Society of Manufacturing Engineers

Staff

David Arnold, vice president/chief technical officer of Kennametal Inc., Latrobe, Pa., is among the new members elected into the College of Fellows of the Dearborn, Mich.-based Society of Manufacturing Engineers. Others are: Dennis S. Bray, executive vice president of Cincinnati Inc.; Thomas Charlton, Jr., a consultant in North Kingstown, R.I.; Fukuo Hashimoto, senior scientist and director of advanced process technology for the Timken Co., Canton, Ohio; Bruce M. Kramer, director of Engineering Education and Centers for the National Science Foundation, Arlington, Va.; Don A. Lucca, a professor at Oklahoma State University at Stillwater; Rajiv Shivpuri, professor of industrial and systems engineering at Ohio State University in Columbus; and Klaus Weinmann, professor at Michigan Technological University in Houghton.

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Mixing it up: it takes a team of experts and a great deal of cross-fertilization to produce successful MEMS
Feature focus: working together: MEs and Ees

DeGaspari, John

The name says it all: Microelectromechanical. The devices are produced by a team effort, in which electrical and mechanical engineers bring their own brands of expertise to bear on a number of tasks that often run concurrently. Different companies, from giant electronics firms to small start-ups, have their own unique ways of doing this. Yet many try, through frequent meetings, to encourage the exchange of ideas between engineering disciplines that fosters collaboration.

"The best design for MEMS is done by a team that is expert in both mechanical and electrical engineering. It's a multidisciplinary program," said Roger Grace, a sensor and semiconductor consultant based in Naples, Fla. Grace observed that the biggest applications for micro devices tend to be mechanical ones: pressure sensors, accelerometers, and inkjet printer heads. But new applications are reaching into different markets--bio, chemical, optical, radio frequency--that are adding new engineering disciplines to the MEMS mix. That trend is demanding flexibility, communication, and better design tools.

Michael Huff, founder and director of the MEMS Exchange in Reston, Va., a clearinghouse for MEMS design and fabrication centers, said the area is a specialty that typically imposes a learning curve on both electrical engineers and mechanical engineers. Electrical engineers familiar with integrated circuits typically want to rely on standard integrated circuit process technology, while mechanical engineers often lack fabrication experience and may not appreciate the degree of difficulty and cost involved.

The Big Picture

Companies that have successfully produced microscale devices talk of an environment in which teams of specialists work together toward a common goal.

Mike Judy is the MEMS design and computer-aided design manager of Analog Devices' Micromachine Product Division, located in Norwood, Mass. It produces accelerometers and gyroscopes. "The more effectively you can understand the big picture, the better you will be able to do your more specialized job," he said. Despite talk of generalists, team members' primary job functions in designing micro devices remain focused. For people to do their jobs effectively, Judy sees a need to bolster general knowledge while contributing expertise.

At Analog Devices, teams work together from early in the design process and continue to evolve as the project progresses. Small teams identify next-generation products. Typically, a marketing team will identify a niche for a specific product. Design teams start small--perhaps four or five people--and may grow to around 20 as the product develops, said Tim Brosnihan, a process development engineer.

Early team members may include an electrical engineer who handles circuit design and a mechanical engineer. As a project progresses, teams discuss mechanical and electrical specifications to find a design that meets those specifications. Formal meetings take place weekly, yet team members meet informally more frequently. Collaboration is high, because much of the work runs concurrently, said Brosnihan.

Dave Monk is the systems development engineering manager for the Sensors Product Division of Motorola in Tempe, Ariz. He has responsibility for analog and mixed-signal design for transducers, and for MEMS design, package development, test development, and system engineering. Motorola's culture is strongly rooted in electrical engineering, yet a look at its MEMS operation
brings home the multidisciplinary nature of the work.

Monk speaks of skill sets. Process engineers, who run fabrication processes such as etching and photolithography, typically have expertise in chemical engineering or materials science. The engineers responsible for the process flow of a given device are often electricals, who interact frequently with chemical engineers, materials scientists, and physicists. Generally, there are electrical or mechanical engineers who link product engineering and assembly. Project leaders, who may come from various backgrounds, tie it all together, and are responsible for project management, as well as for intraproject communication.

Recently, Motorola introduced two MEMS products, a tire pressure sensor and a low-g accelerometer. Products start out as a potential market opportunity; proposals are taken to a program steering group that often consists of general management and marketing.

The project enters a definition phase. A project leader is assigned who identifies its scope, required resources, and a general schedule. A planning stage follows when the lead people of different functional groups are brought in.

The sponsor of the project, the business manager, and the engineers get together to discuss what they think they can really do, taking into consideration the wishes of the customer. The tire pressure sensor, for example, required a new transducer, circuit, package, and test. Various engineers were involved in IC design, fabrication process development, packaging, and other aspects of the product.

The group also resolves timing conflicts and goes through a risk mitigation process.

The project then goes into an execution phase. In the case of the tire pressure sensor, this consisted of a team that included members with responsibility for transducer and analog and mixed-signal designs, process development in the manufacturing lab, and package and test development.

Product engineers provide the link to the assembly area. When the first prototypes are produced, the product engineer is responsible for providing input back to the designers and providing samples to customers.

Once the design appears practical, the working device undergoes qualification testing, such as shake, rattle, and roll tests, temperature cycling, and shock tests. The tire pressure sensor required a probe test, a testing of the wafer after completion of fabrication, before assembly. Any devices that don't pass this probe measurement are eliminated.

When the tests are complete, the device enters a ramp-up phase in which the manufacturing area is prepared for high-volume production. Documentation for qualification is completed and marketing materials are finished. Once the yields are in line and the group is meeting its cost estimate targets, the project goes back to the program steering group and the project is closed.

Monk said that this flow is fairly standard and includes once- or twice-a-month meetings with the project steering group, in which progress is discussed in detail. The tire pressure sensor project, which was rather broad in scope because it included new transducer, process, integrated circuit test, and package, took about four years from start to finish. Monk said the company tries to base new generations of products on the same platforms, so variations can be brought out much more quickly.

MEMS development is including ever more diverse disciplines as it reaches into new applications. Kurt Petersen, president of Cepheid, a Sunnyvale, Calif., supplier of MEMS-based test systems for DNA analysis, calls developing bio-MEMS products a very complex, interdisciplinary task. "An ideal situation is to have people who are not just electrical engineers or mechanical engineers, but who have experience on either side," he said.

It's the same throughout, he said. In the company's development area, mechanical engineers, electrical engineers, molecular biologists, chemists, quality assurance specialists, manufacturing engineers, and software developers are all lumped together intentionally.

Because of the relative complexity of Cepheid’s instruments, mechanical engineers account for one of the highest portions of its technical staff, while electrical engineers are a relatively small group, Petersen said. There is a sizable
software group, which is involved in building test systems. The largest group is bio, whose members develop assays and the various steps to process biological samples. A chemical group develops the reagents.

Communication is key, and mixing up various disciplines promotes exchanges of ideas. Core team meetings occur once a week, but informal meetings occur every day, Petersen said. He added that the facility is designed with plenty of small conference rooms that are constantly used. Core teams typically consist of 10 to 12 people.

"We make a really big effort to get quality and manufacturing people involved from day one," said Petersen. Most jobs are done concurrently. The one exception is fluidics. Biological chemicals react to various materials in different ways, so modifying designs or materials could change the biology, said Petersen. This hampers the biologist from doing a really thorough testing and assay development until the design is nearly complete, he said.

Michael Huff of the MEMS Exchange noted that MEMS is a difficult design environment because of the various fields--mechanical, electrical, and thermal--that interact with each other and must be modeled accurately during device design. "Simulation of that becomes an incredibly tricky business," he said. Another problem is the gap in the design tools used by electrical engineers and mechanical engineers. Linking the two often leads to errors.

Mike Judy of Analog Devices notes that CAD software used in circuit design and finite element tools are separate, and there are very few examples of where the tools could be merged together. "It doesn't really overlap very well today," he said. Judy observed that MEMS software is continuing to bridge some shortcomings as it matures. Traditional finite element analysis software has begun to offer multiphysics coupled analysis, while specialized MEMS tools have become easier to use as they mature, he said. But he added, "Neither is there yet, as far as what MEMS companies really need."

Dave Monk of Motorola remarked that electrical engineers and mechanical engineers traditionally use different software. Electrical engineers are versed in two-dimensional layout tools, while mechanical engineers are more likely to be trained in finite element analysis or in solid modeling. Motorola's engineers use both: Spice or Cadence to design electronic circuits, and Ansys and solid modeling tools such as Pro/Engineer for mechanical design, he said.

At Motorola, resistors, capacitors, and transistors are built within an electronic engineering group, while transducers are built by a transducer design group. Transducer engineers must develop the mechanical model and translate that into an electronic representation that could be used in the electrical engineers' toolset.

"The real challenge is that we have got to get those systems to talk," said Monk. "We are still struggling."

Motorola has been working with various software houses to come up with a seamless design toolkit that would allow design files to be passed back and forth. That ability would help electronic engineers determine how a transducer affects the rest of the design, Monk said. He said a closer linking of the two could help manufacturers more clearly define product specifications, as well as manufacturing yields.

Paul Lethbridge, product manager for the electronics sector and the MEMS initiative manager at Ansys in Canonsburg, Pa., believes that electronics engineers and mechanical engineers tend to work more closely in the development of micro devices than their counterparts do in the macro world. He said that MEMS design and analysis software suppliers have made strides in applying multidisciplinary skills to design products of increasing sophistication.

Packaging and Testing

Tim Brosnihan of Analog Devices noted that engineers who handle packaging and in-package testing during manufacturing are involved early in the process. Those people have a lot to say about how the die is handled. If it were just a circuit die, there would be a variety of options. But mechanical elements require very specific ways to dice the wafer, handle the chips, and put them in packages, he said.

Packaging is largely the domain of the mechanical engineer, according to Monk. In MEMS, the mechanical engineers are working with silicon, where the system could be
affected by the stress of the package, he said. The mechanical engineer must design the package and keep in mind the package's effect on the device itself.

In the bio-MEMS area, packaging involves an extra layer of complexity, because devices may combine fluidics with optical and electronic detection, said Peterson of Cepheid. There are also issues that are associated with human interaction and ergonomics.

Monk said that electrical engineers and mechanical engineers work closely together on testing. The company has a test development group that works with outside vendors to integrate test equipment into a system. He describes test systems at Motorola as semicustom. Ideally these are standard on the electrical engineering side. Electrical engineers might build the test boards where the parts are mounted for testing and write the software for the tester. Mechanical engineers would handle designing the physical stimulus module into the test.

Starting Early

The flowering of MEMS design teams at many companies today sprouted from seeds planted much earlier at engineering schools. Roger T. Howe, professor and associate chair of electrical engineering at the University of California at Berkeley and director of the Berkeley Sensor and Actuator Center, said that the school had a goal of "blurring the identities" between electrical and mechanical engineering disciplines. His hope is that electrical engineering and mechanical engineering graduates could cross disciplines without the concern of losing those identities. That is a trend that many in the industry credit for fostering how various teams work together to design MEMS.

Robert O. Warrington, the dean of engineering at Michigan Technological University in Houghton, said that prominent MEMS-focused doctoral-level programs, such as those at the University of California at Berkeley, are beginning to trickle down to the master's level at various universities.

Michigan Tech is a participant in the Wireless Integrated Microsystems program in cooperation with the University of Michigan and Michigan State University. An enterprise program at Michigan Tech, tied in with the Wireless Integrated Microsystems Center, allows engineering undergraduates in their sophomore year to participate in 30-person interdisciplinary teams.

Michigan Tech has also initiated team teaching and course development by electrical engineering and mechanical engineering faculty, as well as by materials science and physics departments. The school emphasizes micromachining--milling, drilling, and electrical discharge machining at the micro level.

Jonathan Bernstein, vice president of technology at Corning IntelliSense in Wilmington, Mass., noted that historically micro fabrication labs have been within the electrical engineering departments of universities, yet students trained in MEMS are multidisciplinary, a phenomenon that is reinforced when students are hired by industry. "A lot of MEMS engineers started out doing electrical engineering, but they really don't do what is considered classical electrical engineering any more," he said.

Good communication between disparate groups is a critical component to designing and producing MEMS. This can only become more important as micro technology reaches new applications. Companies are trying to provide an environment that allows engineers with very specialized skills to collaborate on aspects of a project.

After all, they don't want to lose sight of the big picture. They are out to market a product that is more than the sum of its parts.
Military news

Staff

Navy Seaman Recruit Cheng Yang completed U.S. Navy basic training at Recruit Training Command, Great Lakes, Ill.

Yang is a 2003 graduate of Wausau West High School.

Marine Corps Pfc. Matthew L. Krueger completed 12 weeks of basic training at Marine Corps Recruit Depot, San Diego.

Krueger is a 2003 graduate of D.C. Everest Senior High School.

Capt. Ed Matthaidess III completed an assignment with the 3rd United States Infantry Regiment and has been assigned to the 172nd Infantry Brigade (Separate) at Fort Wainwright, Alaska, as an Operations and Liaison officer with the brigade headquarters. The 172nd Infantry is leading the army effort toward transformation to a lighter and more lethal force by deploying with the new STRYKER combat system that brings mobility and combat systems to a new level of capability. The brigade is scheduled for intense training at the National Training Center at Fort Irwin, Calif., followed by exercises at the Joint Readiness Training Center at Fort Polk, La., with deployment following shortly thereafter.

Matthaidess, a RANGER and Infantry officer, is a 1995 graduate of Wausau West High School and a 1999 graduate of the U.S. Military Academy at West Point. He holds a master's degree from Loyola College in Baltimore, Md.

James P. Servi has graduated from the Army ROTC (Reserve Officer Training Corps) National Advanced Leadership Camp at Fort Lewis, Tacoma, Wash.

Servi is a 2000 graduate of Merrill High School, and is a student at Michigan Technological University-Houghton.

Brian B. Lupfer has been promoted to the rank of second lieutenant in the U.S. Air Force. Lupfer is a physician's assistant with the 97th Medical Group at Altus Air Force Base, Okla.

He is a 1991 graduate from Wittenberg-Birnamwood High School.
Superintendent search in works
Oakland Intermediate back on task amid probe

Amy Lee

WATERFORD TOWNSHIP -- He's a longtime South Lyon school board member and structural engineer. She's a former legislator who has spent most of her life advocating education at the state and local levels.

Both have volunteered to serve a school board that for months has attempted to fend off public outrage over allegations that board members misspent public tax dollars. Board members also have endured criticism for lacking oversight of former Superintendent James Redmond, whose spending practices at Oakland Schools are the subject of an investigation by the state Attorney General's Office.

The controversy prompted the August resignations of two board members. The remaining three Oakland Schools board members last week chose George Ehlerl of South Lyon and Pan Godchaux of Birmingham to fill the posts until the June 2004 election.

"People who know me know I like to fix things," Ehlerl said. "I'm not afraid of scrutiny or questions or to make decisions. And I was disturbed by many of the things I was reading in the paper."

Now that the board is again at full strength, launching a permanent superintendent search tops the Oakland Schools to-do list. Deputy Superintendent Dan Austin has served as Interim Superintendent since Redmond's departure.

The board fired Redmond in January and requested the state's investigation. The Oakland Schools board is also under investigation by the state Attorney General's Office for allegedly submitting improper expense reports.

Both Ehlerl and Godchaux will tour Oakland Schools' new building on Pontiac Lake Road and meet key staff today. The two also plan to meet with lawyers next week to get a briefing on the 50-some Freedom of Information Act requests the district has received this year, Ehlerl said.

The Oakland Intermediate School Board controls a $245 million operation that provides special and vocational education services to school districts across Oakland County, as well as coordinates and hosts several professional development workshops for continuing teacher education.

Friends asked former state Rep. Godchaux to throw in her name for consideration for one of the board seats, Godchaux said. The 57-year-old was term-limited out of office in January, and she chose against facing a fellow female Republican for a Senate seat, she said.

"Education was always my core issue, and I was excited to be able to get my finger back on the pulse" at Oakland Schools, she said. "There are accountability issues and things that weren't done right. But I'll leave the investigation to the attorney general or prosecutor's office. What's important is to make sure the systems are in place to provide accountability and open communication."

Oakland Schools' board members all deny they misspent money, and they have said they expect to be exonerated when the Attorney General's Office completes the investigations. But the allegations and negative publicity around the board began to detract from the work of Oakland Schools, said Tony Rothschild, a former member who resigned in August.

"I felt that by replacing me, it would help settle things down at Oakland Schools and allow it to get on with the mission," he said. "We were very responsive and ordered the investigation, but that all got swept to the side" in the media frenzy.
State Rep. Ruth Johnson wants the state's intermediate school districts to play by a new set of rules. Johnson, R-Holly, is investigating the district's spending practices under subpoena power she obtained as a member of the House Education Committee.

Johnson will hold hearings this fall on misspending and has sponsored legislation to ensure resources go directly into the classroom.

The proposal calls for intermediate school district board members to be elected by constituents, rather than by representatives of local school boards, and be subject to recall. The bills would allow an intermediate school district to be dissolved and an accountability board put in place through a ballot initiative or local school board support.

Ehlert and Godchaux disagree with Johnson's proposal to have a general election for intermediate school district boards; both argue that since Oakland Schools serves school districts, school districts should be the ones to choose members for the board.

Ehlert, however, supports adding legislation to allow for a recall of intermediate school district board members, while Godchaux said she prefers the system to remain as is.

"I'm not suggesting there might not be a better way to have oversight," she said. "But if we allowed recalls, this whole board would have been gone and the state would have appointed five new people who were way behind the eight ball."

Ehlert said he intends to run for his Oakland Schools board seat in the June 2004 election; Godchaux said she is unsure whether she'll run. Two six-year terms will be up for grabs in June, as well a four-year term.

"There's no way all of the issues will be thoroughly resolved by June, and I want to be here to see it through," Ehlert said. "Until the general public can trust the organization, there's work to be done."

What's next

Two new members will join the Oakland Schools Board of Education at 7 p.m. Oct. 14 at 2111 Pontiac Lake in Waterford Township.

About Oakland Schools

The Oakland Intermediate School District is financed by Oakland County taxpayers through an annual property tax. The combined millage rate for 2003-04 is 3.3991. The budget is divided into three funds:

* General fund: 0.2021 mills or $25.7 million a year.
* Special education fund: 2.5682 or $143.5 million a year.
* Vocational education fund: 0.6288 or $38.5 million a year.
* Grant awards exceed $38 million annually.

Source: Oakland Schools
Pan (Patricia Ann) Godchaux
Age: 57
Hometown: Birmingham
Education: Bachelor's degree in American government from American University in Washington D.C.; master's degree in teaching from Wayne State University; certified elementary school teacher.

Experience: Republican state representative for the 40th District (Birmingham/Bloomfield area) from 1996-2002; Birmingham Public Schools Board of Education member from 1987-1996; taught third grade at Clinton Elementary School in the Detroit Public Schools from 1994-1996; served in the public health division of the Peace Corps in Bolivia in 1968-1969 working to eradicate tuberculosis.

George Ehlert
Age: 47
Hometown: South Lyon
Education: Bachelor of science in civil engineering with an emphasis on structural engineering from Michigan Technological University.

Experience: Co-founded Ehlert/Bryan Inc., a structural engineering firm with offices in Southfield and Washington, D.C., in 1981; member of South Lyon Schools Board of Education since 1992; currently serving as the board president.