Advanced Monte Carlo techniques in the simulation of CMOS devices and circuits

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In this paper we describe advanced Monte Carlo simulation techniques that are used to study statistical variability in contemporary and future CMOS technology generations at the levels of physical transistor simulation, compact model and circuit simulation. First we will review the major sources of statistical variability in nano CMOS transistors focusing at the 45nm technology generation and beyond and will introduced the advanced 3D statistical physical statistical simulation technology and tools used to forecasts the magnitude of statistical variability. Figure 1 illustrates the statistical current-voltage characteristics of a typical 35 nm transistor. Statistical

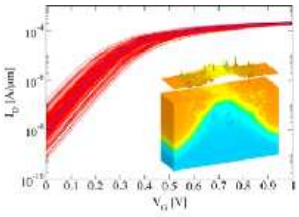

Fig. 1 statistical current-voltage characteristics of a typical 35 nm transistor.

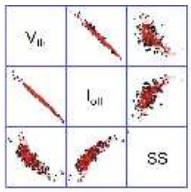

Fig. 2 correlation between key transistor figures of merit obtained using naïve and PCA parameter generation.

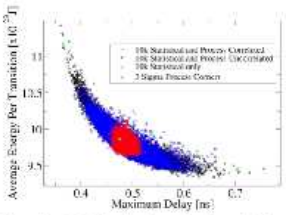

Fig. 3 statistical circuit simulation of an adder subject to different variability components.

compact models are used to transfer the variability information obtained from the physical simulations into the circuit simulation and design domain. Sensitivity analysis allows the selection of optimal statistical compact model sets of parameters. Principle component analysis (PCA) and nonlinear power method (NPM) techniques will be presented allowing statistically accurate parameters set to be generated and used in statistical circuit simulation. Fig. 2 illustrates correlation between key transistor figures of merit obtained using nave and PCA parameter generation strategies.
Finally statistical circuit simulation strategies will be presented that allow trade off between performance, power and yield in the CMOS circuit and systems design process. Fig. 3 illustrates the results of the statistical circuit simulation of an adder subject to different variability components.