MOSQue : A Novel TCAD Database System with Efficient Handling Capability on Measured and Simulated Data

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Abstract-- A novel TCAD Database System MOSQue is introduced. MOSQue is a database system for impurity profile and electric characteristics data. This system has an easy-to-use GUI which enables design engineers to refer to data for ULSI development systematically. MOSQue is also utilized on parameter tuning for process and device simulators for the purpose of precise design specifications as it efficiently administrates the relations on measured and simulated data.

I. INTRODUCTION

As the MOS ULSI technology advances, managing vast measured and simulated data with a central database system and processing them in well organized and systematic way have become the key factor for efficient ULSI development. In order to realize this approach, an easy-to-use database system for characterizing the performances of MOS ULSI is indispensable. This would also enable the efficient tuning of parameters on device and process simulators, and realize the precise ULSI design specifications based on the statistical distributions of the real data and scientific approach. Considering the easiness of operations, the user interface also should be well customized for this purpose. For example, in order to analyze statistical distributions of the measured characteristic on wafers, it is desirable that the chip allocation on the wafer is displayed and the data is manipulated directly on the displayed chip for graphics processing or parameter extractions on the measured data. For parameter tuning of the simulators, correspondence between measured and simulated data is also a very important factor. Wafer Mapping Screen[1] is known as a database system for MOS characteristics, which displays SPICE model parameter distributions on wafers and performs statistical calculations. However, it lacks the functions of displaying graphs of I-V characteristics and cannot handle database for simulated data. We have, for the first time, developed database system called MOSQue which has an efficient GUI (graphical user interface) and the processing capability for huge amount of measured and simulated data with hierarchical structures.

II. A NOVEL TCAD DATABASE SYSTEM MOSQue

MOSQue manages two kinds of data; one is 1D and 2D impurity profiles and the other is electric characteristics on measured and simulated data. Fig.1 is one of the main panel of MOSQue. This panel shows the as-implanted and post annealed SIMS (Secondary Ion Mass Spectroscopy) data together with simulated data. Fig.2 is the other main panel of MOSQue showing electric characteristics database. This panel is divided into two sections at the center; the left half is for retrieving measured data, and the right one is for simulated data. Graphs for specified electric characteristic are shown by selecting menu buttons. Followings are major advantages which had been difficult to achieve before introducing MOSQue in ULSI designing:

(1)Common data sharing by central database management

Originally, measured and simulated data were kept individually by each engineer and it was not easy to refer to other engineers' data. MOSQue for the first time enabled design engineers to handle these data commonly. Due to this central database management, engineers are released from time consuming and tedious work of searching the data already measured or simulated by other engineers and storing them into their individual database for the purpose of reference, re-use, or further investigations.

(2)Referring to stored data with simple and easy operations

MOSQue has an easy-to-use GUI, which enables any design engineers to retrieve data from database systematically. For instance, in MOSQue, the electric characteristics of both measured and simulated data have hierarchical structures. Users first select a lot name, then a wafer name, desired characteristics, chip location and gate length. For the data selected in this order, graphs for electric characteristics such as Id-Vd, Id-Vg and threshold voltage vs. gate length are depicted on the screen. Users can also retrieve process flow tables for measured data and corresponding input data for simulated data by clicking the menu buttons. Since exact process flow tables including manufacturing equipments can be traced, device engineers can use MOSQue as reference database in device designing and detailed investigations for ULSI development. The selected input data for simulators enables the engineers to modify it for further investigations on the related structures or by changing the process conditions. For data comparison or editing, MOSQue has an original graph tool called SXGraph. SXGraph has many special functions for plotted data handling, unique among of them are the functions such as "copy and paste" and "line move" directly on the graph panels, which are not included in general similar graph tools[2]. Due to this unique tool, users can compare or investigate not only measured and simulated data in database, but also compare their data just measured or simulated with data in database.

(3)Correlation between measured and simulated data

For developing ULSI with TCAD technology, measured and simulated data should be compared in an efficient way. As the result of parameter tuning on simulators, measured and simulated data with same process and electrical bias are stored together with mutual relational information. As MOSQue has information on this relations, users can easily retrieve the corresponding simulated data while viewing measured electric characteristics data, and then can merge them in one graph for easy comparison using the SXGraph which was mentioned in (2). Users can also see the correspondence between the process flow for manufacturing and the input data for simulator at a glance, which enables detailed investigations on the data and has also educational effects on simulation techniques.

III. TYPICAL APPLICATION EXAMPLE

We have already built database of the measured and simulated data for 0.35μm and 0.25μm generation technology into MOSQue, which is utilized for the improvement and tuning of process and device simulators. For example, the reverse short channel effect is devised to the process and device simulators utilizing this system, and the simulated result is compared with the measured data using MOSQue. Fig.3 is the SXGraph window for the profile simulation of phosphorus impurity compared with SIMS measurement. Users can retrieve input data for process simulator for this simulation from MOSQue panel and show on the screen (fig.4). Also, actual process flow tables can be shown through MOSQue operation. Fig.5 is the SXGraph window on which threshold voltage vs. gate length graph of simulated and measured data are shown. Fig.6 shows the simulated saturation current vs. gate length compared with measurement data. The processing of fig.5 for example can be handled by the following procedures on the screen: (1)show threshold voltage vs. gate length graph of measured data; (2)retrieve simulated data which corresponds to the measured data and show its graph; (3)merge two windows of SXGraph.

IV. CONCLUSIONS

We have for the first time developed a novel TCAD database system MOSQue which enables shared data environment and has efficient GUI and processing capability for huge amount of measured and simulated data. This system allows design engineers to refer to data in database for ULSI development in a convenient way. As MOSQue administrates the relations of measured and simulated data, it is also utilized on parameter tuning for device simulators and the precise design specifications based on the statistical distributions.

REFERENCES

[1]"Wafer Map Distribution of Statistically Correlated Parameters," The Simulation Standard, Silvaco, September, 1996

[2]For Example, "Microsoft Excel Users' Guide," Microsoft, 1989

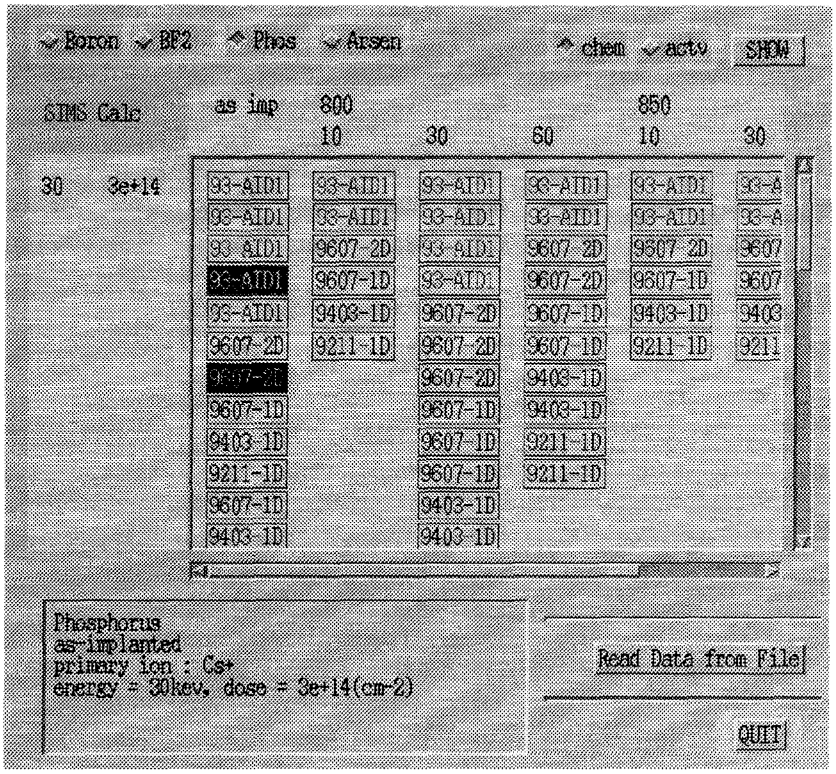

Fig.1 MOSQue main panel (impurity)

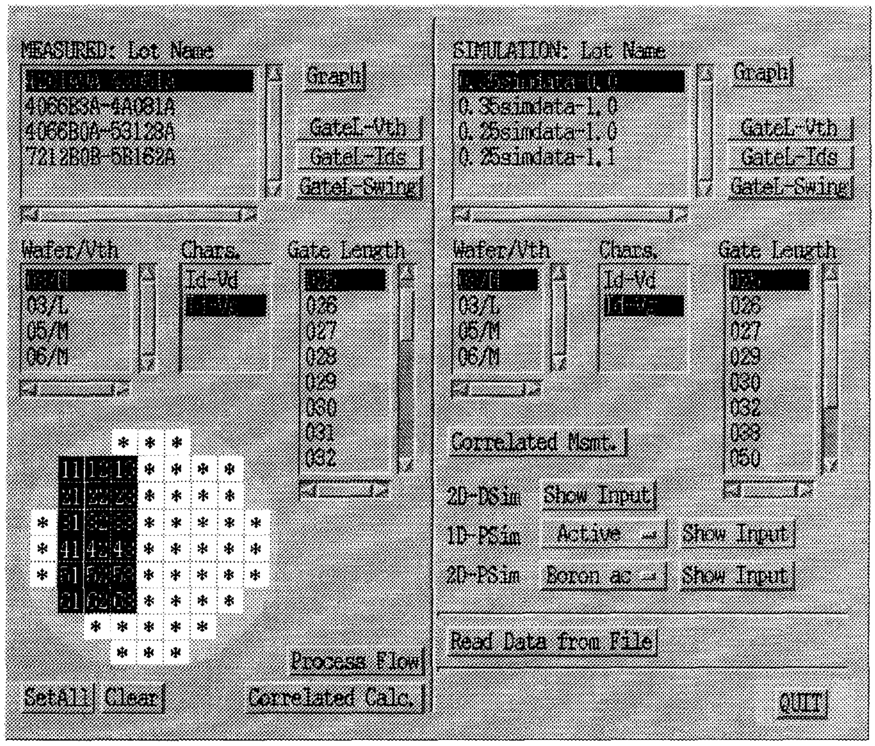

Fig.2 MOSQue main panel (electric characteristics)

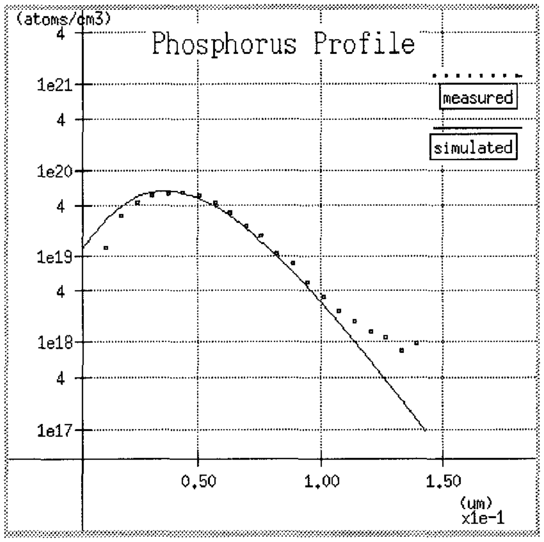

Fig.3 Profile of as-implanted phosphorus into Si

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INIT   WIDTH = 4 THICK = 2 MATE = SI ORIENT = 100 N ■ 5e+14
DIFF   TIME ■ 10 TEMP ■ 850
OXID   PRESS ■ 1.48 TIME = 51 TEMP = 850 AMBIENT ■ DRY
DIFF   TIME = 5   TEMP = 850
DEPO   MATE = POLY ORIENT = 100 THICK = 0.06  TEMP = 610
DEPO   MATE ■ SIN ORIENT = 100 THICK ■ 0.1  TEMP ■ 27
MASK   0.2 1.79 2.19 3.78
ETCH   MATE ■ SIN
ETCH   MATE = POLY THICK = 0.02
MASK
DIFF   TIME = 30  TEMP = 950
OXID   THICK = 0.27 PRESS ■ 0.652 TIME = 71  TEMP = 950
DIFF   TIME = 30  TEMP = 950
ETCH   MATE = OX THICK = 0.01
ETCH   MATE = SIN TIME = 0
ETCH   MATE = POLY TIME = 0
ETCH   MATE ■ OX THICK ■ 0.01
DIFF   TIME = 10  TEMP = 850
OXID   THICK = 0.01 PRESS = 0.48 TIME = 17  TEMP = 850
DIFF   TIME = 30  TEMP = 850
MASK   0 2
IMPL   DOPANT = P DOSE ■ 8e+12 ENERGY ■ 350
IMPL   DOPANT = P DOSE ■ 1.8e+12 ENERGY = 80
IMPL   DOPANT = B DOSE ■ 2.4e+12 ENERGY = 15
MASK   2 4
IMPL   DOPANT = B DOSE ■ 1.6e+13 ENERGY = 280
IMPL   DOPANT = B DOSE ■ 4e+12 ENERGY ■ 60
IMPL   DOPANT = B DOSE = 4e+12 ENERGY = 100
MASK
ETCH   MATE ■ OX THICK = 0.033
DIFF   TIME ■ 10  TEMP ■ 850
OXID   THICK = 0.01 PRESS ■ 0.495 TIME = 15  TEMP = 850
DIFF   TIME = 30  TEMP = 850
DEPO   MATE ■ POLY ORIENT = 100 THICK = 0.07 TEMP = 550
....

DIFF   TIME = 0.0417 TEMP ■ 1050 TEMPE = 800
DIFF   TIME = 0.167 TEMP = 1050
ETCH   MATE = OX TIME = 0   TEMP = 0
ETCH   MATE ■ POLY TIME = 0   TEMP = 0
ETCH   MATE = OX TIME = 0   TEMP = 0
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Fig.4 Input data for process simulator

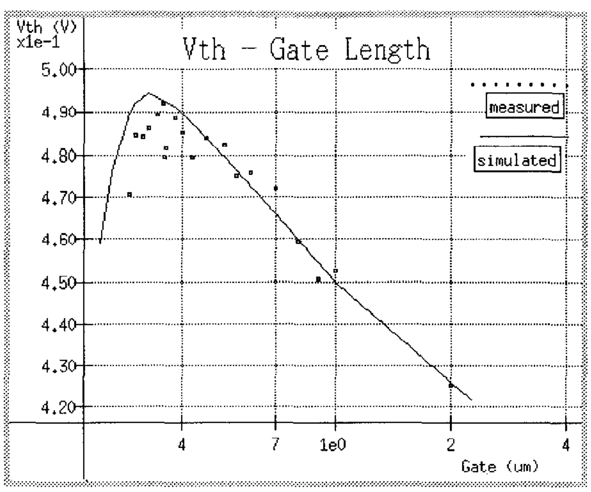

Fig.5 Vth vs. gate length

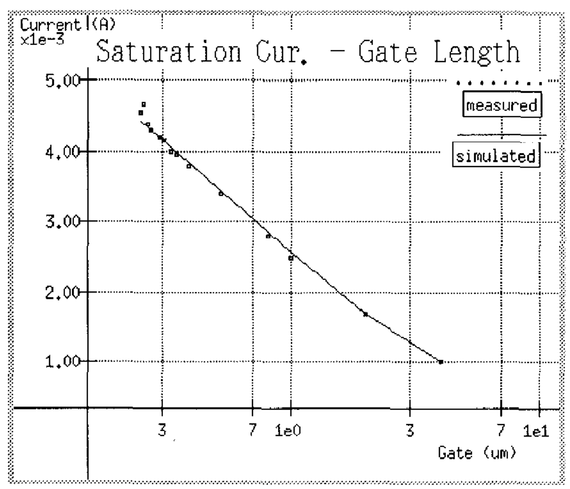

Fig.6 Saturation current vs. gate length