# Microelectronics, from Westinghouse to General Instrument to Zilog

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In 1962, Harry Knowles from Motorola was named to develop a new Westinghouse entity called the Molecular Electronics Division to be located a few miles away from the Westinghouse Defense and Space Group campus not far from the Baltimore Washington International Airport. I was working at the Westinghouse Research Laboratories in Pittsburgh as Manager of the Solid State Devices Department when Harry asked me to become the Engineering Manager for this new division.

Under Harry's leadership, a very modern microelectronics plant was built at Elkridge, Maryland, a few miles from the Defense and Space Group campus. The clean room facilities were state of the art for the time and there were separate fabrication facilities for R&D, Pilot operations and Production.

As the division grew, I added the responsibility of Operations Manager. Harry left Westinghouse in 1966. After a period where I was the Assistant General Manager of the Division, I was named the General Manager in 1967.

The wafer processing strength at the Molecular Electronics Division was in bipolar integrated circuit technology. The first digital design project was creation of a line of bipolar resistor-transistor-logic (RTL) circuits which went to market as the Westinghouse 200 Series. However, the division also had substantial depth in bipolar linear integrated circuit design, strengthened by the leadership of Dr. Jimmy Lin who moved from the Research Laboratories to Elkridge as the Manager of Advanced Development.

Shortly after the formation of the division, Westinghouse was invited to quote on the linear bipolar integrated circuit set for the Minuteman II guided missile program. The Molecular Electronics Division was chosen by Autonetics Corporation to design and produce that chip set. We believe that a factor in this award was the success of the Westinghouse Research Group's 1961 design and pilot production of a fully integrated 5-Watt audio amplifier. The development and production of the Minuteman circuits proceeded at the Elkridge site and was an early revenue generator for the division.

Another business line grew from the design and manufacture of low power bipolar ICs for the hearing aid industry. As we recall, that line was quite profitable for the division.

The Molecular Electronics Division came into existence during the period of intense American involvement in the Vietnam, War. The design and production of bipolar integrated circuits for aircraft cockpit display and bomb fuses was a significant revenue source for the division. That activity involved very high unit volume and the business was growing at the time that operations of the division as a commercial entity were terminated.

While the division overall was never profitable due to the heavy load of the research and development required to remain competitive, the losses were small and the customer base and revenues were expanding. However, a decision was made by the Corporation to discontinue its commercial operations. Early in 1969 the division was merged into the Defense Group; the idea being that it would serve that group's need for custom ICs to be used in its service to the defense industry.

Looking back, there were other options. Westinghouse could have spun off the division into a stand-alone commercial entity, as is now so often done today when a business no longer fits the objectives of the corporation. The Microelectronics division had an existing customer base, strong linear design capabilities and a well-trained, well-led production organization. While, like any other integrated producer, the business was going to need capital to participate in the integrated circuit "micron race," the existing fabrication, assembly and test facilities were quite capable of meeting current linear bipolar integrated circuit competition as our wins against competition for the high volume weapons fuse business clearly demonstrated. The division had been doing its own R and D for a number of years and was not dependent upon the Westinghouse Research Laboratories for either processing or design technology.

Had the times been right for such a spin-off, perhaps something like Analog Devices or Linear Technology might have emerged. While admittedly it would have been difficult to build a digital integrated circuit powerhouse on the East Coast of the US since so much of that technology was West

  

Coast driven, Analog Devices certainly proved that an East Coast presence was possible in the linear IC business.

Another option might have been to sell the division to an existing competitor that would benefit by the existing business, skills and facilities.

However, to the best of our knowledge, no such options were explored. The Westinghouse Defense Group had wanted always direct possession of the resources of the division, which it apparently perceived would strengthen its position as a major federal defense contractor. Handing off the division to Defense apparently relieved corporate management of having to pay attention to a business that seemed so foreign to its often re-stated business objectives.

Of course, as time went on, as I recall, the Westinghouse Defense and Space Group was itself sold.

While I was offered an appropriate position in the defense group and temporarily accepted it, my personal objective was to remain involved in the integrated circuit industry and I began to look for employment elsewhere.

The options seemed to be to either move my family to the West Coast (I had previously had opportunities to move there) or stay with the industry on the East Coast. My wife and I had family responsibilities on the East Coast at the time so we began to look at East Coast opportunities as our first step.

An old acquaintance from my IEEE Committee activities, Bill Hittinger of Bell Laboratories, was recruited to be President of General Instrument Corporation of New York. Bill contacted me to see if I was interested in joining him there as he worked to “rationalize” the GI investment in microelectronics.

I had already known a little about GI in that I had met with Monty Shapiro who was one of the founders of that company some time earlier. At that time, Monty wanted to get my views about the future of the technology. Monty was not a technologist (rather, he had apparently started out as a labor relations attorney) but I quickly found that he had a very good “nose” for emerging opportunities and had lead GI into forward-looking investments in cable television, off-track betting and microelectronics, among other ventures, in his time as the President of the corporation.

I prefered my experience at General Instrument and its culture in contrast to Westinghouse. Whereas, in my opinion, the Westinghouse culture might have been described as “Gentlemen’s Club with a Side of Politics” the General Instrument culture appeared to me to be “Lower East Side Manhattan with a Side of Street Brawl.” General Instrument gave me an education in real business, which I found to be very valuable in the years thereafter.

The origins of General Instrument were said to go back to the activities of some entrepreneurial folks who started out manufacturing record playing machines during the period when every home wanted a multi-speed automatic record player. At some point, Monte Shapiro had become associated with that group and had begun building what one might say was a “mini-Geneen conglomerate.” [after Harold Geneen, president of ITT]. Monty would either buy a small company in some “niche” business or hire a small group of entrepreneurs who had a particular business or technology interest. To assemble these pieces, General Instrument used leverage and, of course, a heavy debt load on the P/L.

The organizational structure was fluid but most of the newly acquired pieces felt that they reported back directly to Mr. Shapiro since he had brought them into the corporation in the first place. There was a small corporate staff for Human Resources, Legal and Accounting and these activities looked over and often had final say in these functions in the separate business units.

The semiconductor activities at General Instrument in 1969 included an MOS division, a hybrid circuits division and a rectifier division. Those names were descriptive of what these groups did although the formal titles were subject to change. All three of these activities had their headquarters at the Hicksville, Long Island, New York site. The MOS division included a start-up near Naples, Italy, an R&D activity in

  

Salt Lake City, Idaho, a design and manufacturing facility in Glenrothes, Scotland and lingering associations with at least two entrepreneurial groups that had split off from General Instrument after initially having been part of an earlier acquisition. The rectifier group had a major manufacturing facility in Taipei, Taiwan where General Instrument usually established factories to manufacture products that grew to require high volume production. The hybrid circuits division was pretty much self-contained at Hicksville but had begun to look at assembly operations in Mexico.

In a number of cases (example, the Naples, Italy and Glenrothes, Scotland facilities) the corporation had made use of government incentives to fund these remote sites.

I reported to work at the Hicksville headquarters of the General Instrument Microelectronics Group on a snowy morning in February 1969. When I arrived at the plant, I found what might be best described as "chaos." I was informed that the person with the title of "MOS General Manager" had been locked in his office by a group of employees the previous week and was nowhere to be found. Within the first several weeks, the roof over the manufacturing floor collapsed from the weight of the snow and my assignment was to achieve the best possible outcome on the business corporate interruption insurance. To add to my increasing misgivings, one of the financial representatives from corporate took me aside and suggested that the company might be missing a payroll because a large balloon payment on some of the debt was coming due.

After enjoying the "tailored for IC production" plant Harry Knowles had designed for Westinghouse at Elkridge, Maryland, my first tour of the Hicksville plant did little to lift my optimism as to the General Instrument future in microelectronics. The DI [de-ionized] water facility had a dirt floor. The hybrid circuits and small rectifier pilot assembly areas were not even in partitioned rooms, never mind not in semi-clean rooms. The attempts that had been made to build clean room facilities for MOS IC production appeared to me to be less than industry standard and employee gowning and working practices seemed to be "fairly casual." I could see why Bill Hittinger had called for help.

My first assignment from Mr. Hittinger was to resurrect the Hybrid Circuits Division, which had stable revenues with a solid customer base, but was losing money in what should have been a profitable undertaking. The solution to the problem was fairly obvious. The hybrid group had twice as many hourly employees as it needed. While fixing that problem would have appeared to be pretty obvious, in the Hicksville environment it turned out to be rather difficult to do. First of all, the hourly employees were all members of a union bargaining unit, which needless to say had a lot to say about such a significant layoff. Second, I began to run into the "friends of Monty" syndrome. When I went to remove or replace a salaried employee who was apparently either not capable or not interested in doing the job, I would hear "You can't do that because he (or she) is a friend of Monty." In the first case I acted upon, I got a gruff phone call asking me what I thought I was doing and that gave me pause. However, after pondering the alternatives, I decided that my job was to satisfy Bill Hittinger's direction and fix the problem and while I got some further calls, I still had my job.

Mr. Hittinger left General Instrument as its President toward the end of 1970 to become the General Manager of RCA's Solid State Division. At that time, Mr. Shapiro re-assumed the Office of President of the corporation and my new boss became Rein Narma who joined GI from Ampex as the Group Vice President for Semiconductors. Rein then named me to the position of Operations Manager for what was now General Instrument Microelectronics, consolidating the MOS and hybrid activities. I served in that position under short-term General Managers until 1973 when I assumed that position.

While all of this was going on, progress was evident in the microelectronics business on the technology and business fronts. The splinter operation in Italy was closed. The Philco-Ford IC assembly factory in Kaohsiung, Taiwan was acquired by GI Microelectronics and expanded both in capacity and the ability to do final test which substantially shortened the time between chip fab and customer delivery. A brand new chip plant on a large site for expansion on Williams Field Road in Chandler, Arizona was acquired out of the bankruptcy of the Bowmar digital watch company.

  

The acquisition of the Chandler site provided a real step forward in the ability of General Instrument Microelectronics to compete via low-cost high-yield MOS chip manufacture. First of all, it freed the division from some of the difficult labor relations that existed in Hicksville. Further, the acquisition occurred at the time of major layoffs at Motorola Semiconductor, which resulted in the availability of excellent fab personnel in the management, engineering and operator categories. I often observed that the more senior off-shift fab operators from Motorola knew as much about the equipment setup and maintenance than the on-shift process engineers – and maybe more! While we retained some pilot line capability at Hicksville, the center of GI Microelectronics manufacturing moved to Chandler.

The Kaohsiung, Taiwan plant acquisition was also very fortuitous. Kaohsiung was at the southern end of the island whereas the huge General Instrument complex for television components and rectifiers was in Taipei. That give Microelectronics insulation from the politics, labor relations and governmental complexities that inevitably existed at the very large Taipei site.

In 1973, Frank Hickey became the President of GI and took full control of the company. Shortly thereafter, I was named the Vice President and General Manager of the Microelectronics Group and reported directly to the President. Frank was a tough, hands-on manager and demanded very close attention to all details of the business from his subordinates. He also cut through some of the old political ties, did thorough on site visits "roof to basement" of all of the GI facilities and held his direct reports to making their monthly numbers meet their forecasts or he would need to know the reason why.

I would be remiss not to mention two GI associates who played a very major role in the ultimate success of the GI Microelectronics business. Bernie Rohrbacher held the position of Microelectronics Operations Manager and had manufacturing responsibility for many of the facilities. Bernie was one of the best "fab problem solvers" that I met in my career and had an excellent rapport with the operators on the floor.

Jim McGarry worked in the early years on the re-construction of Microelectronics as a general manufacturing consultant. Jim had been trained under Geneen at ITT and had a unique ability to pull together those working on an issue and quickly arrive at a solution.

From 1972 on, the new GI Microelectronics was achieving milestones that put its revenue on an upward path. Among these were:

Design and production of the first fully integrated calculator chip, designed in Scotland and produced in Scotland, Hicksville and Taiwan.

Design and production of the first consumer electronics TV game chips designed in Scotland and Hicksville and produced in Scotland, Hicksville, Chandler and Taiwan.

Design of the ubiquitous PIC microcontroller product line designed in Hicksville and still in production today by the Microchip Corporation, the successor to GI Microelectronics, at the Chandler, Arizona location.

Design of the industry's first 16-bit CPU, the CP1600, at Hicksville. The CP1600 then became the "engine" in the General Instrument all solid state TV tuner which replaced the rotary mechanical tuners previously manufactured by the millions in the General Instrument Taipei plant.

Design of a non-volatile memory chip using the oxide/nitride layer process that had been invented at Westinghouse and then further developed at NCR. That chip, the ER1400 was also used in the all solid state TV tuner chip set and, as with the CP1600, produced in very high volume. While the rest of the industry adopted the thin oxide approach to non-volatile semiconductor memory, GI continued to produce the ER1400 for general consumer applications for many years.

Incorporation of the oxide/nitride non-volatile memory on the GI PIC microcontroller line.

  

Design, with Mattel, of the first programmable TV game, Intellivision. in which low cost ROM cartridges provided the game play. The Intellivision system utilized the CP1600 16-bit CPU as part of its chip set along with one or more custom chips produced by G.I.

Development of a very dense ROM structure which permitted G.I. to gain and hold share in that market. With that, creation of a "fast track" for new ROM programs in its chips which was shorter by at least two weeks than the industry completion at the time. Being able to test and ship to Far East board assemblers was a real asset in that competition.

Investment in chip designs for text to speech and speech to text. That endeavor was too far ahead of its time but expanded the GI microelectronics reputation as a major player in the consumer electronics chip area. However, one of our speech chips did end up in a singing birthday card produced by a well-known greeting card manufacturer.

In addition to investment in new fab buildings and modules at the Chandler site and continued expansion of the Kaohsiung, Taiwan assembly and test plant, a new fab was added at the Glenrothes, Scotland site. That fab was oriented toward production of chips for the British telecom and German TV industries. At that time there was a preference on the part of European customers (tax preferences, as I recall) to have a European design and production source for their custom and standard integrated circuits.

No longer strategic to the Microelectronics business, the hybrid product line was sold to a small investment group and, at the request of the corporation, the Microelectronics Group became the temporary home for a silicon wafer manufacturing company in California which it evaluated and then shut down.

On the financial side, GI Microelectronics was profitable every year from 1972 to 1984 with the exception of a small loss in one year in the middle of that period. Further, all of the growth in the Microelectronics Group was funded from internal cash generation. The success of the Group was recognized in both the trade press and on Wall Street where I was frequently asked to make presentations to the investment community.

It is pretty clear that our target market was chips for consumer electronics. That was a very natural market for the Microelectronics business given General Instrument's past and, then, present. That was even convenient given our headquarters location, close by the then East Coast headquarters of some major toy and game manufacturers. As the programmable video game business began to develop on the West Coast (Atari, Mattel, for example) we already had an established reputation for understanding that market and making those chips and enjoyed a good reception there.

However, the consumer eectronics business presented some special challenges for chip manufacturers. It was (and maybe still is) "boom" and "bust." If the customer's product was a hit, everyone wanted to place high volume orders for the chips that powered it and double and triple ordering immediately occurred. However, when the customers' market either saturated, or moved on, the inventory of chips, either already shipped or in process, became worthless. Accordingly, we developed safeguards to deal with that issue and managed to avoid most of the big inventory write-offs that would certainly have created a very bad relationship with the GI Corporate.

The other aspect of being in the consumer electronics chip business was that some customers had figured out that not paying for the chips that they ordered made them even less costly than negotiating the best possible price in the first place. The "ploy" there was to claim "defective" and refuse to pay for the product. Again, we developed safeguards to deal with that issue and try to avoid those write-offs.

These and other techniques we developed in the process of creating a predictable revenue stream may have hampered growth but they were responsible for our record on profitability and we ultimately put them into a self-published book called "Forward Controllership" which, it turned out, would be required reading at our next venue.

  

In August 1984, I was approached by the EXXON Corporation (then still headquartered in New York City) with an opportunity to become the CEO of the Zilog Corporation. Exxon had acquired Zilog as part of a business diversification program several years earlier and was growing tired of its continuing losses. In the ensuing discussions it was evident that they had become frustrated by the performance of the several management teams that had been hired to improve performance and wanted a "new broom." From those discussions I could also sense that it would be my job to determine if the company was worth fixing, should be sold off or wound down. Since the move to Zilog would require a coast-to-coast relocation and the chances for success on the other end were not too great, negotiations took a while but on November 15, 1984 I left GI and headed for California.

Zilog had become known as the creator of the Z80 [microprocessor]. One of the GI acquisitions which I had temporarily managed used the Z80 in its products so I was familiar with the device. On the other hand, from a market standpoint, it had become a "one trick pony." Different management groups before and during the time Zilog was acquired by EXXON had tried to find a sequel to that ubiquitous product but without much success.

The first month after I reported for work as the CEO the books closed for the Components Division of Zilog closed with a loss almost equal to the revenue.

The company had also branched out into the system business. It was never quite clear to me why the world was waiting for another computer manufacturer in 1985 but there was the Zilog Systems Division. What I quickly discovered was that the systems business was pretty well run but probably did not have a future. On the other hand, the chip business might have a future but needed some major changes in both strategy and the way it was being run.

As a simple example, the Components Division product development strategy, as it was explained to me in my first meetings with management, seemed to be to develop Zilog versions of chips in sectors already well served by much more able competitors. This would, presumably get the customers come swarming to the doors because "it was Zilog." Programs to develop 16- and 32-bit versions of the Z80 were dominant in the dialog. ("Intel anyone?")

On the other hand, programs to capitalize on the work of some guys in the back room who had a good start on chips for the then rapidly growing digital communications market or microcontroller versions of the Z80 with special features for growing markets were not given equal billing. Shifting the product development, marketing and sales focus to compete where the company had a chance to win was a very obvious priority.

EXXON was watching carefully in my first months at Zilog because some of the things that I said needed to be done were the exact opposite of what they had previously been told, but other than being sure that my changes made sense as best they could understand them, they were fully supportive.

The other area that needed urgent attention was the existing overhead in the chip division. You can't lose the same number of dollars in a month as your revenue and continue with the same overhead. There were five buildings being occupied by the company on its Campbell, CA campus with people in all of them. Those numbers had to be reduced and quickly. With EXXON's support we began to consolidate the operations of the company into less floor space and deal with the headcount issue. Things like that never make one popular and I have no doubts about my reputation during that period.

This is where my little book on "Forward Controllership" became the Zilog bible. Fortunately, Zilog had a CFO originally from EXXON who was totally sympathetic to the policies and procedures described in the book and he adopted it as the structure for Zilog's financial control system. We could now show EXXON month-by-month improvements taking place in the P/L and on the balance sheet.

In addition, whereas the product, market and sales strategy in the chip business required major surgery, we were delighted to find that the Zilog chip plant at Nampa, Idaho, had adequate in facilities and a very good workforce. To add to our delight, there was a newly constructed building (unoccupied) that had been built for another EXXON venture right next door and it was crying out for utilization as a highly automated wafer fab.

The Zilog chip assembly plant was in Manila, Philippines. Again, I was encouraged by the attitude and capabilities of the staff there. It was very evident that they already had the engineering talent to do their own packaging development. They were missing the charter to do the final test and shipping and we began to change that.

With some semblance of order in strategy, market focus, product development and financial control in evidence on the chip side, we began to look at the future for the systems division. As already noted, it had good management and some excellent engineering resources. The division had won a very nice order from a government agency to build a substantial quantity of custom computers. However, there was a serious disconnect. The plan was to use the 32-bit CPU, to be developed and produced by the chip division, and that project was way behind on its development schedule and was not going to provide the engine those systems needed.

Systems management was already looking around for an alternative 32-bit CPU and had identified one under development at AT&T which seemed to satisfy the requirements. We met with AT&T, found that their chip was on schedule and arranged a supply contract for the product.

That left the problem of setting up a manufacturing facility to produce the quantity of computers required under the contract that the division had with the government agency. We had vacant space in one of the buildings on the Campbell, CA campus and created a small assembly line there.

We were appropriately nervous about the performance, quality and reliability of the product. We required extensive performance testing and reliability stress evaluation on the computers before going into production and were very pleased with the results. The AT&T chips (as I recall, we purchased a chip set) performed “as specified” and the design tolerances on the computers were such that the quality and reliability acceptance tests were passed with good margins. To assure that we had created a product that would not cause trouble in the field, we followed up by getting reports from the customer on up-time experience in the field and the performance appeared to be exceeding the contractual objectives.

As already said, the priority issue in Components was to craft a market strategy and product development plan that “met the times” *and* fit the capabilities of the organization. Consumer product chips had not been the central focus of most visible IC competitors. The business and industrial side received most of the attention. That probably occurred due to a number of factors including the disdain that Wall Street usually had for consumer products (oh, yes, now there is Apple!), the fact that design and production of consumer products had, by this time, largely moved to the Far East, the expectation that margins were always lower and the “comfort” many of those in the IC industry had with business and industrial segments. As a simple example, when General Instrument Microelectronics had pursued and was enjoying the Mattel Intellivision business, only one competitor stayed in the race for the design win and only one (a different one) tried to upset the design win after GI was in full production of the chip set.

On the other hand, high volume consumer products were utilizing more and more chips and the design of the end products was increasingly being done in the Far East. The usual progression was evident. First the Far East vendor was a contract manufacturer, then he branched out into designing new products for the original customer and finally searched for and got the rights to sell other versions of the product to other end customers in exchange for favorable ongoing contract manufacturing terms. At the time however, the Far East end product design groups did not yet have in-depth experience with either chip selection or chip programming and often relied on the chip vendor to do the applications work.

Here is where existing Zilog resources “added the sauce.” While the Z80 CPU had been receiving all the attention, the company had a very able MCU [microcontroller], the Z8. The architecture of the chip was such that yields were favorable and there was a small but enthusiastic cadre of marketing and applications engineers who were anxious to see more resources put behind the product.

A simple but very doable "strategy" evolved. Make the Z8 the engine for a new business group that would concentrate on designing versions of the Z8 oriented to the needs of the Far East consumer end products suppliers, do the applications work for them necessary to incorporate a chip or chip set into their new products, use expedited ROM turn around to help them get into production and then follow on with an aggressive cost/price reduction program to protect the design-in as their end product became successful in the market place and volume grew.

We were concerned that the General Instrument PIC product line might be a competitor. However, Microchip, the successor to GI Microelectronics seemed to be pursuing a strategy of offering free design tools to their customers while the Zilog strategy was differentiated by offering free, working designs.

Our VP of Sales was able to attract really excellent sales managers with strong technical backgrounds in the Japan, Hong Kong/Singapore and Korean areas and they in turn added very capable local applications resources. This meant that the design and programming work could be done either at the customer's site or in the local Sales Office. A smaller, but similar structure was added in the UK and Germany.

We now had a second business unit to provide growth while the existing Z80 business unit provided a stable revenue base and cash flow.

There was a third opportunity for growth also available. This was the period of enormous activity in what we will (probably incorrectly) characterize as the "digital data parsing, arranging and dispatching" industry. Zilog already had a popular line of SCCs (serial communications controllers) and had embarked on the design of even more capable additions to that line. The market for these chips in ever faster modems (for the internet) had certain consumer products aspects (short design cycles, fast ramp up, cost competition) which seemed to fit the need for the same planning and manufacturing skills being developed for the Z8 business. We did not create a new business unit for the SCC product line but rather assigned it to the Z80 business unit.

The Components Division achieved profitability in 1986 and revenues were on a healthy upward trend. The obligation that Zilog had to the federal customer in the System Division was successfully fulfilled and the business was put into a wind down mode.

In early 1989, EXXON indicated that it was time for Zilog to move on. The spin-off of Zilog is a whole other story but the end result was that Zilog was "bought out" by Warburg Pincus a few months later. The Warburg people were experienced technologists, good business people and patient investors. We could not have done better. In the process of the buyout, we acquired the vacant building on the Nampa, Idaho site and put it "in the bank" for a major expansion of our chip fabrication facilities as the revenues grew.

We have already talked about the dangers inherent in service to the consumer products market in our description of the General Instrument period. When a product takes off, the demand may be seasonally driven, the double ordering is inevitable and the end of the demand is sudden. The struggle of who pays for the over-inventory and over-ordering is intense. Claims of bad product are one aspect. Unpaid receivables is another. The customer filing a Chapter 11 to get out from under his problems is not unknown.

With that experience in mind, our goal was a very firm agreement on product performance with the end customer on all large orders. We required a sign off on detailed test results which were measurable on industry standard equipment for "pass" or "fail." We would not take any order where the performance of the chip in the end customer equipment was specified on a functional basis (make the little car go "28 feet per second".) We would meet the detailed electrical specifications but the customer was responsible for the fact that the application worked in his production design, even if we had helped him in the design-in process. Our sales people argued that we were way out of bounds in taking that position and would not be competitive, and it probably cost us some business, but we kept our collections and receivables up in the top tier among industry reports.

  

Along with that, we installed a separate function in our Q/R [Quality/Reliability] department whose job was to do continual life testing of our products and publish the actual (not edited) results in a month bulletin which we made available to our customers. In a sense, we went overboard in trying to avoid the customer having any real and demonstrable basis for refusing to take and pay for what he ordered and our product returns and inventory write-offs were very low.

We also adopted a more aggressive posture on the interface with distributors. Components distribution had become a very major business, often showing better P/Ls than that of the chip manufacturers could report themselves. The distributors liked to have deep inventories of popular products so that they could compete on off-the-shelf delivery but, of course, wanted to avoid the costs of inventory write offs when the products they stocked were slow moving.

The distributors enjoyed an advantage in that the component manufacturers sales departments would be anxious to meet their sales forecasts each month and be very open to end-of-month discounts. This often led to low margin business which did not fit the Zilog financial objectives. We elected to pursue a strategy that minimized the distribution channel. Obviously the Zilog sales organization felt that would impede our revenue growth but profitability and cash flow were our immediate needs and direct to end user sales better met those objectives.

One of the most significant new product initiatives in the implementation of the Z8 strategy came from a young MBA who found an independent entrepreneur who had designed a very small but powerful digital signal processing (DSP) core. A digital signal processor might be said to be a CPU specifically designed to parse and process digital and analog information.

We formed a partnership with the designer and took a license to the technology. The next step was to put the digital signal processor core on the Z8 MCU. Why? Our applications engineers and the customers' engineers were very familiar with programming Z8s but the programming of DSPs was new to them. Our software folks simplified the task by writing a program in which the Z8 programed the DSP and that opened up a new market for us almost immediately. As one simple example, digital signal processing is used widely in speech synthesis. Our new Z8 cum DSP products found their way into designs for leading brands of telephone answering machines.

Another new product initiative was based on the recognition that most of our customers shipped infrared remote controls with their television and stereo entertainment products. There were even remote controls for ceiling fans that used the Z8 as a controller. We captured these customers by virtue of doing the infrared control programming required and maintained a data bank of the host of codes that were already in the commercial realm. That segment of our consumer products activity grew rapidly and we eventually began tooling and manufacturing the IR controls ourselves as an added service to our customers.

These and other "innovations" to provide service to our Far East and European customers that they were not yet ready to provide for themselves very much enhanced the strength of our customer relationships. As example, the Korean industry was in the process of overtaking Japan as the main supplier of television sets at the time and all three major Korean manufacturers of TV sets were volume users of our chips.

Zilog achieved either a major position or important position in a number of market niches during the 1990s. We had positions in the TV on-screen display and remote control markets. We were the only producer of a chip set for a two-way remote control at that time (and that market is very hot today.) We had positions in the portable telephone and telephone answering machine market and teamed with a major home security company in doing a Z8-based chip set for user-installable home alarm systems. We had positions in the computer disk drive market. We participated successfully in the mouse and keyboard markets. We had a very good position in the modem and set-top-box markets.

  

Of course, we continued to receive the cash flow from legacy applications of the Z80 and enjoyed the good margins and stability from the sales on the serial communications chip line.

During 1990, our friends at Warburg Pincus determined that the improved stability of the company P/L coupled with its growth prospects made Zilog a good candidate for an IPO. We went on the road early in 1991 and closed in February. Warburg was very generous with the stock options made available to the employees in its investment companies and Zilog was no exception. As I recall, the options were available to all employees who were not in in some way encumbered by some country of residence limitation. This was of great assistance in maintaining the core of our strength in all areas.

The Zilog Board of Directors included two Warburg senior partners, a retired sales executive from a successful major semiconductor company, a successful customer industry segment entrepreneur and the head of a computer and electrical engineering department of a major technical university who also had experience in one of our customer industry segments. That Board was in place and active before and after the IPO and remained largely unchanged until a major change in ownership in 1998.

The senior management of the corporation, assembled prior to the IPO, included a manufacturing executive who had been at General Instrument, financial and human resources executives who had been Zilog employees before I joined the company and engineering, marketing, sales and quality insurance executives with excellent Silicon Valley credentials. That team remained largely intact until the major change of ownership noted above. That team was duly proud to be able to make the claim that, as best we could tell, Zilog achieved some kind of record for unbroken profitable months in an industry where profit volatility was often the norm.

Not only did we keep the emphasis on the quality and reliability of our products, minimizing financial negatives arising from product returns and inventory write-offs, but we also developed and refined systems for measuring the revenue and margin from individual product development projects and used that information to prioritize additional development proposals as they surfaced. This all contributed to year over year revenue growth and consistent profitability and cash flow.

Low cost manufacturing was clearly critical to our strategy and in integrated circuits that means “yield, yield and yield.” We accepted every opportunity to visit the Asian fabs, particularly those in Japan where the quality of the fabs and the discipline of the work force were said to provide yields far superior to those achieved elsewhere. While it may be “politically incorrect” to say so, what we found was that the quality of the fabs was not much different than what could be found in the U.S. at the time but the workforce was what made the difference. To put it in frank terms, the workforce we observed in various shifts on the floor in Japan appeared to be much more oriented to precise work, with no mistakes and no excuses. As one observer put it, the entire workforce had the attitude which you would hope to find in your most skilled dental technician.

Obviously we already knew very well the three major sources of yield loss in integrated circuit fabs. While defects caused by contaminants were the popularly advertised source, in many cases we had found that human errors could be a much larger factor. Human errors occurred in two main categories: failure to set up the processing equipment properly and failure to follow the run card sequence and instructions properly.

The fab in the original Zilog Nampa, Idaho plant was rapidly becoming fully loaded and the time had come to add capacity. As already noted, we had acquired a new and never occupied building from EXXON just a few hundred yards from the exiting plant and we set up a program to turn that building into a “super fab.”

This occurred at the time of a major debate in the industry between the use of sealed containers to keep wafers contamination-free versus clean rooms with ever increasing particulate reduction requirements. It seemed to us that enclosing the wafers in a particulate free space of a cubic foot or so was going to be easier than maintaining a room the quarter of the size of a football field and we elected to go that way in association with a major sealed container manufacturer.

This, of course, meant that all fab equipment we purchased had to be fitted with the load and unload docks for the carriers but that was a small price to pay for the yield improvements we demonstrated in a pilot setup.

The next challenge was how to eliminate completely equipment setup errors and process step sequence mistakes. Our Nampa workforce was very good and quite serious about its mission but it seemed to us that computer technology had reached the point where we could virtually eliminate human error by development of the right electronic systems and controls. Since most fabs have to run several processes (generations and special sequences and steps) the most obvious solution was to have the wafer carrier for a production lot carry with it the equipment setup instructions. Those instructions would be in electronic form (sort of an electronic run card) and would be entered automatically into the processing apparatus so there was no chance for mis-insertion of the process settings by a manual entry error. In addition, since the process sequence was inherent in the electronic instructions associated with the carrier, sequence errors would not be possible since the unload dock would just refuse to open the carrier.

Some of the Japanese fabs we had visited had overhead rail transport of the wafer lots from station to station but we felt that it would be far less costly and require less maintenance to just utilize a fab operator with a clean cart to move the carriers between the sealed carrier loading docks.

The fab our engineers designed was fully equipped with the sealed wafer carriers and their loading docks and the electronic run card system was partially implemented when we put the new module into production in 1995.

From the beginning, the yields from this facility were exemplary. Obviously we did not have access to competitive data but we had one milestone that we reported which, surprisingly, received no challenge. Shortly after the new fab went into was up and running, we noticed that wafer lots of the latest serial communication chip (a fairly large die) were coming out with close to 100% good die on the wafer. Then a wafer came out with 100% yield, we took a picture and did a press release claiming a first. We expected immediate challenges but got none. Either the competitors were not reading the papers that day or we really did have a first. Whatever the situation, the concepts we had implemented were working and our chip productions costs met our new targets.

The production cost of the integrated circuit die is a significant part of the final cost of the product but the assembly and test costs are important factors as well. The Zilog Manila "back end" was very efficient. The quality and attention to detail of the production operators was certainly as good and perhaps better than we had experienced elsewhere and the engineering staff was high caliber. The Manila plant was self-sufficient when it came to the design and procurement of new package tooling and the engineers were capable of doing on site program improvements to the automated final test equipment. Turn-around times from wafer receipt to shipment to customers were measured in days, not weeks.

Management attention in the latter years of the 1990s decade became very much occupied with the "next act." One important initiative was to begin to develop "wireless engineering skills." The demand for chips for wireless routers was clearly ahead and it was likely that the end products should be produced in the Far East. Radio engineering skills had not been prominent among the Zilog engineering cadre and we hired a wireless engineering training company to come in for advanced radio design seminars. To put this knowledge to use, we began to build wireless "front ends" in the engineering labs using existing ICs to gain experience.

Becoming proficient in what was known as "spread spectrum" technology was an important aspect of our "get ready" R&D. Adoptions of this technology are today widely employed in commercial and consumer microwave data communications equipment. There was a battle going on at the time between the "direct sequence" and the "frequency hopping" methods and we aligned Zilog with experts in both technologies. In 1997 we demonstrated what I believe might have been the first portable telephone that used frequency hopping technology.

  

It was my view that given our strategy of providing end product solutions to our Far East assemblers (cum design-to-production competitors,) being sure that Zilog was prepared to fulfill that role in the emerging wireless generation was urgent. We ramped up our R&D, recruiting, associations and pilot design work in support of that expectation.

When we became part of the Warburg Pincus investment family, we were informed that they tried to limit the life of their funds to not too much more than ten years. By the late 1990s, the fund we were in was at the end of that time frame and wind down was already underway. Zilog was one of the few investments still in the portfolio and it was time to "set it free." There were the usual liquidation options: either make Zilog available for acquisition by another fund or make it available for acquisition or merger.

Zilog was purchased by Texas Pacific Group in a deal that closed at the end of February 1998.

  