HiSIM

EXTRACTION FLOW IN UTMOST IV

Background

As CMOS technologies shrink to below 90nm, the need for accurate circuit simulation SPICE model becomes acute. The current SPICE models, BSIM3 and BSIM4, are running out of capability when used to simulate CMOS circuits built in these technologies. The release of the new, speed and accuracy improved HiSIM version 2.4 could not have come at a better time to address these needs.

HiSIM SPICE model has been developed at the University of Hiroshima, Japan, at the initiative of Professor Mitiko Miura-Mattausch. The HiSIM model foundation is a departure from a traditional approach known as 'Vth-based CMOS Model,' and is based on what is now known as a 'Surface Potential-Based Model.' Surface Potential-Based Model accurately represents the physics down to 65nm CMOS geometries and below.

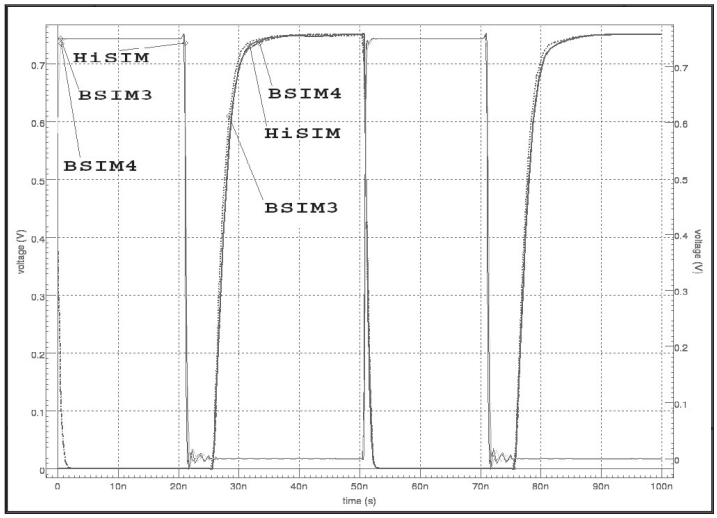
Implementation History

Silvaco introduced the first version of the local optimization strategies for HiSIM version 1.2 in 2002 in its UTMOST-III. Since then, the parameter extraction methodology has been reviewed thoroughly and updated to incorporate the ongoing HiSIM model refinements and improvements.

The Challenge and HiSIM Solution

Conventional MOSFET models often use unphysical parameters to smooth characteristics between the different operation modes. As HiSIM employs the drift-diffusion approximation and preserves correct modeling of the surface potential in the channel, valid over all modes of operation, only physical parameters are necessary. Therefore, HiSIM it is not only accurate, but it also reduces the number of parameters needed to model a MOSFET device. This approach results in :

- No interdependence of major parameters
- Easy parameter extraction
- Smaller set of parameters sufficient to model device characteristics
- Derivatives are continuous over the whole operating range
- One parameter set for all channel lengths and widths

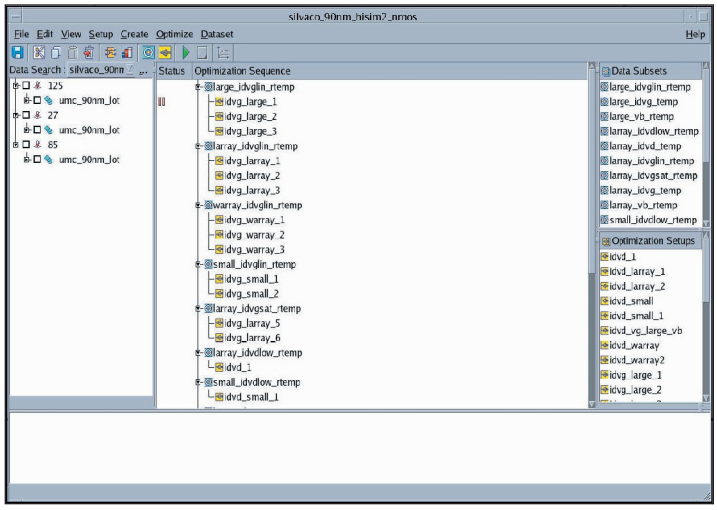


HiSIM simulation shows good accuracy.

Automatic Push-Button Extraction Sequence

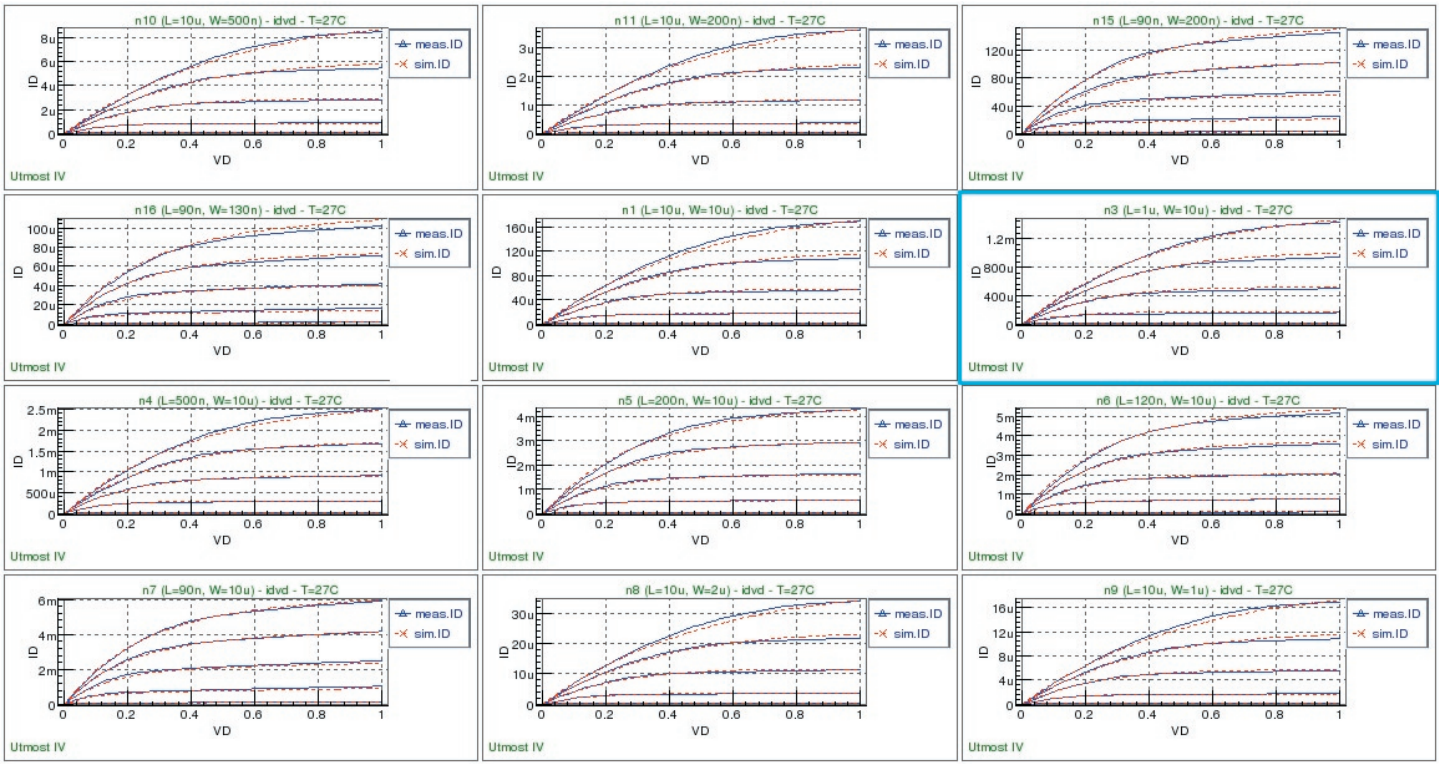
An extraction procedure for the most recent version HiSIM 2.4 has been implemented in the new Simucad's UTMOST IV to provide an easy to use, database-driven environment for the generation of accurate, high quality HiSIM SPICE models.

The bundled push button HiSIM extraction methodology supplied with UTMOSTIV can be easily customized by the end user to model difficult technologies.



UTMOST IV HiSIM extraction flow.

SIMUCAD DESIGN AUTOMATION



Single scalable HiSIM model for a 90nm technology shows excellent fit.

```
.LIB hisim2
*
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+level     = 170          version   = 240          tnom      = 27
+corsrd    = 0            corg      = 0            coiprv    = 1
+copprv    = 1            coadov    = 1            coisub    = 0
+coiigs    = 0            cogidl    = 1            coovlp    = 0
+coflick   = 0            coisti    = 0            conqs     = 0
+cothrml   = 0            coign     = 0            codfm     = 0
+corbnet   = 0            vmax      = 1.6867e+06   bgtmp1    = 5e-05
+bgtmp2    = -9.48365e-07 eg0       = 1.15327      tox       = 2.3e-09
+xld       = 0            lover     = 3e-08        ddltmax   = 0
+ddltslp   = 0            ddltict   = 10           vfbover   = -0.5
+nover     = 0            xwd       = 0            xl        = 0
+xw        = 0            saref     = 1e-06        sbref     = 1e-06
+ll        = 0            lld       = 0            lln       = 0
+wl        = 0            wl1       = 0            wl1p      = 1
+wl2       = 2.13155e-08  wl2p      = 2            wld       = 0
+wln       = 0            rsh       = 0            rshg      = 0
+xqy1      = 0            xqy2      = 2            rs        = 0
+rd        = 0            vfbc      = -1.00473     vbi       = 1.1
+nsubc     = 1.14146e+17  parl2     = 1e-08        lp        = 1.5e-08
+nsubp     = 3.79855e+18  nsubp0    = 0            nsubwp    = 1
+scp1      = 0            scp2      = 0.1          scp3      = 1.43404e-08
+sc1       = 0            sc2       = 2.77035      sc3       = 0
+pgd1      = 0            pgd2      = 1            pgd3      = 0.8
+pgd4      = 0            ndep      = 1            ndepl     = 0
+ndeplp    = 1            ninv      = 0.5          muecb0    = 100
+muecb1    = 27.2632      mueph0    = 0.257974     mueph1    = 30034.9
+muephw    = -0.1         muepwp    = 0.24059      muephl    = -0.0280916
+mueplp    = 1            muephs    = 3.81015e-05  muepsp    = 2
+vtmp      = 0            wvth0     = 0.00281884   muesr0    = 1.98112
+muesr1    = 3.07042e+14  muesrl    = 0            muesrw    = -0.00161676
+mueswp    = 1.04214      mueslp    = 1            muetmp    = 2
+bb        = 2            sub1      = 10           sub2      = 25
+svgs      = 0.8          svbs      = 0.5          svbsl     = 0
+svds      = 0.8          slg       = 3e-08        sub1l     = 0.0025
+sub2l     = 2e-06        fn1       = 50           fn2       = 0.00017
+fn3       = 0            fvbs      = 0.012        svgsl     = 0
+svgslp    = 1            svgswp    = 1            svgsw     = 0
+svbslp    = 1            slgl      = 0            slglp     = 1
+sub1lp    = 1            nsti      = 5e17         wsti      = 0
+wstil     = 0            wstilp    = 1            wstiw     = 0
+wstiwp    = 1            scsti1    = 0            scsti2    = 0
+vthsti    = 1            vdsti     = 0            muesti1   = 0
+muesti2   = 0            muesti3   = 1
+nsubpsti1 = 0            nsubpsti2 = 0            nsubpsti3 = 1
+lpext     = 1e-50        npext     = 5e+17        scp21     = 0
+scp22     = 0            bs1       = 0            bs2       = 0.9
+tpoly     = 2e-07        cgbo      = 0            js0       = 5e-07
+js0sw     = 0            nj        = 1            njsw      = 1
+xti       = 2            xti2      = 0            cisb      = 0
+cvb       = 0            ctemp     = 0            cisbk     = 0
+cvbk      = 0            divx      = 0            clm1      = 1
+clm2      = 20           clm3      = 5            clm5      = 1
+clm6      = 0            vover     = 0.897163     voverp    = 0.490536
+wfc       = 1.7213e-14   qme1      = 0            qme2      = 1
+qme3      = 0            vovers    = 2            voversp   = 0.103599
+gidl1     = 0.2          gidl2     = 1e+06        gidl3     = 0.9
+gidl4     = 0            gidl5     = 0.2          gleak1    = 50
+gleak2    = 1e+07        gleak3    = 0.06         gleak4    = 4
+gleak5    = 7500         gleak6    = 0.25         gleak7    = 1e-06
+glpart1   = 0.5          glksd1    = 1e-15        glksd2    = 5e+06
+glksd3    = -5e+06       glkb1     = 5e-16        glkb2     = 1
+glkb3     = 0            egig      = 0            igtemp2   = 0
+igtemp3   = 0            vzadd0    = 0.01         pzadd0    = 0.005
+nftrp     = 1e+10        nfalp     = 1e-19        cit       = 0
+kappa     = 3.9          pthrou    = 0            vdiffj    = 0.0006
+dly1      = 1e-10        dly2      = 0.7          dly3      = 8e-07
+ovslp     = 2.1e-07      ovmag     = 0.6          gbmin     = 1e-12
+rbpb      = 50           rbpd      = 50           rbps      = 50
+rbdb      = 50           rbsb      = 50           ibpc1     = 0
+ibpc2     = 0            mphdfm    = -0.3         cgdo      = 5e-11
+cgso      = 5e-11        cj        = 0.00107      mj        = 0.29
+mjsw      = 0.33         cjsw      = 1.26e-10     cjswg     = 2.31e-10
+mjswg     = 0.33         pb        = 0.61         pbsw      = 1
+pbswg     = 0.6          )
*
.ENDL hisim2
```

HiSIM model card for a 90nm technology.