# Modeling Facilitates Process Recovery and Design Optimization

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What is a company to do when it has just purchased a sensor technology, but the know-how in its fabrication process is no longer available? Such a client approached Pryor Knowledge Systems for assistance when they found themselves in this bind.

The semiconductor device fabrication expertise of Dr. Roger W. Pryor, our vice president of research and a COMSOL Certified Consultant, was critical to the recovery of the process. Applying his extensive process and modeling experience to the characteristics of the product allowed the client to rapidly build and operate their fabrication line and then to improve on the basic product line.

The solid-state liquid level sensors were designed to be immersed in the coolant and to sense the loss of coolant by the change in conduction in the device due to the related change in temperature. The product line is used in a variety of construction and industrial equipment. Since overheating can ruin these machines, the detection of losses of their coolant is critical.

Samples of each sensor product were measured to determine the dimensions of the semiconductor sensor and its characteristic conduction curve. [See figure 1.]

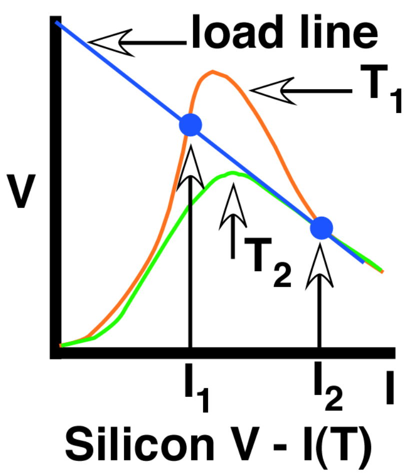


**Figure 1 Thermoresistive Response**

The first model was built to determine the doping levels needed for the semiconductor sensor device to produce the desired characteristic conduction curve. The geometry of the sensor and its materials were specified. Then, a likely doping level was selected, and the model was run. Results were compared to the curve that had been measured, and then the doping level was adjusted until the curves matched.

The resulting doping level was used for the fabrication of new devices. Their characteristic conduction curves were measured to confirm that the recommended doping level achieved the desired results.

Once the ability to build devices to the original design specifications was achieved, Dr. Pryor used further versions of the model to test his recommended modifications to the design. The model dealt with changes in parameters such as the geometry of the sensor, the geometry of the metallic immersion probe case ("cup"), the metal coating thickness, the cup composition, etc. (See Figure 2.) These improvements lowered the cost and improved the yield for these sensor devices.

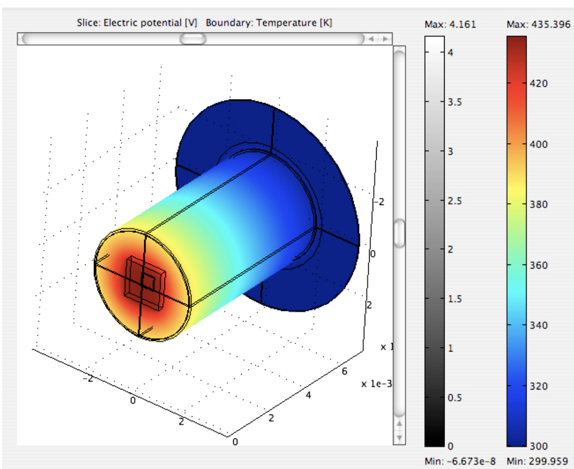

**Figure 2 Voltage Drop and Temperature Profile in Free Air**

These models used the AC/DC and Heat Transfer physics interfaces as well as the basic COMSOL Multiphysics functions. In addition, Dr. Pryor developed series equations that describe semiconductor performance to further enhance the models.

The ability to use modeling to attack these projects meant that the client was able to recover the ability to produce products much more quickly than would have been possible had it been necessary to test each change in parameters on the fabrication line. In addition, the client saved the cost of materials that would have been used in test that might not have produced the desired results.

The client's principle investigator says, "I have found Roger to be knowledgeable and very willing to offer suggestions and solutions to the myriad of barriers we faced in this journey of re-discovery. His expertise in this field has benefited us greatly, to the point now where we feel fairly confident that this product is reproducible and we have enough understanding to enable us to tackle new prospects as they come."