

# Inverse Modeling: Getting the Most from Measured Data

Inverse modeling is a new promising area of TCAD application, which is enjoying increasing attention. The basic idea is to utilize the considerable knowledge encapsulated in TCAD tools to extract information from measured data. Physical and numerical TCAD models can provide a superior basis for interpolation over any set of analytic base functions.

In inverse modeling, a TCAD model is constructed with several physical structure or doping parameters as unknowns, e.g. oxide thickness, channel doping concentration, etc. These parameters are then chosen in an optimization procedure to obtain the best possible fit between electrical measurements and corresponding simulation results.

A good choice of optimized parameters and electrical measurements is crucial for achieving meaningful and physical results. The parameters must span a sufficient number of degrees of freedom. This means that it may not be possible to simultaneously

extract through inverse modeling peak values of multiple channel implants because their effects on certain electrical measurements are similar. At the same time, the selected electrical tests must sufficiently characterize the effects of chosen parameters.

In the example below three structure and doping parameters were chosen: Tox (oxide thickness in the middle of the gate), LDD (peak concentration of the profile) and CH1 (peak concentration of the implant). Three scalar electrical tests were selected to determine the values of the three input parameters: Vth, Idsat and Cd (drain capacitance).

Initial guesses and corresponding

Name	Value	Target	Delta
Iteration 0			
Tox	50	---	---
Ns	1e+016	---	---
CH1	1e+16	---	---
Vth	-0.063062	0.25	125.2%
Idsat	0.00099418	0.0008	-24.3%
Cd	1.0186	1.2	15.1%

electrical test values are shown above. All three have relatively large distances from their target values ranging from 15% (Cd) to 125% (Vth).

These distances are all reduced to less than 0.5% in five iterations as shown below. Given the strongly nonlinear nature of the inverse

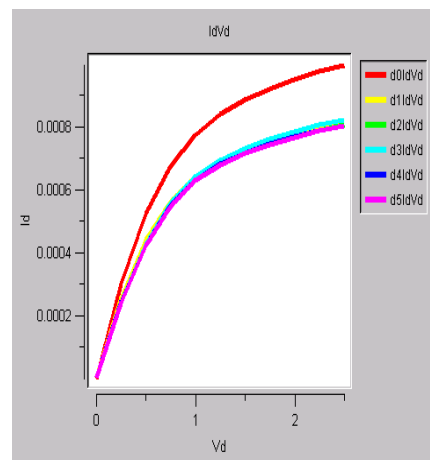
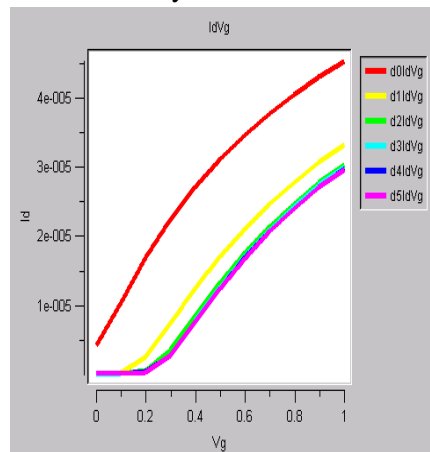
Run	lock	Tox	Ns	CH1	Vth	Idsat	Cd
Run0		50	1e+016	1e+16	-0.063062	0.00099418	1.0186
Run1		53.25	5.682e+016	1.012e+017	0.15839	0.00080435	1.2376
Run2		48.89	-2.233e+016	2.825e+017	0.22834	0.00080313	0.9584
Run3		42.07	4.008e+016	2.685e+017	0.24931	0.00081978	1.2508
Run4		45.6	1.541e+016	2.711e+017	0.24765	0.00080189	1.1656
Run5		45.43	2.47e+016	2.623e+017	0.24924	0.00080018	1.2024

modeling problem, this convergence rate can be considered quite good.

The convergence behavior is illustrated by gate and drain curves for

the initial guess and five iterations:

Inverse modeling appears to be a viable technique which allows to utilize experimental data and TCAD models to extract structure and doping parameters which cannot be directly measured. It can be



also used as a powerful calibration technique to obtain quantitatively accurate simulations.

SEQUOIA Device Designer fully supports this approach through its speed and ease-of-use, parameterized device representation, automatic meshing and numerics, and built-in optimization.