**Motivation**

ITE team involved in Compact Modeling Network has focused its activity in the following areas:
- Development of parameter extraction techniques,
- Analysis and modeling of parameter fluctuations,
- Compact modeling implementation,
- Implementation of automated parameter extraction techniques.

In the presented work results obtained in these fields have been combined in order to develop a versatile tool for characterization of MuGFETs.

**Experimental data**

Data base has been designed in order to reflect structure and details of FinFET measurement data shared by COMON partner.

**Why Qt environment?**

- Freely available
- Qt tool kit provides cross-platform application development and UI environment
- Supplies efficient tools for text processing
- Provides tools for SQL data base manipulation
- Allows for symbolic visualization of model equations (through QtMmlWidget)
- Supplies libraries of widgets (controls, charts, etc.) (plots via QvPlotWidget)
- Computations in Qt applications are fast enough

**Data base**

Data base has been designed in order to reflect structure and details of FinFET measurement data shared by COMON partner.

**Table structure**

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Field</th>
<th>Type</th>
<th>Field</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>id</td>
<td>int</td>
<td>primary key</td>
<td>double</td>
<td>W</td>
<td>sp</td>
</tr>
<tr>
<td>vd</td>
<td>double</td>
<td>NF</td>
<td>int</td>
<td>dev</td>
<td>varchar(20)</td>
</tr>
<tr>
<td>vg</td>
<td>double</td>
<td>T</td>
<td>x</td>
<td>EM</td>
<td>varchar(20)</td>
</tr>
<tr>
<td>ids</td>
<td>double</td>
<td>x</td>
<td>varchar(20)</td>
<td>file</td>
<td>varchar(20)</td>
</tr>
<tr>
<td>L</td>
<td>double</td>
<td>y</td>
<td>varchar(20)</td>
<td>mode</td>
<td>varchar(20)</td>
</tr>
</tbody>
</table>

**Queries**

SELECT ids FROM current WHERE vd == 1.0 and vg == 1.0 and L==0.16 and W==0.055

Extensively used to select data corresponding to different criteria.

**Model implementation and evaluation**

Two MuGFET models have been implemented in the application:
- symmetric doped DGMOSFET (UCL)
- low doped / undoped FinFET / DGMOSFET (Unistra, EPFL)

Verilog-A codes of the models have been a starting point.

**Method of implementation in Qt**

ADM3 [with Qucs XML scripts] has been used to generate C++ code of both Verilog-A models. Two files from Qucs interface have been utilized, namely:
- static parts of `<moduleName>.core.h`, `<moduleName>.core.cpp`, and two functions `initDCQ()`, `calcDCQ()`, to calculate drain currents.
- Code implementation flow-chart:

    **ADM3** $\rightarrow$ **Qucs** $\rightarrow$ **Model Explorer**

    The model equations can be easily visualized using **QtMmlWidget**.

**Parameter extraction**

At the current stage only manual extraction has been implemented. It is done using a set of sliders, corresponding to the set of the given model parameters. Parameter variation by manipulation of sliders is immediately reflected on the charts of model characteristics and shows model characteristics vs measurement data misfit.

Automatic extraction procedures based on deterministic and evolutionary algorithms [6,7] will be implemented (collab. with WUT).

**Measurement data exploration**

Data selection (query) with respect to bias, geometry, e.g output char. may be combined from input char.

**Statistical data visualization**

The application allows for investigation of electrical characteristics of large sets of devices, selected according to different criteria. It enables elimination of devices with characteristics far from typical ones (e.g. inoperable devices, or devices with parametric defects). This is a necessary step before nominal parameter extraction and statistical modeling steps.

In the very near future a functionality will be implemented, which will allow for removing of the incorrect data directly in the application panel.

**Bibliography**


**Perspectives**

- Integration with Qucs
- Automatic Extraction of Model Parameters (Deterministic and Evolutionary Algorithms)
- Statistical Modeling (Backward Propagation of Variance)
- Evaluation of correlations between model parameters (incl. scatter-plot matrices)
- Direct access to data in working area

**Statistical data estimation**

Estimation of statistical distributions describing the raw and processed data is one of the main goals of this work. So far the following functionalities have been implemented in Model Explorer application:

- Histograms of the extracted parameters
- Scatter plots
- Illustrating correlations between the parameters

**Acknowledgements**

This work was supported by Commission of the EC under grants PIAP-GA-2008-218255, ("Compact Modeling Network"), and ACYP-2008-212859 ("TRIADe").

The authors would like to acknowledge a fruitful collaboration with Dr. joaquin Alvarado (UCL), Dr. Nicolas Chevillon (Unistra), Dr. Ashkan Yesayan (Unistra) with respect to Verilog-A codes and helpful discussions. Also a support from Dr. Udit Monga (UNK), and Dr. Jasmin Agassi (Infineon) with respect to measurement data is deeply appreciated.