Kensall D. Wise: Michigan, MEMS and Microsystems

Special Feature

A Big Career from Small Things

William G. Dow Distinguished University Professor Emeritus of Electrical Engineering and Computer Science

Kensall D. Wise, William G. Dow Distinguished University Professor Emeritus of Electrical Engineering and Computer Science, officially retired in June, 2011, though he continues to participate in ongoing research projects - giving his colleagues hope that he will never truly retire.

When Ken came to the University of Michigan from Bell Labs in 1974, he envisioned working with students and colleagues to expand his doctoral research in the use of silicon micromachining for neural probes. As the first hire in his field, the challenges were enormous – but Michigan now had Ken, and Michigan became Ken's playground.

With his unique combination of boundless enthusiasm, inventiveness, practicality, focus on teamwork and education, and dogged determination, he built a world-class program in MEMS (MicroElectroMechanical Systems) and microsystems that is supported by one of the top nanofabrication facilities in the nation.

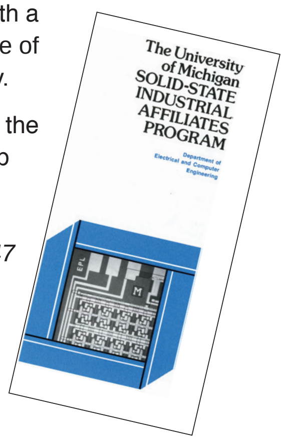
The Early Years

When Ken arrived at Michigan, he was convinced that using semiconductor/silicon technology to make sensors was going to be big. In the early years, the research laboratory was sufficient for Ken to begin to build his program.

“Sensors were a good match for our early lab in East Engineering,” recalled Ken. “They were in their formative stage, so the research didn’t require a lot of high tech equipment. Also, Michigan’s a great place to do the interdisciplinary work required of sensor research.”

Ken recalls working with Dr. Mark Orringer in the Medical School on an esophageal catheter. He marveled that as an assistant professor he was able to collaborate with a brilliant surgeon who would become one of the top thoracic surgeons in the country.

By 1976, he created what was perhaps the first silicon pressure sensor with on-chip readout circuitry. It was also the first micromachined sensor developed at Michigan. *[see the timeline on pp. 44–47 for research highlights throughout his career]*



When he became Director of the Electron Physics Laboratory (later renamed the Solid-State Electronics Laboratory) in 1979, one of the first things he did was to initiate an industrial affiliates program. This program helped raise awareness of the lab’s research among industry.

80’s – 90’s: A New Lab - A New Discipline (MEMS)

Ken was reaching a wall in what could be accomplished with the current facilities by the late 70’s. Some new and used equipment was added which helped, but more important was the arrival of Jim Duderstadt as the new Dean of the College of Engineering in 1981. Duderstadt worked with the State of Michigan to fund a new building that included a true cleanroom facility on North Campus (the existing lab was on Central Campus).

“The new lab was absolutely pivotal to our future work in Solid State and MEMS. Without it, none of our later successes would have been possible,” said Prof. Wise. He formed the Center for Integrated Sensors and Circuits in 1987, the same year the new cleanroom became operational, and began assembling a team of faculty working in this area thanks to several faculty hires in the 80’s and 90’s. Things were definitely starting to look up.

M E M S

MEMS are composed of tiny sensors, actuators, and micromachines and have tremendous marketplace potential. Their use in mobile phones alone is expected to generate annual revenues in excess of $5B by 2017. They are used for precise sensing of the environment, for monitoring infrastructure integrity, and for both diagnosing and treating a variety of health issues. They control the cars we drive and the airplanes we fly. Ranging from a few millionths to several thousandths of a meter in size, MEMS devices are often combined on a single chip with microelectronic circuits to become complete microsystems.

The Solid-State Electronics Laboratory was completed as part of the new EECS building in 1986, and equipped during the following year.

MEMS was coalescing as a distinct discipline in the early 80’s, marked by newly-formed conferences in the field. Prof. Wise and his colleagues were heavy players early on in the *Transducers* conference, which was initiated in 1981, and he was instrumental in establishing the *Solid-State Sensors, Actuators and Microsystems Workshop*, first held in 1984.

“Those were years in which the field was taking shape,” recalled Ken. “We were doing pioneering work with the goal of being the world’s center for MEMS.” This work included groundbreaking research in neural probes, flowmeters, gas sensors, pressure sensors, infrared detectors, and other MEMS devices.

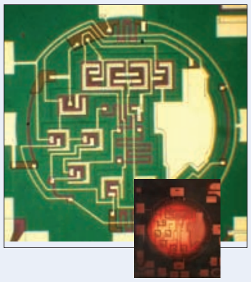
The research was enabled by key long-term programs funded by government and industry. One of these programs, funded by the National Institute of Neurological Disorders and Stroke (NINDS), enabled research in neural probes between 1981 and 2006. Another was the Program in Automated Semiconductor Manufacturing, funded by the Semiconductor Research Corporation (SRC) between 1984 and 1998.

The SRC program became a Center of Excellence, and resulted in novel techniques and devices important to the entire semiconductor manufacturing industry. The neural probe research was so wide-ranging, the devices came to be known simply as the “Michigan Probes.” In the following decade, these probes were distributed around the world to research groups, and are currently being used to explore treatments for epilepsy, Parkinson’s Disease, deafness, paralysis, and other disorders.

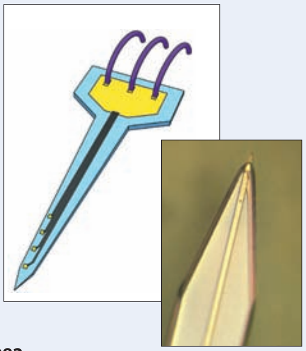
When DARPA formed its MEMS activities in the early 1990’s, one of the first programs funded was a project proposed by Prof. Wise and his former student-turned-colleague Khalil Najafi (Schlumberger Professor of Engineering and ECE Chair). Their plan was to develop a wristwatch-sized device that combined sensors and a microprocessor, and importantly, that was also wireless. Prof. Wise suffered a heart attack during the proposal process, yet amazingly this dynamic team moved ahead seemingly at full steam.

Throughout the 1990’s, Ken’s research became increasingly interdisciplinary as the technology and the lab supported the creation of complete integrated microsystems. In 1998, he changed the name of his center to the Center for Integrated MicroSystems.

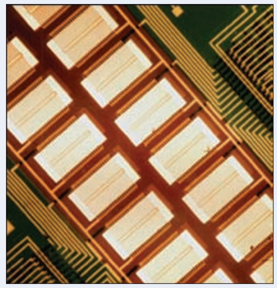
(Continued on page 48)



1976
One of the earliest, if not the first, silicon pressure sensor with on-chip readout circuitry, and the first micromachined sensor developed at Michigan (reported in the 1979 ISSCC award-winning paper).

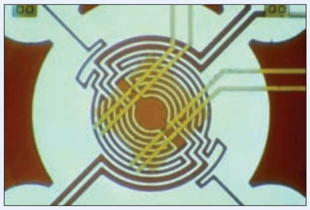


1982
Probes designed to record the activity of neurons in the central nervous system demonstrated the first practical process for building a high-density microelectronic interface to the cellular world.

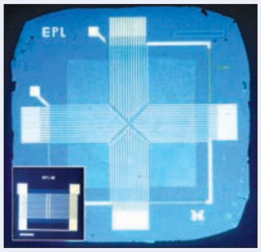


1985
Uncooled thermopile imaging array with on-chip electronics – later commercialized.

1985
World's smallest pressure sensor, a silicon-on-glass structure realized with the dissolved wafer process, capable of measuring blood pressure within the coronary arteries.

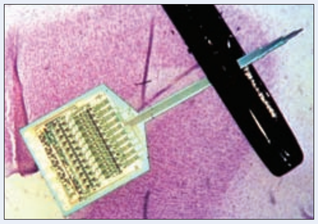


1988
World's first conductivity-based "microhotplate" gas detector.

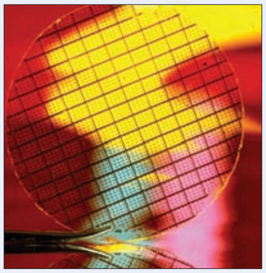


1980
First silicon micromachined uncooled infrared detector. This technology is now found in commercial products, such as appliances, security systems, ear thermometers, and radiometry.

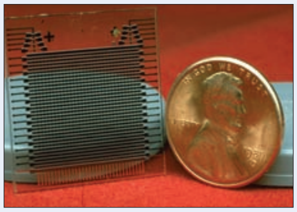
1982
SENSIM, one of the first sensor CAD programs, was developed to analyze performance of newly created silicon capacitive pressure sensors.



1985
First neural probe integrated with on-chip readout circuitry (reported in the 1986 *ISSCC* award-winning paper).



1987
The first high-performance transistors were realized in this silicon-on-glass process, intended for use with LCD displays.



1989
This 1024-element silicon capacitive tactile imager was the largest ever reported (reported in 1990 EDS award-winning paper).

1981-2006 — Director of continuously-funded programs from the NIH/NINDS

1979-1987 — Director, Solid-State Electronics Laboratory (called the Electron Physics Lab until 1984)

1960 1970 1980

1963 Purdue University, BS EE
1963-1966 Bell Telephone Laboratories (Murray Hill, NJ)
1964 Stanford University, MSEE
1965-1969 Stanford University, PhD EE
1969-1972 Research Associate and Lecturer, Stanford University
1972-1974 Bell Telephone Laboratories (Naperville, IL)
1974-1978 Assistant Professor, Michigan

1974
The Electron Physics Laboratory in East Engineering. In those days, coats were worn to keep the clothing clean rather than to protect the devices being made.

1978-1982 Associate Professor, Michigan
1979 Guest Editor, *IEEE Trans ED* and *JSSC*


1980
By 1980, support had been found to expand and improve the lab. It was an important step forward.

1981-85 Associate Editor, *IEEE Transactions on Electron Devices*
1981-99 Member, International Steering Committee for Solid-State Sensors
1982 Professor, Michigan
1982 Guest Editor, *IEEE Trans ED*
1984 General Chair, *IEEE Solid-State Sensor Conference, Hilton Head*
1985 Program Chair, *IEEE International Conference on Solid-State Sensors and Actuators (Transducers)*

1986
The EECS Building was dedicated, complete with the new Solid-State Electronics Laboratory. The new cleanroom facility enabled continuing advances in MEMS, microsystems, and other devices.

1971
ISSCC Outstanding Paper Award "A microprobe with integrated amplifiers for neurophysiology," by K. D. Wise and J. B. Angell

1974
NASA Certificate of Recognition for Creative Development of Technology, (Microminiature Gas Chromatograph)

1976
1938E Award (CoE)

1978
Distinguished Service Award (U-M)

1979
ISSCC Outstanding Paper Award, "Integrated Signal Conditioning for Diaphragm Pressure Sensors," by J. M. Borky and K. D. Wise.

1986
ISSCC Beatrice Winner Award, "An Implantable Multielectrode Array with On-Chip Signal Processing," by K. Najafi, K.D. Wise.

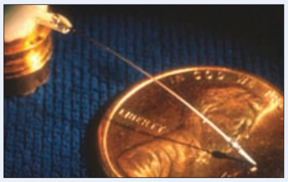
IEEE Fellow, "for leadership in the field of integrated solid-state sensors and engineering education"

IEEE EDS National Lecturer

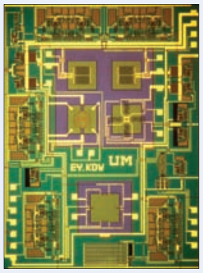
1987
NASA Certificate of Recognition for the Innovative Development of Technology (Integrated Gas Flow Controller)

Students

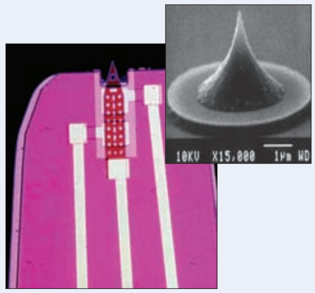
1977 John Michael Borky
1980 Thomas Nelson Jackson
1981 Gholamhassan Roientan Lahiji
Yong Surk Lee
Sea-Chung Kim
1982 Chang-Lee Chen
Ki Won Lee
1983 John Edward Bertsch
Jammy Chin-Ming Huang
Yong Eue Park
1986 Kukjin Chun
Il Hyun Choi
Khalil Najafi
1987 Kenneth Lloyd Drake
Hin-Leung Chau
1988 Leland Joseph Spangler



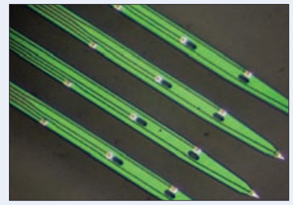
1989
These silicon ultra-flexible cables were the first to successfully interface with chronically-implanted biomedical sensors with negligible leakage and tethering. They were a key element in allowing MEMS-based sensors to operate in harsh environments.



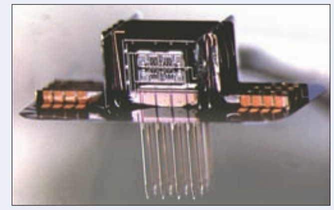
1990
This CMOS micro-flowmeter containing sensors for pressure, temperature, gas type, flow rate, and flow direction with readout electronics was the first of its kind.



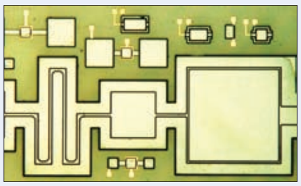
1993
An integrated force microscope with an iridium-coated polysilicon tip pioneers machine vision for semiconductor process control.



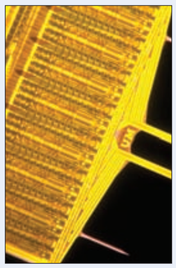
1996
Multi-channel "Michigan Probes" are distributed worldwide, helping to change research directions in the neurosciences.



1997
First 3D CMOS probes for extracellular single-unit recording in the central nervous system.

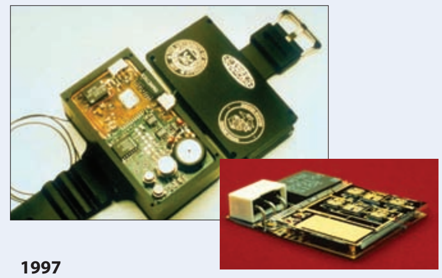


1989
This ultrasensitive silicon pressure-based flowmeter improved flow resolution by 3 orders of magnitude (reported in 1989 *IEDM* award-winning paper).



1991
The first integrated active neural stimulating array with iridium sites was realized at Michigan to advance neural prostheses.

1994
First bulk-micromachined neural probe that allowed *in-vivo* drug delivery at the cellular level along with electrical recording and stimulation.



1997
This microinstrumentation cluster flew on an unmanned aerial vehicle, up-linking data to a satellite. It was the first wireless integrated microsystem developed at Michigan, and pioneered sensor bus interfaces, sensor-circuit integration, power management, and micropower sensors for barometric pressure, temperature, humidity, shock, and vibration.

1984-1998 — Director, SRC Program in Automated Semiconductor Manufacturing (Center of Excellence). Involved several of Michigan's control faculty.

Neural Prosthesis Program – led to the development of the "Michigan Probe."

1987-1998 — Director, Center for Integrated Sensors and Circuits.

1999-2000 — Associate Dean for Research, College of Engineering

1990

2000

1998-2000 — Director, Center for Integrated MicroSystems

1989-91 Chairman, SRC University Advisory Committee

1994 Chairman, JTEC Study on Microelectromechanical Systems Developments in Japan

1995 Co-founder, Integrated Sensing Systems, Inc. (ISSYS)

1997 Member, Technology Working Group on Metrology, SIA National Technology Roadmap for Semiconductors

1997 General Chair, 1997 *IEEE International Conference on Solid-State Sensors and Actuators (Transducers '97)*

1998 Guest Editor, *Proceedings of the IEEE* "Special Issue on Integrated Sensors, Microactuators, and Microsystems (MEMS)"

1998-2002 Senior Editor, *IEEE Journal of Microelectromechanical Systems*

1989
IEEE IEDM Roger A. Haken Best Student Paper Award, "An Ultrasensitive Silicon Pressure-based Flowmeter," by S.T. Cho, K. Najafi, C.L. Lowman, K.D. Wise

1990
IEEE EDS Paul Rappaport Award (with K. Suzuki and K. Najafi) for paper entitled: "A 1024-Element High-Performance Silicon Tactile Imager."

1993
J. Reid and Polly Anderson Professor of Manufacturing Technology (CoE)
Stephen S. Attwood Award for Excellence in Engineering (CoE)

1995
Distinguished Faculty Achievement Award (U-M)

1996
Fellow, American Institute of Medical and Biological Engineering (AIMBE), "for contributions and leadership in the development of integrated biomedical sensors"

Columbus Prize "for an individual American who has improved, or is attempting to improve, the world through ingenuity and innovation," presented at Epcot Center in connection with the Discover Magazine Awards

1998
Semiconductor Research Corporation (SRC) Aristotle Award "for deep commitment to the educational experience of students, emphasizing student advising and teaching through research"

Elected to the National Academy of Engineering "for sensors and microelectromechanical systems"

1999
IEEE Solid-State Circuits Field Award "for pioneering contributions to the development of solid-state sensors, circuits, and integrated sensing systems"

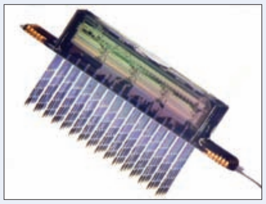
1990 Jin Ji
Euisik Yoon
Christy Lynn Johnson
1991 Steve T. Cho
Mahmoud Ghazzi

1992 Arnold C. Hoogerwerf
Steven J. Tanghe
Nader Najafi
1993 Lai-Cheng Kong
1994 Yafan Zhang
Changhyun Kim

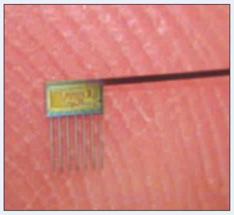
1996 Paul L. Bergstrom
Jingkuang Chen
Janet K. Robertson
Jennifer L. Lund
1997 Andrew D. Oliver
Richard J. De Souza

1998 Tracy Elizabeth Bell
Jinsoo Kim
1999 Qing Bai
Uksong Kang

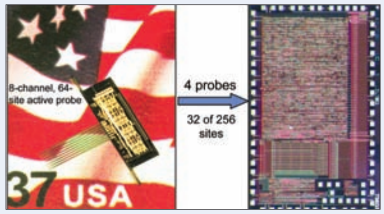
2000 Abhijeet V. Chavan
Collin A. Rich
Andrew J. Mason



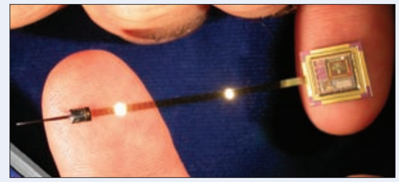
2000
First high-density 3D neural probe array for exploring the organization of the central nervous system.



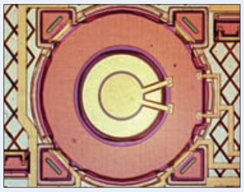
2002
First neural probes containing on-chip CMOS circuitry to record activity in unrestrained animals (collaboration with Rutgers University).



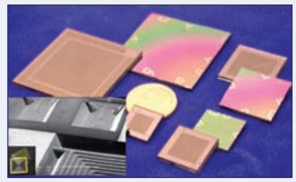
2004
First programmable neural digital signal processor, developed as part of a 256-site system.



2005
This thin-film silicon-parylene array, the first of its kind, was a major step toward improving the frequency range and resolution in cochlear prostheses (reported in 2005 *IEDM* award-winning paper).

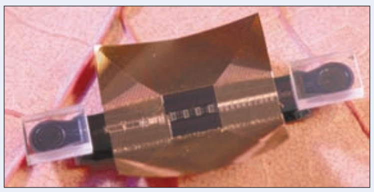


2000
A vacuum-sealed pressure sensor used to allow closed-loop control of an 8b integrated flow controller.

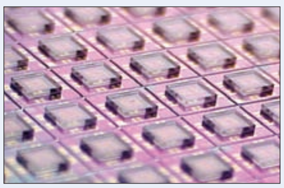


2004
Deep silicon etching technology is used to realize the highest performance chromatographic separation microcolumns in the world.

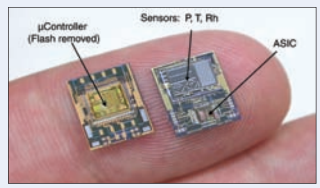
2006
Parylene-insulated gold lead structures are realized to enable folding microsystems for the first time.



2004
First reported pressure/flow-sensing microsystem for use in an arterial stent.



2001
These barometric pressure sensors were the first to integrate a closed-loop vacuum control system into their reference cavity, achieving 25mTorr accuracy.



2005
This 0.15cc microsystem for sensing pressure, temperature, and humidity is a signature example of a generic integrated microsystem.

2000-2010 Director, NSF ERC in Wireless Integrated MicroSystems (WIMS)

2000

2000 Member, National Research Council (NRC) Study Group on Bio-technology for Army Applications

2000 *Fantastic Voyage:* Microsystem Development at the University of Michigan 1975-2000

2005

2003-05 Member, NRC Study Group on Engineering the Health Care System

2006

Courses Developed

1974 Monolithic Device Structures, *major revision*
1975 Analog Integrated Circuits, *new course*
1975 Solid-State Device Laboratory, *major revision*
1976 Integrated Circuits Laboratory, *major revision*
1976 Digital Circuits Laboratory, *new course*
1987 Digital Integrated Circuits, *new course*
1994 Integrated Sensing Systems, *new course*
2002 Societal Impact of Microsystems, *new course*

Prof. Wise regularly taught the Integrated Circuits Laboratory. In 1976, the class project was a 64-bit SRAM chip. Thirty years later, the technology was more complex and the facilities were much better but the goal was the same - to introduce students to the creation of a complete chip.

10 Years of WIMS

Doctoral students graduated:	>150	Participating Universities:	10
Pre-College short courses:	88	Departments/Disciplines:	16
Pre-College short course students:	4,000	International Alliances:	>10
Journal articles published:	306	Patents awarded:	59
Archival conference papers:	>700	Spinoff companies:	12
Core Faculty:	49	Economic impact:	$400M

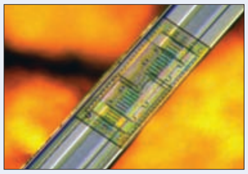
2002
William Gould Dow Distinguished University Professor (U-M)

2005
Michigan Emerging Industry Pioneer Award "In recognition of outstanding leadership to the MEMS, MicroSystems, and Nano Technology Community"

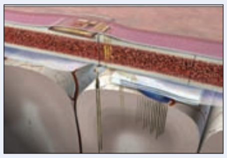
2005
IEEE IEDM Roger A. Haken Best Student Paper Award, "An Integrated Position-Sensing System for a MEMS-Based Cochlear Implant," by J. Wang, M. Gulari, and K. D. Wise

Students

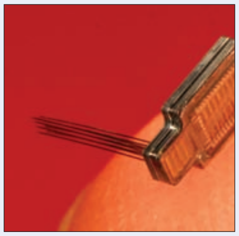
2001 Demetrios Papageorgiou
2002 Marcus D. Gingerich
Patty Chang-Chien
2003 Brian G. Jamieson
2004 Andrew David DeHennis
Roy H. Olsson III
2005 David Frederick Lemmerhirt
Masoud Agah
Ying Yao



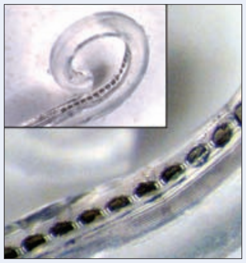
2006
Thermal flowmeters are successfully integrated on the 40μm-wide shank of a neural probe for the first time to meter drug delivery at the cellular level.



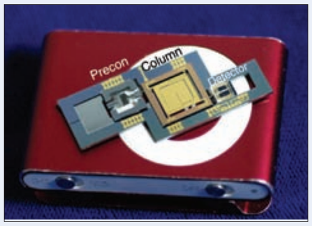
2007
This wireless implantable electrode array was developed for capturing control signals from the motor cortex, fitting on a U.S. penny. It was the first such array ever realized.



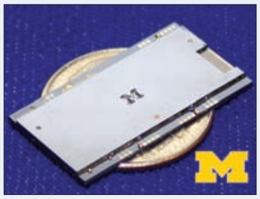
2008
First neural recording array to use deep reactive ion etching to realize high-yield 3D electrode arrays. These electronic interfaces to the nervous system are leading to prostheses for deafness, blindness, epilepsy, paralysis, and Parkinson's Disease.



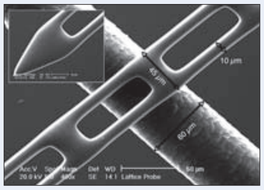
2010
First cochlear implant array specially designed to achieve the stiffness and curl needed for deep insertion, setting the stage for an automated insertion process that will take cochlear implants to the limits set by physiology.



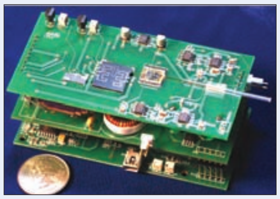
2010
Orion is a prototype gas analyzer that explores the fundamental limits of chromatography-based gas analysis systems in terms of power, speed, and size. Such devices could revolutionize security, environmental monitoring, food processing, and health care by enabling low-cost, widely-deployable gas analysis. Allows breath analysis to determine tuberculosis and lung cancer.



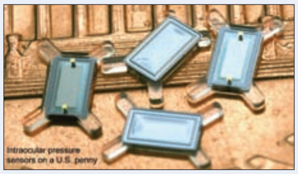
2006
A chromatographic separation system is realized in a structure a little larger than a dime, advancing miniature gas analysis systems.



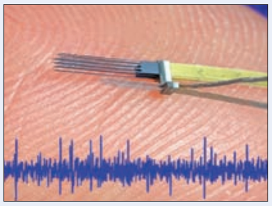
2007
Lattice probe structures, shown on a human hair, are developed to reduce the tissue reaction to electrode arrays implanted in the body.



2010
First palm-size completely integrated gas chromatograph system ever implemented. Called Mercury, it included temperature control electronics, an embedded processor, and a USB interface.



2010
These pressure sensors, shown on a U.S. penny, were developed for a 1mm^3 intraocular microsystem for treating glaucoma. The microsystem also includes an ultra-low-power processor, energy-scavenging power system, and a wireless interface.



2010
This high-density neural probe array pioneered mapping of the auditory system, exploring the mechanisms responsible for tinnitus.

32 Patents

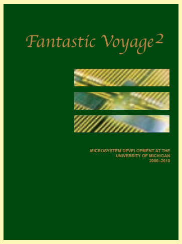
2007 — 2010 — 2011

2007-2011 Director, Solid-State Electronics Laboratory

2007 Chair, Evening Special Topics Session on Implantable and Prosthetic Devices: Life-Changing Circuits" at ISSCC

2008 Co-Chair, NSF Workshop on Micro/Nanoelectronics: Devices and Technologies for Biomedical Applications

2008
Dedication of the Lurie Nanofabrication Facility



2010
Fantastic Voyage 2: Microsystem Development at the University of Michigan 2000-2010

2011-present Ken Wise Retires – yet continues to work on research projects.

Research Highlights:

- Realized the first thin-film cochlear electrode arrays for the hearing impaired.
- Realized wireless implantable microsystems for monitoring neural activity in motor cortex
- Demonstrated wireless pressure sensors to improve cardiovascular care, the treatment of glaucoma, and environmental monitoring.
- Developed smart air-quality monitors to help address global warming.
- Demonstrated hand-held breath analyzers for biomarkers of tuberculosis and lung cancer for use around the world.

2006
Purdue University Outstanding Electrical and Computer Engineer

2007
Henry Russel Lectureship (one of the highest honors bestowed by U-M)

2010
Technology Transfer Career Achievement Award (U-M)

2011
Distinguished University Innovator Award (with Khalil Najafi), for their role developing breakthrough technologies in microelectromechanical systems (MEMS) and working with colleagues, students and industry partners to move these innovations from university laboratories to new startups.

2006 Pamela Tridandapani Bhatti
Joseph Allen Potkay
Helena K. L. Chan
Yang Li

2007 Jianbai Wang

2008 Gayatri Eadara Perlin
Kyusuk Baek

2009 Mikhail Pinelis

2010 Sister Mary Elizabeth Merriam

2011 Razi-Ul Haque
Angelique Johnson

(Continued from page 43)

Shortly after, the path to the NSF Center for Wireless Integrated MicroSystems (WIMS) was set when Ken and Khalil decided to begin the long process of proposal submission in 1998. Ken took on the role of Associate Dean for Research at the College of Engineering in 1999, but when NSF funded the Center, he stepped down after just a year to direct WIMS. Twenty-five years of research and dedication provided the perfect launching pad for this ten-year Center.

00's: Wireless Integrated MicroSystems and the LNF

"We had been mainly a MEMS device group," said Ken. "The big thing about WIMS was it crystallized efforts in wireless as well. That's a paradigm shift. The combination of sensing with embedded low-power circuits and wireless is going to be everywhere."

When Ken took over as Director of WIMS, he truly began to write his own history – through the newsletter *WIMS World*. His Director's Messages reveal his love for history interwoven with reflections on leadership, team building, dedication, students, education, and of course the research: testbeds, system integration, microsystems, and the power of engineering to change society for the better.

WIMS World charts his progress in realizing his dream for *in vivo* implantable devices with wireless monitoring; cheap, efficient, devices for environmental monitoring; and a neural prosthesis for the treatment of deafness, epilepsy, Parkinson's disease, and perhaps even paralysis.

As the WIMS Center got under way, it was clear that for Michigan to continue its state-of-the-art research in MEMS as well as other areas in Solid State, attention must again be turned to equipment and facilities. Again, the Deans (the process began under Dean Steven Director, was expanded under Interim Dean Ronald Gibala, and completed by Dean David C. Munson, Jr.) stepped up and helped make it happen, with the help of alumni and friends of Michigan Engineering.

A key friend was Ann Lurie, long-time supporter of Prof. Wise's research with its direct application to healthcare. She launched the fundraising effort with a $15M gift, and many others stepped up to ensure completion of the $40M expansion and renovation. Another $20M in equipment from the University completed the facility. The College had the names of a few select donors printed on a plaque commemorating their gifts; included are Ken and JoAnne Wise.

At the dedication of the Robert H. Lurie Nanofabrication Facility in 2008, Ken told the crowd that he was as excited as anyone to see what future breakthroughs would be accomplished at Michigan thanks to the facility and the synergy of the faculty and students.

The WIMS Center is the crowning jewel in the remarkable career of Ken Wise. In the booklet, *Celebration: The WIMS ERC: 2000-2010*, he remarked that the microsystems now being developed "are creating a new electronics that will become truly pervasive in solving many of the critical problems of this new century. It will help us preserve the environment, improve health care, protect our national and global infrastructure, provide homeland security, and improve the discovery, generation, distribution, and use of energy."

The ribbon cutting ceremony for the Lurie Nanofabrication Facility

He saluted the people that made it all possible – with particular gratitude for his faculty colleagues who were willing to put aside their own personal research agendas to work for a common goal and make these microsystems a reality.

The Team, the Team, the Team

Ken arrived at Michigan with a vision for building a program in a new field based on sensor technology that would come to be known as MEMS and microsystems. Even in the early days, sensor research was highly interdisciplinary, and Ken gradually drew many others into his world.

He worked with a group of faculty dubbed the "fab five" in the 90's, and when three left for other opportunities, he seamlessly worked in their successors to be research thrust leaders in the WIMS Center. Khalil Najafi remained a member of the team, and the new members from EECS were Yogesh Gianchandani, Dennis Sylvester, and Michael Flynn. It was this "fab five" team, along with Ted Zellers from the School of Public Health, that was awarded the CoE Ted Kennedy Team Excellence Award in 2010 for their work in MEMS and microsystems.

L: Khalil Najafi, Ted Zellers, Yogesh Gianchandani, Michael Flynn, Dennis Sylvester, Ken Wise

A critical component of Ken's team were his students. He created an environment where they felt comfortable yet challenged – a tricky balance to achieve. Even in the early years he attracted a relatively high proportion of under-represented minorities, which in engineering includes women. These students have gone on to excel in industry, academia, and, like his final student Angelique Johnson, new startup ventures.

Memories and Remembrances

The research accomplished at Michigan under Ken's leadership was extraordinary. But it is not at the heart of his work. For that – you'd have to look at the people in his life.

His family was his rock – his pride and joy. Of his wife JoAnne, he said "it's really all about her, because she made it all possible for me." He treasures the time spent with his three boys, Kevin, David, and Mark, and over the years he has fulfilled a number of significant positions in his church.

In the research realm, Ken said, "A lot of my favorite memories involved working with Khalil, especially in the early days when we were trying to build the program. Trying to get a proposal out at the last minute – sacrificing a lot but making it work, even when we really didn't have enough money or time."

"My fondest memories, said Ken, are working with my students, and pulling it off." As Ken was answering this question, a former student came by to say hello – she was using the cleanroom on behalf of her solar energy firm. Many more students came to a special banquet held in September 2010 to celebrate his career at Michigan.

At the banquet, first PhD student, John "Mike" Borky (PhD EE '77), said that Ken established a unique personal relationship with every one of his students, and added, "The knowledge, the discipline, the passion for excellence that Ken and the whole University community imparted were the foundation for all that I did after and all the success that I enjoy."

A more recent student, Andrew DeHennis (MSE PhD EE '01 '04), said he was able to fully appreciate Prof. Wise's vision when, "within a couple years of graduating and being in industry, I developed another remotely powered wireless monitoring system that we are implanting in humans." He began research in this area with Prof. Wise in 1999.

His last student, Angelique Johnson (PhD EE '11), recalled Ken coming in at 7am Saturday mornings to teach Detroit area middle schoolers about MEMS technology. She said she truly appreciated "how much Dr. Wise encouraged his students to reach back into the community, and to influence young minds to get into this field. He pushes his students to excel as human beings, not just researchers. He wants us to achieve more than just new technology. He wants to help us achieve a better world overall."

Looking to the Future

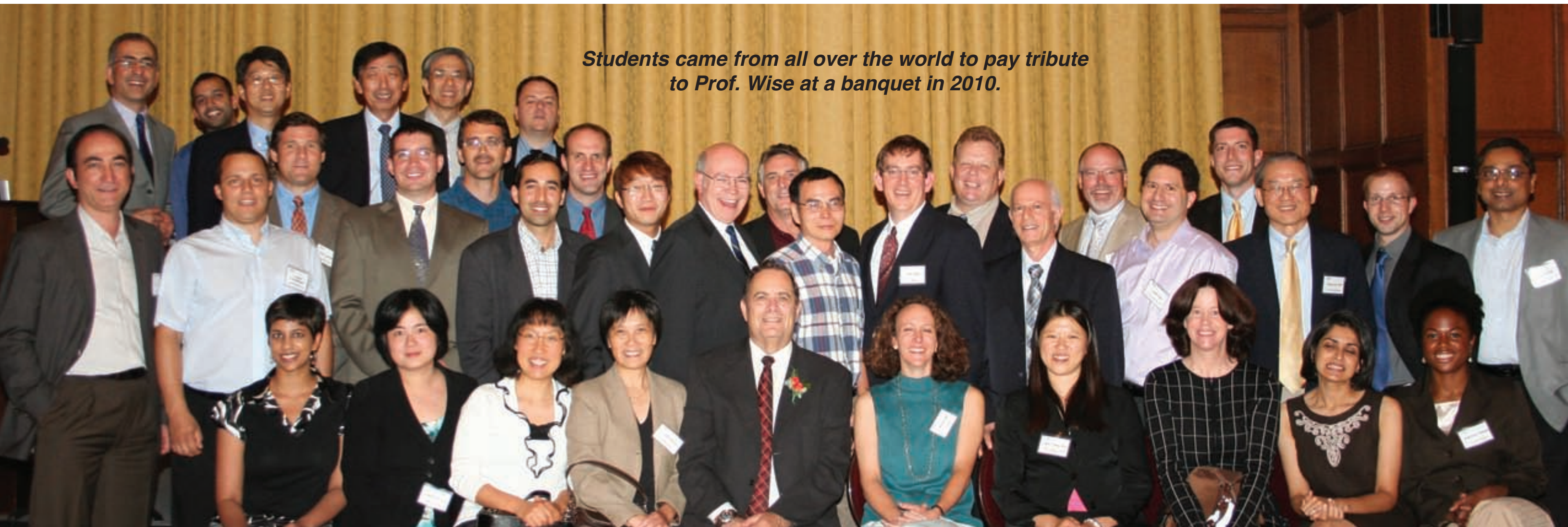
Ken's vision has always been focused on a future built on a firm foundation. During his tenure as WIMS Director, he provided an abundance of writings, photos, and presentations documenting the history of the Center, and then worked diligently to ensure its continuation once NSF funding had ceased. $WIMS^2$ is now directed by his academic "grandson" Yogesh Gianchandani, student of Khalil Najafi.

Ken's career here at Michigan is well summarized by his former student, long-time colleague, and friend Khalil Najafi:

"Ken has been the visionary, the guiding light, and the steady hand who has devoted his career to the creation and development of an amazing set of technologies and devices that have benefited everyone across the world. He is a humble and devoted researcher and teacher who shared his success, his resources, his counsel, and his vision with all of us. He focused the spotlight mostly on us, shying away from drawing attention to his own accomplishments and needs."

"By combining micropower circuits, wireless interfaces, and integrated sensors, a flood of advances has been unleashed to improve health care, the environment, the national infrastructure, and other areas, changing the way we live and improving the quality of life. Ken helped launched this revolution, and it will have far more impact than any of us can imagine."

"Michigan was a great place to spend a career." – Ken Wise



Students came from all over the world to pay tribute to Prof. Wise at a banquet in 2010.