9-608-123
REV: DECEMBER 14, 2010

WILLY SHIH
CHINTAY SHIH
JYUN-CHENG WANG
HOWARD H. YU

Chi Mei Optoelectronics

The pressure from running such a large business is intense. We have responsibility for more than 30,000 employees in Taiwan and China. Any misstep in our strategy can cause a lot of damage. The first tier of liquid crystal display (LCD) manufacturers, Samsung, LG Display, AU Optronics [AUO] . . . they all have just under 20% global market share. We are number four at 15%. Samsung has built a Generation 8 fabrication facility [fab] already, LG Display will ramp one up next year, AUO is building one this year as well. We are building one this year too, but the investment is huge. It's like we're in a tournament: you start out with a lot of players, but now we are down to the final four.

—Jau-Yang Ho, president of Chi Mei Optoelectronics

In 2008, Jau-Yang Ho, president of Taiwan-based Chi Mei Optoelectronics (CMO), and Biing-Seng Wu, executive vice president and one of Ho's key lieutenants, pondered their investment strategy. Under their leadership, the company had grown from a start-up in 1998 to become the fourth-largest LCD panel manufacturer in the world. LCD panels were the key component in numerous electronic display applications, ranging from notebook computers to desktop computer monitors to flat-panel televisions. The panels were manufactured on large sheets of glass 0.5–0.7 millimeters (mm) thick with circuitry printed on them; subsequently, two sheets were placed together in a sandwich with a gel of chemicals between them. For efficiency, factories manufactured multiple panels simultaneously on large sheets of glass. Progressive generations of fabs could handle larger and larger sheets of glass. Thus, a Gen 5 fab could hold 12 17-inch display panels simultaneously on a single sheet of glass, while a Gen 8 fab could hold 18 individual 32-inch TV screens on a sheet of glass that was roughly 2,200 mm by 2,500 mm (7.22 by 8.20 feet), or larger than a king-sized bed. (**Exhibit 1** shows the relative sizes of different generations of glass. An introduction to the technology of LCDs appears in the **Appendix**.)

Out of necessity, the latest factories were highly automated, as human beings could not handle the large glass sheets without breaking them. The factories were enormous in scale and scope, and required as much as a year or more to build and equip, even at the breakneck pace of construction that was the norm in Taiwan. The typical construction and equipment cost for the latest-generation fab was in excess of NT$130 billion (US$4 billion), making barriers to entry very high.

The LCD panel business had witnessed explosive growth over the previous 15 years, driven by the wide and expanding range of applications for flat-panel electronic displays. The industry had also experienced extraordinary cyclicality over this time, with periods of rapid growth fueled by capital investment in capacity expansion, which then created large supply-demand imbalances. These up-

---

Senior Lecturer Willy Shih, Professors Chintay Shih and Jyun-Cheng Wang of National Tsinghua University, and Doctoral Candidate Howard H. Yu prepared this case.

cycles were followed by harsh downturns during which excess capacity was absorbed. The downturns created opportunities for new entrants, and most new firms that went on to be successful had entered the market during one of these periods.[1]

Chi Mei's latest big bet was Fab 8, a Gen 8.5 facility that would be the largest the company had ever built. However, both Ho and Wu had serious reservations about its construction. Ho reflected on the start-and-stop pace of construction: "We actually started clearing the land and building the fab, and then we stopped for almost a year. We stopped because of the industry down cycle and also for financial reasons. In the downturn, we weren't as profitable as we expected, and the pressure on financing of the capital expenditures was intense."

Ultimately, the decision to proceed was a gamble: Ho and Wu were betting on the growth of the marketplace and Chi Mei's strategy to win in the "tournament."

The History of Chi Mei

Wen-Long Shi started a business in Tainan City in 1953. He operated out of his home, employing two to three workers. Shi experimented with a wide range of businesses and products, from toys to daily necessities to surgical equipment, and eventually plastics processing.

In 1960, Shi established the Chi Mei Corporation (CMC) and began construction of an industrial complex at Yen Chen, Tainan. The following year, the firm began shipping two tons of acrylic sheets per month. The chemical name for this material was polymethyl methacrylate (PMMA). It was a synthetic polymer developed in the late 1920s and first brought to market by the Rohm & Haas Company in the United States. Forms of it were sold under well-known brand names such as Plexiglas and Lucite. It was often used as an alternative to glass, as it was lighter, had higher impact strength, and did not shatter. CMC grew rapidly, and its Acrypoly and Acryrex acrylic sheets became extremely popular, earning Shi the nickname, "Taiwan's Father of Acrylics." Inside Chi Mei, he became known as "Founder Shi" or simply "My Founder."

Shi expanded into polystyrene in 1968 by setting up a joint venture with the Mitsubishi Chemical Company of Japan. Mitsubishi not only put in 20% of the capital into the new firm, the Poly Chemical Company, but also provided free access to a basic manufacturing process technology that was still in the pilot stage. Shi was adamant that Poly Chemical develop its own technology internally instead of purchasing turnkey technology.

Poly Chemical expanded its portfolio over the years and, by 1974, was attempting to move into acrylonitrile-butadiene-styrene (ABS) copolymer, an attractive material that was widely used in things like small appliances and toys. ABS was manufactured from three components and required four main processes. In 1976, Poly Chemical's first ABS plant had a monthly production of 200 tons. Rapid expansion every year allowed it to produce 800 tons of ABS per month by 1980.

After Ho earned a degree in chemical engineering, he then joined CMC's research and development center after his two years of mandatory military service. More than half of Ho's classmates chose to continue their education overseas. Though CMC was not a big company at the time, Ho knew that the goal of CMC's newly established R&D center was to develop chemical-related products for the future, so there were good growth prospects. The chemical R&D team was responsible for developing and manufacturing many products, including medicines, polyesters,

[1] See J. A. Matthews, "The Crystal Cycle," *California Management Review* 47 (Winter 2005) for an excellent analysis of the TFT-LCD industry cycle.

acrylic emulsions, water-based paints, and PVAC adhesives. Ho was directly involved in several of the products in different roles, ranging from entry-level engineer to manager.

By 1980, the market for ABS had grown tremendously, and demand was extremely strong. However, Poly Chemical was still experiencing many production and quality problems. In 1981, it was the first purchaser of a new type of production machine from a well-known Japanese equipment manufacturer that pioneered a safer and larger-scale approach to one of the main production processes—mechanical dewatering. Poly Chemical engineers worked closely with the equipment manufacturer for over a year, yet they were unable to get the new process to work. Shi believed strongly in the market potential of ABS and also believed in "consolidating all his firepower" behind a single objective. So he made a company-defining decision in 1982: he shut down all of the chemical-related projects at CMC and transferred key personnel from the R&D center, including Ho, to Poly Chemical to focus all available resources on developing ABS products. As Shi poured more resources into ABS, product quality improved and volumes increased steadily.

Not long after Ho was assigned, the technical team made a breakthrough and got the machine up and running. They were able to ramp up within the next two months, generating acceptable yields and improved product quality. "The existing Poly Chemical technical team had worked very hard on developing this process for over a year. Since I was a newcomer, I assumed that the machine was a total loss and mentally wrote it down to zero. Then I could proceed with an open mind," Ho commented. He convinced his team to change the direction of R&D and redesign the entire process. The technical team, who by now had become very familiar with the machine, was able to make the adjustments very quickly and come up with a new ABS product that caught up with the rapid rise in demand.

Improvements were also happening in other processes; the new low-cost Polylac ABS copolymer had the ability to hold colorants well and became extremely popular with manufacturers of a host of consumer products, like small appliances. In June 1983, Poly Chemical produced 2,000 tons per month. CMC continued to expand quickly and by 1994 became the largest ABS producer in the world. With low-cost-efficient manufacturing, it was able to earn very high margins and rapidly grow its global market share, riding a tide of insatiable demand in the growing Southeast Asian economies of the 1980s and 1990s.[2]

By 1985, ABS had become the dominant product, and Shi merged CMC and Poly Chemical, keeping the CMC name. In 1994, when the president of CMC retired at the company-mandated 60 years of age, Ho was promoted to president. "Everybody was quite surprised," Ho recalled, including himself. The new role put Ho in the key operating position in the company.

Diversifying into LCD Displays

In the late 1980s, Ho started to think that the future for petrochemicals in Taiwan was not very bright. He viewed Taiwan's geographic location as not well suited to the market, from the standpoint of proximity to feed stocks, the cost of land, and increasing environmental concerns. At that time, he made his first visit to the nascent Hsinchu Science-Based Park. The government of Taiwan had established the park in 1980 to encourage the formation of high-technology businesses. Recalled Ho: "In the north at that time I found that everybody in the Hsinchu Science Park was doing pretty well. So I thought, 'We need to invest in high tech.' In 1997, I invited my founder to Hsinchu. For the first

[2] In 1999, CMC's ABS+AS capacity was over 1 million metric tons per year. In comparison, the combined capacity of the top 10 Japanese producers of ABS was 800,000 metric tons per year, and the combined capacity of GE Plastics, Monsanto, and Dow Chemical in the United States was 900,000 metric tons per year.

time in a long time, my founder saw something very, very exciting. At that time I suggested that we invest in high tech. We didn't have a particular technology in mind; we just needed something to diversify into."

Ho's good friend Biing-Seng Wu was then the vice president of the high-tech company, Prime View International, and was widely viewed as one of *the* Taiwanese experts on the thin-film transistors (TFTs) used in the flat-panel display industry. Wu had been the principal investigator on the first TFT-LCD research project at the Electronics Research Service Organization (ERSO), part of the Industrial Technology Research Institute (ITRI).[3] ITRI was at the heart of Taiwan's technology research infrastructure and spawned countless start-ups in the adjacent Hsinchu Science-Based Park. ITRI had been responsible for the original technology transfer of RCA's CMOS semiconductor process from New Jersey to Taiwan. It set up a four-inch CMOS manufacturing line and spun this off as Taiwan Semiconductor Manufacturing Corporation (TSMC), an event that would have a tremendous impact on the establishment and growth of Taiwan's semiconductor industry.

Under Wu, ITRI had begun an investigation of small TFT-LCDs in 1989 and had moved on to three- to six-inch technology in 1990. By 1994, it had set up a line and begun test production of 10.4-inch panels, which were in great demand by the notebook computer industry. But unlike what happened with TSMC, the Taiwanese government suddenly cut the budget, leaving ITRI without enough capital to complete the plant's construction. Instead, the project became part of a technology transfer to Prime View International, and in October 1994, Prime View built the first TFT-LCD production plant in Taiwan.

Wu suggested to Ho and Shi that manufacturing color filter arrays for LCD flat panels would be a very good move for Chi Mei, but Shi disagreed. As Ho recalled, "In 1996, my friend Dr. Wu suggested that we should invest in color filters. My founder said no. He said, 'When a horse is running, it must wear blinders and not look around. . . . We must run ABS only, with no distractions!'"

But in 1997, the petrochemical industry suffered a severe contraction due to the Asian economic crisis. Ho and Shi visited Mitsubishi Chemical, one of Chi Mei's major shareholders and partners, and found that Mitsubishi was investing with its partner Asahi Glass to build a color filter plant in Kyushu, Japan. "We asked Mitsubishi, they said color filter is good," recounted Ho. Later on, because Mitsubishi and Asahi Glass could not do a joint venture with Chi Mei in Taiwan, Shi went back to Ho and said, "Okay, tell your friend to come back." Ho described the circumstances: "So Dr. Wu stayed outside for almost one and a half years. In the fourth week of June 1997, Dr. Wu again came in to give a presentation. The next day, my founder decided and told me, 'Go.' That Sunday night, at about 11:00 p.m., I telephoned Dr. Wu and told him we've got the okay and decided to go."

In fact, Chi Mei had been tracking the TFT-LCD industry since 1996, as many of the key ingredients used in fabricating TFT-LCD panels were based on materials derived from petrochemicals and were therefore closely related to CMC's core products.[4] For example, one of the key materials used in making the color filters, photo resist, shared many of the same ingredients with acrylic plastics. But Shi was skeptical of direct investment because he was not sure whether his company could get a grasp on the core technologies. Chi Mei liked to control its own technology, and the company did not see such an opportunity until Wu came into the picture.

[3] The Industrial Technology Research Institute (ITRI) was a nonprofit R&D organization engaging in applied research and technical service. It was founded in 1973 by the Ministry of Economic Affairs (MOEA) to attend to the technological needs of Taiwan's industrial development.

[4] TFT stood for thin film transistor and described an active transistor matrix printed on the glass used to make an LCD display. TFT-LCDs were the highest performance LCD displays on the market.

Shi soon recognized TFT-LCD as a "once in 100-year opportunity for Taiwan." The semiconductor industry included 18 countries with major participants, and Taiwan could account for only about 10% of overall global production. But the TFT-LCD industry counted only Japan, Korea, and Taiwan as major producers, and most of the demand at the time was coming from Taiwanese notebook computer manufacturers.

Color filters were a key enabler of color flat-panel displays, and the color purity, brightness, and optical characteristics were important to display manufacturers. Japanese manufacturers supplied most of the color filters; it was a lucrative business. Color filters were Chi Mei's first step into high-tech, quickly followed by another. Ho explained that by moving to become a full-line TFT-LCD producer, the company would be able to address a much larger market: "When we made the decision to invest in color filters, the investment was about NT$3 billion. But when we looked further, we realized that the main market for color filters was TFT-LCDs and that's actually where the future growth for the industry was going to be. So within two months of when we started investing in color filters, we started investing in TFT-LCDs."

Another consideration in the decision to enter the TFT-LCD industry was that TFT process technologies were not entirely new territory for CMC. TFT processing involved chemical, mechanical, and electronic technologies. CMC already possessed many chemical processing and mechanical technologies. Wu elaborated on the strategy for finding the missing pieces:

> We would examine the missing pieces in our technology map and find suitable people to fit in. In fact, we didn't really need to purchase technologies. When CMO bought equipment, we tended to have vendors share valuable information. They might reveal who else owned the same equipment, who were the materials providers, and things like that. CMC hired many retired "masters" to be our consultants and purchased several unprofitable companies for their patents.

Although CMC was privately held, profitability from its petrochemicals operations made it cash-rich, with almost all of its credit lines unused. At the time, CMC had a strong desire to fund the TFT-LCD investment internally. But Ho and Wu realized the importance of being a public company in order to attract the right talent, and they were able to convince Shi. The share offering marked the transition into a publicly traded entity called CMO, partially controlled by CMC. CMO's 2006 Annual Report detailed a long line of fund-raising activities to finance what subsequently turned into a huge string of investments. (See **Exhibit 2** for a list of key fund-raising transactions.)

Founder Shi's Management Philosophy

Shi espoused three credos as his guiding principles: (1) business was a way to pursue fulfillment, (2) people-oriented management was important, and (3) harmonious relationships were valuable. These credos set a very powerful tone within the company. (See **Exhibit 3** for a profile of Shi and his philanthropic and artistic interests.)

A highly decentralized decision-making model enhanced this management philosophy. While Shi would sometimes be involved in major capital investment decisions, he tended to take a very hands-off approach to operational decision making, preferring to empower his key managers. This made the company a very attractive place to work, allowing it to draw personnel from many quarters of Taiwanese industry when new initiatives were launched. Shi described his philosophy:

> I think we've created an environment where people with good ideas come to us, whether internally or externally. One of the strengths of Chi Mei's culture is the entrepreneurship and

> flexibility. So we encourage our people, and we also constantly try to improve. Going from the chemical business into the TFT-LCD business, many outsiders said it was too big a change. But we didn't look at it that way; we've gone through many changes, and this was a huge opportunity. So that's just part of the old trick of being very flexible and very welcoming of these new opportunities.

The power to attract talent would later turn out to be a key enabler, as the company expanded into areas that required specialized technical expertise. When more and more teams moved to CMO, Shi felt a little pressured. He fended off criticism by saying that Chi Mei didn't lure people away from other companies, it just built a good environment and set up "stages" for people to develop businesses. People would just "jump on the stage" to perform. In fact, when people praised Shi for making yet another big strategic move, he invariably said that there were no people behind the scenes making the decisions. All CMO did was build a good environment and everything else followed.

During his years at ITRI, Wu had developed a strong network that brought access to a primary source of talent in the field. The rapidly growing cluster around ITRI and the Hsinchu Science-Based Park also become a deep reservoir. And CMC's increasing participation as a supplier of plastics for backlights and other components helped as well.

There were other sources of engineers. Japanese manufacturers had set up manufacturing plants for less-advanced LCD displays (so called TN and STN LCDs) in the 1980s. Hitachi had established an STN LCD module facility in Kaohsiung in 1983, and Sharp also produced LCD modules in Kaohsiung starting in 1986 to feed the pocket calculator and other industries in Taiwan. These firms were a training ground for many Taiwanese engineers, who jumped to firms like CMO for their lucrative stock grants. Some LCD firms, particularly AUO, also drew heavily from the semiconductor industry, where the manufacturing process technology and industrial engineering challenges were similar. Taiwanese universities were also rich sources of talent.

The Growth of Chi Mei Optoelectronics

Though CMO grew out of CMC, the character of the business was quite different from its parent. As Wu explained, "The alignment of these two businesses is really quite different. In CMO, we need the high pressure of the market. We need engineers in Taiwan to manage the ones in China. Not everyone from Taiwan likes to work over there and they would often quit."

Ho realized that CMO would be playing a very different game than CMC, and that he would need a correspondingly different organizational structure with different resources, processes, and priorities. He opted for a separate subsidiary, with an independent structure and compensation model as well. He quickly redesigned the pay structure by enlarging the compensation differential across various rankings and put in a larger performance bonus component. Ho recalled proudly, "It only took one board meeting to have it approved!"

Ho, Wu, and Shi all recognized the importance of attracting key talent and the value such talent placed on an autonomous unit structure with decentralized management and the flexibility to act quickly. Reflected Ho, "Our founder really played a key role for CMC to move from the petrochemical industry into the high-tech sector. He understands the fundamental differences between the two businesses and is willing to let go of part of the old traditions."

Building Fab 1

As CMO began construction of its Fab 1, a Gen 3.5 facility, it licensed the basic TFT-LCD technology from ITRI and also licensed multidomain vertical alignment (MVA) technology, which enabled wide viewing angles, from Fujitsu of Japan. Wu elaborated:

> From the start, CMO's strategy was different from other Taiwanese panel makers. We licensed the basic technology from ERSO, and then modified the licensed TFT structure and developed a new structure in Fujitsu's fab. Since this new TFT structure was our own design, we could modify the process by ourselves as needed. Other Taiwanese panel makers transferred the entire TFT-LCD technology—they didn't develop their own processes, they essentially copied the processes from the Japanese panel makers. There was a huge difference in these two strategies. Transferring technology did not have any risks in the beginning; however, not only do we need to pay an initial technology transfer fee, but if we needed to change the process flow, we would also need to get approval from the original technology licensor.[5]

CMO was able to take advantage of one of the industry downturn cycles to enter the industry. Japanese firms were more willing to license technology to Taiwanese partners during this period to help fend off competition from Samsung, LG Philips LCD, and other Korean manufacturers, which other Taiwanese competitors took advantage of as well.[6] The pioneering Japanese manufacturers were thus able to extend their window of profitability on older Gen 3 technology by generating licensing income, as they invested in their own next-generation plants.[7] AUO, which had started out by modifying a 4-inch semiconductor wafer line to build its first TFT-LCD line, was able to ink a technology transfer deal with Mitsubishi of Japan and IBM Japan. Chunghwa Picture Tube (CPT) signed a similar technology transfer deal with Mitsubishi for a Gen 3 facility and was able to leverage this into the first larger-sized TFT-LCD facility in Taiwan. (**Exhibit 4** describes some of the core manufacturing technologies for TFT-LCDs and where Taiwanese industry learning came from.)

CMO was able to test out some new, experimental cell structure designs using Fujitsu's equipment and develop its internal processes as it was building its own first factory, Fab 1. Recounted Wu,

> We paid a lot of money for two runs, two tests. We also asked them to take a look at our new structures. We sent our engineers to Japan to test for three weeks. . . . We had no way to develop these new ideas otherwise. We found our new electrode structure would cause a production bottleneck that we needed to overcome. The capacity of Fab 1 was 50,000 mother glasses per month, but in the first phase we actually only did 6,000 pieces because we didn't have the confidence yet that we had the right equipment to do this structure.

CMO also agreed to work as a Fujitsu supplier for LCD panels. As Chi Mei built Fab 1, Fujitsu sent in people to validate CMO's production methods. Wu explained: "As we wanted to move into the larger sized TV panels, we needed that kind of specific knowledge. In essence, we exchanged our production capacity for Fujitsu's technical support. Not only did we get an 'instant' customer that way, we also had someone from Fujitsu come into our fab and make sure we did it the right way."

---

[5] The fee was paid for the initial transfer; subsequent changes or adjustments required separate approvals.

[6] LG Philips LCD was a joint venture between LG of Korea and Philips of the Netherlands. Philips eventually sold much of its share position, and the company was renamed LG Display in 2007.

[7] For an excellent discussion of this history, see T. Murtha, S. Lenway, and J. Hart, *Managing New Industry Creation* (Stanford, CA: Stanford University Press, 2001).

Fab 1 was a Gen 3.5 facility and could handle glass that was 620 mm by 750 mm. As in other fabs, the need for precision alignment meant the building structure had to be extremely rigid. Fabs employed enormous quantities of steel in their construction and were usually multilevel buildings to facilitate equipment floors sandwiched between levels that provided air handling and utilities. The actual manufacturing took place in a clean-room environment, as dust and particle contamination caused tiny defects that interfered with the operation of an LCD. If a finished LCD had such a defect, it generally had to be thrown away, decreasing the factory's yield. The booming semiconductor manufacturing industry in Taiwan provided a deep pool of knowledge and skills in clean-room operations and fab construction, as the challenges were similar. CMC's experience in petrochemical plant production also provided homegrown construction management expertise. (**Exhibit 5** shows the exterior and interior of Fab 1.)

Ho talked about the start-up of Fab 1:

> One of the benefits of our relationship with Fujitsu is that very early on, when we first entered the industry and built our fab and manufactured our product, we had no one to sell to because we were brand new and no one knew the quality of the panels that we were making. With Fujitsu, we brought their team into our fab, here. We had the relationship with them, and that allowed them to validate our quality. Because they brought their people in and checked our processes, they had confidence in our quality and bought our products.

In the end, the total investment in Fab 1 was NT$30 billion. Reflecting on this emergent investment strategy, Ho commented, "The NT$3 billion quickly turned into NT$30 billion." And that was only the beginning. (**Exhibit 6** shows a time line of CMO's major milestones and additional fab investments.)

Building an Intellectual Property Base

During his years at ITRI, Wu became the one person who amassed the most TFT-LCD patents in Taiwan. ITRI was also the source of CMO's initial TFT-LCD technology, which it licensed in mid-1998. CMO then set about developing a new cell structure in-house, which it tested by "renting" Fujitsu's equipment for two test runs, as described earlier. By early 1999, CMO had already started filing for its own TFT-LCD patents. As Wu explained:

> One of the key philosophies that we have is we don't outright purchase a complete technology package. We try to develop what we need to and we may put in some basic technology or hire an outside consultant to develop our proprietary, internal technology. What that allows us to do is to understand that technology much better and it's much quicker for us also to improve that technology. That also gives us a basis to cross-license with other companies. We have some valuable patents that some other companies would like to use and we can enter into cross-licensing agreements.

In mid-1999, CMO took another step to strengthen its technology base: in addition to becoming a foundry supplier to Fujitsu, CMO also licensed Fujitsu's MVA technology, which enabled wide viewing angles for large-size TV panels. CMO believed that only by implementing solutions firsthand could it understand the technology intimately enough to come up with its own proprietary innovations. CMO's R&D team subsequently achieved several breakthroughs while working with the original MVA technology, developing its own proprietary "Omniview Color," which significantly reduced the color shift of skin tones when viewing the panel from wide angles.

CMO also acquired access to most of IBM's LCD-related intellectual property (IP) when it purchased IBM's LCD business and Gen 3 TFT-LCD fab in 2001, providing CMO with an IP umbrella that shielded it from some of the other IP-related problems within the industry. (See **Exhibit 7** for a list of Chi Mei's key agreements.) In 2002, along with other Taiwanese LCD peers, CMO licensed a set of common TFT-LCD patents from the ERSO unit of ITRI.

The One-Drop Filling Decision

As CMO developed its capabilities, it sometimes took some major technological risks. One of the best examples was the decision to implement one-drop filling in Fab 2. While Fab 1 was still under construction, Shi realized that the accelerating rate of competition in the LCD industry necessitated bold investment decisions, so he approved the construction of Fab 2, a Gen 4 facility. (See **Exhibit 8** for photos of Fab 2.) This in itself was a risky decision, as the team under Ho had not yet established any history or much of a learning base with Fab 1.

By this time, Ho and Wu had become convinced that the key to the market was going to be flat-panel televisions, which meant larger panel sizes (32 inch, for example) than were used in notebook computers and computer monitors. This brought a different set of technical challenges. A Gen 4 mother glass could be conveniently cut into two 30-inch panels, but the process of filling them with liquid crystal material was going to be lengthy because of the sheer size. The established technology, known as "vacuum fill," meant putting the sandwich in a vacuum chamber and allowing the liquid crystal material to get sucked into the evacuated space. But the large panel size meant that it could take as long as three days to fill, and the slowly advancing liquid crystal slurry would carry a band of impurities at the front of the wave as it moved from the edges inward.

At that time, Fujitsu VLSI (subsequently acquired by the Japanese equipment maker Ulvac) was developing an experimental technology called one-drop fill (ODF), in which many, many micropipette dispensers would each place a single drop of liquid crystal material between the two pieces of glass before they were sandwiched.[8] This meant that precisely the right amount had to be metered, with no gaps from underfilling or excess from overfilling. CMO had sent a senior R&D team to evaluate the ODF equipment; he came back extremely impressed by the potential of the new technology. Implementing a completely new technology like this in production entailed enormous risks. If the technology failed, it could take a year and a half to switch back to the conventional process. The upside, if it was successful, was also very high because of the improved productivity that would become possible. It would reduce the process time for filling larger panels from three to five days to five minutes. But no one in the industry had the appetite for the implementation risk it entailed.

To mitigate the risk, Ho decided to divide Fab 2 in half and implement half the capacity with the older technology and gamble half the capacity on ODF. Wu recounted: "I suggested to President Ho that he report the decision to the chairman since we were risking 50% of the capability on our new fab. That could really potentially bankrupt our company if anything went wrong. But I remember Mr. Ho saying, 'No, people at the board level don't have the technical expertise to make the decision for us.'"

Ho was very careful in making that decision. The technical team members were highly confident they could make it work. But, as Ho recalled: "Of course, if that turned out the wrong way, I'd get killed! But we really didn't have much of a choice. Our existing technology back then wasn't superior

[8] H. Kamiya et al., "Development of One Drop Fill Technology for AM-LCDs," *SID Symposium Digest of Technical Papers* 32 (June 2001): pp. 1354–1357.

to our competitor's. We desperately needed a breakthrough. But once that decision was made [investing in ODF], our team became very focused and made it work."

Ultimately, the gamble paid off, and CMO not only became an industry pioneer in using ODF but also filed many ODF-related patents. Coming from CMC where process technology was far more mature and predictable, Ho pointed out that the size and risk associated with the process technology bets were in a whole different league: "In my life, I have taken so many gambles. Back in those days, there were several critical environmental issues for us. In Fab 2, our technology was inferior; we had to come up with a breakthrough. Second, we knew we needed to focus on LCD TV because that was going to be hot, we thought."

Ho reflected on some of the differences he had experienced in running CMC compared to CMO: "At CMO, the size of capital investment is 10 times CMC, the market size is 10 times, product diversity is 10 times, but product life cycle is one-tenth, the number of customers is one-tenth; speed of technological change is 10 times, risk is 10 to 100 times." (**Exhibit 9** is a summary of Ho's comparison.)

Integrating Vertically

Though Chi Mei had originally intended to make only color filters, it had quickly moved into making the TFT-LCD sandwich. This became a highly competitive segment as Samsung, LG Philips LCD, AUO, CPT, Hannstar, and others piled on capacity. From 2003 to 2004 alone, as many as 15 Gen 5 fabs came onstream across Asia, driving finished panel pricing down. The capacity-driven boom-and-bust cycle put intense cost pressure on the panel manufacturers, which had to source many expensive components to assemble finished displays.

In the early part of the decade, display drivers (driver ICs) could make up 15% to 20% of the overall production cost of an LCD display. At that time, there were very few suppliers producing this critical component in the market. CMO relied exclusively on Texas Instruments (TI) for its supply. Severe shortages in the market drove CMO to assemble a team of engineers and start exploring the feasibility of manufacturing driver ICs in-house. Strategically, CMO management felt that to be successful over the longer term, the IC design team needed to have exposure to a more balanced customer portfolio, instead of supplying CMO exclusively. Therefore, management decided to spin off the team into a separate entity, Himax, so that it could engage other customers without conflict. Starting with more than 70% ownership when it first established Himax, CMO deliberately let its equity stake be diluted during subsequent fund-raising rounds to a 14% ownership. With the support of CMO as its first customer, Himax ultimately was quite successful generating revenues of almost US$1 billion in 2007. Although CMO maintained a competitive bidding process between Himax and other IC vendors, it sourced the majority of its driver ICs from Himax, while CMO accounted for around 60% of Himax's revenues.

CMO was able to move into photomasks, polarizer films, and many other key components by simply leveraging its expertise in chemical manufacturing. The company was also able to leverage CMC's capabilities in plastics to supply PMMA light guide plates for the LCD backlights (120,000 tons-per-year capacity) and polycarbonate for light diffusion films on top of the backlights. With the Himax model as a successful first step in upstream integration, over the years CMO formed a web of tightly linked subsidiaries across its supply chain. (See **Exhibit 10** for CMO's affiliates.) Although the Chi Mei Group did not necessarily own these subsidiaries 100%, the company often had a large enough equity holding to maintain influence over various strategic issues. These efforts at vertical integration helped alleviate some of the concerns about the availability of critical components.

All these efforts made CMO one of the most vertically integrated of Taiwan's TFT-LCD manufacturers. Although the move toward vertical integration seemed natural in retrospect, CMO was really a pioneer at a time when most competing Taiwanese TFT-LCD manufacturers thought outsourcing of components was the way to go. This desire for vertical integration had its roots in the history of CMC when people took pride in their own technical capabilities and manufacturing competence. They gained confidence from their past experiences in successfully integrating advanced technologies with their own manufacturing skills. They realized that the component costs accounted for 60% of the total cost of an LCD panel, so vertical integration allowed them to be far more competitive. Ho commented on how some of the capabilities came to CMO: "The TFT industry is unique in its cluster effect, so in the science park we have a lot of suppliers come in and tell us ideas. . . . I think we've created an environment that people come to us, whether internally or externally. We can make better offers to acquire the expertise."

Differentiation in a Commodity Business

Considering the degree of technical difficulty and the enormous capital investments required, it was ironic that standardization of TFT-LCD panel sizes and interfaces made them a pseudo-commodity with spot market pricing fluctuating according to supply and demand. In this environment, each of the manufacturers competed primarily on price, therefore focusing ruthlessly on costs. Some attempted to differentiate their offerings with different driving schemes or color filters, backlighting schemes, frequency response for better television signals, and low motion blur. But in the end, supply and demand were the principal drivers of pricing.

From Fabs 1 and 2, CMO followed quickly with its first Gen 5 fab onstream in the fourth quarter of 2003, a Gen 5.5 fab in the first quarter of 2005, a second Gen 5 in September 2006, a Gen 7.5 in May 2007, and a Gen 6 ramp-up in the first half of 2008. This enormous growth outpaced industry capacity growth, but revealed a different view of the optimal product in the marketplace.

Though many analysts focused on the generation of a factory that a firm chose to build as a reflection of aggressiveness about technology, CMO focused on its view of product mix that each fab could efficiently produce. Wu explained:

> When you look at a fab generation, it is not a brand-new technology. The generation purely reflects the size of the glass. So when we talk about Gen 3.5 versus Gen 5.5, it is just the size of the glass. Of course there is certain handling technology that needs to be included when dealing with larger size glass, but the actual TFT design rules do not change from generation to generation. So what we look at in terms of what generation to build, for us, we think in terms of technology, product, and customer. When we look at the size of a substrate, we think about how we will cut it in order to minimize the glass wastage and produce the product that people want. That is actually the main focus of our decision on which generation to build.

CMO was the only firm in the industry to build a Gen 5.5 fab because it felt there would be strong demand for 32-inch televisions, and Gen 5.5 glass could be cut more economically than Gen 6 glass. And the smaller Gen 5.5 equipment was less expensive than Gen 6. But after fab construction had already been committed, they found that 22-inch-wide-format (16:10) PC monitors were a very good fit as well because they could be cut quite economically. A Gen 5 fab could produce eight 22-inch-wide monitors simultaneously, but a Gen 5.5 could produce 12 at a relatively small increase in capital cost. That translated into a huge cost advantage.

CMO's early recognition of the importance of large panel sizes was not a surprise, given the industry consensus at the time. But the company was forced to rapidly refine its manufacturing process technology and practices to generate economically viable yields, something that was more difficult with large panels than small ones. Not being first with fabs of a particular generation also allowed CMO to observe and assess the industry capacity landscape and then place its bets according to where it saw product demand. Smart, well-placed bets like Fab 4 (Gen 5.5) and Fab 5 (second Gen 5) and tight operational discipline then allowed the company to thrive.

In the Middle of the "Tournament"

Wu reflected on the impending Fab 8 decision:

> In the past, know-how was a big issue. Even when we did Gen 5.5, we were afraid our fundamental knowledge wasn't strong enough. Later we were not confident that the equipment makers could deliver. Now we have very high confidence in our technical abilities, but we worry about market demand. We didn't know if 42-inch would become the mainstream size. With the huge investments in the Fab 7—it costs about NT$100 billion—we were worried about the market and financial issues. We had to choose the right size and the right timing.

The TFT-LCD industry had gone through a number of up-and-down cycles since CMO entered it. CMO took advantage of some of the cycles to acquire key technologies and assets. During the down cycles when CMO lost a lot of money, people at the management level took a lot of heat. The scale of losses was not something they had ever experienced in petrochemicals.

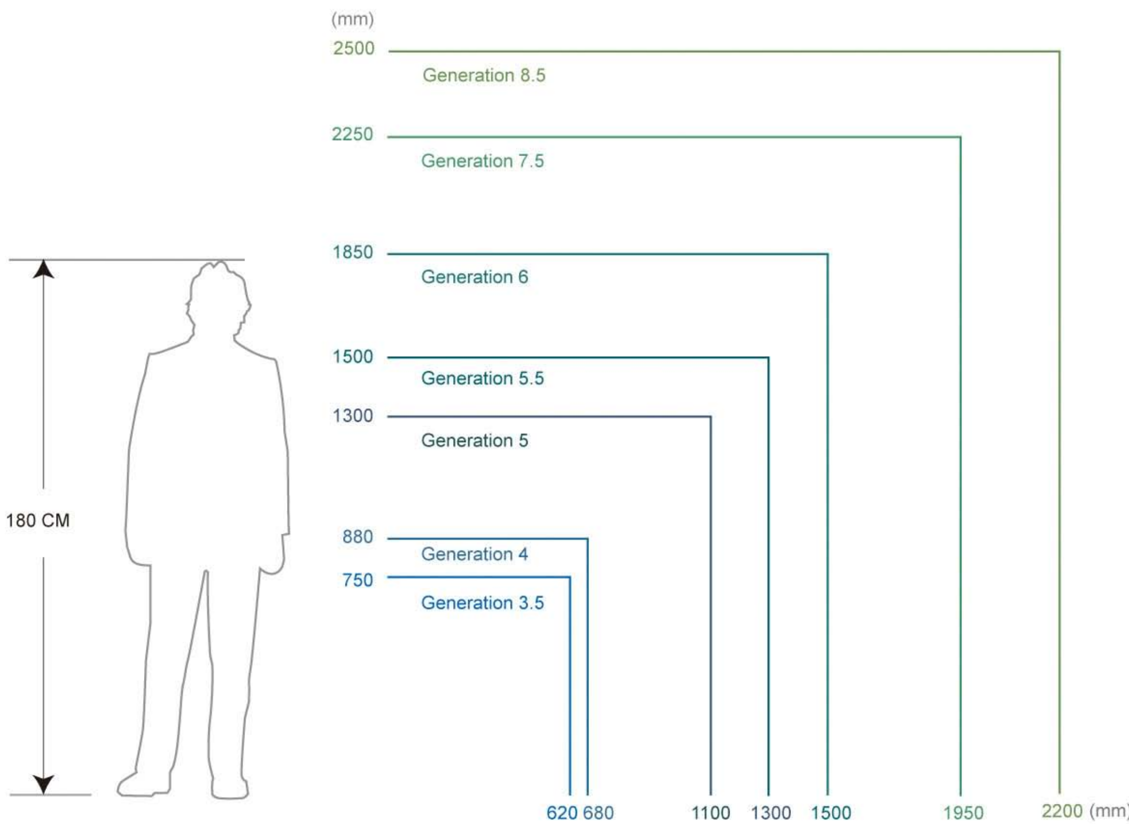
As the U.S. economy hit a major slowdown in the fourth quarter of 2007 driven by a credit squeeze, the question Ho and Wu faced was whether to maintain the pace of investment in new fabs. Consumer discretionary spending had slowed dramatically in the key U.S. market, though flat-panel television sales seemed to be holding up well. Lead brand producers suggested that they were not seeing problematic build-up in inventory channels, but consumer discretionary spending could be fickle. Now the challenge was, would they get it "right"?

The Fab 8 decision had been pending for a long time. The enormous capital needs and the cyclicality of the LCD business were beginning to look similar to the violently cyclical DRAM business. But Wu highlighted some major differences:

> The business of LCDs is very different; it's actually not a commodity. The depreciation cost [in the manufacture of an LCD panel] is actually quite low, 5% to 10% of the total cost, but for DRAM chips it is about 70%. If you look at the cost of producing an LCD panel, materials are around 60% to 70% of total cost, so in a down season, we can stop production. We don't buy materials, and we can stop production. But with DRAM, nobody can afford to stop their production in the slow season.

Fab 8 was planned to be a Gen 8.5 facility, the largest that CMO had ever built. In the market for large-size televisions, LCD technology clearly would win over plasma displays, so the team was becoming more confident. But Ho felt that as a professional manager, he had to take into account the enormous financial risk. As Ho and Wu pondered the decision to restart, Shi reminded them, "As long as the market is still growing . . ."

Exhibit 1 LCD Glass Generation Sizes



Source: Chi Mei Optoelectronics.

Exhibit 2 Chi Mei Optoelectronics Key Fund-Raising Transactions

Year and Month	Price (NT$)	Authorized Shares (000)		Paid-in Capital (000)		Remarks (all quantities in thousands)	
		Shares	Amount	Shares	Amount	Sources of Capitalization	Capital Increase by Assets Other Than Cash
1998.08	10	300,000	3,000,000	75,000	750,000	Founded 735,312.5	Shares for Acquiring Technology 14,687.5
1999.05	10	600,000	6,000,000	375,000	3,750,000	Cash Offering 2,941,250	Shares for Acquiring Technology 58,750
1999.1	10	600,000	6,000,000	600,000	6,000,000	Cash Offering 2,205,937.5	Shares for Acquiring Technology 44,062.5
1999.05	10	1,700,000	17,000,000	1,070,000	10,700,000	Merge Offering 4,624,800	Shares for Acquiring Technology 75,200
1999.09	20	1,700,000	17,000,000	1,620,000	16,200,000	Cash Offering 5,500,000	
2001.01	42	1,700,000	17,000,000	1,698,187	16,981,870	Cash Offering (Preferred Shares) 781,870	
2003.01	33.5	3,000,000	30,000,000	1,878,187	18,781,870	Private Placement 1,800,000	
2003.05	31.61[1]	3,000,000	30,000,000	2,098,035	20,980,351	ECB-1 Conversion 2,198,481	
2003.07	10	3,000,000	30,000,000	2,356,934	23,569,339	Dividend Shares 2,588,988	
2003.08	19	3,000,000	30,000,000	2,856,934	28,569,339	Cash Offering 5,000,000	
2003.11	GDR:43.2, ECB1:26.67, ECB2:43.52[1]	3,750,000	37,500,000	3,372,234	33,722,343	Cash Offering GDR:4,500,000 ECB-1:651,422 ECB-2:1,581	
2004.06	43.52	3,750,000	37,500,000	3,445,510	34,455,103	ECB-2 Conversion 732,760	
2004.08	ECB2:43.52	5,000,000	50,000,000	3,896,044	38,960,442	ECB-2 Conversion: 267,498 Dividend Shares: 3,632,151 Employee Stock Bonus: 605,690	
2004.11	43.52, 38.356[2]	5,000,000	50,000,000	3,896,601	38,966,008	ECB-2 Conversion 5,566	
2005.04	38.356	5,000,000	50,000,000	3,958,639	39,586,386	ECB-2 Conversion 620,377	
2005.06	10	7,500,000	75,000,000	5,458,639	54,538,386	Cash Offering Preferred Shares through Private Placement: 15,000,000	
2005.07	GDR:47, ECB2:38.356	7,500,000	75,000,000	5,976,737	59,767,372	Cash Offering GDR:5,000,000 ECB-2 Conversion: 180,986	
2005.09	10	7,500,000	75,000,000	6,699,594	66,665,944	Dividend Shares: 6,208,722 Employee Stock Bonus: 689,850	
2005.12	38.356, 32.969[3]	7,500,000	75,000,000	6,699,897	66,998,970	ECB-2 Conversion: 333,026	
2006.05	47.7	7,500,000	75,000,000	7,049,897	70,498,970	Cash Offering Common shares through Private Placement:3,500,000	
2006.08	10	8,600,000	86,000,000	7,359,383	73,593,831	Dividend Shares: 2,626,421 Employee Stock Bonus: 468,440	
2006.12	31.6	8,600,000	86,000,000	8,064,383	80,643,531	Cash Offering Common shares through Private	

Year and Month	Price (NT$)	Authorized Shares (000)		Paid-in Capital (000)		Remarks (all quantities in thousands)	
		Shares	Amount	Shares	Amount	Sources of Capitalization	Capital Increase by Assets Other Than Cash
2007.01	48	8,600,000	86,000,000	7,986,196	79,861,961	placement:7,050,000 Series A Preferred Shares Were Redeemed:-781,870	

[1] CMO's first Euro Convertible Bond issue was fully converted into 284,990,314 common shares in 2003. Also, CMO's second Euro Convertible Bond issue was fully converted into 214,179,538 shares in 2005.

[2] Due to shared dividends declared from 2003 earnings that were paid in 2004, the conversion price of our ECB-2 was adjusted from NT$43.52 to NT$38.356. Of the ECB-2 that were delivered for conversion, 19,707 shares were converted at NT$ 43.52 and 358,920 shares were converted at NT$38.356.

[3] Due to shared dividends declared from 2004 earnings that were paid in 2005, the conversion price of our ECB-2 was adjusted from NT$38.356 to NT$32.969. Of the ECB-2 that were delivered for conversion, 9,318,494 shares were converted at NT$38.356 and 23,984,059 shares were converted at NT$32.969

Source: Compiled by casewriter from Chi Mei Optoelectronics 2006 Annual Report, http://www.cmo.com.tw, accessed April 15, 2008.

Exhibit 3 The Chi Mei Museum and Chi Mei Founder W. L. Shi

The Chi Mei Museum

Wen-Long Shi started his first business venture when he was 18 years old. As founder, he is the driving force behind the Chi Mei Group, the largest ABS producer in the world and an industry-leading TFT-LCD panel manufacturer. He is also the power behind one of the most prestigious private museums in the world, as well as one of Taiwan's largest nonprofit medical centers. Shi has dedicated his life to promoting the advancement of society and the cultural enrichment of the community. He has said, "CMC or CMO may not be around 500 years from now, but Chi Mei Medical Center and Chi Mei Museum could still be alive and well."

Birth Date	February 1928	Leadership Roles
Birthplace	Tainan City, Taiwan	
Education	Tainan Industrial Vocational High School, Taiwan	
Career	1953–1959	Cofounder, Chi Mei Plastics Main product: plastic toys and daily necessities
	1960–2004	Founder/Chairman, Chi Mei Corporation Main product: cast acrylic sheets, ABS, AS, PS, TPE, LBR, PMMA resins
	1997–2004	Founder/Chairman, Chi Mei Optoelectronics Corp. Main product: thin-film transistor liquid crystal displays
	1997–2001	Founder/Chairman, Pro Atch Technology, Inc. Main product: computer monitors
Social Activities		
	1970–Present	Adviser, Tainan Fishing Association
	1976–1978	Adviser, Tainan Youth Symphony Orchestra
	1977–Present	Founder/Executive Director/Chairman, Chi Mei Cultural Foundation
	1986–1988	Founder/Executive Director, Tainan Operatic Symphony Orchestra
	1987–Present	Chairman, Chi Mei Medical Center (nonprofit)
	1996–2000	Adviser to the President of the Republic of China (Taiwan)
	2000–2006	Senior Adviser to the President of Republic of China (Taiwan)
Other		The 4th Nikkei Asia Prize Winner for Economic Growth, 1999 Nihon Keizai Shimbun, Inc.

Source: Chi Mei Optoelectronics.

Exhibit 4 TFT-LCD Key Process Technologies

Process Step	Challenges	Sources of Talent and Experience
TFT array manufacturing	Large-scale patterning of substrates, deposition of Si layers on glass	Similar to the semiconductor industry, but glass instead of silicon wafers. Clean-room practice, industrial engineering similar to semiconductors. Engineers from the semiconductor industry a deep talent pool
LCD cell fabrication	Critical technology with a very steep learning curve. Key determinant of yield	Japan, through licensing or technology transfer
Assembly	Assembly skills and labor management	Extensive Taiwan industry experience, from Japanese TN/STN LCD facilities in Kaohsiung, and Taiwanese tech manufacturing

Source: Casewriter.

Exhibit 5 Chi Mei Optoelectronics Fab 1

Source: Chi Mei Optoelectronics.

Exhibit 6 Chi Mei Optoelectronics Time Line

1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
	Fab 1 *Gen 3.5*		**Fab 2** *Gen 4*		**Fab 3** *Gen 5*		**Fab 4** *Gen 5.5*	**Fab 5** *Gen 5* **Fab 6** *Gen 6* →	**Fab 7** *Gen 7.5*
CMO Founded 14.1" TFT Developed in house	CFA Production on-stream	Panel shipments reach 100,000 units	Acquires IBM Yasu Japan TFT facility Forms IDTech Develops 20.1" ultra High resolution panel	Develops 30" high quality TV panel CMO lists on Taiwan Stock Exchange	Begins mass production of 30" TV panel Becomes 2nd largest WW supplier of large size TV panels (>20")	Becomes #1 WW supplier of large (>20") TV panels	Sells IDTech To Sony Develops 56" TV panel Begins mass production of 42" and 47" TV panels	Forms Delta-CMO Opto-electronics to manufacture mercury-free LCD backlights Forms Chi Mei Lighting to commercialize LED backlights Begins construction of Fab 8, a Gen-8 facility	Initiates production Of 42" and 47" TV panels at Fab 7, a Gen 7.5 facility

Source: Compiled by casewriter from company annual reports.

Exhibit 7 Chi Mei Optoelectronics' Key Agreements

Agreement	Contracting Party	Term of Agreement	Summary	Remarks
Technology cooperation agreement	ITRI	May 1, 2002~April 30, 2009	Cross-license arrangements	
	IBM	Effective as of September 24, 2001; may be terminated as provided in the agreement	Flat-panel display-related technology patent licensing	
	Dai Nippon Printing	Effective as of March 11, 2002; may be terminated as provided in the agreement	DNP provides know-how and consulting on color filter manufacturing process	
Technology transfer agreement	Kyocera	December 26, 2006	Sold OLED technology and equipment	
	Vestel	February 17, 2006	Technology transfer and cooperation of TFT-LCD modules	
Cross-license agreement	Sharp	Jan 1, 2006~Dec 31, 2010	CMO and Sharp may use each other's patents relating to LCD technology	
	Hitachi	Jun 1, 2005~Dec 31, 2009	CMO and Hitachi may use each other's patents relating to LCD technology	
License, settlement, and release agreement	Guardian	Jun 1, 2005~Dec 31, 2009	CMO settled certain outstanding disputes with Guardian and entered into certain cross-licensing arrangements.	
	Thomson	Jan 1, 2005~Dec 31, 2009	CMO and controlled subsidiaries received a license to produce complete LCD display monitor units.	
Sale and purchase/OEM agreement	Sony	Feb 1, 2004~Mar 31, 2007	Sale and purchase of LCD	Nonrenewal option
	Philips	Jul 1, 2006~Jul 1, 2007	Sale of LCD	Nonrenewal option (one year)
	Sharp	Jun 1, 2005~Jun 1, 2006	OA OEM	Nonrenewal option
Procurement agreement	Corning	Jul 21, 2004~Dec 31, 2009	Glass substrate supply	

Source: Compiled by casewriter from Chi Mei Optoelectronics 2006 Annual Report, http://www.cmo.com.tw, accessed April 15, 2008.

Exhibit 8 CMO Fab 2

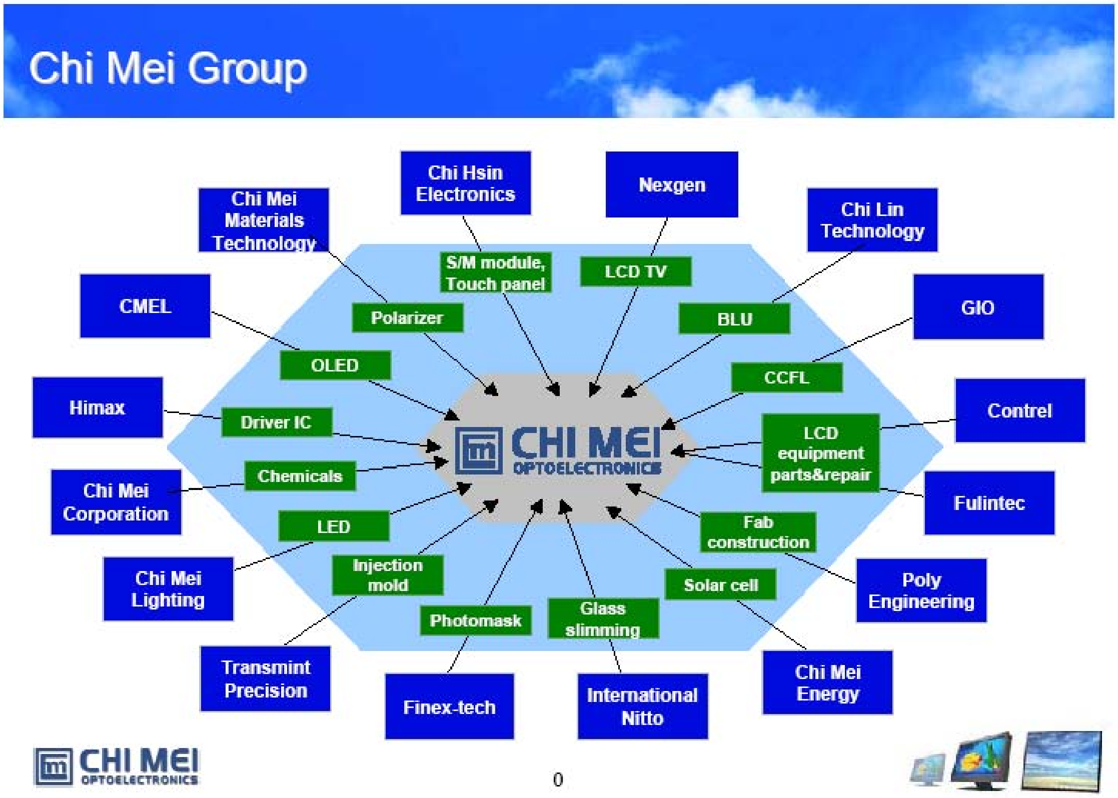
Source: Chi Mei Optoelectronics.

Exhibit 9 Differences between the LCD Industry and the Plastics Industry

Attribute	**CMO**	**CMC**
Size of capital investment	10X	1X
Market size	10X	1X
Product diversity, product category, product application	10X	1X
Product life cycle	1X	10X
Number of customers	1X	10X
Type of customers	Big customers	Mom and pop
Size of customers	10x	1X
Product target	Consumer market	Industrial market
Inventory value	Always goes down	Fluctuates
Speed of technological change	10X	
Risk	10X to 100X	1X
Dependency on human talent	10X	1X
Salary differentials	Big	Small
Compensation gap	5X to 10X	1X
Importance of staff's tenure	Less important	More important
Need to go public	Is a must	Not necessary

Source: Compiled by casewriter from interviews.

Exhibit 10 Chi Mei Optoelectronics Affiliated Companies



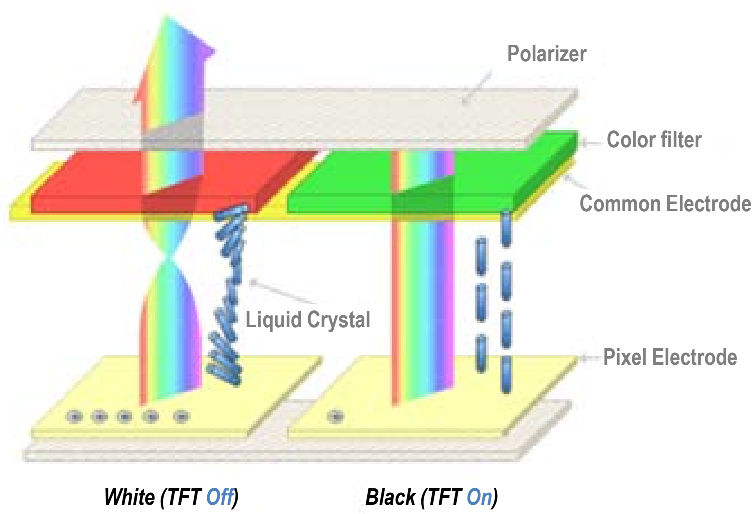
Source: Company presentation.

Appendix TFT-LCD Technology

TFT-LCD displays made use of some very unusual properties of a chemical substance known as liquid crystals. While there were three very familiar states of matter—solid, liquid, and gas—liquid crystals were a phase of matter somewhere between solid and liquid. They might actually flow like a liquid, but their molecules had a solid crystallike quality. Nematic liquid crystals were a particular type of liquid crystal that had what was called an orientational order. That meant that while the molecules might seem to be distributed randomly, they were all lined up in the same direction.

Each red, green, or blue pixel or picture element of an LCD display had a pair of transparent electrodes, usually a thin layer of indium tin oxide (which was transparent despite its conductivity) that had been patterned on glass and a layer of polarizer on the top and bottom that were aligned perpendicularly. If there was no filler, light passing through from the bottom polarizer would be blocked by the top one. The surfaces of the two opposing electrodes were then treated so that they would align the liquid crystal in a particular direction, and the gap between the electrodes was filled with a twisted nematic liquid crystal.[9] Since the electrodes had been treated to align the liquid crystal in perpendicular directions, the liquid crystal molecules arranged themselves in a helical structure. The liquid crystal material was bi-refringent, meaning that it rotated the light coming from the bottom and passed it through the polarizer at the top (left red pixel in drawing below).

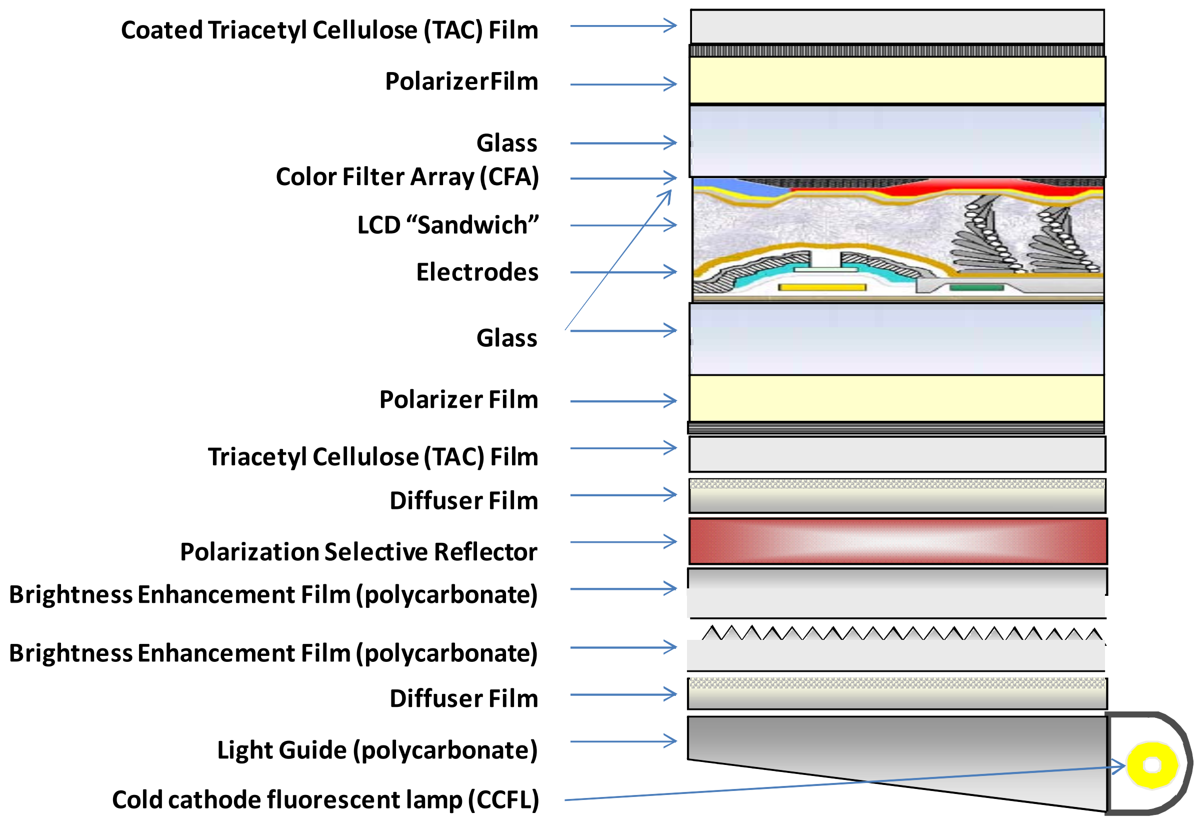
If a voltage was applied across the electrodes, the liquid crystal molecules would line up with the electric field and untwist. This prevented the transmission of the polarized light, rendering the cell gray or black (right green pixel below). Hence, the green pixel in this example appears dark:



Source: Chi Mei Optoelectronics.

[9] Twisted nematic liquid crystals were the most common form used, but other forms were used as well, depending on the design of the particular cell.

The LCD sandwich thus acted as millions of tiny "light valves" that turned on or off depending on whether voltage was applied. In order to turn this array of light valves into a display, a uniform white backlight had to be placed underneath the LCD sandwich. In practice, this was usually done with a cold cathode fluorescent lamp that was optically coupled to a plastic light guide. The light guide spread the light over the lower surface of the LCD sandwich, but intervening layers of brightness enhancement films (usually textured polycarbonate sheets) were interposed to even out the light distribution before the light made it to the lower polarizer. Thus, the entire stack of materials was necessary to make a functioning TFT-LCD panel (see below).



Source: Casewriter.