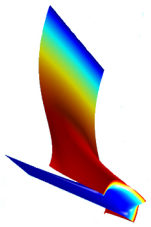

Photodetector Model Speeds Semiconductor Circuit Optimization

By Beverly E. Pryor, President
Pryor Knowledge Systems, Inc.

Pryor Knowledge Systems recently assisted a major international company in the sensor industry to optimize a new device design through multiphysics modeling in a fraction of the time and cost associated with building and testing multiple physical prototypes.

Our client had developed a design for a photodetector that centered on a high resolution, high energy, and high voltage semiconductor PiN diode. This device was designed to detect high speed, high-energy laser pulses.

The physical design and doping levels of the PiN diode and its related circuitry needed to be optimized to meet the specifications for such an application and to perform as effectively as possible.

The client came to Pryor Knowledge Systems for assistance in this design optimization. They desired to determine the transient response of the current design. They then wanted us to test modifications as needed to improve performance, without the cost of fabricating each change in diode properties and circuitry.

Dr. Roger W. Pryor, the vice president of research at Pryor Knowledge Systems and a COMSOL Certified Consultant, has years of experience in designing and fabricating semiconductor devices for both industrial applications and academic research. Moreover, he had developed techniques and equations specifically designed for modeling semiconductors using the COMSOL Multiphysics® software. "It all goes back to first principles", says Dr. Pryor. "Once your model reflects the physics of the application, the results will reliably reflect the actual performance of the system being modeled."

The model was built as a two-dimensional approximation of what would normally be a three-dimensional device. This approach minimized calculation difficulties and facilitated rapid convergence without significant loss of relevance in the results. First, the model defined the PiN diode alone, using functions from the basic and AC/DC modules. Results of this model were compared to experimentally derived performance curves for similar devices. (See Figure 1.)

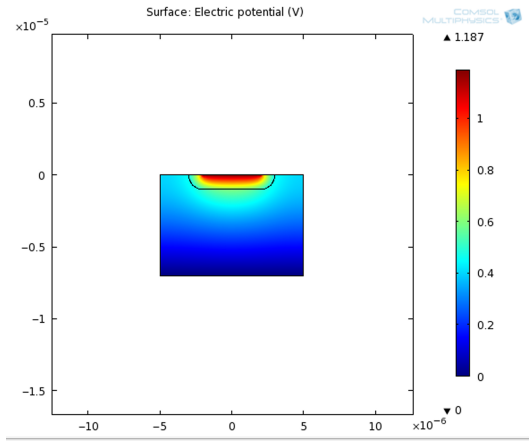

Figure 1 PiN Diode Solution

Once we were satisfied that the outputs of the diode model were behaving correctly, then the entire circuit was modeled, using the capabilities of SPICE in COMSOL Multiphysics. (See Figure 2.) Taking advantage of his expertise in selecting the values for the initial variables, Dr. Pryor was able to produce results quickly that identified dead design paths and highlighted the best-performing options. "The ability of COMSOL to incorporate equations tailored to the application and to model circuitry with the SPICE capabilities allows for the development of advanced integrated models", Dr. Pryor says.

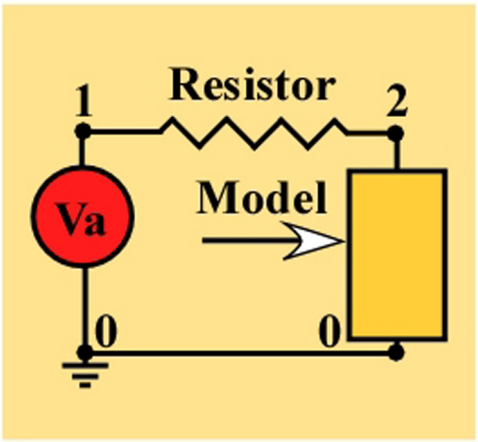

Figure 2 PiN Diode SPICE Circuit

The elapsed time to develop the model and run several variations on the design was in the range of days to weeks, compared with hardware trials that typically take weeks to months. The cost of the modeler's time was two or more orders of magnitude lower than the cost of fabricating several device modifications.

The client has used the results of the model to refine the design of their photodetector and is pleased with the performance of the resulting devices. Dr.

Pryor presented a similar photodiode modeling technique at the COMSOL User Conference in Boston in October 2010. [1]

References

1. Pryor, Roger W., “Modeling PiN Photodiodes”, Pryor Knowledge Systems, Inc. Web. October 2010. http://www.pksez1.com/Modeling_PiN_Photodiodes.pdf