Summer internship report (2014/8/4 – 2014/10/31 @TSMC in Taiwan)

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Ph.D. course 2nd year
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The summer internship at TSMC (Taiwan Semiconductor Manufacturing Company) in Hsinchu, Taiwan was held from Aug. 4th to Oct. 31st in 2014. The TSMC is a one of the biggest companies in the foundry business, which was founded by Morris Chang in 1987. He is an inventor of the foundry business to dedicate the semiconductor foundry for the customers (NVIDIA, Qualcomm, Broadcom, etc.), and the total sales in the foundry business is expanding more than $30 billion [1]. Samsung Electronics in Korea, GLOBALFOUNDRIES in the US, Intel in the US, and UMC in Taiwan are the competitor in the foundry business. TSMC remains a leader with the sales of more than $20 billion and the operating margins of more than 30%. The market capitalization ranks as 72nd in the world.

The Hsinchu city is called as “Taiwanese silicon valley” which is positioned in the center of the electronics industry in Taiwan. A lot of companies (ex. MediaTek) hold the head quarter in this city. Especially, in the Hsinchu Science Park, there are a lot of companies and universities (National Chiao Tung University and National Tsing Hua University), and a lot of young engineers are provided from the universities.

Fig. 1 shows a picture at the National Chiao Tung University. The university is the largest and most competitive university in Taiwan for the integrated circuit design. The number of the faculty in the integrated circuit design department (almost 50 professors) is much larger than University of Tokyo (less than 10 professors). Interestingly, the electronics engineering is the most popular department in the university because the semiconductor industry pays much better salary compared with other industries. Most of the graduates of the university choose to get a job in the science park, and they can earn at least two times higher salary than the average in Taiwan. The good salary of the industry corrects a lot of excellent students, and the excellent graduates support the

Fig. 1 Picture in National Chiao Tung University

industry, and the expansion of the industry gains larger employment. The positive-loop in the city sustains the growth and progress of the Taiwanese semiconductor industry. I feel this is an opposite situation in the Japanese semiconductor industry, and the competitive landscape in the Asia is changed from "*Japan as No.1*" to "*Taiwan as No.1*" in the semiconductor industry. Japanese companies and universities are exactly defeated in the view of the competence and the number of students and engineers. The fact that my home country is going into a decline makes me a little bit lonely; on the other hand, this view was very good lesson to consider my future career.

During the internship in TSMC for three months, I worked as an analog circuit designer in the IP solution group. The assigned project is to reduce power consumption and a phase noise of a crystal oscillator. In the first month (in August), I evaluated and clarified the issues of a previous product in TSMC. The previous architecture had some severe tradeoff between the power consumption and the phase noise; therefore, we decided to change the whole architecture to avoid the very severe tradeoff. From September, I tackled to design a crystal oscillator with a new architecture to reduce the power consumption and the phase noise for two months. Finally, the new crystal oscillator achieved much lower power consumption and lower phase noise compared with the previous design in TSMC. Additionally, a new modeling method to extract an accurate model of a crystal was developed by measurements. The new model results in much more accurate simulated results compared with the previous models. Finally, I measured some samples to compare between the simulated results and the measured results. The feedback by the measurement would assists to surmise some parasitic effects in the commercial product.

The new architecture which I developed may be adopted in a new commercial product in one or two years, and the development in this internship is submitted to the US patent. The submission of a patent by only a summer intern is a first time in the long history of TSMC. I am confident about the progress in the summer internship for three months. The development of a new architecture, modeling of a crystal, and the measurement were very valuable experience to understand the industrial way to evaluate the reliability. The experience in TSMC must assist me to achieve a good work in the university.

Finally, I would like to express the gratitude for my supervisors (Prof. Sakura and Prof. Takamiya), colleagues in TSMC, MERIT project. The assistances from them are very useful and helpful to get the very valuable opportunity in TSMC.

[2] http://techon.nikkeibp.co.jp/article/COLUMN/20140212/333562/