Female professor: a role model in microelectronics

As the only female professor of microelectronics in Australia, Professor Rodica Ramer describes the growing importance of radio frequency microelectromechanical system technologies and how her team’s research is shaping future generations of communication devices.

What are the main reasons for which very few women pursue a career in electrical engineering? What is being done to address this?

In the past, I used to hear high school students asking ‘What is electrical engineering?’ This lack of awareness was very surprising, and was perhaps due to too few science education programmes available in some schools. Electrical engineering is everywhere around us, and I am sure that fewer and fewer students will ask this question now that almost everyone owns a smartphone.

I was the only female academic in the School of Electrical Engineering and Telecommunications at the University of New South Wales (UNSW) for more than a decade, but now I have two female colleagues representing the profession very successfully. In terms of female students, their number has increased substantially in the past few years at both undergraduate and postgraduate level. Several of them have achieved the highest academic performance, and many of them work at top high-tech electrical engineering companies in Australia and overseas.

Nowadays, the attitude towards women in society has changed, with females in all ranges of activities accepted and welcomed in fields once reserved for men. This is due to a concerted effort by all of society, at all levels of activity, to achieve gender balance and diversity.

Why have you dedicated your research to radio frequency microelectromechanical systems (RF MEMS)-based microwave devices, their functions and their unique elements?

Our research interest is in the area of microwave and millimetre-wave devices and materials. We use different technologies such as waveguide, microstrip, stripline, coplanar waveguide (CPW) and RF MEMS to design and fabricate these devices. We develop novel technologies and techniques for the optimisation, characterisation, simulation, design and fabrication of RF MEMS-based circuits for wireless communications systems.

RF MEMS, with their intrinsic features and versatility to integrate both electronic (2D) and microelectromechanical (3D) devices, represent the key technology that can offer wide operational bandwidths, on-chip passive components, negligible interconnections, practically ideal switches and resonators in a planar fabrication process. RF MEMS are compatible with existing integrated circuits and monolithic microwave integrated circuits, and offer a reduction in weight, volume, cost and power consumption together with improved functionality.

The devices developed in your laboratory include RF MEMS switches. Why did you choose to investigate these switches in particular?

Following the advancement in MEMS technology, RF MEMS switches (with very low loss and power consumption) are being explored for different microwave applications. RF MEMS switches are very valuable as they ideally combine the advantages of mechanical and semiconductor switches in a planar fabrication process compatible with existing integrated circuits and monolithic microwave integrated circuits. They are not only small in size, and show excellent RF performance, linearity and low inter-modulation distortion, but they can also be incorporated to modify the electrical length and further develop other miniaturised, low loss, low power consumption and low cost microwave circuits.

What is next for you? Are there any new areas you would like to explore?

We are currently exploring devices at higher and higher frequencies in the millimetre-wave range, preparing for a wide range of industrial applications that will come with 5G mobile communications and their infrastructures, as well as the forthcoming generations of radar and satellite communications.

We are also investigating more complex circuits than those currently used with a view towards the integration of multiple standards for wireless communications.
RF MEMS for optimised technologies

Research from the School of Electrical and Telecommunications Engineering, University of New South Wales, Australia, seeks to meet the future requirements of communication technology using a new generation of reconfigurable radio frequency microelectromechanical systems switches, filters and antennas.

MICROELECTROMECHANICAL SYSTEMS (MEMS) technology for the fabrication of radio frequency (RF) devices has become a key enabling contributor to wireless communication. The global market for RF MEMS technology is forecast to grow from US $50 million in 2014 to over US $450 million in 2018. The majority of the RF MEMS market will be in mobile devices, although the high-end market, such as the automotive industry and radars for commercial, military and space applications will continue to grow.

LEADERS IN THE FIELD
The current challenge is to meet the requirements of evolving generations of communication technology, while addressing the issues of power consumption and bandwidth. Rising to meet these challenges is Professor Rodica Ramer, who currently leads the Microwave to Millimetre-wave Engineering Research (MMER) group at the University of New South Wales (UNSW). As the first female professor of electrical engineering, her projects introduced RF MEMS research to Australia, and her team is now working in the most advanced and successful RF MEMS laboratory in Australia, and one of the best in the world.

RF MEMS technology has enjoyed significant interest during the past decade due to the advancements in wireless technology. It is well known that RF MEMS devices offer attractive performance characteristics at microwave frequencies. They also exhibit similar advantages in the millimetre-wave spectrum in terms of high isolation, low insertion loss, low DC power consumption and excellent linearity.

RF MEMS SWITCHES
Over the past 10 years at UNSW, Professor Ramer and the MMER students have developed some unique and novel designs using RF MEMS switches to achieve reconfigurable RF front-end circuits. These fully integrated novel building blocks include multiport RF MEMS switches, switch matrices, reconfigurable filters and antennas.

“For higher operational power and performance, we designed 3D waveguide-type microwave and millimetre-wave devices. Some structures incorporate RF MEMS into the 3D electromagnetic configurations to achieve various functions such as band-pass, band-stop filters and phase shifters,” Professor Ramer explains.

The basic building block for the reconfigurable RF front-end circuits developed at the MMER laboratory is a cantilever beam switch. A novel switch cell can then be easily integrated into a matrix without any topology limitations, which can be used to create a RF MEMS switch matrix, where it enables the structure to expand to larger configurations. The broadband scalable switch matrix has been fabricated and tested with excellent RF performance.

RECONFIGURABLE FILTERS
Professor Ramer and the MMER students have also created a filter that can switch between 60 GHz and E-band spectrums using RF MEMS switched capacitors, and can provide good channel isolation while being small in size. An application of such reconfigurable filters is a gigabit short-range backhaul where, depending on the spectrum availability, the backhaul might need to operate at 60 GHz or E-band.

QUASI-YAGI ANTENNA
A new millimetre-wave frequency reconfigurable quasi-Yagi antenna has been developed by Professor Ramer’s team, printed on a quartz substrate and integrated with RF MEMS switches. Simulations show that the reconfigurable antenna can be successfully reconfigured into two different frequency bands with excellent RF performance even when using different biasing materials for the biasing lines.

The resulting devices achieved excellent physical properties, dimensions and RF performance that are unmatched by any competing RF and microwave technologies. In addition, the devices developed by the MMER group can be fabricated using an all-metal fabrication process, also developed at UNSW. “Our thinking behind innovation is that you should always want to move forward and apply more strict conditions to your devices, and then find the best way to design and fabricate them,” Professor Ramer concludes.