Request for Proposal

PROCESS AND DEVICE SIMULATION SOFTWARE FOR SEMICONDUCTOR NANOELECTRONICS DEVICES

August 2016

Government of India
Indian Space Research Organization
Space Applications Centre
Ahmedabad-380015
INDIA
Request For Proposal (RFP)

The Indian Space Research Organization (ISRO) requests your company to submit proposal and quotation for Process and Device simulation software for Semiconductor Nanoelctronics Device as detailed in this document.

The document is divided in three sections as below:

**Section-A:** Gives the general idea about SAC/ISRO and the intended use of the proposed system in brief.

**Section-B:** Gives the guidelines to suppliers for preparing responses against this RFP.

**Section-C:** Gives SAC’s technical requirements of the Process & device simulation software in detail.
Section – A

Space Applications Centre, Ahmedabad is engaged with the development and realization of various satellite payloads as well as R&D activities for ground hardware. To support these activities variety of technology developments are being taken up including Nano-electronics technology. The proposed software “Process and Device simulation software for Semiconductor Nanoelctronics Device” is required to simulate the different processes involved in the fabrication of semiconductor nanoelectronics device as well as devices based on characteristic physical and structural properties of semiconductor thin films. The general system description and other details have been given in Section C.
Section – B

Guidelines to Suppliers

I. Guidelines for preparing quotations:
   1. The quoted offer shall be strictly in two parts:
      i. PART-1: ‘Technical Bid’
         Giving all technical details as required in the document, delivery schedule and un-priced replica of Price Bid including all applicable taxes, commercial and payment terms etc.
      ii. PART-2: ‘Price Bid’
         All break-up prices along with the commercial terms& conditions.
   2. The supplier shall prepare detailed price break up for important work/supply elements Supplier shall provide as far as possible detailed cost break up on per item basis and work basis to enable SAC to evaluate their offer.
   3. The suppliers are requested to acknowledge the receipt of the RFP and their willingness / inability to respond and quote for the same.
   4. Technical catalogs, literature and detailed data sheets of all items offered by the supplier in support of their offer must be enclosed. Lack of information or ambiguous presentation of technical information shall weaken the merit of their offer. The supplier must ensure that their quotation along with all the details reaches SAC/ISRO before the due date.

II. Guidelines for preparing technical details:
   1. Only those suppliers who have adequate exposure and experience in the manufacturing/maintenance/support of such equipments need to quote. At the time of submission of quotation, suppliers should provide necessary documentations explaining the heritage of the quoted system wherein they should bring out since when the quoted system is in the market. The supplier should also provide a list of their existing customer base (with their full contact details such as name, telephone number, fax and email etc.) for similar systems supplied, installed and operational in last 10 years.
   2. The offered software should be a latest version with all options included to meet the requirements of this RFP.
   3. Supplier shall prepare detailed compliance statement with reference to all the specifications/conditions/sub points of this tender document clearly indicating quantitative values offered wherever applicable. It shall also clearly indicate ‘C’ for total compliance and ‘NC’ for non-compliance. Supplier shall also highlight compliance with better or superior specification wherever offered giving detailed merits and description. Supplier shall read all below mentioned specifications, description/values and remarks and indicate their agreement/compliance to each one separately as well as attach required supporting documents/details substantiating unambiguous compliance of each
specification. Supplier shall also read total tender document and submit a signed copy indicating that all parts of the tender has been read and understood before submitting their offer. Compliance statement must contain clear and unambiguous response of supplier for all main as well as sub points of this tender document. Supplier shall attach additional documents if required giving due reference of respective specification number.

4. It is necessary for the supplier to furnish complete information as required in various sections of this RFP for proper evaluation, assessment and consideration of the proposal.

5. The statements in the compliance sheet must duly be supported with facts in the original brochures / literature (to be supplied along with the Technical Bid) of the equipment. Plain compliances without adequate supporting documents are liable to be rejected.

6. The supplier shall attach additional information such as applications developed, papers published, copyrights and patents, application notes, if any, which may provide more insight on quoted system.

7. The supplier may seek clarifications, if any well in advance before submitting the quotations through our purchase department. Supplier revealing any price information either knowingly or unknowingly in their technical bid as well as during subsequent communication unless it is asked from our purchase department would disqualify the offer for further consideration.

8. To assess the capabilities of the quoted system, SAC reserves the right to request the supplier to characterize SAC specified sample wafer/substrate. The participating suppliers must comply with this point. If the bid has been made by an Agent (other than the manufacturer), an authorization certificate must be submitted along with the technical bid.
**Section-C**

**Process and device simulation software for Semiconductor Nanoelectronics Device**

**I. GENERAL DISCRPTION**

The following proposal is for installation, commissioning and demonstration of complete software package for process and device simulation. This software should have the capability to simulate the electrical, optical, and thermal behavior of semiconductor devices. It should provide physics-based, easy to use, modular, and extensible platform to analyze DC, AC, and time domain responses for all semiconductor based technologies in 2D and 3D. It should be packed with competent and robust multi-threading algorithms for reducing simulation time while retaining accuracy on parallel CPU machines. It should solve yield and process variation problems for optimal combination of speed, power, density, breakdown, leakage, luminosity, or reliability. The software package should be fully integrated with various modules such as process and device (GaN based HEMTs, QDIP, GFET etc.) simulation software, comprehensive visualization module and extensive database of examples.

The detailed specifications of individual modules are as per paragraph II below:

**II. TECHNICAL SPECIFICATIONS OF THE SOFTWARE**

1. **Process simulation capability:**

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<tr>
<td>1.1</td>
<td>Process simulation software</td>
<td>This software should be capable for simulation of fabrication processes used in modern semiconductor technologies preferably but not limited to:</td>
<td>Exact scope of process simulation should be clearly brought out with support literature and application notes.</td>
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<td>• RF Devices: HEMT, FET, HBT, GFET, BJT, JFET, IGBT, SOI, TFT, Fin-FET etc.</td>
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<td>• Multiple Gate FETs (MuGFETS): FinFET, FlexFET, Gate-All-Around (GAA) FETs, etc.</td>
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<td>• Quantum dot and other IR detector and Sensor devices</td>
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<td>The system should possess physical models for following processes but not limited to:</td>
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<td>• Doping diffusion including rapid thermal annealing (RTA)</td>
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<td>• Ion implantation with fast Monte Carlo module</td>
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<td>• Oxidation with stress effects</td>
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<td>• Physical deposition &amp; etching e.g. CVD, PVD, plasma etching, RIE, etc.</td>
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<td>• Epitaxy and stress formation and strain/stress engineering</td>
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<td>• Optical lithography</td>
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<td>The advanced process module should be capable of</td>
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interactive visualization of 2D structures and distributions as well as 1D cross-sections

- Run-time extraction of important process parameters
- Optimization of process flow and calibration of process models
- Creation and modification of process flow input decks including automatic control of layout GDS2 mask sequences

The system should be capable of providing process simulation for variety of materials used in the semiconductor industry but not limited to:

- Silicon Carbides (SiC), Compound Semiconductors, e.g. GaN, AlGaN, GaAs, AlGaAs, InGaAs, InP etc.
- Silicon, Silicon Germanium (SiGe), Silicides, e.g. WSi, TiSi2, CoSi2.
- 2D materials, e.g. Graphene, MoS2, WS2, MoSe2, WSe2 etc
- All Schottky and Ohmic contact metals and dielectric/insulating materials used in Semiconductor Nano electronics device technology

2. Device simulation Capabilities

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| 2.1     | Device simulation software | The device simulation software system should be capable of:  
- Analyzing and characterizing the electrical, optical, and thermal performance of various 2D or 3D devices.  
- Fully integrated with process simulation software, comprehensive visualization package.  
- Solving yield and process variation problems for optimal combination of speed, power, density, breakdown, leakage, luminosity, reliability etc.  
- Support parallel processing on multi-core and multiple processor machines  
- Physical models for a Silicon, III-V, III-N, II-VI, IV-IV, Graphene, polymer/organic etc.  
- Compatible with other device simulators (SPICE) or other TCAD tools | Exact scope of devices simulation should be clearly brought out with support literature and application note. |

3. Modules:

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<td>3.1</td>
<td>Physics base Modeling</td>
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- Physics based models should include drift-diffusion, energy balance transport equations, | This module should be |
| 3.2 | Physics base Modeling for Advanced Materials | - Should be capable to simulate devices fabricated using advanced materials.
- Library of binary, ternary and quaternary semiconductors as well as other important advanced materials along with material parameters.
- Inclusion of models for graded and abrupt heterojunctions, and simulates binary structures such as MESFETS, HEMT’s etc. DC, AC and time-domain solutions for general nonplanar homojunction and heterojunction semiconductor device structures.
- Boltzmann and Fermi-Dirac statistics with band gap narrowing.
- Interface to Quantum for quantum statistics. Drift-diffusion and energy balance transport models with advanced mobility models.
- Trap dynamics for DC, transient and AC. Models for Shockley-Read-Hall, optical, and Auger recombination, impact ionization, band-to-band, and Ohmic and Schottky contacts.
- DC, AC and transient device characteristics should be simulated.
- Calculated DC characteristics include threshold voltage, gain, leakage, punch through voltage and breakdown behavior.
- Calculated RF characteristics include cut-off frequency, s-, y-, h- and z parameters, maximum available gain, maximum stable gain, maximum frequency of oscillation and stability factor.
- Interface provision that allows user-defined, composition dependent, models and material parameters. |

| 3.3 | Thermal effect Simulation | - It should be able to model heat generation, heat flow, lattice heating, heat sinks, and effects of local temperature on physical constant.
- It should provide appropriate environment for design and optimization of power devices.
- Applications should include characterization of electrostatic discharge (ESD) protection, device design, thermal failure analysis and heat transfer. |
### 3.4 Optoelectronics Device Simulation
- Modeling of light absorption and photogeneration in non-planar semiconductor devices.
- It should account for arbitrary topologies, internal and external reflections and refractions, polarization dependencies and dispersion.
- Optical transfer matrix method analysis for coherence effects in layered devices.
- It should be applicable to a wide array of device technologies including CCDs, solar cells, photodiodes, photoconductors, avalanche photodiodes, MSM photodetectors, phototransistors, and optoelectronic imaging.

This module should be capable for both 2D and 3D device simulation.

### 3.5 Quantum Mechanical effect simulation
- It should provide a set of models for simulation of various effects of quantum confinement and quantum transport of carriers in semiconductor devices.
- It should allow quantum mechanical calculation of bound state energies and associated carrier wave functions self consistently with electrostatic potential.
- Should associate with Schrodinger solvers with Non-Equilibrium Green Function (NEGF) Approach in order to model ballistic quantum transport in 2D or cylindrical devices with strong transverse confinement.

This module should be capable for both 2D and 3D device simulation.

### 3.6 Circuit simulation
- It is a circuit simulator that includes physically-based devices in addition to compact analytical models.
- Physically-based devices are used when accurate compact models do not exist, or when devices that play a critical role must be simulated with very high accuracy applications of power circuits, high performance digital circuits, precision analog circuits, high frequency circuits, thin film transistor circuits, and optoelectronic circuits.
- Compact analytical models for high power circuits including variety of devices such as diode, HEMT, bipolar, thyristor, GTO, MOS and IGBT devices.

This module should be capable for both 2D and 3D device simulation.

### 3.7 Noise simulation
- It should capable to analyze small-signal noise generated within semiconductor devices.
- It should capable for accurate characterization of all small-signal noise sources and extracts figures of merit for circuit design.

This module should be capable for both 2D and 3D device simulation.

### 3.8 User define other standard language model interface
- An Interpreter which allows convenient and flexible definition of physical models and material parameters via standard language interface (e.g. C, C++, etc.)
- It should have user defined functions at run-
time, while maintaining fast execution times.  
- Wide range of functions such as doping, composition fraction, defect density of state, temperature and composition dependent band parameters, as well as mobility, recombination and generation models should be there.

4. Other interactive tools:

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| 4.1     | Run time interactive tool     | This tool should have following capabilities:  
- An interactive runtime and input development environment within which most of the TCAD and several other products can run.  
- It should have numerous simulator specific and general debugger style tools, such as powerful extract statements, GUI based process input, line by line runtime execution and intuitive input syntactical error messages.  
- It should contain an extensive library of hundreds of pre-run examples decks which cover many technologies and materials. |

| 4.2     | Graphical display and analysis tool | This tool should have following capabilities:  
- A powerful tool is required to visualize 1D and 2D structures produced by TCAD simulators.  
- It should provide visualization and graphic features such as pan, zoom, views, labels, and multiple plot support.  
- Plotting engine should support all common 1D and 2D data views including: 1D x-y data, 2D contour data, 2D meshed data, smith charts and polar charts. Exports data in many common formats (jpg, png, bmp, SPICE raw file, and CSV) for use in reports or by third party tools. |

5. Other terms and conditions:

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| 5.1     | Software compatibility | Software shall be compatible with following workstation/hardware specifications  
- Processor: Dual Intel Xeon E5-2667v4 3.2 2400 8C 1st CPU  
- Chipset: Intel H8/Q8 series  
- RAM: 128GB DDR4-2400 (8x16GB) Reg RAM  
- Hard Disk: 512GB PCIe SSD drive and 3 * 2 TB SATA HDD  
- Graphics Card: NVIDIA Quadro M 5000 8GB graphic card  
- OS: RHEL Linux and Windows |             |                  |
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<th>Section</th>
<th>Description</th>
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<td>5.2</td>
<td><strong>Software license</strong>&lt;br&gt;All modules and sub modules of softwares should have perpetual license.&lt;br&gt;The simulation data generated by the software should be in the format compatible for direct export to spreadsheet like MS excel etc.</td>
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<td>5.3</td>
<td><strong>Version of Proposed software</strong>&lt;br&gt;The proposed software should be the latest version which is technically and application point of view compatible with RFP requirement. The same should clearly be mentioned in detail in quotation.</td>
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<td>5.4</td>
<td><strong>Onsite Warranty and Extended Warranty</strong>&lt;br&gt;One-year onsite warranty should be provided by supplier. Additional support for the minimum period of five years should be quoted as extended warranty/AMC.  &lt;br&gt;Supplier shall note that the extended warranty shall be on post payment basis.</td>
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<tr>
<td>5.5</td>
<td><strong>Installation &amp; demonstration of performance at SAC.</strong>&lt;br&gt;Software shall be installed at SAC by manufacturers or their qualified representatives and performance of all main and sub modules shall be demonstrated at SAC as per specifications/ Purchase order.  &lt;br&gt;Using installed software supplier need to demonstrated the process and device simulation result for standard GaN HEMT, GaAs QDIP, etc devices.</td>
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<td>5.6</td>
<td><strong>Training at SAC</strong>&lt;br&gt;Supplier shall provide necessary training to SAC engineers/technicians.</td>
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<td>5.7</td>
<td><strong>Details of existing cliental</strong>&lt;br&gt;Supplier should provide details of existing users of the software especially Indian users along with contact details.</td>
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<td>5.8</td>
<td><strong>Authorization</strong>&lt;br&gt;Offer should be from original developer agency or from their authorized representative.</td>
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<td>5.9</td>
<td><strong>Support documents</strong>&lt;br&gt;The offer should be properly supported with relevant technical leaflets, catalogues as well as application notes demonstrating the claims of the quote. Publications by other agency using the offered software may also be indicated/provided.</td>
</tr>
<tr>
<td>5.10</td>
<td><strong>Compliance</strong>&lt;br&gt;Point by point compliance for all the RFP specification should be provided with clear indication of compliance/non-compliance unambiguously.</td>
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