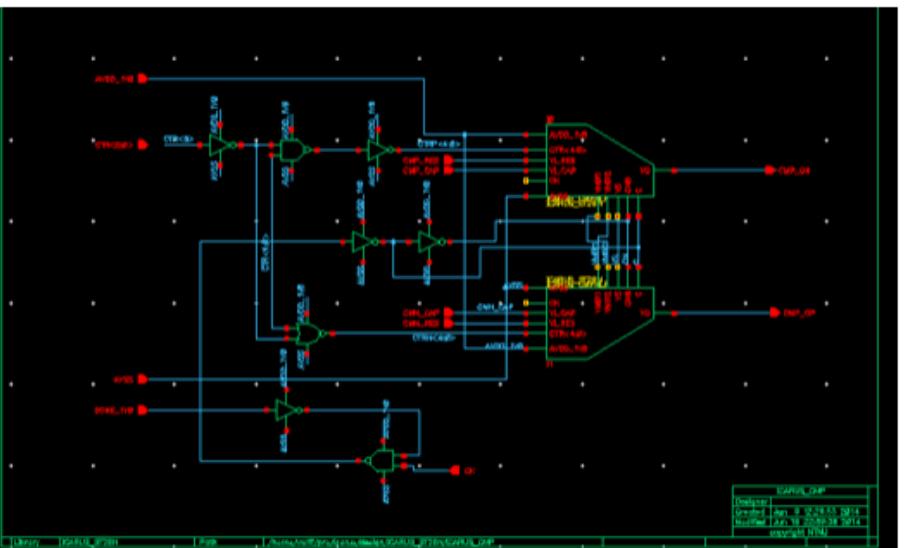
284 parameters in BSIM 4.5



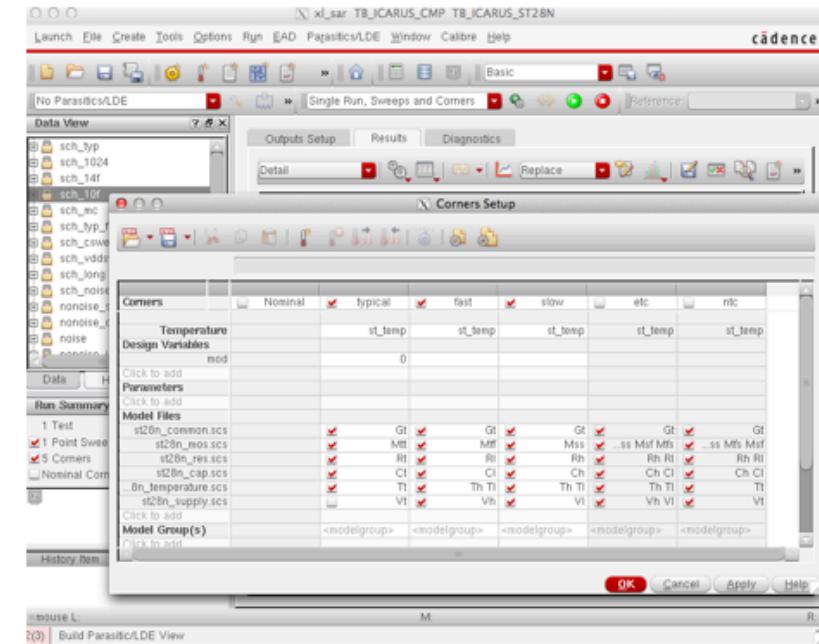
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.MODEL N1 NMOS LEVEL=14 VERSION=4.5.0 BINUNIT=1 PARAMCHK=1 MOBMOD=0
CAPMOD=2 IGCMOD=1 IGBMOD=1 GEOMOD=1 DIOMOD=1 RDSMOD=0 RBODYMOD=0 RGATEMOD=3
PERMOD=1 ACNQSMOD=0 TRNQSMOD=0 TEMPMOD=0 TNOM=27 TOXE=1.8E-009
TOXP=10E-010 TOXM=1.8E-009 DTOX=8E-10 EPSROX=3.9 WINT=5E-009 LINT=1E-009
LL=0 WL=0 LLN=1 WLN=1 LW=0 WW=0 LWN=1 WWN=1 LWL=0 WWL=0 XPART=0
TOXREF=1.4E-009 SAREF=5E-6 SBREF=5E-6 WLOD=2E-6 KU0=-4E-6 KVSAT=0.2
KVTH0=-2E-8 TKU0=0.0 LLODKU0=1.1 WLODKU0=1.1 LLODVTH=1.0 WLODVTH=1.0
LKU0=1E-6 WKU0=1E-6 PKU0=0.0 LKVTH0=1.1E-6 WKVTH0=1.1E-6 PKVTH0=0.0
STK2=0.0 LODK2=1.0 STETA0=0.0 LODETA0=1.0 LAMBDA=4E-10 VSAT=1.1E 005
VTL=2.0E5 XN=6.0 LC=5E-9 RNOIA=0.577 RNOIB=0.37
LINTNOI=1E-009 WPEM0D=0 WEB=0.0 WEC=0.0 KVTH0WE=1.0 K2WE=1.0 KU0WE=1.0
SCREF=5.0E-6 TVOFF=0.0 TVFBSDOFF=0.0 VTH0=0.25 K1=0.35 K2=0.05
K3=0 K3B=0 W0=2.5E-006 DVT0=1.8 DVT1=0.52 DVT2=-0.032 DVT0W=0 DVT1W=0
DVT2W=0 DSUB=2 MINV=0.05 VOFFL=0 DVTP0=1E-007 DVTP1=0.05 LP0=5.75E-008
LP0B=2.3E-010 XJ=2E-008 NGATE=5E 020 NDEP=2.8E 018 NSD=1E 020 PHIN=0
CDSC=0.0002 CDSCB=0 CDSCD=0 CIT=0 VOFF=-0.15 NFACTOR=1.2 ETA0=0.05
ETAB=0 UC=-3E-011 VFB=-0.55 U0=0.032 UA=5.0E-011 UB=3.5E-018 A0=2
AGS=1E-020 A1=0 A2=1 B0=-1E-020 B1=0 KETA=0.04 DWG=0 DWB=0 PCLM=0.08
PDIBLC1=0.028 PDIBLC2=0.022 PDIBLCB=-0.005 DROUT=0.45 PVAG=1E-020
DELTA=0.01 PSCBE1=8.14E 008 PSCBE2=5E-008 RSH=0 RDSW=0 RSW=0 RDW=0
FPROUT=0.2 PDITS=0.2 PDITSD=0.23 PDITSL=2.3E 006 RSH=0 RDSW=50 RSW=150
RDW=150 RDSWMIN=0 RDWMIN=0 RSWMIN=0 PRWG=0 PRWB=6.8E-011 WR=1
ALPHA0=0.074 ALPHA1=0.005 BETA0=30 AGIDL=0.0002 BGIDL=2.1E 009 CGIDL=0.0002
EGIDL=0.8 AIGBACC=0.012 BIGBACC=0.0028 CIGBACC=0.002 NIGBACC=1
AIGBINV=0.014 BIGBINV=0.004 CIGBINV=0.004 EIGBINV=1.1 NIGBINV=3 AIGC=0.012
BIGC=0.0028 CIGC=0.002 AIGSD=0.012 BIGSD=0.0028 CIGSD=0.002 NIGC=1
POXEDGE=1 PIGCD=1 NTOX=1 VFBSDOFF=0.0 XRCRG1=12 XRCRG2=5 CGSO=6.238E-010
CGDO=6.238E-010 CGBO=2.56E-011 CGDL=2.495E-10 CGSL=2.495E-10
CKAPPAS=0.03 CKAPPAD=0.03 ACDE=1 MOIN=15 NOFF=0.9 VOFFCV=0.02 KT1=-0.37
KT1L=0.0 KT2=-0.042 UTE=-1.5 UA1=1E-009 UB1=-3.5E-019 UC1=0 PRT=0
AT=53000 FNOIMOD=1 TNOIMOD=0 JSS=0.0001 JSWS=1E-011 JSWGS=1E-010 NJSS=1
IJTHSFWD=0.01 IJTHSREV=0.001 BVS=10 XJBVS=1 JSD=0.0001 JSWD=1E-011
JSWGD=1E-010 NJD=1 IJTHDFWD=0.01 IJTHDREV=0.001 BVD=10 XJBVD=1 PBS=1 CJS=0.0005
MJS=0.5 PBSWS=1 CJSWS=5E-010 MJSWS=0.33 PBSWGS=1 CJSWGS=3E-010 MJSWGS=0.33
PBD=1 CJD=0.0005 MJD=0.5 PBSWD=1 CJSWD=5E-010 MJSWD=0.33 PBSWD=1
CJSWGD=5E-010 MJSWGD=0.33 TPB=0.005 TCJ=0.001 TPBSW=0.005 TCJSW=0.001 TPBSWG=0.005
TCJSWG=0.001 XTIS=3 XTID=3 DMCG=0E-006 DMCI=0E-006 DMDG=0E-006 DMCGT=0E-007 DWJ=0.0E-008 XGW=0E-007
XGL=0E-008 RSHG=0.4 GDMIN=1E-010 RBPB=5 RBPD=15 RBPS=15 RBDB=15 RBSB=15 NGCON=1
JTSS=1E-4 JTSD=1E-4 JTSSWS=1E-10 JTSSWD=1E-10 JTSSWGS=1E-7 JTSSWD=1E-7 NJTS=20.0
NJTSSW=20 NJTSSWG=6 VTSS=10 VTSD=10 VTSSWS=10 VTSSWD=10 VTSSWGS=2 VTSSWD=2
XTSS=0.02 XTSD=0.02 XTSSWS=0.02 XTSSWD=0.02 XTSSWGS=0.02 XTSSWD=0.02
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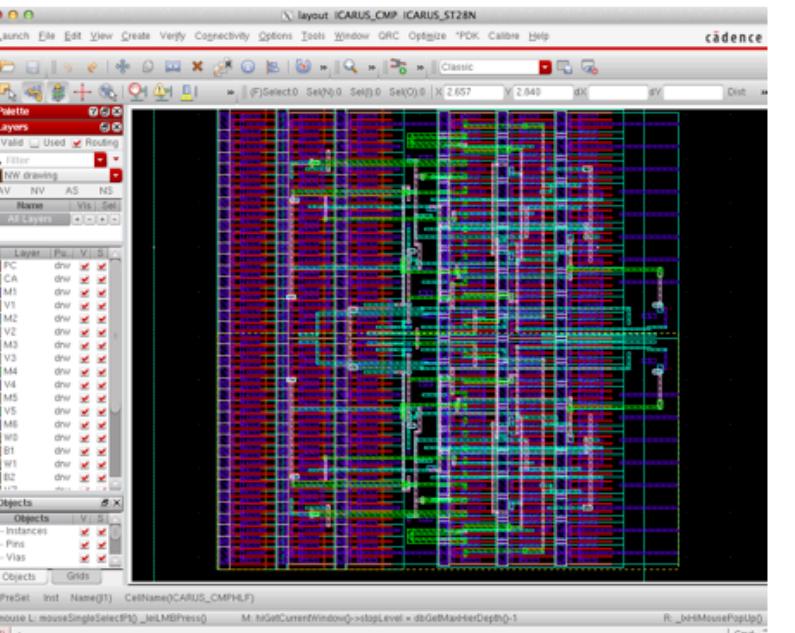
Schematic



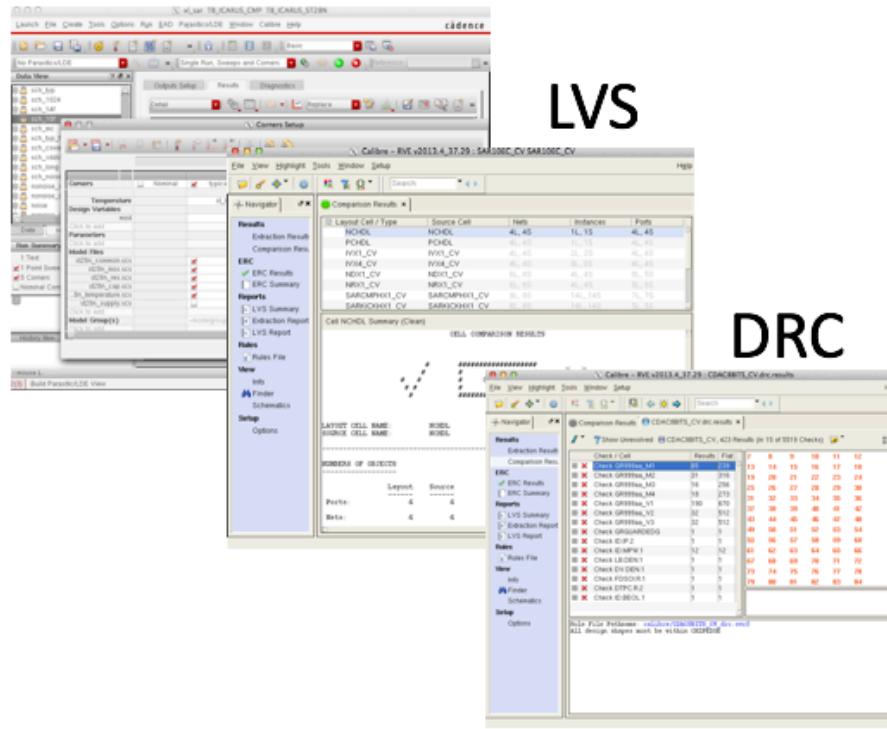
Simulation



Layout

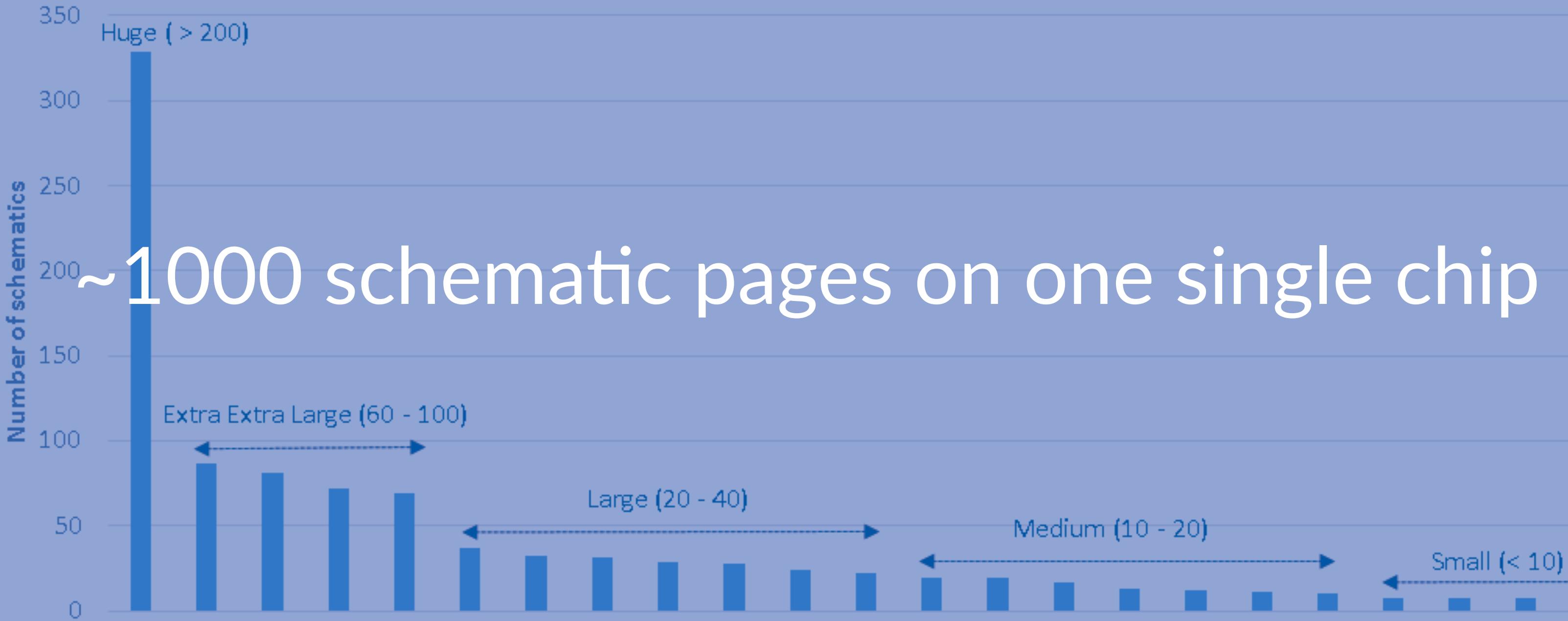


Simulation



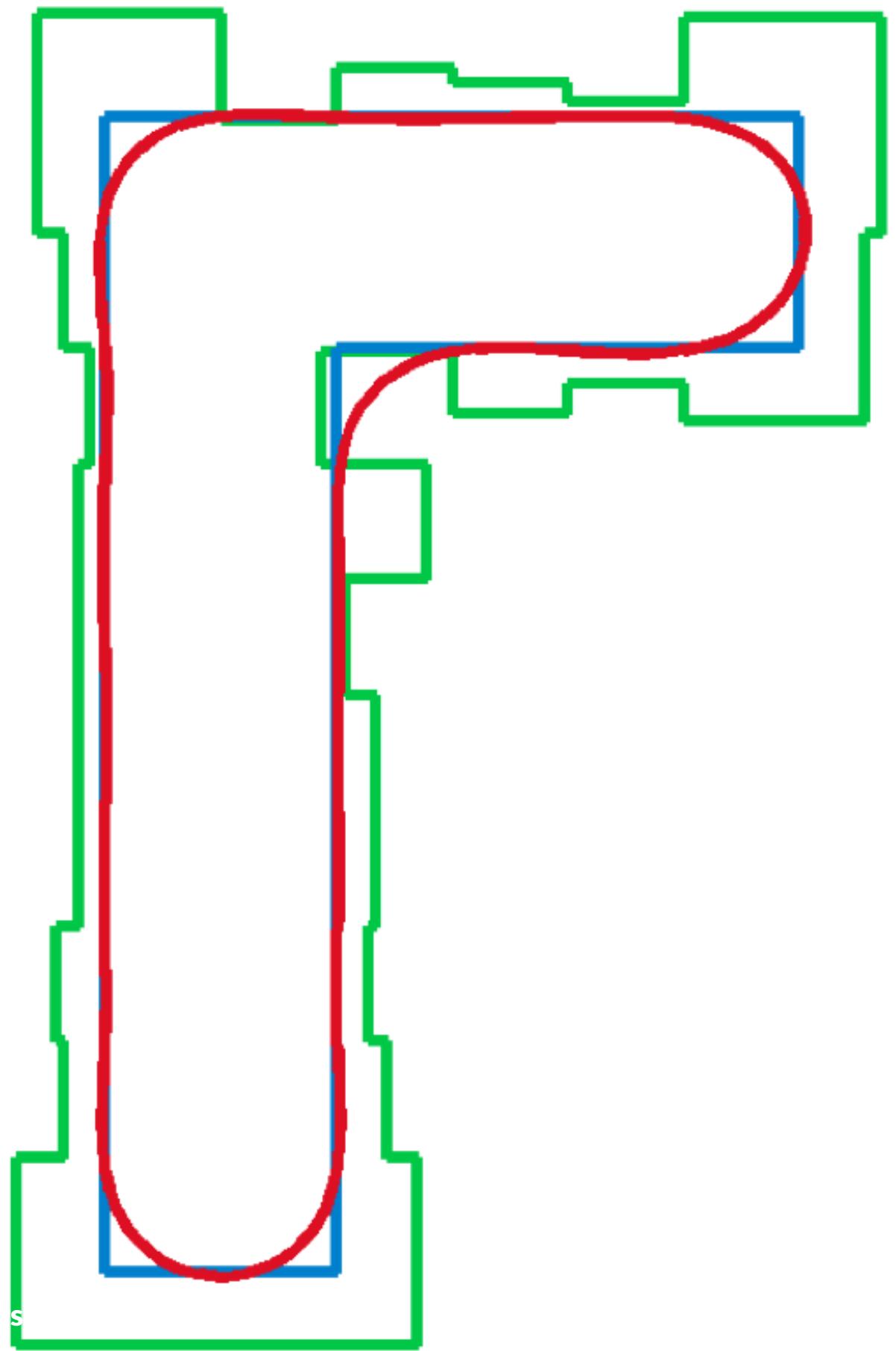
LVS

DRC



Game menu





Optical proximity correction

What you see is not what you get

Blue = Pattern we draw in our CAD programs

Green = How the mask actually looks

Red = Pattern on chip

Don't panic!



NORDIC
SEMICONDUCTOR

Smarter Things

Want to help me make
a better world?

And have fun at the same time.

<http://www.nordicsemi.com>

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