WiSys Ref: T180055

Semiconductor Quantum Dot Computer Aided Engineering (CAE) Simulation Tool

Market and Background

With the continued development of semiconductor technology, it is now possible to fabricate nano-scale material structures called Quantum Dots (QDs). The properties of QDs have earned them the characterization of "man-made atoms". However, unlike nature's atoms, one of the key advantages of QDs is the ability to engineer them for specific applications. Currently there is a rapidly increasing level of novel applications for QDs in the photonics, optoelectronics, renewable energy, and medical device industries. The global market for QDs has been growing significantly in recent years. A BCC Research market report indicates that in 2016, global revenues for the QD market were at $610 million and by 2021 this market will see revenues exceeding $3.4 billion. That is a compound annual growth rate of 41.3% for that five-year period. Even though the commercial prospects for QDs are growing significantly, the development of these material structures is still very labor intensive and expensive. The design, modeling, and fabrication of QDs is still mainly carried out using a trial-and-error method. There is an unmet need for a commercial software program that scientists and engineers can use to aide in the design of semiconductor QDs.

Research and Development Status and Commercialization Needs

A Professor of Electrical Engineering at the University of Wisconsin – Platteville has developed a software simulation tool for the computer aided engineering (CAE) of Quantum Dots. The CAE simulation tool accepts input of the QD parameters and then computes and returns the resulting optical and electronic properties. This includes QD structures with an InAs core and a GaAs matrix, and can be extended to any III-IV materials. The CAE tool simulates the most popular pyramidal and half-ellipsoidal QD shapes and can be extended to any arbitrary geometric shape. Compared with the often-incomplete results reported in the literature, this CAE simulation tool returns all possible electronic states within the QD. The CAE simulation results also supported the experimental data for the corresponding QD.

The simulation tool (Q-Dot) currently runs as an application in the COMSOL platform and does not require a supercomputer for calculations and processing. This prototype is available for testing and supported by an accompanying user manual. Additionally, a separate quantum wire simulation tool (Q-Wire) is also available for testing as an application in the COMSOL platform. Similarly, this prototype is supported by an accompanying user manual.

Current efforts are ongoing to continue developing the CAE simulation tools. While the results for Quantum Wire simulation have a high level of confidence, improvements are underway to eliminate instances of spurious results for Quantum Dots. WiSys is seeking a strategic partner skilled in the design, modeling, and fabrication of Quantum Dots and Quantum wires. There is interest in working with a partner to test the beta versions of the CAE simulation tools and provide feedback when modeling both Quantum Dots and Quantum Wires. Additionally, there is interest in identifying a partner with a 3D finite element method solver for further development and testing of the CAE simulation tools.

Applications and Key Benefits

- Computer aided engineering (CAE) simulation tool for the design of quantum structure materials that can reduce time and costs associated with current modeling options
- Processing and computation of QD optical and electronic properties without requiring the use of a supercomputer
- Simulations can be run using various III-IV materials and any arbitrary geometric shape
- When tested against known QDs, the CAE simulation tool returned figures that aligned with the experimental data
- Simulations return all possible electronic states of a QD and thus more complete results than what is available in the literature

- Designed for use in both commercial environments and for academic research where semiconductor quantum structure materials are used

Intellectual Property

A US patent is pending for this technology. For more information, please contact our licensing team at licensing@wisys.org.