A Perspective for the Quartz Crystal Devices Industry and Technologies in Taiwan and China

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Abstract—Taiwan and China as the fastest growth area in past 20s years for Quartz Crystal Devices Industry, including crystal resonators and oscillators. This paper surveys the industry development history in both Taiwan and China side, some key factors and turning points for the technology and industry emerged and will be presented. Recently, these crystal companies are facing challenges from both traditional quartz crystal giant Japan makers and innovative new solutions US companies. Meanwhile, from 2008, after the financial storm, the market demands for quartz crystals increase slowly and unit price drop continuously. In 2013, Japan’s low-currency-rate policy makes pressure even higher. Facing the challenge from other crystal makers and the growth need for the revenue, Taiwan and China crystal companies need to put more efforts on products innovations and do better jobs on supply chains. Some major efforts will be reviewed and for the Quartz Crystal Devices Industry – The technology evolution and competitions still on the way.

Keywords—Quartz, Crystal Devices, Industry, Taiwan, China

I. INTRODUCTION

Taiwan and China (or so called the global China area) are one of the major quartz crystal devices supply area in the world currently, and also the fastest growth area in past 20s years. They contribute as an important page in global quartz crystal devices industry development. Based on QIAJ (Quartz crystal Industry Association of Japan)’s data, Taiwan and China’s brand companies shared about 23% market in 2011 [1].

The original driving forces for quartz crystal devices technology are different for Taiwan and China. Taiwan is majorly from the electronics industry development need, which PC and consumer applications dominated in the beginning. On the other hand, China, at first, is from the military need, some research institutes and companies born and still active in today’s high-end quartz oscillators market (like No. 54 institute of CETC (China Electronic Technology group Corporation), No. 10 institute of CETC, and No. 203 institute of CASIC, etc.). From 1979, China open-policy started, the low labor cost and local government policy attracted worldwide (including Taiwan, Japan, etc.) electronics makers arrived and built manufacturing bases, and formed another wave for China crystals industry growth.

Based on the same language and similar culture, Taiwan Crystal Makers contributed quite a lot in China Quartz Crystal Industry growth in this period. Today, China already became the biggest quantity quartz crystals manufacturing area in the world, and also the biggest purchasing/application area for quartz crystal devices.

The technology origin is from 2 major sources for Taiwan Quartz Industry, one is from Japan and another is from USA. From 1970s, the first quartz crystal company – Mercury founded, Taiwan crystal makers built long term relationship between Japanese companies and Taiwan side covering raw materials, equipments, and production management and process technologies. From about 1980s, a USA company, Motorola built a quartz crystal company in Taiwan. Although this company closed in 2002, many good technology staffs and managers moved to other companies and contributed to Taiwan quartz crystal industry.

Through the past decades developments, the local suppliers for supports including quartz raw material, packaging materials, production equipments already grew up in sustainable status.

The review will be briefed as three portions, the early paths (from 1950s to 1990s), fast growth (from 1990s to 2010s), and recent challenges.

II. THE EARLY PATHS (1950S–1990S)

It is believed that the first quartz crystal devices plant in China is plant 707 in Beijing, built-up in 1958 and main purpose is for military communication equipments needs [2,3,6,7]. From 1950s to 1979 (China Open-policy started), there were several institutes in China (institutes 203, 54, and 10, etc.) studied frequency control devices to support military or space-investigation related works, however, the major factories were plant 707 and 607 (plant 607 built-up in 1965 in Xianyang, Shanxi basically was split and duplicated from plant 707 for defense strategy purpose). Based on collectable information and resources, they tried and struggled out the quartz crystal devices and related technologies. Mr. Han, XiZhen (Fig.1 (Left)), was the key leader for the development, who had been studied in Russia before. The plant 707 had already built up all necessary technology portions from synthetic quartz growth, round/strip quartz wafers, assembly
metal can and base manufacturing, assembly processes and some machines to support assembly and testing. After 1979 to 1990s, the other state-own plants gradually joined the industry to support domestic quartz crystals needs with the technological help from plant 707 or 607 [6,7]. In 1987, the industry association of China founded, named PCAC (Piezoelectric Crystal Association of China). About 20s units (state-own plants or national institutes) as members joined at first. PCAC is a platform for technology/ equipments/ human-resources information-sharing, the member number increased fast after that. It was about 1987, Motorola built company for communication devices in Tianjin, before early 1990s, Motorola setup quartz wafers and quartz crystal devices production lines, also in Tianjin.

For Taiwan, the first quartz crystal devices company is Mercury in Taipei city, founded by Mr. Yen, Sen-Tong (Fig. 1 (Right)) in 1971. Mr. Yen born in 1928 and received Japanese educations when he was young, and then he studied for education and became a teacher in a primary school. When he started to make quartz crystal devices, already age 43, but he was very energetic and willing to share knowledge. He built good relationship with Japanese quartz crystal field, and helped to translate crystal books from Japan to Taiwan. Mercury still is active in the industry today, they focus in niche markets (customer majorly in USA and Europe) [5].

In 1976, two companies founded in Taiwan, one is Taitein in Taipei, and another is Harmony in KaoShung (a Japanese company KDS had the major share). Taitein is the first company in Taiwan had Tuning Fork resonators and OCXOs products. In the beginning, it was a department inside Tai tein electrics corporation. In 2000, Taitein went independent and became public in 2008. Both Taitein and Harmony already became the major quartz crystal devices manufactures in the world today.

In 1980s, a Japanese cordless phone maker, Uniden, built up manufacturing base in TaiChung, Taiwan, and also built quartz crystals factory for their own need. Around 1987, Taiwan salary increased and Uniden planned to move the plants to Philippines or China to save cost, the key managers inside decided to form their own companies, and come out Aker and Siward. Siward is the first company in Taiwan became public.

In 1983, TXC was founded in Taipei by Paul Lin and Peter Lin brothers. In the first 10 years, the company scale was not big compared to existed major ones, however, it grew up faster and faster, and already became the biggest company today in Taiwan. TXC worldwide share more than 10% in 2012. Paul Lin was also the first chairman for QIAT (Quartz Industry Association in Taiwan) which founded in 2002. Today, TXC already become one of the leading companies in this field.

Around 1985, Motorola built a quartz crystal devices company in TaoYuan to supply their own need. It was once the biggest and with best technologies for wafer process and assembly processes during 1985 to early 1990s in Taiwan. In 1999, Motorola sold this company to CTS, and then in 2002, CTS decided to close it. In 1997, some persons worked in Motorola decided to form new company for SAW devices, named TST (Taiwan SAW Technology), and started quartz crystal resonators from 2001. During 1997 to 2002, many good engineers and staffs spread into quartz crystal industry in Taiwan, some joined Hong Kong or China companies later.

In early 1990s, many today’s major quartz crystal companies already founded in Taiwan, the customers were mostly foreign ones for PCs and consumer applications, and the products still in metal can type. For the raw materials like quartz bar, metal holders and can, were majorly from Japan, so as the production equipments. Some wafer processes machines, like lapping, had local suppliers. These Taiwan companies worked hard to improve customer services, production management, and process quality control, so accumulated energy and valuable initial experiences, and also built the technological communication channels with Japanese makers/suppliers. Meanwhile, along with the open-policy in China, governments encouraged private companies setup and welcome foreign investment. The combinations of policy and very low labor cost attracted worldwide electronics related businesses setup production sites in China. These would stimulate foreign and domestic people’s will to build up quartz crystal related companies, and would start another new growth in China quartz crystal industry.

Fig. 1. (Left) Mr. Han, XiZhen (1929 – 2009), the key leader of plant 707, the first chairman of PCAC (Piezoelectric Crystal Association of China). (Right) Mr. Yen, Sen-Tong (1928 - ). The founder of the first quartz crystal devices company in Taiwan, Mercury. Now the company is run by his son and active in niche market.

III. FAST GROWTH (1990s~2010s)

China companies number increased from 20s in year 1987 to more than 200 in year early 2000s, 10 times increase within 15 years. The quality control and management were lack behind for many small new companies. However, it created strong demands for human resources, equipments, materials, and engineering technologies. Many engineers and staffs originally worked in plant 707 and 607 (it is believed, 607 contributed many more people to the industry companies than 707) joined and adapted for the new situations and competition challenges. Around 1990s to early 2000s, many global famous companies also built up or increase production bases in China, e.g., NDK in Suzhou, KDS in Tianjin, Toyocom in Wuxi, EPSON in Suzhou, and Taiwan public companies like TXC in Ningbo, Taitein in Shenzhen and Nanjing, Siward in Wuxi, Harmony in Shenzhen, etc. This introduced more competitors into China, but also brought into new quality control methods
and concepts, skills for management, and process technologies know-how. Through the fast growth period, China industrial face changed, some companies grew up and big enough to compare with worldwide famous ones, and created some equipments and materials suppliers in sustainable way.

It is estimated, in China area, includes foreign companies and domestic companies, produced more than 400 million units per month for metal can type AT-cut resonators, for SMD type AT-cut products, and for tuning forks[6]. China already became the biggest manufacturing area for quartz crystal devices.

Today, China also is the biggest market for quartz crystal devices. In year 2013, the import money amount was about 3017 millions USD, increased 15.4% compared to 2012. While the export money amount was 1437 millions USD, increased 36.47% compared to 2012 [7]. The difference between import and export is large.

Not only China companies grew up fast, Taiwan companies’ business also increased, especially after year 2000. Compare early 2000s and 2010s, based on the public companies data, Taiwan crystal industry revenue increased as more than 4 times, as shown in Fig.2. In the same period, Japan companies revenue kept in relative stable level. During the period, Taiwan companies made great efforts on ceramic based SMD type quartz devices. Reduced the gap about product development gaps about miniaturization and production gap about automations and quality controls. Based on the efforts, Taiwan companies gradually became the major supply sources about miniaturized quartz crystal devices other than Japan (Japan still the biggest supply source today). Fig. 3 shows the major quartz crystal devices companies in Taiwan.

For culture quartz, China already could satisfied most demand for quartz crystal frequency control components based on existed built capacity, and gradually improved quality. Because the devices size continuously decreased when new demands introduced, the number of wafers or strips increased per culture quartz bar. This also limited the total demand, and hence recent years cultured quartz companies re-integration and number reduced, and improved the quality to make better shape for the industry.

For metal can type quartz resonators, like HC-49U/S, China already had full supply chain companies including holders, metal can, production equipments based on long years developments. On the other hand, ceramic base SMD type resonators, China makers still have gap between advanced makers (Japan and Taiwan makers). Similar situations for the raw materials and equipments. Many Japan suppliers already built up manufacturing in China, including ceramic base (like Kyocera in Shanghai, NSSED in Suzhou), equipments (like Sansel-Denshi in Tianjin, Showa in Shanghai), etc.

For scientific and engineering research related to quartz crystal industry, the internationally renowned research work on crystals are being done at Shanghai Institute of Ceramics, CAS and Institute of Crystal Materials, Shandong University. There are research works on acoustic wave devices in the Institute of Acoustics, CAS and Nanjing University. The Piezoelectric Device Laboratory, Ningbo University, has been focused on the analysis of quartz crystal resonators through analytical and experimental approaches. Electrical circuit analysis and design are done in University of Electronic Science and Technology in Chengdu and Xi’an. [3]

In 2004, a symposium called Symposium on Piezoelectricity, Acoustic Waves, and Device Applications (SPAWDA) started in Ningbo University, and followed in Zhejiang University, 2006. The Symposium was sponsored by major organizations including the Chinese Society of
Theoretical and Applied Mechanics (CSTAM), the Acoustical Society of China (ASC), and the IEEE UFFC Society. This year will be held in Beijing during Oct-30 to Nov-2 by Institute of Acoustics, Chinese Academy of Sciences, Beijing Jiaotong University [3, 4].

From 1990s to 2010s, Taiwan and China companies refined the production and achieve better price-to-performance products, combining with aggressive customer services, they had a fast growth period. However, recent years changes happen, especially after 2010, the revenue decreased for many companies.

IV. RECENT CHALLENGES

Recently, these crystal companies are facing challenges from both traditional quartz crystal giant Japan makers and innovative new solutions US companies. Meanwhile, from 2008, after the financial storm, the market demands for quartz crystals increase slowly and unit price drop continuously. In 2013, Japan’s low-currency-rate policy makes pressure even higher. Besides those, the cost factors in China also were changing. Salary in China increased every year, and the facility cost like electric and water price getting higher and higher. Labor supply became insufficient compared before, especially the coastal areas.

On the other side, Chinese or Taiwan brands companies in electronic industry already grew up, some even ranked onto tops in the world, e.g., Lenovo, Huawei, Acer, hTC, etc. The market for quartz crystal devices also increased in China and Taiwan. The potential opportunities increased, but also laid out higher challenges for products innovation and better quality and service under today’s globalization business environments.

Besides above, the demands on social responsibility, including environment protections, labor rights, health and safety, also became stronger than before in China.

The companies need to do better jobs on different faces, innovations will be must for survival. A new shaping about the industry is on-going.

V. CONCLUSIONS

Taiwan and China as the fastest growth area in past 20s years for Quartz Crystal Devices Industry, including crystal resonators and oscillators. This paper surveys the industry development history in both Taiwan and China side, some key factors and turning points for the technology and industry emerged presented.

Facing the challenge from other crystal makers and the growth need for the revenue, Taiwan and China crystal companies need to put more efforts on products innovations and do better jobs on supply chains. The technology evolution and competitions are still on the way.

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The authors recognized this paper is definitely not completed for the review and perspective descriptions about quartz crystal devices industry in Taiwan and China. They will continue the work with grateful for all people will help in coming future.

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