RELIABLE STRUCTURES AND WEARABLE SYSTEMS CALL FOR MULTIPHYSICS SIMULATION

Engineers at STMicroelectronics use numerical simulation to optimize their semiconductor solutions for a wide range of applications.

By **VALERIO MARRA**

THE INCREASING DEMAND FOR miniaturized electronics and Internet of Things (IoT) devices has created new challenges for the specialists who design microdevices such as actuators, controllers, drivers, sensors, and transmitters. From responsive equipment and wearable monitors to energy efficient lighting in the office and automation in the factory, engineers need to bridge the microscopic components of semiconductors and our macroscopic world with reliable and innovative products. This shift has inspired engineers to find new solutions by exploring their ideas in the virtual world of numerical simulation.

STMicroelectronics, a world leader in designing and manufacturing semiconductor solutions, employs 7500 individuals in the area of research and development (R&D). Lucia Zullino, technology R&D engineer at STMicroelectronics explains their efforts, "In our field we need to analyze very small structures and understand their interaction with large packages in different configurations over a wide range of environments and applications."

For semiconductor manufacturers, the choice of material and design is critical. This is where simulation plays an important role in the evaluation of materials and performance parameters. "Much of our work is done through the COMSOL Multiphysics® software, which we use to validate hypotheses and to optimize products," explains Zullino. "There are about 30 users within STMicroelectronics, and although we belong to different departments and work in various locations, we are continually building and sharing knowledge about mathematical modeling techniques used in several projects."

MULTIPHYSICS SIMULATION FOR RESEARCH AND PRODUCT DESIGN

SIMULATION IS USED TO understand multiphysics interactions at every stage of the development process for several products. A few examples include: optimizing an epitaxial reactor for faster wafer production, controlling reactant flow distortion in the wet etching process, and investigating the interaction between die and package at the microscopic level. In addition to design and manufacturing of microchips, engineers at STMicroelectronics work on the design of miniaturized actuators such as micromirrors used in recognition technologies that require optics and cameras. Simulation was also used in another actuator-related project to investigate printheads and compare the effectiveness of two different working principles: displacement of ink through pressure-generated bubbles or using a membrane actuated by a PZT a ceramic material made of lead zirconate titanate. Through this work the researchers were able to determine that the thin-film piezo printhead offers better compatibility with a wide variety of inks, higher printing speed, superior print output quality, and extended printhead lifetime.

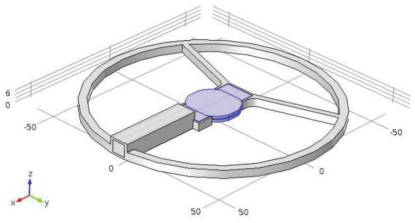

Figure 1. Geometry of the embedded structural health monitoring sensor. The sensing part is highlighted in blue.

SENSING CONCRETE HEALTH

GOVERNMENTS AND BUSINESSES have been implementing various sensor technologies to monitor the performance of concrete for years. In one development project simulation was used to analyze the properties of concrete and predict the capacity of an embedded sensor (Figure 1) to monitor age-related changes and relay a signal to the surface. This structural

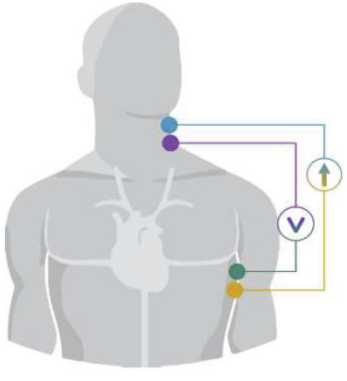

Figure 2. Technique used to measure the bioimpedance of an organ.

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>
> **—LUCIA ZULLINO, TECHNOLOGY R&D ENGINEER AT STMICROELECTRONICS**

health monitoring (SHM) system has already been deployed in Italy. It is being used on various structures to assess the health of concrete and log damage following any unexpected stress that may impact the structural integrity and reliability of the system.

» WEARABLE MEDICAL MONITORING

OVER THE YEARS, STMicroelectronics has developed many healthcare applications. In one prototype project, a patch was designed to measure the bioimpedance of an organ, such as the heart, inside the human body (Figure 2). Working from medical imaging of human organs, researchers created a 3D model (Figure 3) to run an AC/DC simulation in the frequency domain (Figure 4) and assess the effect of the electrode shape and position on the measured physiological parameters. The simulation results they obtained (Figure 5) correlated closely with real-life measurements and enabled the development of a wearable configurable patch capable of indicating physiological changes. These sensors will enable doctors monitoring various heart conditions to get real-time data to provide patients with the best care using the latest technology.

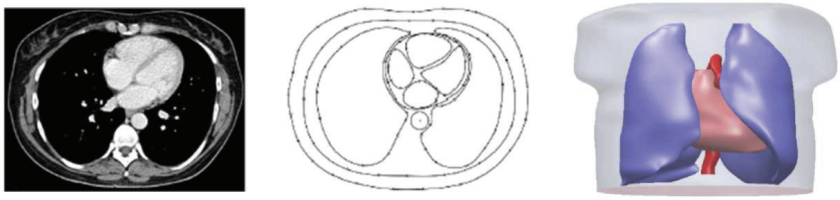

Figure 3. 3D model created from computed tomography (CT) images (left), postprocessed with CAD tools (middle), and then interpolated to generate the volumes (right) needed for the analysis.

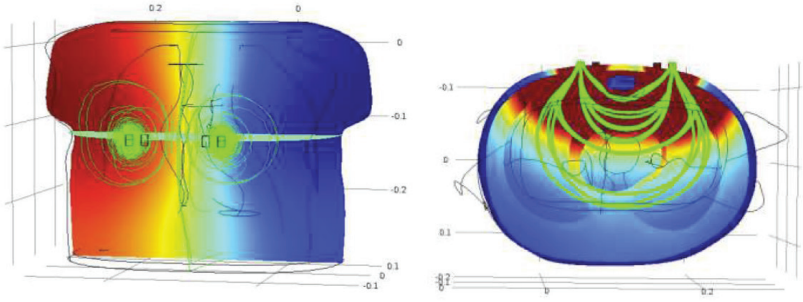

Figure 4. Simulation results showing the electric voltage and current distribution in a human torso.

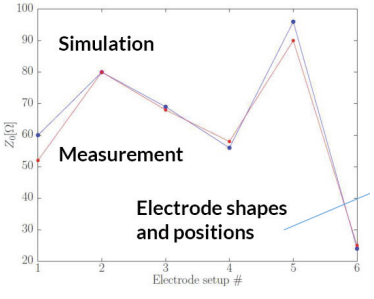

Figure 5. Comparison between measured and simulated bioimpedance values (left) for different electrode shapes and positions (bottom).

» TACKLING MORE AND MORE COMPLEXITY THANKS TO SIMULATION

"THROUGH SIMULATION we have learned a lot about potential problems and we have gotten better at optimizing semiconductors for the outside world. Simulation now drives product design, both for internal and external customers," comments Zullino. She and her colleagues see opportunities to continue using multiphysics simulation in all aspects of development. She shared that studies on humidity inside packaging and the potential for corrosion are already in progress.

"We can assess materials and structures more quickly and screen for the best ones, which means less time spent on trials, better technical decisions and quicker business decisions," concludes Zullino. "Compared to physical testing, we can implement new solutions and verify them at zero cost. Simulation is one of the key tools that drives innovation."