



## Making it Seamless To Migrate Technologies

### Unconventional Variety

If Abraham Lincoln were alive today, he might believe that a wafer fab can run some processes all of the time and all processes some of the time, but not all processes all of the time. In that, he'd be supported by conventional wisdom.

So what would Mr. Lincoln think of Micrel Semiconductor, a company that churns out a staggering variety of analog products in a single fab? He might think Micrel would run only a few processes; but if he did, he'd be wrong.

"We do every kind of technology," noted Guy Gandenberger, Vice President of Wafer Fab Operations at Micrel. "We do bipolar, BiCMOS, DMOS, CMOS Si gate and CMOS metal gate, MEMS, SOI, and even extreme High Voltage Technology.



*Micrel Headquarters in San Jose, CA*

### Matching Product and Process

The reasons behind this plethora of processes are partly historical, and partly market driven. Micrel originally was a contract test service company that began offering foundry services and developing proprietary products after acquiring a small wafer fab in the early 1980s.

The new business proved profitable and grew to the point that Micrel began to concentrate almost exclu-

### Fast Facts

<b>Headquartered:</b>	San Jose, CA, USA
<b>Founded:</b>	1978
<b>Sales:</b>	\$276 million (2015)
<b>Employees:</b>	678
<b>Major Markets:</b>	Telecommunications Mobile & Computers Foundry Automotive
<b>Processes Run:</b>	Bipolar, CMOS BiCMOS, DMOS
<b>Parametric Testers:</b>	Reedholm (3)

sively on integrated circuit manufacturing. Today, 95% of revenues come from proprietary products and 5% from foundry services.

As standard practice, Micrel keeps process recipes developed over the years as an arsenal of fabrication formulas. What's more, these differing recipes can be mixed and matched so that different modules can be combined to produce hybrid processes that merge features of the parent processes into a new process. Thus, Micrel's manufacturing versatility is demonstrated by running over 20 technologies with 310 process flows in a single fab!

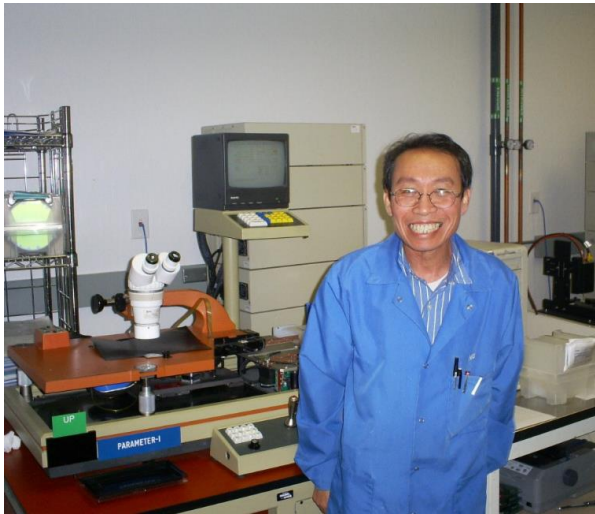
Micrel doesn't try to be all things to all foundry customers. Rather, it offers niche capabilities that are crucial to the success of Micrel's proprietary products. Their specialty is building high performance analog power integrated circuits that require processes supporting 80V operation. However, many of the 2408 proprietary products deliver excellent low current performance.

Micrel's varied manufacturing capabilities are very useful in meeting diverse market demands. "We look at the function that we want to do, and then we devise what mixture of technology will do that best at the least cost," remarked Gandenberger.

This freedom helps Micrel create difficult designs and is the reason they have posted year-to-year revenue growth in 23 out of 26 years and have been profitable in 25 of the 26 years since they were founded.

## Taming a Passel of Processes

This manufacturing flexibility is managed in a number of ways. As Gandenberger notes, “We installed a world-class training organization that ensures employees are trained at the highest level. Secondly, through electrical recipe management, we ensure that every lot, every time, gets exactly what it needs for its specific processing requirements. Finally, with quality as the primary goal, we are staffed with the world’s best employees and technical staff.”



*Huu Doan and one of the RI-40 test systems*

Another way to manage the process is with in-line parametric testers. At critical steps, parametric testers are used to measure such things as resistance and plot I-V curves. Through clever test structures, Micrel engineers ferret out key transistor parameters such as gain before product completes the manufacturing cycle.

This data is used in pass/fail testing of a lot and is fed into an SPC control system. When the product is complete, another slug of data is taken on the parametric tester. The finished devices are sent off to wafer sort, packaging, and final test. Test data is also used in trend line and other statistical analysis.

Parametric testers from Reedholm have been filling this vital function since the company was founded. Low cost, upgradeability, and ease of use are three key reasons why Reedholm equipment was selected. Just as important is that Reedholm hardware is extensible and up to the measurement challenges presented by different processes.

“Because we do high voltages, the Reedholm instruments have to go to high voltages and be accurate. At the other end of the spectrum, we make the best hearing-aid amplifiers in the world. These operate at 1 $\mu$ A total current draw. At the end, you have to be able to measure things that are in the nA regime,” commented Gandenberger.

It is through efforts like this that Micrel pulls off the seemingly impossible—they manage to keep a large number of manufacturing processes under control and meet yield expectations.

## The Future

Micrel manufactures wafers at its 150mm wafer fab in San Jose, continuing to survive were others have faded. Micrel is one of the few remaining fabs in San Jose and has thrived through realizing world-class efficiencies with world-class cost. Gandenberger observed that “Reedholm has gone with us every step of the way including quick migration of technology advancements. Micrel’s fab improved 5 technologies nodes in the past 5 years and is currently qualifying a .35 $\mu$ m technology. Their systems have been low cost, high uptime, with a seamless ability of migrating from one technology to the other.”

Another vital factor for growth is Micrel’s ongoing fast response to manufacturing problems. In that effort, Micrel has found a significant partner. Speaking of Reedholm equipment and support, Gandenberger said, “It works great, and one thing about Reedholm – if we have a problem, they get on it right away.”



*Guy Gandenberger*