MOS TRANSISTOR CHARACTERIZATION of uEff, Leff & Rseries

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A software program, BSIMjr, is described which operates on linear region surface channel MOS transistor I-V data, to extract the following characteristics:
1-Effective mobility, uEff[Vbs,(Vgs-Vtx)].
2-Effective electrical length, Leff=Lmask+dL, dL=dL[Vbs,(Vgs-Vtx)].
3-Source/drain series resistance, Ro[Vbs,(Vgs-Vtx)]; where inversion charge Cox*(Vgs-Vtx) defines Vtx; and we define Vgt=(Vgs-Vtx).

No model assumptions are made regarding uEff, dL and Ro; and in fact BSIMjr can be viewed as a "measurement instrument" which independently measures the above three characteristics. MOS transistor current drive is degraded by the combination of these three phenomena and BSIMjr is believed to be the first program to independently measure these characteristics. Applications are validation of models and profiles in device simulators as well as characterization for technology development and manufacturing control.

BSIMjr

BSIMjr, and the steps it performs, are described in the following:
1-An extended charge sheet model of J. Brews(1), is developed for short channel lengths and non-uniform channel profiles, and employed to model threshold characteristics Vtx(Ids). Fig 1 is an example of Vtx(Ids) extracted from Vgs(Ids) data.
2-The Vtx(Ids) characteristics for a short channel device, in inversion, [see Fig 2, from data of ref(2)], is used to generate Ids(Vgt) characteristics for all device sizes, from measured Ids(Vgs) data. In particular, in BSIMjr, values of Vgt are identical for all device sizes, and tables of Ids (Vgt) are analyzed instead of the measured data of Ids (Vgs).
3-The method of G.J. Hu(3), [where the intersection of Vds/Ids(fixed Vgt) versus Lmask for two closely spaced values of Vgt, yields dL(Vgt) and Ro(Vgt)], is extended to exploit the exactness of the Ids(Vgt) "data" from steps 1 & 2 and yields the "measurement instrument" for uEff, dL and Ro.

It is shown that for any value of Vbs; the uEff, dL and Ro characteristics are independent of channel length and depend only on Vgt. This is an attractive result for supporting the characterization of device simulators.

Shown in Fig 3 are results of BSIMjr analysis on a device with Leff of approximately 0.25 microns(2). Note that series resistance is a maximum for Vbs=-3 and low gate drive (129 ohms) and is reduced to 78 ohms at Vbs=0 and high gate drive. While Leff is largest (0.31 microns) at Vbs=0 and high gate drive and is smallest (0.22 microns) at Vbs=-3 and low gate drive. With modulated dL and Ro, uEff also fits well a universal mobility model(4), with parameters(uo, Eo & no) as shown on Fig 3.

SUMMARY

BSIMjr measures independently three drain current degredation effects in surface channel MOS transistors. These are the modulation of channel length (dL(Vgt)), value of and modulation of source/drain series resistance (Ro(Vgt)), and the surface channel mobility (uEff(Vgt)).

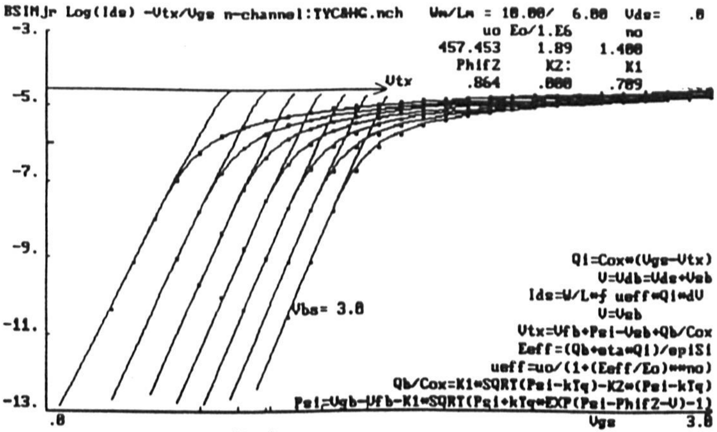

Fig 1

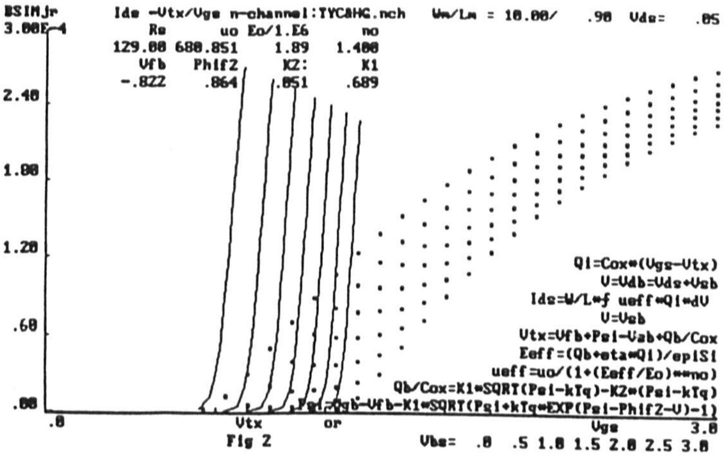

Fig 2

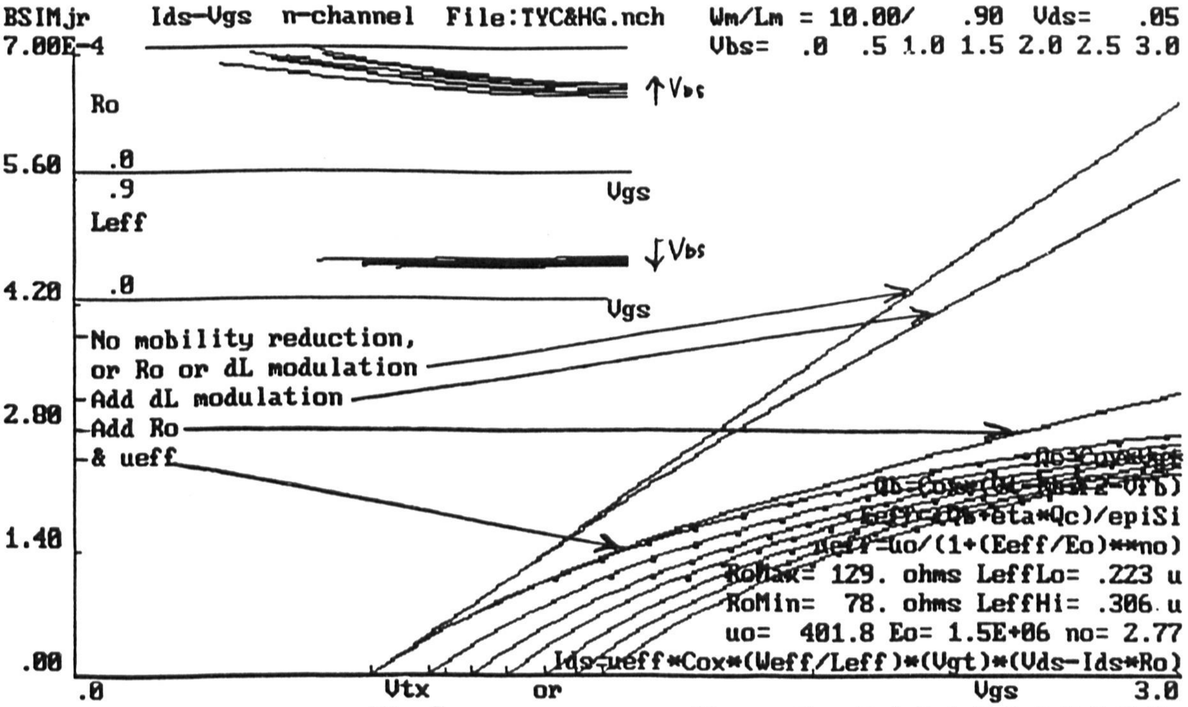

Fig 3

REFERENCES

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(3) G.J. Hu, C. Chang & Y.T. Chia, "Gate-Voltage-Dependent Effective Channel Length and Series Resistance of LDD MOSFET's", IEEE Trans. on Elect. Devices, ED-34(12), p 2469, 1987.

(4) S-W. Lee, "Extraction of MOSFET Carrier Mobility Characteristics and Calibration of a Mobility Model for Numerical Device Simulation," Solid State Electronics, Vol. 33, No.6, pp 719-726

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