CUSTOMER CASE STUDY

INTELLIGENT MEDICINE AND INTEGRATED CIRCUITS

How does a biomedical IC designer integrate MEMS to keep the body from destroying a CMOS, and earn a Technology Pioneer award?

The expectation for improved treatment of chronic diseases is rising, and the cost of high-function ICs and wireless connectivity is falling. The point at which these curves meet is the threshold of "intelligent medicine," where Proteus Biomedical's products harness technology to personalize pharmaceuticals and medical devices to individual patients.

Networked Leads for Implanted Therapies

Proteus takes an existing product like a pacemaker or a dose of medication and improves its performance by personalizing it to the patient's circumstances.

For example, about 15% of heart patients with implanted Cardiac Resynchronization Therapy (CRT) devices have the unintended consequence of uncontrollable hiccups. This occurs when the energy traveling from the implanted pulse generator (IPG) down the lead (a thin catheter inside the heart) to the electrode stimulates not only the heart muscle, but also the phrenic nerve leading to the diaphragm. Physicians often remedy this side effect by moving the electrode surgically, or switching off the therapy, both of which yield suboptimal results.

"The placement of the electrode is crucial to the successful outcome of the implant procedure," explains Proteus' Co-Founder and Chief Technology Officer Mark Zdeblick. "The remedies up to now have defeated the goal of delivering the right energy to the right area of the heart at the right time."

Proteus, in partnership with two of the major manufacturers of cardiovascular implantable devices, incorporates satellite ICs inside of the lead that goes into the heart, each with a chip and multiple electrodes. This allows the physician to switch the energy electronically among multiple electrodes (instead of two or four), keeping it focused on cardiac tissue and away from the nervous system, in particular the phrenic nerve.

The ICs in each of the satellites receive and decode signals from the IPG, store configuration in memory, and steer energy among the electrodes. The 0.5μm ICs, designed with Tanner Tools, consume negligible power, fed by the pacing pulses from the IPG.

MEMS and CMOS in the Heart

Zdeblick describes the next problem that Proteus faced: "If you implant a standard CMOS chip, body tissues and fluids destroy the silicon and aluminum within a week."

This led Proteus to develop its MEMS-based ChipSkin™ technology, an extremely thin and durable wrapper to protect the chip and preserve performance of the ICs in the otherwise inhospitable environment of the human body. The MEMS coating on the CMOS chip prevents corrosion and preserves the connections among the chips.

Proteus had to build its own foundry to process the MEMS for ChipSkin, because no commercial foundry had the exact equipment needed for this application.

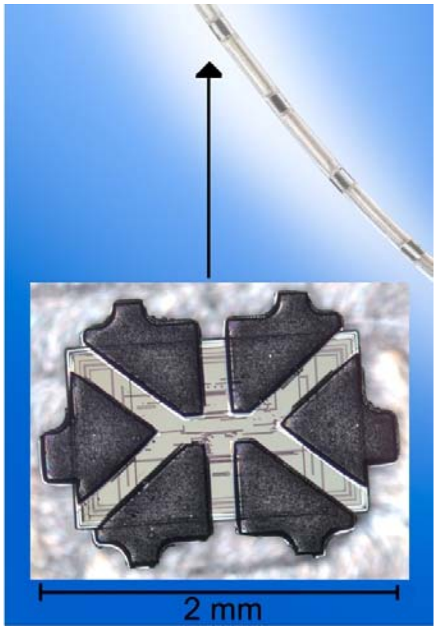
Getting Productive in Short Order

Originally, Zdeblick selected Tanner Tools for their value, and because he was wary of Unix- and server-based suites that would have required much more IT infrastructure.

"What I liked most about Tanner is that I could sit down and start doing circuits immediately without asking any questions. Their design kits contain examples of the transistors and circuits we needed to become productive very quickly. There was almost no need for instructions."

- Mark Zdeblick
Co-Founder and CTO
Proteus Biomedical, Inc.

"Tanner's price-point was right for us as a start-up," he continues. "I envisioned a chip with fewer than 5,000 transistors and an operating frequency around 1MHz, so I knew that it wouldn't take high-end tools to meet our needs. As I began to use the tools, I found the Tanner UI remarkably intuitive. Even without formal training, everyone here who



Networked Lead Enabled by ChipSkin Technology uses L-Edit has become productive with it right away. And, because it's PC-based, I do most of my design work on my laptop away from the office, which I couldn't do with a high-end suite."

Proteus engineers use L-Edit for the masks they send to their CMOS foundry and for the masks they use in their MEMS process. They have been able to implement unusual cells and run LVS on them, collaborating with Tanner and the foundry to design some of the extraction deck for unique transistors.

"We all think that running LVS with node highlighting in L-Edit makes it much easier to get LVS clean," notes Zdeblick. For example, we have some custom circuitry for ESD protection, and we've been able to modify the decks to implement it. With other tools it's very hard to understand how the LVS deck works, and to edit it requires specialized training, but L-Edit with node highlighting has made it vastly easier."

Chip on a Pill

Another area of Proteus' business is in personalizing pharmaceutical therapies. Symptomatic heart failure patients, for example, must take multiple drugs daily to maintain quality of life, but not all patients adhere to their prescribed regimen.

"Humans are not made to take medicine every week for the rest of their life," explains Zdeblick, "It's hard to adhere to a chronic dosage regimen, so we've developed Raisin™. It's a chip on a pill that, when ingested, broadcasts a code unique to the drug. We can pick up the code with electronics in an implanted device like an IPG, or with a surface device like a skin patch, then route it securely over the Internet via e-mail. A person can understand how their body is responding to medications, and can share that information with their physician or a caregiver to help stay healthy."

As another example, published in *The British Journal of Cancer*, the survival rate for many breast cancer survivors on a life-long regimen of tamoxifen drops off by about 10% for missing one dose out of five. Proteus envisions Raisin as part of a system that will provide both patients and physicians with more information about the efficacy of treatment. Proteus gained global recognition when the World Economic Forum named it a Technology Pioneer for its approach to personalizing therapy.

Relying on Design Kits

Proteus relies on Tanner's process design toolkits (PDKs), customized for their foundries.

"It was very easy to understand the PDK both in DRC and LVS at the most granular level," concludes Zdeblick, "and we could edit it without any training whatsoever, simply by opening it up. We make our own DRC and LVS decks for the MEMS part of the process, and because our MEMS lies directly on top of the CMOS, it was important to have an integrated solution.

"Tanner Tools gave us an easy way to integrate CMOS to MEMS without needing an outside specialist or consultant to do it."

Proteus Raisin - Ingestible IC

FEATURED CUSTOMER

Proteus Biomedical, Inc.

Redwood City, California, USA

INDUSTRY/APPLICATION

Intelligent medicine – pharmaceutical and device therapies integrated with physiologic sensors and in-body computers connected to a wireless network for:

- Cardio resynchronization therapy (pacemakers)
- MEMS-based protective wrappers
- IC-enabled drugs

THE SITUATION

Biomedical application features a CMOS chip with a MEMS wrapper containing unusual cells and unique transistors.

THE SOLUTION

Proteus uses L-Edit with node highlighting to understand and edit the LVS deck, and a Tanner design kit to integrate CMOS and MEMS designs.

TANNER EDA TOOLS

HiPer Silicon Suite:

- S-Edit – Schematic Capture
- T-Spice – Analog Simulation
- L-Edit – Physical Layout
- HiPer Verify – Physical Verification (DRC/LVS)
- Custom PDKs

Tanner EDA

About Tanner EDA

Tanner EDA is a leading provider of PC-based electronic design automation (EDA) software solutions for the design, layout and verification of analog/mixed-signal ICs, ASICs and MEMS. Its solutions help speed designs from concept to silicon and are used by thousands of companies to develop devices cost-effectively in the biomedical, consumer electronics, next-generation wireless, imaging, power management and RF market segments. Founded in 1988, Tanner EDA is a division of privately held Tanner Research, Inc.

Corporate Headquarters
825 South Myrtle Avenue
Monrovia, CA 91016-3424 USA
Tel: +1-626-471-9700
Toll-Free: 877-325-2223
sales@tanner.com
www.TannerEDA.com