Microelectronics Education in the South of Brazil and Outcomes

Ricardo Reis and Sergio Bampi
PGMicro - Graduate Program on Microelectronics / PPGC - Graduate Program in Computing
Universidade Federal do Rio Grande do Sul (UFRGS)
Av. Bento Gonçalves, 9500.CP15064. CEP 91501-970. Porto Alegre, Brazil
{reis,bampi}@inf.ufrgs.br

***Abstract*—This paper presents a historical review and addresses the process established to start the development of a Microelectronics environment in the South of Brazil, based on the graduate and undergraduate education on microelectronics developed over the years at the Federal University of Rio Grande do Sul, at Porto Alegre. For example, one of the strategies was to found a Microelectronics research group at UFRGS and then promote the education of Microelectronics not only at the UFRGS Federal University, but also throughout the South of Brazil. The education process that was adopted at UFRGS will be presented. Under the Microelectronics Group initiative, a set of events (summer schools, conferences and workshops) was set up in the South, as an important action for the dissemination of the area within other universities and companies. The presence of students and faculty members in international activities had also an important effect. It will be presented the results of this process that were very significant, considering the microelectronics network that was established in the South of Brazil. The industrial milieu in the South of Brazil was also impacted by the Federal University activities. The paper addresses how the industrial environment progressed in Brazil – with retreats and forward moves - and the outcomes for the current industrial scenario. The impacts of this process in the development of the field in the whole country are also addressed.**

I. INTRODUCTION

The set up of the academic environment to support the development of the Information Technology Sector started in the UFRGS (Universidade Federal do Rio Grande do Sul) at Porto Alegre, in the beginning of the seventies. A group of professors from the Electrical Engineering Department, from the Data Processing Center and from the Physics Department started the Graduate Program on Computer Science. This Graduate Program had a strong group on conventional hardware design, where many dissertations finished by the development of pre-industrial prototypes of digital equipments. This initiative by the Federal University was responsible for the spin off of several companies that started an IT industrial environment in the state of Rio Grande do Sul. They worked more notably in the fields of industrial automation, data communication equipment and computers of the early 1970 vintage. Most of these companies exist till nowadays, since they were able to keep their internal capability to develop both their hardware and their own software technologies. After this transfer of technology to the industrial sector, there was recognition in the Graduate Program that the University, and the Graduate Program in Computing in particular, should work on new technologies that the industry would need in the future. So, it was clear that the technologies that the local industry in South America lacked were the complex of technologies and know-hows that had to do with microelectronics that is the integration of circuits onto a chip. In the mid-1970s the industry worldwide moved to VLSI era, which led later to the system-on-chip era. Then the head of the Graduate Program, professor Daltro Nunes, encouraged new students and provided the support for young researchers and faculty – most with the M.Sc. degrees acquired at UFRGS - to leave for Ph.D. programs abroad (most in France and Germany) in the field of microelectronics. So, by the end of years 70, some young researchers went abroad to prepare a PhD in the field of Microelectronics. The first destination was the ENSIMAG, Grenoble, where the ARCHI team leaded by professor François Anceau was starting researches in the field. Others went to other destinations like Stanford, Munich, Kaiserslautern, Karlsruhe and Louvain-la-Neuve. By the end of 1981 they started to return from Europe, Altamiro Susin being the first one that returned to Porto Alegre with a Docteur Ingénieur degree in Microelectronics by the Institut National Polytechnique de Grenoble (France). In 1983, the Microelectronics group at the Federal University was officially started as part of the Graduate Program in Computing. Early members were Altamiro Susin, Tiaraju Wagner and Ricardo Reis. At that time in Brazil other groups were also working in Microelectronics, in Sao Paulo and Campinas, in topics related to the fabrication of circuits. At the UFRGS Microelectronics group we decided to focus and promote the fields of IC Design and EDA development, by starting a new event that became the first national event in the field, the SBCCI, initially named Brazilian Symposium on Integrated Circuit Design, later changed to Symposium on Integrated Circuits and Systems Design. The first SBCCI

was organized by our group and held in Porto Alegre, from 7 to 11 November 1983 [1].

II. International Cooperation

Since the beginning of the Microelectronics Group, it was clear that we should use as reference for our research and educational activities, the international state-of-art in the field. At the very beginning of our group the participation and publication of papers in the main international conferences was encouraged. This was important to obtain some visibility of the group outside of the country and to expand the international ties of the group, which had commenced with the first Ph.D. thesis defended by Brazilians in France, Germany and, in one case, in the USA. The establishment of international cooperation was a mainstay of our team, in which all the students – at even the Master level – were encouraged to engage in. The first formal international cooperation was done with the ARCHI group of INPG, in 1980, using the framework of CAPES/COFECUB, a cooperation program established by French and Brazilian Governments, at the level of their Ministries of Education. Since then, several formal research cooperation projects were done with TIMA and LIRMM (France), Darmstadt and Karlsruhe (Germany), Louvain-la-Neuve (Belgium), INESC (Portugal), IMSE and Univ. Sevilla (Spain). Nowadays the international cooperation is also extended to the exchange of undergraduate students under cooperation programs with France, Germany and USA. Another important collaboration that UFRGS had since 1990 was under the cooperation programs that promoted the Ibero American or Latin American cooperation like ALFA Program, Cyted, Iberchip and others.

III. Undergraduate Scholarships

One very important factor of attraction for students to work in the field of microelectronics was the inclusion of undergraduate students as part of our research teams. The CNPq (Brazilian Science & Technology Support Agency) is the main provider of scientific initiation scholarships to undergraduate students. We engage in our research teams undergraduate students from Computer Engineering, Electrical Engineering and Computer Science. In Brazil, the students start their engineering undergraduate just after high school, with about 17 or 18 years old. The undergraduate courses takes about 4.5 to 5 years. We engage in our research projects, generally students that are in the third to the tenth semester. The engagement of young students is good, since gives more time to the students to increase their maturity in research. Some of them finish their undergraduate course with results that let them to be co-authors of papers in international conference or journals. Some have already a research experience and results that can be the basis for a master or PhD work. As they work in a research team, they are witness of the work of PhD and Master students, and they can have a daily interaction with the more experienced members of the research team. It is also possible to say that a large percentage of the PhD and Master students we had, started as undergraduate students in our research projects. A large number of the best PhD works where done by students that started working as undergraduate students in our research projects.

IV. CMP

In the beginning of the Microelectronics Group, one of the first challenges was to prove to local companies and funding agencies that our group had the knowledge and the capability to design a chip locally. Since Brazil never had a MOS-capable lab or company, the only route to silicon prototyping was through the other nations multi-project wafer programs. Then UFRGS became one of the first and regular users of the CMP Program established at INPG in France. In 1984 our group, with the work of a few Master and undergraduate students designed a simple controller chip that sent to fabrication in France through CMP, and that was later tested and used to control an elevator prototype exhibited in a large IT Expo in Rio de Janeiro.

V. Graduate Education

The Microelectronics Graduate Education started at the Master Level under the umbrella of the Graduate Program in Computer Science (at that time the Master Course could take up to four years of work, or even more). The first Master Student (1980) was Ingrid Jansch Porto, who designed a digital system in I2L, under the supervision of Anatolio Laschuk, to be fabricated in a bipolar facility in Brazil. The second one was Antonio Todesco (nowadays working at AMD, USA), his advisor being Altamiro Susin. The subject of his work was the development and design of a RISC microprocessor. Only later, in 1989, the PhD Program in Computer Science was started at UFRGS with an emphasis in Microelectronics. In 2002, as a response to a Ministry of Education CAPES action willing to set up Graduate Programs in Microelectronics, UFRGS started a multidisciplinary Graduate Program on Microelectronics with the participation of professors from the Electrical Engineering Department, Informatics Institute, Physics Institute and Chemistry Institute. In this Program the students have exposure to device fabrication, device physics, digital and analog design, EDA, and testing and characterization of semiconductors. There is at least one mandatory course in each of these subjects. The students have access to a small, academic clean-room with furnaces, lithography, implanters, metal deposition and all the essential steps to build integrated devices on silicon.

One action that is regularly done with PhD students is to promote their internship in research labs of international companies working on microelectronics or in research labs of universities in other countries. Several students also do PhD in “cotutelle” between two universities and receiving a PhD diploma from both universities or even one PhD diploma emitted and signed by both universities.

Micro and nanoelectronics is also part of the new Nanotechnology Center of the University.

VI. Undergraduate Education

The undergraduate courses started just after high school and takes in general five years. The selection process to be enrolled undergraduate course of UFRGS has in our fields about 10 to 15 candidates per position, we have in general good students. The students have to select their courses when applying for a position, so before the selection process that is based in 5-day exams. In the undergraduate courses the students have basic courses (Physics, Mathematics) in parallel to courses related their field of option. For example, students in Computer Engineering or Computer Science have a course on "Computer Organization" when they are in the first year of the University (17 or 18 years old). The undergraduate education courses, where microelectronics is included, are: Electrical Engineering, Computer Engineering and Computer Science. The main courses related to microelectronics are: Digital Circuits, Integrated Circuit Design I and II, Digital Systems, EDA, Analog Circuits. Each one of them takes 60 hours in one semester. In Integrated Circuits I and II the students have an experience in designing with professional EDA tools. It is important in our opinion to put the young students in contact with professional tools as soon as possible.

VII. Education Outcomes

In 1984, it was started a local event, named SIM, that started as a UFRGS Seminar on Microelectronics and that later becomes The South Symposium on Microelectronics with already 25 editions. Each student should prepare a short paper with 4 pages, in English, that will be part of formal proceedings. This is in general a first experience of a local student in presenting a paper in a conference. One important action was to motivate students and lectures from several universities in the State of Rio Grande do Sul to start activities in the field of microelectronics. One regional action was to set up in 1989 a series of regional summer schools in Computer Science/Engineering where microelectronics was always one of the subjects. The first edition was organized in the Federal University of Santa Maria. Later, in 1998, it was started a series of Regional Microelectronics Summer Schools (EMicro) organized each year in a different city of Rio Grande do Sul. The first edition was in the city of Pelotas (South Rio Grande do Sul). The EMicro has basic courses to students that don't have experience in the field as lectures in state-of-the-art topics given by researches from Brazil and from many other countries. The EMicro together with the SIM (South Symposium on Microelectronics) keeps moving each year between different locations of the State of Rio Grande do Sul. This fact is helping to promote the microelectronics and to attract new students to do a Master or PhD work. One important outcome is that nowadays there are professors with PhD in Microelectronics that are engaged in several universities of the State (like PUCRS, UFSM, UFPel, UCPel, UNIPampa, Unijuí, UERGS). We can say that it was constructed a Network of Microelectronics between these Universities.

VIII. Conference Organization

The starting of the SBCCI Symposium in 1983 [1] under the sponsorship of the Brazilian Computer Society (SBC) and organized by UFRGS, was an opportunity to promote the fields of Design, Test and EDA in Brazil. Moreover, the positive evolution of SBCCI in scope and quality also promoted an increasing relationship between the Brazilian research community in those domains with the International community. SBCCI provided, in a smaller scale here in Brazil, the same effect that the DATE event had in the European Community in Design, EDA and Testing. In 1998, SBCCI started to be published internationally by the IEEE Computer Society Press [2]. Later, as ACM SIGDA started also to co-sponsor the SBCCI Symposium, jointly with IEEE CASS, SBMicro and SBC, the SBCCI Proceedings moved to be published by ACM Press, as they are still today [3].

The UFRGS Microelectronics group also organized several editions of international conferences like IFIP EDAF (1994) on Design Frameworks, IFIP VLSI (1997), IEEE CS ISVLSI (2007), IFIP/IEEE VLSI-SoC (2009), IFIP Edutech (2009), IEEE LASCAS (2010) for Circuits and Systems Society.

IX. Industrial Setting And Impacts

The commercial microelectronics industrial activity in Brazil started in the 1960s with back-end (packaging) and later with a few bipolar (linear and LSI circuits) wafer factories. Due to the lack of investment by the TNC (transnational corporations) and the higher financial barriers that resulted from the submicron VLSI era started worldwide in the mid-1980s, Brazil never had a wafer fab with NMOS or CMOS capability, not even a 6 inch fab of any type. In the 1990-1995 period, all TNCs ceased to operate factories in Brazil, closing down back-end and wafer fab operations. SID Microeletrônica was the last factory to close down a bipolar wafer fab in the state of Minas Gerais by mid-nineties.

In Brazil the IC design activity experimented a large impulse with the design group at the Telebras group R&D center. Telebras was a large holding of more than 25 telephone companies, all under federal state control. Telebras started an IC design group for telecom (switched/commuted central office equipment) in the year 1981. That group designed over the years more than 50 ICs that went commercial. The privatization of the telecommunication companies in 1998 led to closing of that group altogether. A few other smaller commercial design companies, like Vertice Sistemas Integrados, Itaucom, and Elebra Microelectronics – all controlled by larger Brazilian investment groups – operated under local control and offered commercial design and introduced chips in the market. All three also closed such operation by the mid-90s.

The research and educational activity at the Master's level at Porto Alegre (solely at the Federal University of Rio Grande do Sul) was since the beginning focusing on MOS circuit and system designs, as well as on EDA tools for physical, logic and digital system design. The knowledge and HR (human resources) produced in these fields by UFRGS contributed to provide people and motivation for young engineers to endeavor into the field. However, the closing-down of several of the local start-ups, of the TNCs operations, of the Telebras group, as well as the distinctively sway of the TNCs away from any advanced chip development in the Brazil, altogether led to the narrowing of the job market for any VLSI IC designer or EDA master's engineer that was graduated in the 1990s at the Federal University. Nonetheless, the Microelectronics Group at the Federal University kept researching tutoring undergraduate and graduate students, collaborating with the centers of excellence in Europe as listed in the previous section, as well as initiated, in the year 1989, the registration of the first Ph.D. students at the Graduate Program in Computing at the Federal University. In the early 1990s a new Master Program on Electrical Engineering started at UFRGS under the vision and direction of Altamiro Susin, also a senior member of the Microelectronics Group.

In 1997 Motorola Inc. started a new operation in Brazil: it set up its Brazilian Semiconductor Design Center (BSTC group) near Campinas in the State of Sao Paulo, which grew steadily over the following 10 years to become a 200-strong group of designers in the area of microcontrollers, power management ICs, analog CMOS, automotive IC design, among others. Hence, several designers who had left the previously closed operations (at Telebras, Vertice, Itaucom, and others) in Brazil could find jobs in the Motorola Company. The design group led by Eng. Armando Gomes at Motorola BSTC started to hire the Federal University students as well as other graduates from a dozen of schools which kept a focus on microelectronics education in Brazil. That group had the lowest turnover rate of professionals within the Motorola Company.

The years 2000-2002 saw a repositioning of the Brazilian government with respect to the microelectronics industry. The foreclosure of several companies in the previous 10 years was a bad record to be overcome. In the year 2000 only 5 companies operated microelectronics in Brazil: two back-end packaging, two discrete fabrication and the Motorola design center. Two plans for the Microelectronics industry rebirth in Brazil were drafted by the Ministry of Science and Technology (MCT in Brazil): the National Microelectronics Program (announced in the 3Q 2001) and the version 2 of the same Program, announced in December 2002. In this new strategy the construction of a small volume CMOS fab was part of the plan, as well as the lauching of a support program to enhance the design capability in commercial design houses. Part of the plan was also to offer Master's and Ph.D. level scholarships for top-level schools like UFRGS.

The strong and high level activity of UFRGS in the South of Brazil was one the main reasons for the choosing of Porto Alegre as the location of the first CMOs wafer fab in South and Latin America, the CEITEC center. It leveraged a memorandum of understanding reached between the Government of Rio Grande do Sul State, the local city and Universities, and the Motorola Company in the USA, which agreed to donate a full set of CMOS-capable wafer fab equipment to the state of Rio Grande do Sul. An agreement signed in June 2000, a year before the Federal Government announced the PNM Plan aforementioned. It is fair to say that the local State of Rio Grande do Sul stimulated and asked the federal government to set up an industrial policy towards microelectronics in the year 2000 and 2001. In [1] Wirth, Bampi et al., presented a positional paper to the SBMICRO Society and later to the Government. The CMOS wafer fab in Porto Alegre is not fully operational, and CEITEC was transformed in 2008 in a federal state-owned company. In 2010 a new semiconductor company is being constructed in the Porto Alegre region, HT Micron as a joint venture of Korean Hana Micron and local companies. HT will be dedicated to packaging of integrated circuits, DRAM in particular.

The CEI (IT companies' incubator of the Instituto de Informática at UFRGS) was also the location of the starting of Nangate Brazil, a branch of the EDA Nangate Company, based in Denmark. At the early stages of business development, under 2 years old, there are also Portochip and Trianda, housed at the UFRGS incubator, startups dedicated to the design of chips and electronic systems design. The CEI is also the location of NSCAD, which is an engineering team with very low overhead costs that is responsible for training in IC Design as well management of EDA environments. NSCAD started in March 2005 at UFRGS University, as part of an academic project of the Microelectronics Group of the Federal University, supported by the FINEP agency. NSCAD is nowadays an independent service supported by the Ministry of Science and Technology. NSCAD is also the responsible for an EDA Training Center (CT) that was established at UFRGS with the goal of providing intensive, professional-oriented, one year training in IC Design using professional EDA tools, to enhance the level of specialization and productivity of the junior designer. These designers are educated in 80 to 100 student groups, divided in smaller design teams, to educate on commercial design practices, and hence provide the required HR to spur the activities of design houses or design companies in Brazil. A second CT was established in Campinas.

X. CONCLUSIONS

The Microelectronics Education developed at undergraduate and graduate levels at UFRGS has been a key contributor for the development of the field of Microelectronics in the region. From the early engaging of new undergraduate students in the field (a scientific initiation that is key to entice young students to study complex issues in Microelectronics), to the high level standard of M.Sc. and

Ph.D. level research, the group has contributed to educate several generations of designers. The young engineering and computing students take part on a larger community, that the events and international interactions that we strive for organizing bring closer to Brazil. Hence, the international collaboration that started between academia – in Brazil and Europe most notably – has grown towards a network of initiatives that make it possible now to relaunch a commercial activity in Microelectronics, with more high technology companies interested in the South of Brazil as a source of ideas and talent – not just as the emergent market that Brazil surely is.

REFERENCES

[1] SBCCI1983, First Brazilian Symposium on Integrated Circuit Design, Porto Alegre, November7-11, 1983. proceedings Porto Alegre, SBC, 1983

[2] SBCCI1998, 11th Brazilian Symposium on Integrated Circuit Design, Búzios, RJ, September 30 to October 3. Proceedings, IEEE Computer Society, 1998, ISBN 0-8186-8704-5

[3] SBCCI2008, 21st Symposium on Integrated Circuits and System Design, Chip in the Pampa, Gramado, Brazil, 1-4 September 2008, P. ACM Press, 2008. ISBN 9781605582320.

[4] Wirth, G, Bampi, S. et. al. "Challenges for Semiconductor Manufacturing in Brazil". In: XVI Congress of the Brazilian Microelectronics Society, 16th Intl. Conference on Microelectronics and Packaging. SBMICRO, 2001, Pirenópolis. pg. 254-259.