2011 Joint Conference of the IEEE International Frequency Control Symposium and European Frequency and Time Forum
May 1-5, 2011 San Francisco, California, USA

Quartz Crystal Industry of China at Crossroads

Ji Wang[1], *Liansheng Jiang*[2], *Min-Chiang Chao*[3], *Xuming Chi*[4], *Jianwei Hu*[5], *Zhuzhi Ye*[6], *Lihu Pan*[7], *and Weiqiu Chen*[8]
[1]Piezoelectric Device Lab, School of Mech. Eng. & Mechanics, Ningbo University, Ningbo, Zhejiang 315211, CHINA
[2]Piezoelectric Crystal Association of China, P. O. Box 120, Beijing 100015, CHINA
[3]TXC (Ningbo) Corporation, 189 West Huangshan Rd., Ningbo, Zhejiang 315800, CHINA
[4]Zhejiang East Crystal Electronic Co., Ltd., 555 Binhong Rd., Jinhua, Zhejiang, 321017, CHINA
[5]Ningbo Hiking Electronics Tech. Co., Ltd., 11 Qixin Rd., Ningbo, Zhejiang 315051, CHINA
[6]Timemaker Crystal Tech. Co., Ltd., Bldg. 63/6F, Majialong Industrial Zone, Shenzhen, Guangdong 518000, CHINA
[7]Beijing Institute of Radio Metrology & Measurements, P. O. Box 3930, Beijing 100854, CHINA
[8]Department of Eng. Mechanics, Zhejiang University, 38 Zheda Rd., Hangzhou, Zhejiang 310027, CHINA
E-mail: wangji@nbu.edu.cn

Abstract—**Quartz crystal devices have been playing important roles as enablers in modern electronics, and China also has a strong industry for circuit applications in the beginning and as a leading global supplier and end-user lately. The transformation of the quartz crystal industry in the US and Europe has led to the globalization and reorganization of the production of quartz crystal devices in China with significant impact in the market and technology. It has also been known that as a producer of quartz crystal products, leading companies in China have been collaborating with partners outside China for technology and marketing to promote trade and production. In the meantime, many manufacturing hubs for leading OEM companies of consumer electronics industry, with telecommunication and appliances in particular, have been using many quartz crystal products from Japan and Korea. It is possible that large producers in Japan and Korea will continue their production through technology leadership, but the market share can be significantly weakened by Chinese manufacturers. As an initiative to foster the technology development and innovation, Chinese companies have been encouraged and assisted through various partnerships such as joint ventures with foreign companies, research and development collaboration with universities, and governmental subsidy for innovative and quality products, to upgrade technology and serve the high-end application in China.**

I. Introduction

The quartz crystal industry in China has been making great impact on the global market and industry landscape through supplying vast quantity of lower-end products and force many manufacturers in the United States and other countries to move their production facilities to China and other low-cost nations. This has been noted in the industry for a while and many strategies to counter change have been developed and implemented. For instance, many manufacturing operations of US companies have been relocated to China or even sold to other operators as major indicators of industry-wide changes. On the other hand, the Chinese industry has also been greatly influenced by changes in the US, notably the emergence of newer technology such as the micro-electrical-mechanical systems (MEMS) and film bulk acoustic resonators (FBAR) products which are already invading certain portion of traditional market of acoustic wave resonators in electronic products and new applications. One frequent question we encountered in various occasion is that how the new and emerging technologies in the US will impact the existing investments in the quartz crystal and larger acoustic wave device industry? Then an immediate question followed is that do we need to invest in quartz crystal technology while the emerging products are imminent? The answers to these questions will not only impact the individual company looking for advices but also the industry in China and the global market.

Fig. 1 Major production clusters of quartz crystal products in China (Quartz crystals; Resonators and oscillators)

As an attempt to address these and similar questions and answering more outside of China, we have already had many discussions in China in various occasions with business and industrial leaders. Our general impression is that while the quartz crystal industry in China is growing at a much faster

This industry surveying project is supported by Zhejiang Province through the Key Team of Excellence for Technological Innovation under Grant 2011R09025.

pace than the overall economy because the electronics sector has been the leading force of the recent fast growth and it is specially encouraged by central and local government under many incentives, which often are on competitive basis in coastal regions. In addition, the quartz crystal and acoustic wave device industry in China is still one of the many high-tech sectors and product categories under special promotion in economic plans and policy. Of course, as many of us already know, there are also generous incentives on tax-relief from local governments and export tariff refund for selling products to international market. Such coupled efforts in promotion of quartz crystal industry and other sectors have significant effect on the fast growth, since the production of quartz crystal products have been growing over 10% a year as shown in Table 1. Besides, quartz crystal manufactures outside China, Japan in particular, have been under intensive pressure in terms of the change of market share and fast advances in product quality and manufacturing efficiency. In other words, the gap between Chinese manufacturers and the leaders in Japan has been shrinking and it is always a question of how the advantage can be kept or changed for different competitors.

Table 1 Yearly production of quartz crystals in China

Year	Product (billion pieces)
2002	1.08
2003	1.21
2004	1.39
2005	1.54
2006	1.77
2008	2.25
2009	2.41

For a snapshot of quartz crystal industry in China, here are some basic figures: there are about 500 hundred companies with annual production of 3 billion pieces of quartz crystal products in the Year 2010. The total annual sales are about 1 billion US dollars, about a quarter or less of the international total sales. Not surprisingly, also contrary to our impression, China buys more quartz crystal components than it produces (see Table 2), obviously leading manufacturers of electronic products like computers and mobile phones use more components made outside of China. Most lower-end products are made with everything, production equipments and raw materials included, supplied in China while the high-end products are made with Japanese equipments and even materials. Also there are Japanese engineers, some retired, working in Chinese companies for the production and design.

Table 2 Quartz crystal export and import in China

Year	Export (pieces, billions)	Import (pieces, billions)
2008	0.94	1.43
2009	1.05 (USD 0.8 billion)	1.61 (USD 2 billion)
2010	1.18	1.80

As an indicator of slowing moving up of business ladder, two major producers of quartz crystal products have been listed in stock changes in China so far: Jingyuan Electronic, Tangshan, and East China Electronic Crystal Company (ECEC). It is a measure of maturity of these leading companies in the business world in China. Research and development is inadequate in this industry in China because many companies cannot afford the talents and related costs.

II. Industrial Resources and Advantages

In the international market, the competitive edge of Chinese quartz crystal products is the price, as the majority consumer products made in China. This is the outcome of the abundance of low-cost labors available to industry. Of course, as said before, the preferential policy for electronics components including quartz crystal products also plays an important role in the fast growth in recent years. The availability of land, raw materials, and electricity in certain regions are also major factors of the continuing growth.

If we look into the quartz crystal industry further, we can find more factors which contributed to the fast growth of the sector in China. One major reason is the availability of quartz crystal resonator production equipments from Japan, which enable many companies to make competitive products without invest too much efforts in making and improving production lines as did by major producers in Japan and the US before. Actually, there are also manufacturers in Hong Kong and China to accelerate the growth through even lower costs in obtaining a quality production line. Of course, this also contributes to the fact that many products from Japan are almost same because they do not differentiate from the production equipments and accessories needed for the packaging of resonators and oscillators. With the production line installed, the manufacturing is a straightforward process as we know, and it can churn out products with the standard supplies of all elements and accessories. In other words, the entry barrier of quartz crystal products is relatively low and this also contributes to the fast spread of companies making the same products in China. In fact, companies are clustered after one demonstrated the technology and production process.

We have mentioned that even leading producers of quartz crystal resonators lack technical capabilities in research and development, thus keeping the products and process in a much lower level in the global competition. There are a few focused research institutes in government laboratory systems, such the few in the China Electronics Technology Group Corporation (CETC), and BIRMM, and the research groups and laboratories in leading companies such as the Beijing Chengjing Electronic Technology Company (China 707), which have relatively strong technical team to engage in research activities for the design and fabrication. It is generally expected that these work should contribute to advances of technology of the quartz crystal industry in China, but in fact this did not happen. The main reason, as we can guess, is that most such research oriented organizations are also production companies making devices for specific applications of their parental industry. For instance, BIRMM is an affiliate of the space industry in China and their products are being used primarily in the space programs. As a result, it is regrettable that these research laboratories, with considerable resources in technical talents and equipments, cannot be utilized effectively to lead the industry. Earlier attempts to improve the overall maturity of quartz crystal products in China through research led process did not succeed as the mass production seems not always correlated with the technology supremacy they have. This reminds us how to use the full potential of research laboratories in the quartz crystal industry in China in the near future is still a

challenge to be solved. However, recently increased participation of the annual Symposium on Piezoelectricity, Acoustic Waves, and Device Applications (SPAWDA) by industry is a good sign of embrace to technology and research through interactions with academic institutions.

On the other hand, there are many manufacturing subsidiaries of leading international quartz crystal producers in China today. Their core developments activities are largely kept in the home office like Japan and the US, as we always meet engineers come to China to discuss potential products for Chinese markets. However, more or less, as we have seen in past few years, many engineers and managers from such companies are also migrating to Chinese companies and this will inevitably add momentums to accelerate changes. Many such multinational companies, particularly manufactures from Japan, are concentrated in Yangtze Delta (including Suzhou, Nanjing, and Zhejiang), while a few others particularly Korean companies are in Yantai area and a few others are in Shenzhen area. Some of them are joint ventures with local partner companies in China and this will contribute to the growth of Chinese companies with technology and management advantages. It is clear that the globalization of this industry will also give the advantage, although limited, to the Chinese industry.

It has been clear that the economic growth and accumulation of wealth in China in recent decades add the power to invest in the quartz crystal industry also, as it is viewed as one of the high-tech sector with relatively lower entry barrier. Indeed we have seen new companies of various sizes in almost every process of quartz crystal products through crystal growth, blanks, holders, and equipments. The global financial crisis has some effects on the growth and investments in this traditional technology and the further relocation to China is expected. On the other hand, it is generally sensed that newer technologies in competition with traditional frequency control devices have some impact on the sentiment of investment, because many investors are not sure how and when the alternative technology will phase out the current products. This concern also reflects the lack of research and understanding of the technology trend in this industry and applications. It is generally recognized now that new technologies will replace some products and applications with a much lower pace and it is not the situation that the technology will end abruptly soon. The recent emergence of a few more joint ventures and some expansions of major companies in China may prove that concerns caused by MEMS and FBAR technologies have been smoothed and there are more interests in further investment and improvement of development and production in the quartz crystal industry in China. To speed up the process, again, a short cut is being taken by many companies through increases of investments in buying existing design and technology from international companies. Particularly, many companies in China have expressed interests to buy some small quartz crystal companies to acquire the technology in product development they need badly. Also it is suggested that many companies in the US and Japan may be in the position to sell some of their know-how and technology while their value are at the peak when there are great demands from China. The time window for such buying mood may be limnited and the progress in technology in China could cause depreciation quickly.

III. Major Players and Growth Potentials

Most Chinese manufactures of quartz crystal products are less well-known even in this global industry, because we do not see engineers and business leaders from China in the IEEE International Frequency Control Symposium and other important occasions. Their appearance in international trade shows is also limited, although we sometimes see Chinese companies in a few events like in Las Vegas and Munich. The reason of their absence in international events is that their products are usually not marketed with their own brand, as most other industries in China. Or, this is the true meaning of "Made in China", while most product today are created outside of China. This is the business strategy of a country and industry while the technical capability is limited and low-cost labor supply is abundant. Such a business practice has its disadvantages, but it will take a long and slow path to change giving the economic and technological reality in China. Then it is easy to understand the choices of Chinese companies and industry, and it also offers the strategy for outsiders to choose the right road to enter the seemingly prosperous and strong economy.

There is a relatively fully fledged quartz crystal industry in China with manufactures for quartz crystal material, quartz blanks and chips, packaging and accessories, and all equipments for the making of resonators. This means the production of quartz crystal devices can be done with all essential materials, accessories, and services in Chinese companies for lower-end products. For high-end products, we know that many elements, especially the holders and high performance materials have to be imported from Japan and the US. The size of market and amount of demands in China is significant and all the major equipment makers and material suppliers have opened offices and branches in China and have been enjoying fast growth of businesses in recent years even with a bright future.

As the industry grows in the technology and market, an industrial association of piezoelectric devices, **Piezoelectric Components Association of China** (PCAC, http://www.chinapcac.org), has been established by the major producers. It is the only official trade association of quartz crystal and acoustic wave device industry in China, and has been enjoying the support nationwide with intensive contacts with global major producers of the industry and joint activities with similar groups. The PCAC has a major mission of promoting the industry and support members through sharing information on government policy and regulation, market, technology, and trade. It is also leading the task to maintain national standards on quartz crystal devices as the IEC TC-49 counterpart. It also holds annual trade shows and meetings of leading producers to review market and technology trends.

Zhejiang East Crystal Electronic Co., Ltd. (ECEC, http://www.ecec.com.cn) is one of the two listed company with top annual sales (about RMB 300 million / USD 45 million). ECEC has been working with TXC for distribution and improvement. The ECEC has manufacturing equipments

and support expertise from Japan. The company is actively seeking growth opportunities with emphasis on engineering and technical leads.

Beijing Chengjing Electronics Technology Company, Ltd. (China 707, http://www.china707crystal.com) is the first quartz crystal resonator manufacturer in China with many years in supporting the nation's needs of technology. After many years and extensive investments by government, Chengjing has also maintained an up-to-date production line for full line of products. It also has invested in research and engineer training with leading academic institutions. Chengjing has also been actively engaged in global marketing of products with its own brand and sales force.

Beijing Institute of Radio Metrology and Measurements (BIRMM, http://www.casic203.com) is a research laboratory of the space engineering company for time standards and metrology in space navigation and communication. To satisfy the precision needs of its space programs, it maintains a division with technical capabilities in the design and manufacrurngof precision quartz crystal products. This is a research laboratory turned production company with many lines of products. BIRMM has a strong presence and interaction with the international frequency control technology community through participation of international conferences and invited visits by many leading experts in Europe and the US. To enable the technology transfer, it is seeking to expand the production capacity and new product development partner outside China. BIRMM also maintains a subsidiary for mass production of quartz crystal products for consumer products.

One fast growing company in the quartz crystal industry is the TXC Corporation, which is the major producer of quartz crystal products and has its major outpost in Ningbo, China as the **TXC (Ningbo) Corporation** (http://www.txccorp.cn). TXC Ningbo is gradually grows its own production and technical capabilities to enable autonomous business in China. TXC (Ningbo) has been helping many quartz crystal companies in China through partnership in quality management, equipment, and engineering capabilities and improvements are clear and significant. TXC (Ningbo) has also been forming close relationships with universities and laboratories for technical capability building and new products.

As a domestic grown company in China with relatively short history, **Timemaker Crystal Technology Company, Ltd.** (http://www.timemaker.com) started as a manufacturer of crystal blanks, but the business has been expanding to resonators through the partnership with Rakon of New Zealand. There are investments in engineering capabilities through collaboration and in-house improvements. The engineering team of Rakon will provide design and support to Timemaker and the joint venture in Chengdu.

Other major producers of quartz crystal products include Jingyuan in Tangshan, close to Beijing, another listed company in the quartz crystal industry with annual sales about RMB 300 million (USD 45 million). Hualianxing (reorganized as part of China Electronics Panda Crystal Technology Corporation, CEC Xtal) is another major producer of quartz crystal resonators in Nanjing. Major clusters of quartz crystal companies are in Beijing, Yantai, Shanghai, and Shenzhen. Production centers of quartz crystal materials are in Lianyungang, Hohhot, and western regions.

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.

The quartz crystal industry in China also faces challenges in the road ahead. First of all, to supply quartz crystal devices in coming decades with the latest trend of globalization, rising of labor cost, and technology advancement, quartz crystal companies in China have to upgrade the technical capabilities in every aspect: design, process, equipment, and applications. With the increasing of competition, professional engineers with both analytical and experimental skills are needed in product development and production lines. Most companies need to improve the marketing and sales capability in global scale to improve the profitability and product development pace. Investment on technology is essentials and possible through government support and long term planning. The production capability of quartz crystal industry has the weight and size to make a global impact, and industrial relocation and manufacturing concentration in China provide unique opportunity to accelerate the change. Demands of technology and know-hows in China offer opportunities for Western and Japanese companies in the near future. Chinese industry needs to invest on technology through well-trained engineers, management efficiency, and marketing and sales skills. Chinese industry should also invest in the new and alternative technology to satisfy the international market as it emerges as a strong industrial player in the near future.

IV. SUMMARY

There are heavily invested production facilities and adequate material supply for quartz crystal products in China. Production equipment are on par with international standard and production management are also up to the need. The major hurdles are on the engineering capabilities of design and precision manufacturing, but the rising cost of labor, land, and energy should also be kept in mind. Quartz crystal and frequency control products are still encouraged with government incentives on investment and aid, but the true advantage has to be maintained for the future growth and included in new investments. Globalization should also be expanded to include technical talents and intellectual properties for balanced and sustainable growth.