

The Change of R&D system of Japanese Chemical Corporations in the 1980's Concerning the Case of Polysilicon business in Tokuyama Corporation

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Abstract When low growth started since the first oil crises, the importance of the R&D section was re-estimated for a lot of chemical corporations in Japan. A new business isn't achieved easily if there is no cooperation with R&D. To connect research with product development directly, the R&D section was put in the business section. As a result, the disorganization of Central Research Institute had to be measured. And the ratio of corporate research has decreased, too. In this paper the history of the R&D system of Tokuyama Corp. is analyzed.

The existence of a leader who can adopt the best investment is important; Yuuji Fujii, director in the planning division, succeeded polysilicon business. He was both an engineer and a manager, and his standpoint worked effectively. He organized the project team, and this business was completed from the start for three years.

Though the process from R&D to a new business is difficult, it is not to be done spending a long time. This is a case shown that the concentration in a short term is good. And it is worth bringing up a lot of talents through forcibly researching, developing and making the business.

But this business was forced to shutdown due to the change in the external environment, appreciation of the yen induced by the Plaza Accord, silicon cycle and Japan-U.S. semiconductor friction. Therefore, the plant shut down for one year. He got the responsibility pursued from management.

However, growth was expected for the semiconductor industry if it looked far ahead. He thought that he was sure to restart the polysilicon business, and to expand development if time passed. It seems that he had such a conviction about a leader's role that he left the company to take responsibility.

This business has grown up as the center business of this company, and the second place in the world that follows the Hemlock Semiconductor Corporation in the polysilicon business for the semiconductor.

The system of R&D of the project initiation type is adopted for a lot of chemical corporations in Japan now. Let me see the change of the R&D system in the 1980's through the case with the polysilicon business of Tokuyama Corp..

1 Introduction

After World War II, chemical corporations in Japan started their revival from the defeat by pursuing European and American technology licensing. Many enterprises constructed large-scale equipment, and aimed at cost reduction during the high economic growth period of the 1960's in Japan. These occupied the center of company activities. There were not so many areas in which research and development became the main activity.

The growth strategy till then was encouraged on a lot of chemical corporations in Japan. But they began to review this strategy after the first oil crisis in 1973, the environmental pollution issue, and measures for safety due to fire accidents of industrial complex.

As the low growth started after the first oil crisis, the importance of the research and development section was re-estimated by many chemical corporations. Chemical corporations were demanded to develop a new business in the 70's. A new business from this time isn't achieved easily if there is no cooperation with the research and development. This is why product development became a complex process, being different from the general-purpose goods development. To maintain and develop the business, the support of the research and development was requested.

Enterprises had collected the grade at various levels according to customer requirements. As the demand standard to customers' products went up, impurities became problems in production. Purity levels had to be raised to the limit in order to comply with high specifications. Therefore, each company expanded its research and development section. To connect research with product development directly, the research and development section was put in the business section. As a result, the disorganization of Central Research Institute was measured. And the ratio of corporate research has decreased, too. This is a change from a past system of the Central Research Institute to the business section research. The change in the research and development strategy is expressed.

When the history of the research and development of Tokuyama Corp. was analyzed, this company added to its business through its own technology of an existing chemical product. It was chiefly done before the first oil crises. "Oil crises and the mercury contamination shock put a brake on our past expansion route. At the same time, the research section changed from an accessory into a hopeful section," said Shikata, former director of Tokuyama Corp., looking back at that time. The theme was decided from the search theme, and the linear model (R&D → manufacturing → market making) came

to be realized. In addition, both the project and research sections cooperated from the start-up, and have advanced to a system of promoting the business.

In the 90's came the depression of the Japanese economy, and the company could not help sparing a lot of resources of the research and development of its company for their continuance and the upgrade of present business. On the other hand, the company also must do research and development that will be connected in the new future. As a result, the conclusion that has been reached in the situation is "University- industry cooperation."

Its own research and development resource cannot be actually distributed though the importance of a new research and development is recognized. Moreover, many new businesses specialize on only one field and find difficulty in relating to two or more fields. They often treat a boundary area, and corresponding by one alone became impossible. In that case, a coordinated third party is acceptable in not only "University" but also "government", and there is actually a lot of "Industry". Additionally, the financial institution is requested to participate. As a result, many chemical corporations have learnt the management technique of "University- industry cooperation". The method of successfully connecting becomes important for these enterprises.

We analyzed how the system of the research and development of the chemical corporations in Japan has changed according to the passing of an era. But the system doesn't function only by management; the idea and the system must coincide in order to make the theme from the research and development to a business reality. The existence of the strong key person who promotes R&D to a business is necessary. Moreover, the reform of the system of the Laboratory is paid attention to here.

2. From the R&D of polysilicon to Commercialization

Tokuyama Corp. had consistently persisted in commercialization by the development of its own technology since was established. However, surviving as a chemical corporation in such a research system became difficult in the 80's. The top management of this company also had recognized that.

This company had done business based on cement, the electrolysis soda, and the petrochemical resin in those days. In the situation with the remaining influences of the first oil crisis, they newly established the energy conservation promotion headquarters. And they made an effort to efficiency improvement and the reduction of energy in the factory. They grandly enhanced the home generation of electricity, and did well. But they felt a sense of crisis in the corporate structure where a large amount of energy was consumed. And they felt the necessity for making a new business that became a new

pillar that would contribute to the future. This company had to begin to move aiming at the establishment of a new business.

Table1 Main products of Tokuyama Corp.

Business Areas		Main Products and Businesses
Chemicals		Caustic soda Propylene oxide Methylene chloride Soda ash Calcium chloride Vinyl chloride monomer/polymer Isopropyl alcohol (IPA) Polypropylene film Microporous film
Specialty products	Si	Polycrystalline silicon Precipitated silica (White Carbon) Fumed silica
	Advanced materials	Aluminum nitride (Shapal) Pharmaceutical intermediates Optical lens materials High purity chemicals for semiconductor base materials Cleaning solvents and systems Ion exchange membranes Dental materials Medical diagnosis systems
Cement, building materials and others		Cement Ready-mixed concrete Plastic window sashes Cement type stabilizer Waste recycling

Source: Compiled from Annual Report 2008, Tokuyama corp. homepage.

On the other hand, in order to strengthen the system of its research and development, Tokuyama Corp. constructed a new laboratory in Fujisawa city, Kanagawa Prefecture. They participated in the research project of the Ministry of International Trade and

Industry in Japan, and sent researchers to domestic and foreign universities. And various research activities were done there. Moreover, they newly founded a planning division in the research and development headquarters besides integrating a policy planning office in the company. The reason was for the necessity for generalizing some foreign projects. The activity of the research and development had become varied and complex, and had to manage various themes of the laboratory. An organization with the intention of strongly promoting the theme of the research project type had been requested.

Yuji Fujii assumed the position of planning manager as chief of the organization in March, 1979. It was when the hangover of the oil crisis had healed a little. Many chemical corporations were seeking a new product to the growth field that became the pillar of new earnings for survival.

The research and development headquarters planning division had some new themes in the field of dental materials etc. However, a big theme that converted the constitution of the entire Tokuyama Corp. did not exist, and there was nothing for the theme that would bear earnings of the company in the future. And Fujii, Director of Planning Division, felt the necessity for producing the theme that became the pillar of a 10 billion yen large-scale. Therefore, to change the theme of the laboratory, Fujii, who originally believed in aims of strong needs, had the chance of a positive discussion with the laboratory members. However, the members who also believed in aims of strong needs did not change their opinions.

Fujii concluded that it was impossible to change the researchers' way of thinking from the inside of the laboratory, even though one year had not yet passed since he assumed the position of planning manager. So, he intended to plan the business project himself. He thought that it was more reasonable for him to command directly to complete the project than to revolutionize the organization indirectly, enlighten the laboratory members, and change their way of thinking.

On December 21, 1981, fifteen members in total gathered. Six people from the planning division, and nine people from manufacturing know-how, research, and patent information sections from Tokuyama factories gathered together. At first, the theme was greatly extended to the field of electronic industry material and biotechnology, etc. They brainstormed among each other, and decided on a few of the many themes that would evolve. Then they divided themselves into teams of two, and investigated each theme. After their investigations, they reported on the hopeful themes. After half a year, the theme to which Fujii had paid attention was one theme in the reported themes that produced polysilicon with Shirangas. However, this theme was not selected, because they did not think it could be realized. The theme of the polysilicon manufacturing

seemed to be hard to achieve and with much risk. It had difficult reasons such as the risk at the exchange change, the silicon cycle, and a possibility that the manufacturing cost was not suitable so that the cost of the electric power was high. At that time, a monocrystalline manufacturer was producing polycrystals also.

However, Fujii decided on this theme at once. He had already raised three standards. They were "Business that becomes 10 billion yen scale," "the expanding business," "Business for which its own strong point can be made the best use of."¹ Fujii thought that manufacturing polysilicon met these three requirements. However, all project members at that time opposed it due to the difficulty of achievement, the risk, and the cost. Fujii's confidence of success was that Tokuyama was producing the most low-priced electricity in Japan in the home generation of electricity. This business produces a departure material of the semiconductor expected to expand in the future, and uses chlorine and hydrogen, etc., which Tokuyama factory is manufacturing and using.

He thought this business was a content of the chemical plant in the majority of the manufacturing process, and they were able to use its own knowhow and had a very strong point. Then, Fujii cancelled all other themes, selected the members further and ordered them to re-inspect the proposal. After all, the project book was made after half a year, and Fujii was facing a management conference. In the conference the opinion separated into the pro and con, and the meeting became complicated. There were a lot of directors who opposed making the business in the managing board, but Fujii repelled the dissenting opinion. It is said that he was quite reckless, saying that "There is no good one to which all members can agree."²

SE-PJ (Silicon Establishment Project) started in June, 1981. It aimed at commercialization of polysilicon. The development of the processing technology of polysilicon was a start from zero for Tokuyama Corp. The technical problem that had to be solved in manufacturing polysilicon was that of how to treat four chloridization Silang that came out in the polysilicon refinement process. Existing companies adopted the method that four chloridization Silang was burnt by hydrogen gas and dry silica was manufactured. However, a strong patent existed in this method. Tokuyama had to solve the problem of treating this by-product by its own technology. The start of the project is from 1981, but the goal of commercial production was set in 1984 three years later. As for the project, a severe process of completing it within two years substantial was

¹ Hideyuki Hirashima, 'Shipudotou no gotoku –Takesyoushirikon no zigyouka– [Like der Sturm und Drang –Commercialization of polysilicon–]', "Gekkan Kagaku Keizai [Monthly Chemical Economy]"September 2003, The Chemical Daily co., p.14.

² Ibid., p.14.

targeted, including the research, development, the design, production, and the order from customers. It was not possible to research by spending enough time, for this target had to be made into a business in a short term. Moreover, it was necessary to fix the design data through experiment, from which the range was limited. The development, experiments, and basic design were all advanced at the same time. In order to commercialize by the deadline, they proceeded with two or more tasks at the same time. Manufacturing polysilicon was the task to make metallic silicon of about 98% of the purity of the eleven nine. A basic content of the process was a refinement in chemical manufacturing. Therefore, the analysis of impurities was important. In this project, they needed to develop the technology that made driving of the entire plant change flexible according to demand. As for consuming a large amount of electric power, the development of the technology that suppressed power cost was also greatly needed.

The research and development was done within the severe time limit. Leader Fujii helped his subordinates to take a necessary device. And, so as not to cause the delay of the research and development by the financial deficit, he was managing it. This project was given in the silica processing as it is lucky. The beginning of the dry silica commercializing was discovered from the data that researcher Yoshio Mitani might throw away as an experiment error. As a result of the effort in a painful research and development, the plant construction of the polysilicon 200t in the annual output, and the dry silica 500t was started in November, 1983, and completed in July, 1984. This project achieved the target of commercialization from the start-up of the project for four years, and from project beginning in two and a half years. At first in the operation of the plant, the troubles were consecutive, and they dealt with the problems. As soon as the supply began, the plant became full operation at once, and the second stage of construction was planned in December. The production of polysilicon reached 1000 tons in annual output in August, 1985. Until 1000t plant construction was finished, the business went well. But the appreciation of the yen induced by the Plaza Accord in September, 1985 and the Japan-U.S. semiconductor friction happened after this. In addition, the profit was not suitable for this business against the wave of the silicon cycle. As for the polysilicon plant of Tokuyama Corp., the operation had stopped for about one year because of these factors.

Fujii had demonstrated a strong lead, and the project was commercialized in a short term. However, it was not possible to act against the economic climate, the decrease in demand, and the exchange market price. The polysilicon business faced the crisis. The promoter Fujii determined himself to undertake all responsibilities. Though nothing is said when the business promoter has succeeded, the responsibility is often asked when

failing once. There is the tendency to give a demerit mark in Japanese companies. He retired from the director of Tokuyama Corp., and left the company in August, 1987. After he left, the semiconductor industry had recovered; also demand started growing, and polysilicon businesses of Tokuyama expanded along with it. The company has reinforced production capacity of 1500t in 1991, 3300t in 1995, 4800t in 2001. This business has grown up as the center business of this company, and keeps developing afterwards. The polysilicon business has become the second place in the world that follows the Hemlock Semiconductor Corporation in the polysilicon business for the semiconductor.

Table2 History of polysilicon manufacturing

1981	R&D beginning	
1984	Production activation	
	Production capacity	200 ton/year
1985	Production capacity	1,000 ton/year
1991	Production capacity	1,500 ton/year
1995	Production capacity	2,000 ton/year
1997	Production capacity	3,300 ton/year
2001	Production capacity	4,800 ton/year
2004	Production capacity	5,200 ton/year

Source: Compiled from Tokuyama Corp. internal material.

3. The Reform of the Laboratory

The new Fujisawa laboratory of Tokuyama Corp. was established for the purpose of promoting to accumulate its own technology based on research and development. In the mass production of general-purpose goods by the introduction of a foreign technology, it was difficult for the company to continue. Many chemical corporations had recognized the necessity for developing their own specific technology and creating new markets. Society and the economical situation had greatly changed since the first oil crisis. The management style of the chemical corporations had changed greatly from mass production and the big sale. The actions against the sudden rise in the price of the raw material, the saving resource measures, the antipollution policy, and responsible concern for the environment, etc. were requested from the chemical corporations. However, a new product from the research and development in the laboratory did not appear easily. There was a sense of crisis in the chemical corporations in Japan, which

might be attacked on three directions from the United States, Europe, and Asian enterprises that were recently gaining power.

As a result, to deal with the new situation, many companies in Japan came to aim at the constitution conversion all together. While observing the movement of a rival enterprise, they chose the road to collecting many kinds of chemical products through research and development. Tokuyama Corp. also did similar movement, and the Fujisawa laboratory was established in such a trend.

Takashi Yoshioka had assumed the second generation head position of the Fujisawa laboratory in 1981. To create a new business, he declared the five "Management ideas in the Fujisawa laboratory." They were: (1) "We must use information over time and space. Do not shut oneself up in the laboratory," (2) "The research aims at the home run of a baseball game. Do not plug away like a bunt," (3) "Commercialization must enter uniquely to a market with R&D results as the weapon. It is uninteresting for us only to imitate it," (4) "Money mustn't be spared, providing you want to utilize an existing technology effectively. Time is money," (5) "On the occasion of making to the business, don't stick to an independent business. It is an age of making the compound forms supplemented with strong points among each other."³ Head Yoshioka denied a linear model of the development sequentially advanced to basic research, applied research, commercialization, and sales. The research and development of the Fujisawa laboratory was to advance a lot of tasks at the same time; doing development of basic technologies, production technology development, patent strategy, and marketing strategy to promote the creation of a new market. The way of thinking in the Fujisawa laboratory was a rejection on the movement for the reconsideration of such a past laboratory. This policy is one example of indicating a direction of R&D and development and the laboratory in Japan at that time.

³ Takashi Yoshioka, Interviews.

Table3 Development of Specialty products business

SP business	Background	Research and project beginning	Commercialization	Key factors of growth
Optical lens materials	Basic research	1976	1984	Material development
Aluminum nitride		1981	1985	A pioneer business
Medical diagnosis systems		1979	1987	It develops into JV.
Pharmaceutical intermediates		1981	1993	Organic synthetic technology
Cleaning solvents and systems		Business project	1975	1977
Dental materials	1981		1984	High technology
Polycrystalline silicon	1981		1984	The largest scale production in Japan
IPA-SE	1983		1984	Technology for realizing high purity
Precipitated silica	1982		1985	Production with silicon

Source: Compiled from Tokuyama Corp. internal material.

The research and development was done under such a policy in the Fujisawa laboratory, and various new businesses were invented in cooperation with the project development department. The laboratory denied the bottom-up type of the past in which the theme was determined from research, and changed its way to the top-down type. Cooperation with the laboratory and the operation division is necessary for the success in the top-down type. If the research and development division doesn't cooperate with the operation division, it won't succeed in making a new business.

4. Conclusion

The polysilicon business making in Tokuyama corp. is the project of the planning initiative type. If there is a plan that other companies cannot adopt when thinking about investment earnings, the existence of a person who can demonstrate strong leadership, deeply understands the technology, and has a managerial sense, is necessary when tying from research and development to making a new business. The existence of the leader who can adopt the best investment is important; he will overcome the difficulty of the present, forecast future, make the best use of its own strong points, and turn on management resources. It is difficult to reach commercialization if the decision of the research, the development, and the management strategy is made separately. In the form that the organization and the person in charge are independent, only partial optimization will be achieved. They will come in conflict with each other due to the division of business, and it won't function well. It is necessary to be united in one person, who gives the decision making from all company viewpoints. In this sense, Fujii in the polysilicon business making was both an engineer and a manager, and his standpoint worked effectively.

The polysilicon business was forced to shutdown due to the change in the external environment, appreciation of the yen induced by the Plaza Accord, silicon cycle and Japan-U.S. semiconductor friction. However, growth was expected for the semiconductor industry if it looked far ahead. Fujii thought that he was sure to restart the polysilicon business, and to expand development if time passed. It seems that he had such a conviction about a leader's role that he left the company to take responsibility.

On the other hand, though the process from R&D to making a new business is difficult, it is not to be done spending a long time. This is a case shown that the concentration in a short term is good. And it is worth bringing up a lot of talents through forcibly researching, developing and making the business. The leader's existence, the management of a short-term concentration, and great capital resources, etc. are important conditions in making a business of a new product.

From the change in environment surrounding chemical corporations in Japan, the laboratory reform had been strongly requested. In the Fujisawa laboratory, a past linear model (basic research → applied research → commercialization → sales) was stopped, and the reform simultaneously moving two or more functions (development of basic technologies, production technology development, patent strategy, and marketing strategy) for new market creation was done. The five "Management ideas in the laboratory" that Yoshioka as the new head declared expresses it. They didn't adopt the

bottom-up type but the top-down type, where the cooperation of the R&D section and the business section was done from the beginning.

However, many enterprises have had to request the basic research from another organizations, such as universities, by the change in such a research system. But the partner isn't limited it to "University." Cooperation with various partners came to be needed in the complex product development that extends to two or more fields. And the companies have to connect many partners with the contract, and do two or more projects simultaneously and concurrently. Therefore, the ability of management to do them is necessary in addition to the accomplishment of R&D.

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