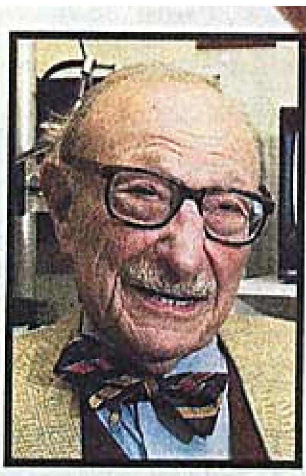
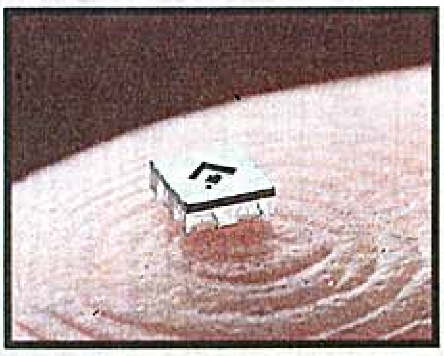


Little big MEMS



These minuscule high-tech machines, many made and sold in New Jersey, help make everything around you work

By MARTHA McKAY
Staff Writer

Hard by the Leonia railroad tracks in a nondescript red-brick building is a small company that makes small machines.

Really small machines.

Called Kulite Semiconductor Products, it's run by founder Anthony D. Kurtz, a Teaneck native who favors bow ties, holds a Ph.D. in physics from MIT, and is, by all accounts, a towering figure in a microscopic world.

Kurtz started his company in 1959 and holds close to 200 patents related to the manufacturing of Lilliputian machines called MEMS, or microelectro mechanical systems.

You can't see them, but these days MEMS are practically everywhere.

Like ants at a picnic, they've invaded our lives by the tens of millions: in car air bags, aboard planes, inside medical equipment, and even tucked inside the common ink-jet printer.

MEMS make "available infinitely more information," Kurtz explained. "Without MEMS, we wouldn't have fuel-efficient jets, we wouldn't have reliable missiles, we wouldn't have off-shore oil, and we wouldn't have cheap blood-pressure measurements."

Most of the tiny machines, crafted out of silicon and other materials, are no larger than the head of a pin, with parts smaller than the width of a human hair.

Although many MEMS are still on the drawing board, their migration to commercial use has proven to be a bright spot in an otherwise beleaguered high-tech economy.

Today, there are 1.6 MEMS devices per person in the United States and that number is ex-

See **MEMS** Page B-2

MEMS to come

- A MEMS device that fits on a contact lens to help regulate the pressure on a glaucoma patient's eye.
- A MEMS accelerometer that fits into a hand-held computer, allowing user to change functions by tilting the device as opposed to pushing buttons.
- A MEMS-equipped pair of goggles that functions as a computer monitor; the user can see through them as well as see information displayed on the goggles. Would be handy for surgeons, military personnel, or industrial workers.
- A MEMS jet engine used for miniature military planes that could fly undetected and gather information.
- A MEMS device that floats through a patient's bloodstream to dispense small doses of medicine.
- A MEMS device the size of a grain of sand used to explore space.

STAFF PHOTOS BY BETH BALBIERZ

Kulite is run by Anthony D. Kurtz, top, a Teaneck native with a penchant for bow ties and physics. Above, 15 MEMS sensors and structures. Top right, a MEMS chip on a fingertip.

MEMS: High-tech mighty mites help move world

From Page B-1

pected to grow to nearly five by 2005, according to the MEMS Industry Group, a trade organization based in Pittsburgh.

The research firm Cahners In-Stat measured $3.2 billion in MEMS sales in 2000 and expects that to rise to $11.2 billion in 2005.

"All of us now own MEMS devices and we're going to own a lot more of them in the future," said Beau Farmer, a physics professor at the New Jersey Institute of Technology and director of the state-funded New Jersey MEMS Initiative Program.

The program, operated by NJIT under a five-year, $1.7 million state grant, is only one of scores of organizations and corporations where MEMS are being developed, made, and sold in New Jersey.

Farmer estimates at least 120 New Jersey companies are working on MEMS projects, spanning such industries as telecommunications, power, pharmaceutical, and military supply.

He said the list of New Jersey companies involved in some type of MEMS work is long and includes such names as Sarnoff Corp., Measurement Specialties Inc., and Kearfott Guidance and Navigation Corp. The power industry and pharmaceutical businesses in the state are also busy working on MEMS projects.

"There are start-ups and incubators all over — it's more pervasive than you might imagine," Farmer said.

At Lucent Technologies' Bell Labs, for example, MEMS devices under development will one day be installed in new types of voice and data networks, explained Susanne Arney, director of Bell Labs' Micromechanics Research Department.

These MEMS will allow a network operator to move traffic across a network of fiber cables in a much more flexible way than networks are capable of today. The new network, for example, would get rid of bottlenecks that occur when many people are trying to access one Web site, Arney said.

Although most MEMS work at the labs is related to telecommunications, the researchers there also spend some time delving into other uses. One engineer, for example, has done some work on a MEMS device that can distinguish smell — an "electronic nose," Arney said.

And Bell Labs recently developed and now sells a MEMS device much heralded in the world of telecommunications that's made of millions of tiny mirrors used to send large volumes of voice and data at high speeds over a fiber network.

Unfortunately, MEMS use in the field of telecommunications has dimmed with the slumping telecommunications market — companies have merged, disappeared, or stopped working on MEMS applications. But because MEMS are used in such a wide variety of industries and most companies occupy their own niche with little or no competition, MEMS continue to thrive.

"MEMs are fairly well-insulated from the effects of the greater economy," said Marlene Bourne, senior analyst with Cahners In-Stat.

In part, companies doing MEMS research are continuing to do so because they weren't yet counting on sales revenue, Bourne said.

MEMS themselves, however, are nothing new.

The concepts and the tiny machines have been around since the late 1950s and the niche captured by Kulite is one of the most mature.

Kurtz has led the way in the field of pressure sensors, minuscule devices that measure pressure change in all sorts of places — he invented the concept, said MIT physics Professor Alan Epstein.

And though still relatively small in size — 400 employees and $50 million in annual sales — Kulite's inventions have had a big impact on the world of MEMS.

Take home blood-pressure devices. Kulite invented the MEMS device that makes them possible, but Kurtz wanted no part of the large market he predicted would develop.

"I'm more interested in the obscure," he said, adding that there's no money in mass production.

"I'd much rather make 10 things for $500 than a thousand things for $5 each — you need a bigger factory, you have huge overhead, and it's much more capital intensive," Kurtz said.

Besides, "I wanted to be a big fish in a small pond," said Kurtz, who blends a sharp eye for business opportunities with the look of a rumpled academic (he's co-authored, with professors from Oxford University and MIT, papers with titles such as "Acceleration Insensitive Semiconductor Pressure Sensors for High Bandwidth Measurements on Rotating Turbine Blades").

Most of the tiny machines, crafted from silicon and other materials, are no larger than the head of a pin.

In part because his company is profitable and because he's established a brain trust of MEMS experts — more than 100 of his employees hold advanced degrees — Kurtz can pursue the types of MEMS projects he wants.

For example, Kulite sensors were used to develop the world's first artificial heart that debuted last year. They sit inside Formula One race cars powered by engines from Porsche, Jaguar, and BMW. And they're used extensively by the military on board helicopters, fighter jets, Humvees, and tanks, Kurtz said.

They've also showed up in a few unlikely places.

Kulite sensors have measured how deep trout swim; they've been placed in devices attached to cow udders to control milking machines; and they've gone down the human throat to measure the action of the esophagus.

As for more common applications, Kulite sensors are installed throughout 747 jets: from the engine blades, where they detect when a plane is about to stall and thus allow the engine to use the least amount of fuel to keep airborne, to the wheels where they tell the pilot if the tires are properly inflated.

MEMS may be all around us, but what makes them so great?

For one thing, they can do things that other, larger devices simply can't or can't do as well, Kurtz said.

The tiny pressure sensors used in the jet tires will someday be installed in all regular automobiles so drivers can tell when they need to inflate their tires, he explained.

Or take the MEMS device called an accelerometer that's used today in millions of car air bags to detect an impact and "tell" the bag to deploy. Not only is the MEMS much less expensive, its size allows it to work faster — crashes are detected in milliseconds, as opposed to seconds.

The small size of MEMS means better response times, and less power to run the device, NJIT's Farmer said.

MEMS also make possible the high-resolution color provided by the common ink-jet computer printer; inside is an array of tiny MEMS nozzles that funnel the ink in the right direction.

There's a MEMS sensor used at the tip of a catheter that gives a doctor a much better understanding of where to place the catheter, thus reducing the chance of injury to a blood vessel.

Much MEMS work is still on the drawing board, but just wait, said analyst Bourne.

"This technology has been around since the mid 1960s and there's a tremendous amount of research going on worldwide — we've just seen the tip of the iceberg."

How MEMS are made

First you need silicon and then you need some people who are really good at working with microscopes to make the tiny machines known as MEMS.

The microscopes are crucial because MEMS, or microelectro mechanical systems, can have parts as small as several microns — a human hair measures 100 microns.

Today MEMS are built using methods practically identical to those used to make computer chips.

The basic material is silicon, although MEMS materials are expanding to include ceramics, glass, and polymers.

To make MEMS, a technician deposits thin layers of a semiconductor material on a silicon wafer. After placing a pattern on the wafer by hiding certain areas and exposing others, the technician etches through the layers, in effect machining the desired part.

In another process, layers are built up on the wafer using precision techniques.

Both methods are used to create a wide range of shapes including gears, springs, nozzles, mirrors, flexible membranes, and tiny rotors, said Luc Frechette, a professor of mechanical engineering at Columbia University who is using New Jersey Institute of Technology's MEMS lab to build a MEMS turbine.

Frechette's MEMS turbine can be used to make a miniature combustion engine about the size of a man's shirt button that would replace battery power cellphones, personal computers, and other devices.

Although MEMS perform highly technical feats, today's MEMS devices are "extremely basic," Frechette said. "They are not sophisticated from a mechanical perspective at all."

It can take decades to develop a MEMS device, but the actual production time is short. Building a MEMS device can span several days to several weeks.

And instead of building just one, the technique is truly one of mass production.

For example, out of a single silicon wafer about the size of a large cookie, you can make tens of thousands of identical MEMS devices.

— MARTHA McKAY