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Starting a new team in microelectronics development—SWOT and new initiatives

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As highlighted in the November 2004 issue of *IEEE Spectrum*, numerous leading scientists and engineers agreed that the integrated circuit (IC), comparable with the Internet, was one of the most imperative technology inventions of the last 40 years. However, due to limited human resources and financial support, the IC research activities at the University of Macau (UM) did not progress as fast as those at other mainstream universities worldwide in the last decade. At the beginning of the 21st century, an explosive growth in Macau's economy and international visibility has created many strengths and opportunities but also weaknesses and threats for university education, research, and development. This paper discusses those issues and presents several initiatives that are being undertaken at the UM in order to establish a new research team for microelectronics development.

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When the first IC of Macau, *UMChip*, was developed back in 1993, the UM was recognized as one of the earliest universities in China to offer high-end analog and mixed-signal IC education with silicon fabrication as the experimental proof. At that early stage, ten master's students under the supervision of a visiting professor from Portugal finished the *UMChip* as a course project in 1993, by using the software design tools donated by the Technical University of Lisbon, Institute Superior Técnico, Portugal. The R&D work has continued since then, but with relatively slow progress. The main bottlenecks at that time were a lack of students and facilities such as laboratories and funding for purchasing advanced equipment and access to silicon technologies. After an enormous amount of hard work, the Analog and Mixed Signal VLSI Laboratory was founded in 2003—the first laboratory in Macau dedicated to IC education and R&D. The laboratory has been financially supported by the research committee of the UM since its inception. Since 2006, additional financial support from the Macau Science and Technology Development Fund (FDCT) has further helped to secure access to the most advanced technologies that are essential yet very expensive.

A remaining key issue is to create a secure human infrastructure. Building up a new research team with talented students and state-of-the-art facilities and establishing cooperation with different mainstream universities and companies have become necessary to accelerate the local IC R&D. These critical issues are addressed through highlighting strengths, weaknesses, opportunities, and threats (SWOT) as they pertain to the UM and concludes with the depiction of new initiatives that have been undertaken.

SWOT's going on

An examination of strengths and weaknesses shows that Macau is a relatively small city in China, near Hong

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Kong, with a population of roughly 600,000. With the exposure and growth of its economy in recent years, the FDCT was founded by the local government to support local science and technology R&D activities. Through the FDCT, universities are entitled to obtain more funds to elevate education and enhance R&D capabilities. Although the financial support has been in place, the number of local students enrolled in the Faculty of Science and Technology (FST) of the UM has not experienced a remarkable growth. A recent survey focused on high school student career direction, carried out by the UM, shows that interest in engineering studies has fallen. This fact directly affects the local human resources as it is the primary ingredient for a sustainable growth of local R&D.

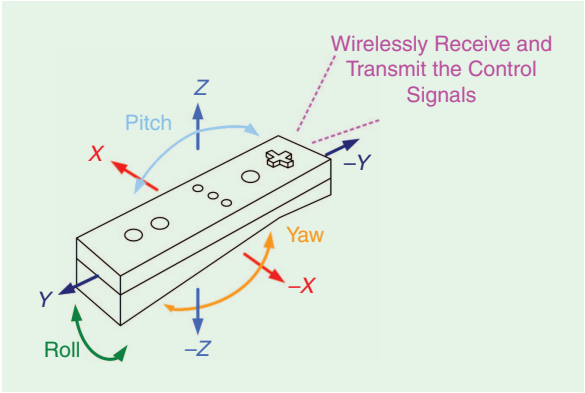

Fig. 1 The operation of a Nintendo Wii controller involves three Cartesian axes movements and three rotational movements detection, and wireless communication (http://www.nintendo.com/wii/what).

In terms of global human resources, although the UM is an international university using English as the teaching medium, it experiences difficultly in attracting high-quality postgraduate students from mainland China and foreign countries. International companies show little interest in establishing in Macau, primarily also due to the limited human resources there. The cooperation potential between industry and university is therefore weak. In fact, many university students show interest in IC design. Regrettably, if they cannot see strong career opportunities locally, most of them will eventually pursue their careers in different directions. These limitations lead to a complicated circumstance to build up a strong research team.

Opportunities and threats abound as the explosive growth of the consumer electronics market in the last two decades has led to a great demand for engineers to join the IC industry. In order to attract more young people to this field, the promotion of science and technology in high schools and universities is very critical.

Nowadays, computers, television, cell phones, and iPods lose most of their attractiveness in motivating students to start their career in microelectronics R&D. An informal discussion with students told us that they trusted the developments of those products were among the hottest in engineering study in the past few decades but have entered into a mature status already. Reigniting modern students' curiosity on IC requires more attractive topics as motivation. Examples include: How do green ICs help to improve the environment and energy savings? How do biomedical ICs improve the quality of life? Such topics have the potential to attract students whose interests lie in science, engineering, or both. It is reasonable to say that the multidisciplinary technologies are creating many new opportunities challenging the modern electrical engineering (EE) education.

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However, multidisciplinary education has its own challenges; for example, building a hospital laboratory for experimenting with biomedical ICs requires a considerable amount of investment to obtain human resources and equipment. In terms of human resources, designing an implantable chip for acquisition of biopotential signals requires researchers/engineers who have exhibited good knowledge and practice of both EE and biomedical engineering. Considering the fact that many small- or medium-sized universities in less-developed countries get little to no funding from the government and industry, the success of future microelectronics education and R&D in these countries will largely depend on the available funds and the relationships between the professors, government, and industry. Fortunately, in Macau, the FDCT has provided the UM with an advantage, at least in terms of funding.

New initiatives in UM

In the UM, several initiatives have been undertaken in order to assist the development of a strong research team in microelectronics. At the university level, one such initiative is to build up a good reputation locally and internationally through research excellence. Part of this initiative includes promoting highly qualified research projects to a category known as "university level," which entitles the projects to obtain more financial support to attract high-quality students to enforce their team. In addition, researchers in key areas may propose an invitation of renowned professors and experts from around the world for consultation.

At the department level, in the research line of which I am in charge, the initiative is to set up a junior research training program (JRTP). Its objective is to educate the next generation of our students in an earlier stage of their career, giving them practical hands-on experience in designing simple projects and knowledge about the state-of-the-art development. Several students have already joined and they are currently involved in a research project with postgraduate students. For instance, a third-year student has started research into complementary metal-oxide-semiconductor (CMOS) power amplifier reliability in ultrascaled technologies. The associated knowledge covers solid-state device physics and wireless communication systems as well as microelectronics that they have taken in the past semesters. The student reviews the textbook basics and studies the state-of-the-art power amplifiers reported recently in leading journals and conferences. Of course, students will frequently encounter difficulty in digesting the materials and performing a simulation. Periodic group meetings with open discussion are imperative to ensure the students can keep pace with the project, understanding the other projects from their labmates through discussion, assisting them in formulating the research strategy, and concluding with a study report and presentation.

The third initiative is to encourage faculty members to participate in local student sections of the IEEE and the Institution of Engineering and Technology, and network with high-school students through activities, technical visits,

and seminars. Through those endeavors, many opportunities will be available to understand for what the students are looking. For instance, teenagers may be more interested in the operation of funny electronics products rather than hard theory. One example is the Nintendo Wii videogame console; it involves a tri-axis accelerometer to detect movements within the three Cartesian axes and also rotational movements (roll, pitch, and yaw), and a bluetooth transceiver IC for wireless communication (Fig. 1). One seminar at the UM is an introduction of the Wii to high school students when they visit the university and to the junior undergraduates when promoting the JRTP.

The fourth initiative is to exchange the education and research team development experiences with the professors and other Graduates of the Last Decade (GOLD) Members in different regions working in the related fields. For instance, GOLD representatives of the IEEE Circuits and Systems Society have met at the IEEE International Symposium on Circuits and Systems (ISCAS) 2008. We have an education workshop to exchange information and localized strategies that were particularly successful in their country. The discussion includes the topics of how to stimulate the interests of first-year undergraduate students in EE through more laboratory projects and connect industry and academia to reform and create curricula that can address the new problems in the 21st century and beyond. Special classes given by engineers from industry are important for young researchers to understand how their knowledge gained in university as well as academic research related to practice in industry. The industrial speakers also highlight what combination of skills and knowledge will match the jobs they offer, giving references for students to decide their study roadmaps.

Conclusion

Compared with other places, it is true that the IC R&D in Macau is currently more an oasis than a sea, though there is much potential and optimism for its expansion. With the prospect of being a national-partner-key laboratory with several areas of research (wireless, signal processing, power, and biomedical) dedicated to analog and mixed-signal IC design, industrial and university supports as well as participation of students are the turnkeys to continued excellence. Starting a team with talented students and seeding research knowledge into their minds will be a challenging task and will require more initiatives that help to address the presented SWOT analysis.

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Read more about it

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