TCAD and Cognitive Visualization in Electronic Engineering Education

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Russian Higher Educational System

The comparison between classical Russian education and Bologna process

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Russian Federation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Square, km²</td>
<td>17 125 191</td>
</tr>
<tr>
<td>Population, million</td>
<td>146.78</td>
</tr>
<tr>
<td>Human population density, person/km²</td>
<td>8.56</td>
</tr>
<tr>
<td>Average wage, $/year</td>
<td>6912</td>
</tr>
<tr>
<td>State language</td>
<td>Russian</td>
</tr>
<tr>
<td>Quantity of higher education in the TOP 300 list</td>
<td>5</td>
</tr>
</tbody>
</table>

The case study country characteristics
Devices in Space Missions

Coordinate-operator feedback circuits are widely used in air- and spacecrafts’ control systems, but they need to be radiation-tolerant due to space environment. It can be simulated in Sentaurus TCAD.
Sentaurus TCAD

Sentaurus TCAD is the leading tool in EDA (Electronic Design Automation), a professional new-generation multidimensional device simulator, which features simulation of electrical and thermal characteristics of silicon-based and compound semiconductor devices.
Cognitive Visualization in Sentaurus TCAD

Distribution of generation of free charge carriers. Next step — Augmented Reality?
Cognitive Visualization in Sentaurus TCAD

Current peak in microcapacitor, induced by heavy charged particle

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Info {
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  datasets = [
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    "minus OuterVoltage" "minus InnerVoltage" "minus QuasiFermiPotential" "minus DisplacementCurrent" "minus eCurrent"
    "minus hCurrent" "minus TotalCurrent" "minus Charge" "plus OuterVoltage" "plus InnerVoltage"
    "plus QuasiFermiPotential" "plus DisplacementCurrent" "plus eCurrent" "plus hCurrent" "plus TotalCurrent"
    "plus Charge"
  ]
}

Data {
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  0.00000000000000E+00 -4.74234804854622E-11 -4.59783521935876E-10 -5.0720700241338E-10 -2.00237797431117E-16
  1.50000000000000E+00 1.4999999999697E+00 0.00000000000000E+00 0.00000000000000E+00 4.74234804854628E-11
  4.59783521935876E-10 5.07207002421338E-10 2.00237797431111E-16
  4.00000000000000E-1
}
```
Our Experience

Respondents: >40 undergraduate engineering students.

Statistics about operating systems familiar to students

Operating systems used by students on the daily basis
Our Experience

94% of students are ready to study new operation systems (including Linux distributions), if this is necessary for their future education and work.

Linux distributions pertaining systems statistics

Linux distributions used by students regularly
Conclusions

• Sentaurus TCAD can be used to calculate SPICE models of SOI MOSFET, to generate models of electrostatic MEMS and estimate their tolerance of heavy charged particles, etc. Graduates must be able to exploit such industrial tools, but Sentaurus TCAD requires Red Hat Enterprise Linux to work.

• Sentaurus TCAD has a lot of built-in visualization instruments, which can graphically show different processes in semiconductor devices. We can use built-in visualization tools as a basis for cognitive visualization and develop the visual thinking of students. Also we see a possibility for future use of AR technologies in electronic engineering education.

• All students are familiar with Linux-based operation systems (92% growth in comparison with 2015).

• Almost 30% of respondents use Linux-base operation systems regularly.

• Almost all students (94%) are ready to study new operation systems if they need them for future education, for example, in Sentaurus TCAD courses.
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Thank you for attention!

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