JPRS L/9995

21 September 1981

Japan Report

(FOUO 56/81)

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SCIENCE AND TECHNOLOGY

MIDDLE, NEAR EAST PROVIDE MARKET FOR LARGE PLANTS

Tokyo BUSINESS JAPAN in English Vol 26, No 8 Aug 81 pp 41-43

[Article by Shigeru Matsui]

[Text]

IT was only after the first oil crisis at the end of 1973 that Japan's industrial plant exports to the Middle and Near East began progressing along the right lines. Since then, Japanese enterprises have been exerting efforts to advance into the area in order to secure the oil resources that support Japanese industry and to seek markets for Japanese-made industrial plants.

As indicated in the attached table compiled by the Ministry of International Trade and Industry, Japan's industrial plant exports to the Middle and Near East after fiscal 1975 have shown fluctuations in share and value in relationship to the nation's total industrial plant exports: 21.8% in fiscal 1975, 36.3% in fiscal 1976, 21.5% in fiscal 1977, 16.3% in fiscal 1978, 31.0% in fiscal 1979 and 19.5% in fiscal 1980. This shows that the nation's industrial plant exports to the Middle and Near East increased at the annual growth rate of 24.4% over the past six years.

Currently, the Ministry of International Trade and Industry (MITI) hopes to achieve more than $10 billion a year in industrial plant exports. In fiscal 1979, such exports rapidly increased by 35.2% to $11,780 million as compared with $8,730 million in the previous fiscal year. Even though MITI hoped to see the value of such exports in fiscal 1980 surpass the $10-billion level, they remained at the level of only $8,930 million, showing the first negative growth in the past decade.

The main causes of this decline were the conflict between Iran and Iraq and the uneasy political situation in the Middle and Near East as a whole. Because of the Iran-Iraq war, Japan's industrial plant exports to both countries were suspended. The nation's exports of port facilities to Iraq were also suspended and new negotiations for other exports were postponed.

Nevertheless, MITI plans to export such plants to world markets at a level of more than $10 billion a year. In this case, the largest emphasis is to be placed on exports to the Middle and Near East. In regional shares also, the comparative stability in recent years is expected to result in more negotiations for importing larger plants. Relying on abundant oil dollars, such Arabic oil producing countries as Saudi Arabia, the United Arab Emirates, Kuwait, Qatar, Bahrain, Oman, Iraq and Libya are actively engaged in modernization programs and completing thier industrial facilities and infrastructure. This is quite clear when we see their economic development plans. Egypt, with limited foreign currency reserves in the past, has now become affluent as it is now producing some 600,000 barrels of oil every day and receiving a large amount in fees from the operation of the expanded Suez Canal. Overseas Egyptians are also remitting large amounts of foreign currency to their home country.

In addition to such favorable conditions as stated above, the most attractive fact to Japanese industrial plant manufacturers and exporters is that, except for Egypt, all the Arabic oil producing countries repay the costs of such plants in cash.

Japan sought new markets for industrial plants in China, but the large shift in China's economic policy and its lack of foreign currency reserves have suspended almost all the projects, and negotiations for Japanese industrial plants to be exported have all but stopped. There is no such anxiety concerning plant exports to the Middle and Near East.

Despite such favorable conditions, the political uneasiness in the Middle and Near East could result in revolutions, coups d'etat, terrorism and political changes. Even in these cases, however, it is expected that only those in power would change; the basic policy to modernize the nations would remain. Even in Iran's Islamic revolution that overthrew Shah Pahlavi's regime, the new regime led by Ayatollah Khomeini expresses its strong intention to continue to construct the petrochemical plant which was under construction in a joint venture between the Iranian government and Japan's Mitsui group of enterprises.

As far as Japanese industrial plant manufacturers' efforts to establish some footing in the Middle and Near East are concerned, some quick actions were made without proper study in the beginning as they wanted to achieve some notable results. However, the more they have come to understand the actual situation in these areas and accumulated experiences through their undertakings, the more their moves have become effective. They have now entered a phase of fair competition with rival enterprises from Europe and the United States. They have learned many lessons through encounters with Western enterprises on the spot. There are no longer excessive competitions with their overseas counterparts in this market. Under such circumstances, Japanese industrial manufacturers have been classified quite accurately by the Arabic oil producing countries concerning their fields of specialty, technological capacity, and engineering capabilities. As the background of the excessive competitions in earlier years, there was the fact that Japanese shipbuilders, who were suffering from stagnant business, attempted to export various machines for land use and tried to win orders even through dumping to secure some share in the market.

As the Arab oil producing countries came to know the internal situation and capability of each of the Japanese enterprises, these companies could no longer continue dumping their industrial plants. They have undergone a kind of natural selection and those which could not meet the strict requirements of the Arab oil producing countries have gradually been eliminated from the competition. The requirements imposed by the Arab oil producing countries on the technological level of Japanese enterprises are so severe that those which do not have sufficient engineering capability and technological capacity cannot participate in the biddings.

In the case of industrial plants to be exported to the Middle and Near East, each of the plants is so large in both scale and value that it costs at least from several scores of billion yen to ¥200 billion at the most, several times larger than those being exported to Southeast Asia or Central and South America.

This being the case, therefore, no one Japanese manufacturer can produce alone an industrial plant for which it has received an order; instead, several manufacturers are required to take part on a joint basis in the production of the plant by manufacturing portions in which they are technical more advanced than the others. On the part of the Arab oil producing countries also, this type of joint participation is thought more acceptable and it has become a common practice for the Japanese enterprises to organize international consortiums together with European or U.S. enterprises to jointly fill orders for industrial plants.

In the case of industrial plants to be exported to the Asian region, an individual Japanese manufacturer is able to meet the requirements, but it cannot do so in the case of those to be exported to the Middle and Near East.

Japanese industrial manufacturers are no longer trying to sell their products through dumping, but they have their own fields of specialization and technology and now prefer the method of filling orders on a joint basis with European or U.S. manufacturers through an international consortium.

The types of such international consortiums have become rather fixed in recent years depending on the history of cooperative relations with their Western counterparts as well as how they recognize the technical capability of Japanese industrial plant manufacturers. Unless there is agreement, no consortium can be effectively organized, but once they have achieved a good reputation in supplying industrial plants on a joint basis, the participants in such an international consortium are likely to continue their cooperation over a long period of time.

Under such circumstances, the roles of Japanese trading companies in supplying industrial plants to the Middle and Near East have undergone a marked change.

From the end of 1973 when Japanese enterprises began selling their products to the region, Japanese trading companies with their branches on the spot usually have acted as intermediators for them. Then, the more the Arab countries and Japanese manufacturers have come to mutually understand each other, the more the Japanese manufacturers have taken the initiative in such dealings. In the beginning, however, as labor and tax laws in the Arab countries were vague, Japanese manufacturers had many difficulties. Now, over the past five to six years, they have accumulated experience in such dealings and have become more capable in coping with such problems.

Now that international consortiums are supplying more industrial plants to the Middle and Near East, and Japanese trading companies are playing an important role again in handling such details as the timing of export, exchange hedges, etc. They are playing their role not only as a pilot for Japanese manufacturers but also as major actors on the international competition stage.

Industrial Plant Exports by Region
(Shares are indicated by percentage in value.)

Region \ Fiscal year	1975	1976	1977	1978	1979	1980
Southeast Asia	28.4%	15.8%	21.5%	27.6%	16.0%	27.3%
Middle and Near East	21.8	36.3	21.5	16.3	31.0	19.5
Western Europe & North America	2.7	4.1	5.7	2.5	3.9	8.6
Central & South America	19.4	14.7	9.6	23.2	5.0	8.9
Africa	6.1	10.2	22.7	7.3	7.1	18.4
Oceania	0.7	0.8	1.4	3.7	0.4	3.0
Communist Bloc	20.9	18.1	17.6	19.4	36.3	14.3
Amount of Order Acceptances (in $1 million)	5,240	8,010	8,610	8,730	11,780	8,930

Source: Ministry of International Trade & Industry

Now both industrial plant manufacturers and trading companies have accumulated more than seven years experience. As there was a period of dumping in the beginning, some of the manufacturers and trading companies have already been eliminated through natural selection. Those which have endured have become more confident of their ability to provide the Middle and Near East with required products. Japanese enterprises which have achieved good results in one Middle and Near East country are trying now to advance into other Middle and Near East countries.

There are still some problems for Japanese enterprises to solve as they expand their industrial plant exports.

One Japanese trading company man advocates that Japan should try to obtain contracts to export industrial plants for use in sanitation facilities and infrastructure as it is important for Middle and Near East countries to promote their urban development plans in the process of their modernization. Mitsubishi Corporation, for instance, has received an order for industrial plants for use in city planning and urban development from Iraq. These plants will be used in the Bagdad development programs.

It is quite rare for any Middle or Near East country to place orders with foreign industrial plant manufacturers for such plants based on their own ideas. It is more common for them to place orders if they have recognized the concrete plans suggested by the foreign plant manufacturers as appropriate to their needs. These countries can afford to spend sufficient funds in oil dollars, but they are still in the planning stage concerning their use. It is, therefore, the most effective business approach for any foreign industrial plant manufacturer to suggest to them concrete plans for building the industrial plants that are considered important for their modernization and industrializaiton. In this case, these industrial plant manufacturers must fully utilize information they have obtained in advance and develop good personal relationships. Results of field studies they have conducted are also essential.

It has been rather difficult for Japanese industrial plant manufacturers to obtain statistics and data concerning these countries and conduct field studies as they are relatively newcomers to this market as compared with their European or U.S. counterparts who have established a firm footing in the Middle and Near East.

In conducting consulting activities for Middle and Near East countries also, Japanese enterprises are markedly less experienced than their Western counterparts. They lack background information, knowledge of human relations and capability in negotiations. In addition, their Western counterparts have assumed important positions in the governments and enterprises of Middle and Near East countries, virtually working as consultants for these countries.

These gaps between the Japanese plant manufacturers and their Western counterparts result in a marked difference in order acceptances from these countries. Japanese manufacturers cannot depend solely on their technological capability.

Nevertheless, as long as they wish to place emphasis on the export of industrial plants to the region, they are urged to expand their sources of information and improve their capability for successful negotiations and their linguistic ability. While achieving good results in business, they are also urged to strengthen their consulting departments. Fortunately, all the Japanese trading companies, industrial plant manufacturers and engineering companies related to industrial plant export to the Middle and Near East are becoming more and more confident of their capability in doing business with the region.

CSO: 4120/327

SCIENCE AND TECHNOLOGY

ALUMINUM INDUSTRY STRUGGLING FOR SURVIVAL

Tokyo BUSINESS JAPAN in English Vol 26, No 8 pp 93-98

[Text]

THE Japanese aluminum smelting industry, which seemed to have come out of the recession from the latter half of 1979 to the first half of 1980, slipped back to another structural recession as a result of the second oil shock in 1980, the worldwide recession and the yen appreciation. The industry's very existence is being threatened.

The Ministry of International Trade and Industry (MITI) has reopened the Aluminum Subcommittee of the Industrial Structure Council, which is currently working on radical measures to save the industry and is expected to submit a report to the MITI minister soon and to have the measures implemented as part of the government's policy for fiscal 1982. According to the draft of the report, Japan's aluminum smelting capacity will be reduced to around 700,000 tons annually. This is less than half of the 1,630,000 tons in 1977, before the first structural reform, and 410,000 tons less than the 1,110,000 tons recorded after that reform. With such a prospect, all-out efforts will be made to devise a new tariff policy, make import adjustments, conclude special contracts for the supply of electric power, promote the overseas operation of Japanese smelters, and develop a new smelting method which does not require much electric power.

From 1979 to the first half of 1980, the aluminum smelting industries of the Free World, especially major U.S. and Canadian firms which have access to low-cost hydroelectric power produced at home, achieved record results. At that time, the spot import price of aluminum ingots rose to $2,000 per ton because of the worldwide short supply. In April 1980, the import price peaked to nearly ¥660,000 per ton. The domestic market price of aluminum ingots, too, was raised to ¥568,000 in April, representing a 75% price increase in one and a half years. The aluminum industry turned into the black and its accumulated deficit appeared as if it would be eliminated soon.

The second oil shock, however, plunged the world back into recession. The supply-demand relationship of aluminum ingots was reversed overnight, resulting in an oversupply, and the import price plummeted. With the yen appreciation on top of this, the duty-paid import price of aluminum ingots dropped to ¥380,000 per ton. The domestic market price, even though it was lowered by ¥20,000 to ¥488,000 in January this year, was still higher than the spot import price by a margin of ¥100,000. As a result, the sales of domestically produced ingots declined sharply and the stock of the aluminum smelting industry, which had shrunk to 75,000 tons at the end of March 1980, increased to 240,000 tons in just one year. What is even worse for the structural recession, the cost of smelting aluminum is rising in step with the rising oil prices.

According to MITI estimates, the supply of aluminum ingots in fiscal 1981 (April 1981 - March 1982) will be 1,720,000 tons (840,000 tons domestically produced and 880,000 tons imported), down 10.4% from 1,919,000 tons in the previous fiscal year. The red-ink domestic production is expected to shrink to the extent

Table 1. Supply and Demand Statistics for Aluminum Ingots

(Unit: 1,000 tons, %)

Fiscal year / Item	1977	1978	1979	1980 1st half (actual records)	1980 2nd half (esti-mates)	1980 Total	1981 Esti-mates	Growth rates (%) 1978–1979	Growth rates (%) 1979–1980	Growth rates (%) 1980–1981
Production,	1,188	1,023	1,043	559	480	1,039	840	102.0	99.6	80.8
Imports	472	757	678	421	459	880	880	89.6	129.8	100.0
Supply total	1,660	1,780	1,721	980	939	1,919	1,720	96.7	111.5	89.6
Domestic demand,	1,409	1,715	1,848	830	683	1,513	1,690	107.8	81.9	111.7
exports	103	22	2	3	3	6	6	9.1	300.0	100.0
Demand total	1,512	1,737	1,850	833	686	1,519	1,696	106.5	82.1	111.7
Term-end stock	417	323	209	360	580	580	604	64.7	277.5	104.1

Table 2. Supply and Demand Statistics for Aluminum Rolls

(Unit: 1,000 tons, %)

Fiscal year / Item	1977	1978	1979	1980 1st half (actual records)	1980 2nd half (esti-mates)	1980 Total	1981 Esti-mates	Growth rates (%) 1978–1979	Growth rates (%) 1979–1980	Growth rates (%) 1980–1981
Production,	1,227	1,453	1,607	740	570	1,310	1,440	110.6	81.5	109.9
Imports	19	23	31	32	10	42	45	134.8	135.5	107.1
Supply total	1,246	1,476	1,638	772	580	1,352	1,485	111.0	82.5	109.8
Domestic demand,	1,168	1,367	1,568	744	557	1,301	1,431	114.7	83.0	110.0
Exports	75	102	65	19	26	45	50	63.7	69.2	111.1
Demand total	1,243	1,469	1,633	763	583	1,346	1,481	111.2	82.4	110.0
Term-end stock	27	32	31	37	34	34	38	96.9	109.7	111.8

that it is surpassed by imports.

The demand in fiscal 1981 is estimated at 1,696,000 tons (1,690,000 tons for domestic demand and 6,000 tons for exports), up 11.7% over 1,519,000 tons in the previous fiscal year. Despite this increase, the demand still being smaller than the supply, the total stock is estimated to increase by 4.1% to 604,000 tons. The stock stood at 209,000 tons at the end of fiscal 1979 (at the end of March 1980) but increased almost threefold to 580,000 tons by the end of fiscal 1980. This shows a wide fluctuation in the Japanese aluminum industry.

With respect to the aluminum rolls industry, which is the main user of aluminum ingots, it is estimated that the supply of aluminum rolls in fiscal 1981 will be 1,485,000 tons (1,440,000 tons domestically produced and 45,000 tons imported), up 9.8% over the previous fiscal year and the demand will be 1,481,000 tons (1,431,000 tons for domestic demand and 50,000 tons for exports), up 10%. Accordingly, the term-end stock is estimated to be 38,000 tons, up 11.8%. In view of the production peak of 1,607,000 tons in fiscal 1979, the aluminum processing industry now lingers at a deplorably low level and sees difficult years ahead.

As is well known, about 15,000 kilowatt-hours of power is required to refine one ton of aluminum ingots. In the case of the Japanese aluminum smelting industry, which depends on oil-burning thermal power for as much as 70% of its energy needs, the cost of generating the same amount of power is around 15 yen. In Europe, where only coal is used to generate thermal power for smelting purposes, a kilowatt-hour of power costs 9 - 10 yen. Obviously, Japan has little competitive advantage in the world market. In the Japanese aluminum smelting industry, power expenses account for 40% of the smelting costs.

MITI became concerned that Japanese aluminum smelting firms, except those factories provided with the

Table 3. Overseas Aluminum (Alumina) Smelting Projects Related to Japan

	Projects	Production capacity (1,000 tons per year)	Production capacity: Japan's share	Power source	Stage of development
Development projects and imports to Japan	Enzas (New Zealand)	152	75	Hydroelectric power	Completed 1977, now in operation
	Alpac (Canada)	90	45	Hydroelectric power	Completed 1977, now in operation
	Venalum (Venezuela)	280	160	Hydroelectric power	Completed 1979, now in operation
	Almax S.C. (U.S.A.)	180	45	Coal-burning thermal power	Completed 1980, now in operation
	Asahan (Indonesia)	225	225 - α (α: Indonesia's share)	Hydroelectric power	Scheduled for completion in 1982
	Gladstone (Australia)	203	101	Coal-burning thermal power	Scheduled for completion in 1982
	Alfar (Australia)	236	47	Coal-burning thermal power	Scheduled for completion in 1984
	Alcan, Gladstone, Capricorn (Australia)	99	44	Coal-burning thermal power	Scheduled for completion in 1983
	Albras (Brazil)	320	160	Hydroelectric power	Scheduled for completion in 1984
	Alnorte (Brazil)	Alumina 800	320	–	Scheduled for completion in 1984
	Worthree (Australia)	Alumina 1,000	1,000	–	Scheduled for completion in 1984

means of generating hydroelectric power of their own (e.g. Nippon Light Metal Company's Kamahara Factory), might fail, and reopened the Aluminum Subcommittee of the Industrial Structure Council, which is now working on the second structural reform. The subcommittee has agreed that it is necessary to preserve at least some of Japan's aluminum smelting facilities in view of national security. According to the measures outlined for the aluminum smelting industry now under discussion, the "Aluminum Smelting Industry Provisional Measures Law" will be enacted and the following measures implemented.

Reducing power costs

A system of low "policy rates" will be introduced. Also, subsidies will be provided for switching from the use of heavy oil alone to generate power to coal-burning thermal power.

Rationalizing imports

In order to restrain the import of aluminum ingots, MITI will raise the tariff and introduce a tariff quota system, under which a specified amount will be imported duty-free. Also under consideration is the advance checking system for imports.

Promoting technological development

The government will be encouraged to subsidize research and development of the blast furnace method. The government and the private sector will combine their efforts to invest ¥20 - 30 billion in this big project over six or seven years.

Consolidating financial assistance

Low-interest loans will be provided to promote such constructive measures as the shifting of energy sources and their development and import. In addition, measures such as emergency loans, deferred repayment and suspension of debts will be adopted to cope with the difficulty of raising short-term funds at the time of sudden changes in the supply-demand balance and also, with the increase in accumulated debts.

The above-listed measures are based on the premise that the annual domestic smelting capacity will be reduced to around 700,000 tons. The change in capacity from 1,640,000 tons before the first structural reform to 1,110,000 tons and then to 700,000 tons gives some idea of the painful situation in which the Japanese aluminum smelting industry finds itself.

Table 4. Investments and Loans (Unit: ¥100 million)

Fiscal year	1979	1980	1981	1979–1980	1980–1981
Value of investments and loans	686	988	1,626	144.0	164.6

If the recession is over, the demand for aluminum ingots will exceed two million tons in two or three years. About a third of this is to be met by domestic production. Although domestic production entails high smelting costs as compared with imports, an overall price adjustment can be made by importing aluminum ingots refined by Japanese smelters operating abroad and those by foreign smelters.

Japanese aluminum smelters are now jointly working on the development of the aluminum chloride process which is claimed to consume less than 10,000 kilowatt-hours of power to refine one ton of aluminum ingots.

They are also expected to join with MITI in the development of the blast furnace process, which makes use of home-produced clay. In this process, clay is mixed with coke and a solvent in the blast furnace to reduce alumina contained in the clay at a temperature of 2,000°C to obtain aluminum ingots. The Mitsui Group which includes Mitsui Alumina Company is ahead in this field of research.

Although much difficulty is involved in developing this process, it consumes only 1,500 kilowatt-hours of power to refine one ton of aluminum ingots and, for this reason, would remain unaffected by the high cost of oil and surely will prove to be one of the great inventions of the world.

It is most likely, however, that foreign countries will object to MITI measures such as tariff increases and import adjustment, from the viewpoint of liberalization of trade. The domestic aluminum-consuming industries, too, will find MITI measures hardly tenable. It may be difficult, but it will be necessary to settle problems of this kind before any final report can be submitted. ◻

CSO: 4120/327

SCIENCE AND TECHNOLOGY

HIGH-POLYMER WHISKER CRYSTALS SHOW GREAT PROMISE

Tokyo BUSINESS JAPAN in English Vol 26, No 8 Aug 81 p 54

[Text]

THE whisker, sometimes called the "whisker crystal," is a filament-like single crystal resembling a cat's whisker. If it is without flaws, it has outstanding mechanical strength.

Research on whiskers started in Japan about ten years ago. Various whiskers consisting of metals and other inorganic substances have been developed so far. However, it is rather difficult to manufacture high-quality and inexpensive whiskers containing few impurities and conforming to industrial standards.

Now Sony Corporation and the Research Institute for Polymer and Textiles, Agency of Industrial Science & Technology, have jointly established the world's first manufacturing process for high-polymer (plastic) whiskers. Plastic compound materials containing these whiskers as a reinforcing substance permit practical applications.

Plastic whiskers are not yet available in any other country, although numerous types of whiskers made of metals and inorganic substances are available. This is the first instance where industrial materials containing high-polymer whiskers have been developed in Japan.

Sony plans to use whisker-reinforced plastic for the oscillating plates of speakers. Besides having high elasticity comparable to that of carbon-reinforced plastic, the new whisker-reinforced plate is isotropic, that is, its physical properties do not vary with direction. Hence, wide applications are anticipated.

Recently introduced whiskers, chemically known as polyoxymethylene whiskers, were successfully aynthesized about eight years ago in the laboratories of the Research Institute for Polymers and Textiles. Joint research with Sony has finally resulted in the perfection of a process which enables the continuous production of high-quality whiskers almost free from flaws.

The new whiskers are not produced in the form of discrete filaments, but assume the form of tens (or hundreds) of filament-like single-crystals of about 1 - 3 microns in diameter and 150 microns in length growing from a common center in the shape of a sea-urchin.

Their specific gravity (1.49) is smaller than that of carbon fiber (about 1.7). Consequently, they diffuse uniformly in a plastic medium and develop outstanding wetting and adhesion properties.

Sony is testing various polymers, including epoxy resin and polyolefin, as materials suitable for the manufacture of compound whiskers. One recently perfected high-polymer type of whisker has an extremely high Young's modulus of about 10^{11} newtons per m^2. The speed of sound in the whisker-reinforced plastic is 9,000 m/sec. or 1.8 times faster than that in aluminum or titanium, so that the material is ideal for incorporating into audio equipment.

Tensile and bending strength of plastic containing high-polymer whiskers have not been measured yet, for research is at present directed on applications in the audio field. It is believed, however, that this plastic will serve as a very durable isotropic material.

Silicon carbide whiskers are sold at relatively low prices in the United States. Carbide- and tungsten-derived whiskers were sold in Japan, too, at one time, but they have subsequently disappeared from the market. In this sense, perfection of the production process of these high-polymer whiskers at this time is highly significant.

A leading specialist in this field of research in Japan said: "The use of high-polymer reinforcing material is preferable in the manufacture of plastic materials from the standpoint of wetting. High-polymer whiskers may reduce the formation of voids in molded products. At any rate, this invention is very interesting and could open up new fields of application." ◘

CSO: 4120/327

SCIENCE AND TECHNOLOGY

NEW POLYIMIDE RESIN DEVELOPED FOR PRINTED CIRCUIT BOARD

Tokyo HITACHI HYORON in Japanese Apr 81 pp 15-20

[Article by Kenji Tsukanishi, Shunya Yokozawa, Motoyo Wajima, Akio Takahashi, and Takeshi Shimazaki of Hitachi, Limited]

[Text] A multilayer printed circuit material base using polyimide family resin was developed previously for the purpose of forming high density, high reliability, and highly heat resistant printed circuits, but there were problems associated with their stacked layer workability and hardening properties. Because of this history, a new polyimide resin with superior workability and hardening properties, along with material for use with printed circuits (copper clad laminate possesses superior dimensional stability and heat resistance while the prepreg for multilayer adhesion has superior formability, making possible the preparation of a highly reliable multilayer printed circuit board.

This paper introduces the features of this resin, the properties of this material for multilayer printed circuit use, and the properties of the multilayer printed circuit board.

1. Introduction

A material to be used as the base for high density, multilayer printed circuits must offer high reliability and good heat resistance when used in a printed circuit board. In this connection, polyimide resin was studied and attempts to make practical use were initiated. Now, the polyimide family resins which were studied previously were beset with the problems of long forming cycles and narrow operating range compared with the epoxy resins in use in copper clad laminate board (hereafter referred to as MCL), multilayer adhesion use prepreg (hereafter abbreviated prepreg), or multilayer printed circuit board (hereafter abbreviated multilayer board).

A study of the resin and hardening agents was initiated, and a new heat resistant polyimide resin of good workability "HI-L," multilayer material MCL-I-67, and prepreg GIA-67N were developed. This paper introduces the various features of this new resin and the properties of the multilayer material when used in practical situations along with the conditions employed in the manufacture of the multilayer board.

2. High Density Multilayer Board and Uses of This Material

The multilayer board is a printed circuit board with circuits within its inner layers. The process for the manufacture of this board is outlined in Figure 1. Inner layer circuit boards with MCL finished circuits and prepreg were stacked together, press-heated in a multilayer press, and fused into a unitized body. This was followed by hole drilling and hole sealing operations, just as in board printed on both surfaces to obtain multilayer board. At present, multilayer boards of three-eight layers are the most commonly used, and the materials used include glass fabric as the base material and epoxy resin as the binder in the MCL and prepreg.

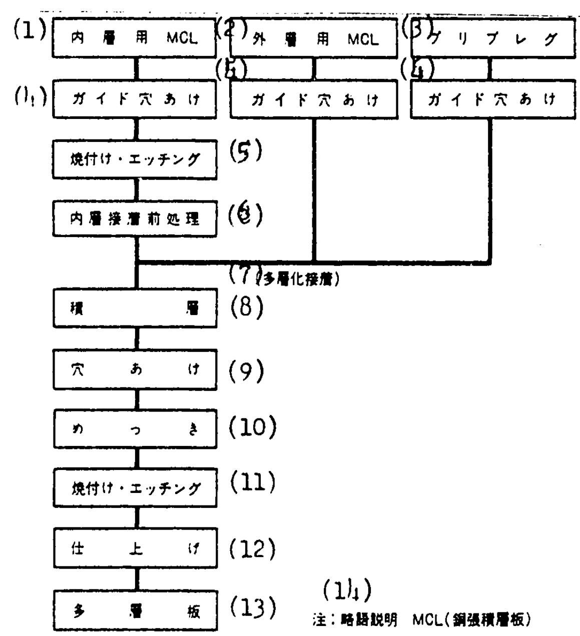

Figure 1. Outline of Multilayer Board Manufacturing Process

Inner layer MCL is circuit finished, prepreg is inserted between inner layer MCL and outer layer MCL. Multilayer bonding is possible by applying pressure and heat.

Key:
(1) inner layer use MCL
(2) outer layer use MCL
(3) prepreg
(4) drilling guide holes
(5) baking, etching
(6) inner layer adhesion pretreatment
(7) multilayer bonding
(8) stacked layers
(9) hole drilling
(10) plating
(11) baking, etching
(12) finishing
(13) multilayer board
(14) Note: explanation of abbreviation MCL (copper clad stacked layer board)

Information processing electronic equipment such as computers use large quantities of LSI, and this equipment is becoming larger, higher speed, and more multifunctional. As a result, the printed circuits which play important roles in interelement connections have to possess even better attributes. The distribution lines have to be shortened in order to improve treatment speed, and the number of distribution lines has to be increased to enable highly densified equipment[1,2] making necessary high density distribution lines (reduction of interplanar spacing, increase in the number of interplanar lines, increase in the number of layers and use of interstitial fiber).

An example is given in Table 1 and Figure 2.

Table 1. Example of High Density Multilayer Board. The number of layers, the inter-lattice spacing, and the number of inter-lattice lines are more dense compared with general purpose multilayer board.

Item	High density multilayer board	General multilayer board
Number of layers (layers)	12 - 26	3 - 8
Inter-lattice distance (mm)	1.27, 2.54	2.54
Number of inter-lattice lines (lines/lattice)	1-2/1.27, 2-4/2.54	1-2/2.54
Interstitial buyer hole	present	not present
Board thickness (mm)	3 - 5	1 - 2
Hole diameter (after drilling)	0.4 - 0.8	0.7 - 1.1
Board thickness-hole diameter ratio (after drilling)	5 - 10	2 - 3

A polyimide resin family material is needed for this type of high density multilayer application because of its superior dimensional stability and heat resistance.[2] When compared with the epoxy family of resins, polyimide resin family material has very little smear formation due to heat generated during drilling. Also, it has small thermal expansion in high temperature heating, and as a result there is high reliabii-ty of through-hole connections at the time of thermal shock. On the other hand, compared with epoxy resins, many problems are associated with the polyimides which are presently being mass produced for such applications. Viewed from the production standpoint, polyimide resins (and denatured polyimide resins) will only dissolve in a special high boiling solvent such as N-methyl-2-pyrolidone, so that workability may suffer at times. More specifically, when glass fabric is soaked with this resin and coated fabric for MCL use or prepreg is manufactured, drying at high temperature to remove the solvent residues still leaves behind considerable residual solvent in the coated fabric or the prepreg, and this may cause the product to lose the heat resistant property which is the specific feature of this class of material.

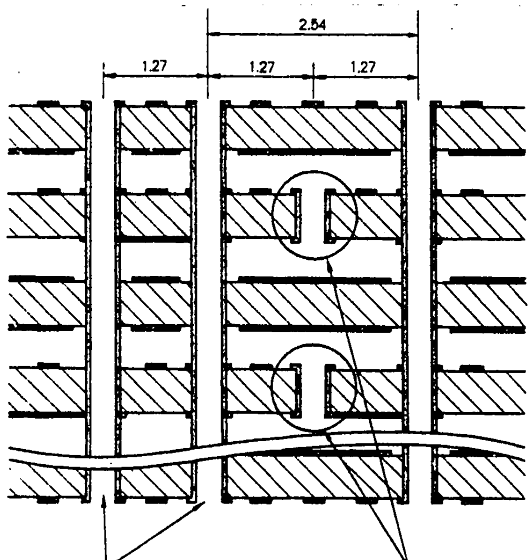

Figure 2. Example of High Density Multilayer Board

By the placement of interstitial buyer holes many more signal layers can be connected for the same number of lattices.

Key:
(1) Interstitial hole
(2) Interstitial buyer hole

At the same time, viewed from the manufacturing end of multilayer board, the high melt viscosity of prepreg is responsible for poor formability during the multilayer bonding operation, the slow reactivity necessitates long forming cycles resulting in reduced workability, and the slow rate of setting at high temperature results in circuit shifting and reduced interlayer adhesive strength--these are some of the problems which are encountered.[3]

3. Features of the New Heat Resistant Polyimide Resin "HI-L"

The new heat resistant polyimide resin "HI-L" is a resin in which several types of functional groups of superior reactivity have been introduced, which has the workability of epoxy resins and the heat resistance of polyimide resins. Its characteristic features are discussed below.

(1) It is readily soluble in low boiling point solvents.

Because "HI-L" resin dissolves readily in low boiling point solvents, it has a wide range of drying temperatures which can be exploited during painting operations, the degree of reaction is readily controlled, and the same type of workability as in epoxy resins can be realized.

(2) The melt viscosity of the prepreg resin is low.

Because low boiling point solvent is used with "HI-L" resin, it is possible to obtain prepreg with low volatile component at low temperature. At the same time, it is possible to control the degree of reaction at a low level, thereby enabling the preparation of prepreg with low melt viscosity at the time of multilayer bonding, as a result of which multilayer bonding is possible at the same temperature and pressure as with epoxy resin.

(3) It has superior setting property.

The presence of several types of functional groups of superior reactivity gives "HI-L" resin superior setting behavior compared with polyimide resins of the past.

An example of this comparison in the form of measurement results obtained through hardening with a JSR type Curastometer at 170°C is shown in Figure 3. The graph shows that "HI-L" resin is adequately hardened after 60 minutes, just as with epoxy resin. At the same time, a product with a transition temperature greater than 200°C can be obtained under hardening conditions of 60 minutes at 170°C. As a result, the posthardening process usually deemed necessary for polyimide resin is no longer needed, and multilayer plate of good location precision is obtained.

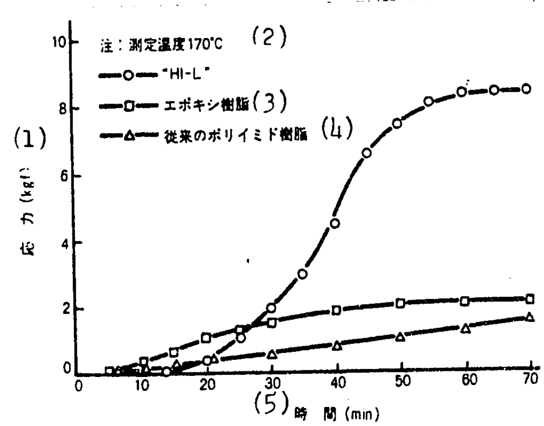

Figure 3. Hardness Characteristic of Prepreg Resin

"HI-L" has high stress, saturates in short time, and has superior hardness

Key:
(1) Stress
(2) Note: Measured at 170°C
(3) Epoxy resin
(4) Polyimide resin in the past
(5) Time

Table 2. General Properties. MCL-I-67 has greater solder resistance and glass transition temperature compared with epoxy MCL

(1) 項目	(2) 単位	(3) 処理条件*	(4) MCL-I-67 (ポリイミド)	(5) MCL-E-67 (エポキシ)
(6) はんだ耐熱性	s	A (7)	300℃, 180以上	300℃, 20～30
(8) 引きはがし強さ	kgf/cm	A	1.5～1.6	1.8～2.0
(9) 曲げ強さ	kgf/mm^2	A	50～55	50～55
(10) 絶縁抵抗	Ω	A	10^{14}～10^{15}	10^{14}～10^{15}
		D-2/100	1.5～2.5×10^{13}	1.0～2.0×10^{13}
(11) 表面抵抗	Ω	A	10^{14}～10^{15}	10^{14}～10^{15}
		C-96/40/90	10^{13}～5×10^{14}	10^{13}～5×10^{14}
(12) 体積抵抗率	Ω·cm	A	10^{14}～10^{15}	10^{14}～10^{15}
		C-96/40/90	5×10^{13}～10^{14}	5×10^{13}～10^{14}
(13) 誘電正接 (1 MHz)	—	A	0.010～0.015	0.017～0.020
		D-48/50	0.012～0.017	0.020～0.023
(14) 誘電率 (1 MHz)	—	A	4.5～5.0	4.7～5.0
		D-48/50	4.6～5.0	4.9～5.1
(15) 吸水率	%	D-24/23	0.15～0.20	0.10～0.15
(16) 耐燃性 (UL-94)	—	A	3.5(0～15)	2.5(0～8)
		E-168/70	4.0(0～15)	2.0(0～9)
(17) ガラス転移温度(Tg)	℃	—	210～220	115～125
(18) 熱膨張係数 (厚さ方向)	$℃^{-1}$	(Tg以下) (19)	5.0×10^{-5}	5.5×10^{-5}
		(Tg以上)	1.5×10^{-4}	2.5×10^{-4}

(20) 注：* 処理条件は次のことを表わす。A(受理状態)、D-2/100(100℃の煮沸水中に2時間浸せきする。)、C-96/40/90(40℃90%RHの恒温、恒湿の気中で96時間処理する。)、D-48/50(50℃の恒温水中に48時間浸せきする。)、D-24/23(23℃の恒温水中に24時間浸せきする。)、E-168/70(70℃の恒温の気中で168時間処理する。)

Key:
(1) Item
(2) Unit
(3) Treatment conditions*
(4) MCL-I-67 (polyimide)
(5) MCL-E-67 (epoxy)
(6) Solder resistance
(7) More than 180 seconds at 300°C
(8) Peeling strength
(9) Bending strength
(10) Insulation resistance
(11) Surface resistance
(12) Volume resistance ratio
(13) Dielectric tangent
(14) Dielectric constant (1 mHz)
(15) Moisture absorbency rate
(16) Heat resistance
(17) Glass transition temperature
(18) Thermal expansion coefficient (in thickness direction)
(19) (less than Tg)
(20) Note: *The following treatment conditions were applied. A (reception state), D-2/100 (immersion in boiling water at 100°C). C-96 40/90 (40° 90 percent RH constant temperature and constant humidity air treatment for 96 hours). D-48/50 (48 hours immersion in 50°C water). D-24/23 (24 hours immersion in 23°C water). E-168/70 (168 hours treatment in 70°C constant temperature air)

4. Properties of MCL-I-67

The properties of polyimide resin MCL (hereafter called polyimide MCL), MCL-I-67, are compared with self-extinguishing resin MCL (hereafter called epoxy MCL), MCL-E-67 (FR-4) and described. The tests were conducted by JIS-C6481, except for certain special members.

4.1 General Properties

Some general properties are shown in Table 2. After 180 seconds at 300°C, MCL-I-67 not only showed no swelling and peeling behavior, but it displayed thermal properties superior to those of epoxy MCL. The other properties were roughly the same.

4.2 Thermal Properties

Table 2 lists the glass transition temperatures (Tg) and linear expansion coefficient in the thickness direction, while the dimensional changes in the thickness direction are given in Figure 4. The thermal expansion in the thickness direction is smaller than that of epoxy MCL. This is why in the event thermal stress is applied, crack generation at the through-holes is suppressed.

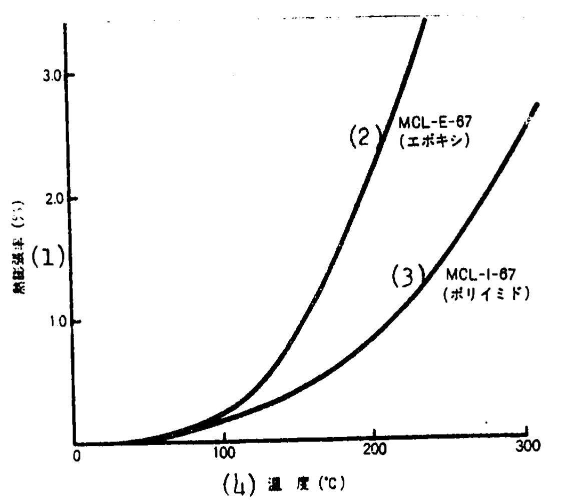

Figure 4. Thermal Expansion in Thickness Direction

MCL-I-67 has low thermal expansion, making it effective against cracks forming in through-holes

Key:
(1) Themal expansion coefficient (percent)
(2) MCL-E-67 (epoxy)
(2) MCL-I-67 (polyimide)
(4) Temperature (°C)

4.3 Thermal Deterioration Behavior

In order to estimate heat resistant life, bending strength after long-term high temperature treatment was measured. The time required for the bending strength to drop down to 50 percent of its initial value was determined, and the result is shown in Figure 5. The result led us to predict that continuous use at high temperature above 200°C is possible.

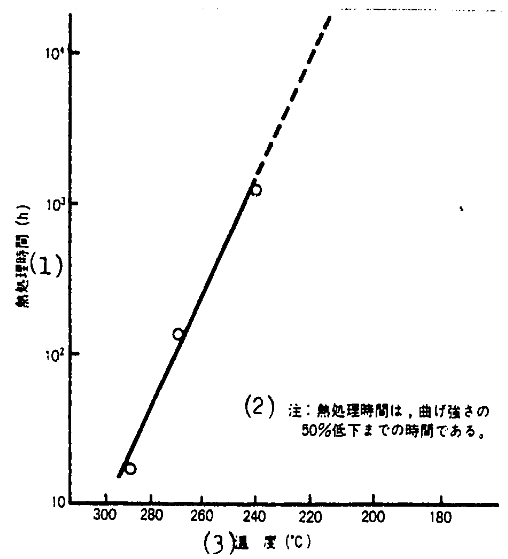

Figure 5. Themal Degradation Property of MCL-I-67.

It is estimated from the thermal degradation properties observed at 240°C, 270°C and 290°C that continuous use at temperature above 200°C is possible

Key:
(1) Treatment duration (h)
(2) Note: thermal treatment time is time for bending strength to fall to 50 percent of its initial value
(3) Temperature (°C)

4.4 Temperature Dependency

The temperature dependencies of the various properties were compared with those of epoxy MCL. Antipeeling strength results are shown in Figure 6, bending strength in Figure 7, and dielectric constant at 1 MHz in Figure 8.

MCL-I-67 undergoes small changes in properties with changes in temperature, making its use possible over a wide temperature range.

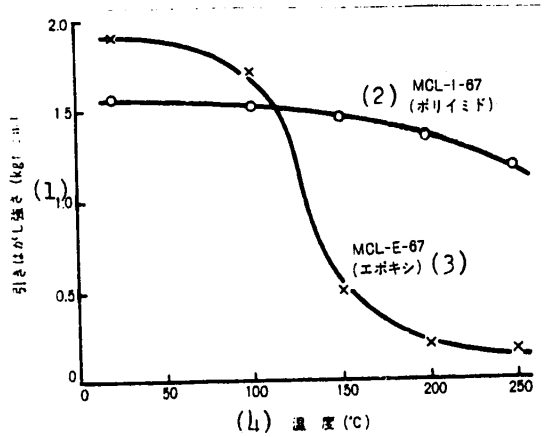

Figure 6. Temperature Characteristic of Peeling Strength

MCL-I-67 has low value at room temperature and the decrease at high temperature is small

Key:

(1) Peeling strength (kgf/cm)
(2) MCL-I-67 (polyimide)
(3) MCL-E-67 (epoxy)
(4) Temperature (°C)

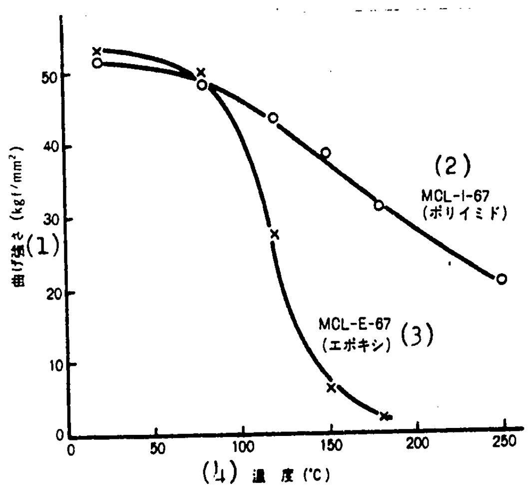

Figure 7. Temperature Characteristic of Bending Strength

MCL-I-67 suffers little decrease in bending strength at high temperature

Key:

(1) Bending strength (kgf/cm)
(2) MCL-I-67 (polyimide)
(3) MCL-E-67 (epoxy)
(4) Temperature (°C)

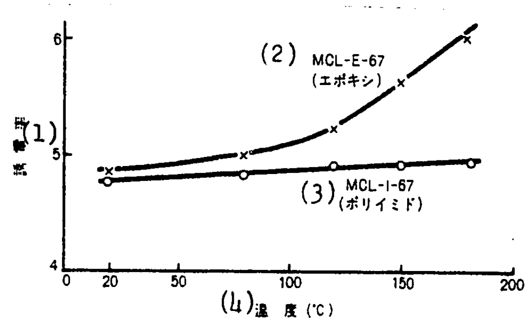

Figure 8. Temperature Characteristic of Dielectric Constant

MCL-I-67 suffers little change and has superior temperature characteristics

Key:

(1) Dielectric constant
(2) MCL-E-67 (epoxy)
(3) MCL-I-67 (polyimide)
(4) Temperature (°C)

4.5 Moisture Resistance

Surface resistance was measured on test material which had been treated at 90 percent RH at 40°C in order to evaluate the moisture resistant property using a comb-shaped pattern for the measurement. As seen in Figure 9, the moisture resistance is of the same order as that of epoxy MCL, indicating its superior moisture resistance.

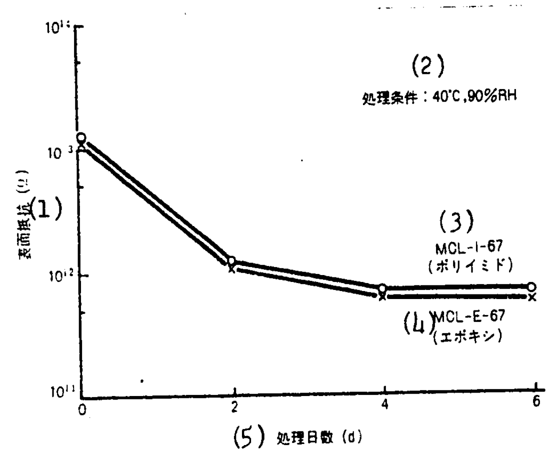

Figure 9. Moisture Absorbing Property of Surface Resistance

This is roughly the same as that of epoxy MCL, and it has superior moisture resistance

Key:

(1) Surface resistance
(2) Treatment conditions
(3) MCL-I-67 (polyimide)
(4) MCL-E-67 (epoxy)
(5) Treatment time (d)

5. Properties of GIA-67N and Multilayer Bonding Conditions

5.1 Properties of Prepreg GIA-67N

Some properties of GIA-67N and epox prepreg GEA-67N are listed in Table 3. GIA-67N can have its properties varied in the same range as epoxy prepreg, and prepreg production adjusted to multilayer adhesion conditions is possible.

Table 3. Properties of Prepreg. GIA-67N has properties on nearly the same order as those of epoxy prepreg

Item	Unit	GIA-67N (polyimide)	GEA-67N (epoxy)
Resin content	percent	50 - 56	53 - 58
Volatile fraction	percent	0.3 - 0.5	0.2 - 0.5
Resin flow	percent	33 - 38	35 - 40
Gelling time (70°C)	s	200 - 300	120 - 200
Melt viscosity (30°C)	P	100	100

Table 4. Conditions for Multilayer Bonding. GIA-67N can be subjected to multilayer bonding under the same conditions as epoxy prepreg and has superior workability

Item	Unit Unit	GIA-67N (polyimide)	GEA-67N (epoxy)
Initial temperature	°C	130	130
Initial temperature retention time	min	25	20
Layer stacking temperature	°C	170	170
Layer stacking temperature duration	min	60	60
Initial pressure	kgf/cm^2	5	5
Duration of initial stacking pressure	min	4-10	4-10
Layer stacking pressure	kgf/cm^2	45	45
Duration of layer stacking pressure	--	Stacking pressure to end of cooling	

5.2 Multilayer Adhesion Conditions

Table 4 shows examples of multilayer bonding using GIA-67N. Multilayer bonding is possible under the same conditions as epoxy prepreg. Because the glass transition temperature is above 200°C under this condition, the post hardening process at high temperature is not required.

6. Properties of Multilayer Plates

6.1 General Properties

Properties such as heat resistance and copper peeling strength of multilayer board produced under the conditions listed in Table 5 are shown in Table 6.

Table 5. Specifications for Multilayer Board. Specifications for multilayer board after test pattern had been placed are listed

Item	Specification
Board thickness	2.0 mm
Number of layers	8 layers
Copper foil used	outer layer 18 μm, inner layer 70 μm
Treatment before inner layer bonding	black oxide treatment
Plate thickness	30 μm
Through-hole diameter	0.9 mm

Table 6. Properties of Multilayer Board. Polyimide board has superior solder resistance, and glass transition temperature

(1) 項目		(2) 単位	(3) 処理条件*	ポリイミド多層板 (4) (MCL-I-67 GIA-67N)	エポキシ多層板 (5) (MCL-E-67 GEA-67N)
(6) はんだ耐熱性		s	A	(7) 300℃, 60以上	(8) 260℃, 60以上
(9) 引きはがし強さ	(10) 外層	kgf/cm	A	1.5～1.6	1.8～2.0
			S_4	1.5～1.6	1.8～2.0
	(11) 内層		A	0.9～1.2	1.6～1.8
(12) 絶縁抵抗		Ω	A	$1.0 \sim 2.5 \times 10^{14}$	$1.0 \sim 2.0 \times 10^{14}$
			D-2/100	$2.0 \sim 3.0 \times 10^{13}$	$1.5 \sim 2.0 \times 10^{13}$
(13) ガラス転移温度		℃	A	200～210	120～130

(14) 注：* 処理条件は、次のことを表わす，A(受理状態)，S_4(260℃のはんだ浴に20秒間浮かべる,)，D-2/100(100℃の煮沸水中に2時間浸せきする。)

Key:
(1) Item
(2) Unit
(3) Treatment conditions*
(4) Polyimide multilayer board (MCL-I-67, GIA-67N)
(5) Epoxy multilayer board (MCL-E-67, GEA-67N)
(6) Solder resistance
(7) More than 60 at 300°C
(8) More than 60 at 260°C
(9) Peeling strength
(10) Outer layer
(11) Inner layer
(12) Insulation resistance
(13) Glass transition temperature
(14) Note: *The following treatment conditions were observed: A (reception state). S_4 (floated 20 seconds on 260°C solder bath), D-2/100 (immersed 2 hours in 100°C boiling water)

6.2 Dimensional Stability

One major problem in the production of multilayer board is the slip in interlayer circuits during multilayer bonding. Interlayer circuit slip is caused by heating at the time of multilayer bonding, thermal expansion and contraction of the interlayer circuit board during cooling, and resin flow of the prepreg. It is necessary to minimize the degree of slip in high density multilayer board to the small slip permissible for the interlayer circuits.

As illustrated in Figure 10, MCL-I-67 has roughly half the contraction during heating and cooling cycles (20° ⇄ 170°C) compared with epoxy MCL. At the same time, its glass transition temperature (215°C) versus deformation is high, while the strength of its base plate is higher than that of epoxy MCL at multilayer bonding temperature (170°C), so it is thought that the scatter in slip values will become smaller. MCL resin 0.05 mm thick and prepreg of 0.05 mm thickness were used to test produce 50 sheets of multilayer board, and these were measured for dimensional changes in their interlayer circuits. As shown in Table 7, the scatter in slip values of interlayer circuits in polyimide multilayer board (3 σ) was less than 0.02 percent, indicating the superior dimension stability of this product. In addition, observations were directed at the through-hole plane, revealing the good dimensional stability indicated in Figure 11.

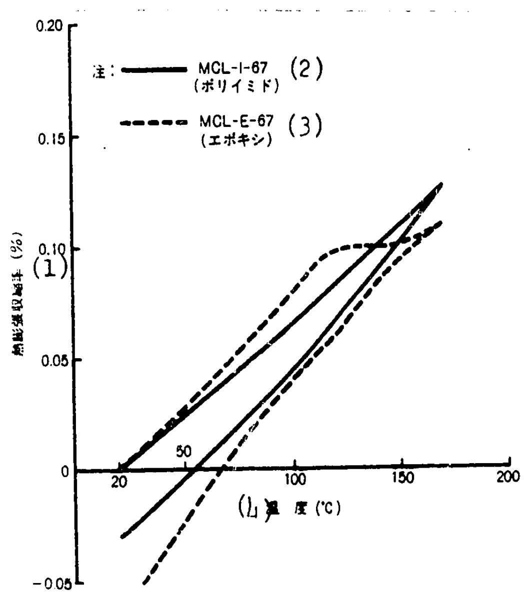

Figure 10. Thermal Expansion-Contraction in Longitudinal Direction
The small thermal expansion of MCL-I-67 is displayed

Key:
(1) Thermal expansion coefficient (percent)
(2) Note: MCL-I-67 (polyimide)
(3) MCL-E-67 (epoxy)
(4) Temperature

Table 7. Scatter in Dimensional Changes (3 σ). Polyimide multilayer board has small scatter in dimensional changes

Type	degree of change (μm)		rate of change (%)	
	length	width	length	width
Polyimide multilayer board	64	90	0.014	0.019
Epoxy multilayer board	110	151	0.024	0.033

Note: size (500 mm x 500 mm)
number of layers (50 layers)

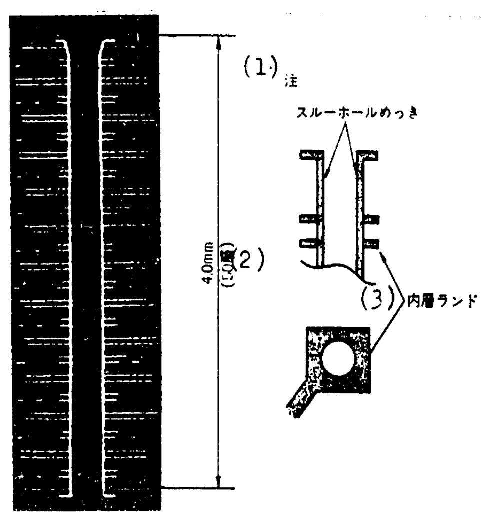

Figure 11. Cross-section of Multilayer Board Through-Hole

The through-hole is positioned at the center of the land showing the good dimensional precision

Key:
(1) Note: through-hole location
(2) (50 layers)
(3) Inner layer land

6.3 Workability for Making Drill Holes

Problems associated with hole drilling in a multilayer board include the generation of smears which interfere with alignment, interlayer copper foil connection and through-hole eyelet connection. A smear has large plate thickness and is more readily formed the smaller the drill diameter; the use of a material which does not generate smears in high density multilayer board is necessary. An example is shown in Figure 12. The smear was determined from cross-sectional observation of 10 through-holes before and after each measurement point, and the rate of incidence was determined from the number of through-holes at which actually harmful smears (more than 30 percent of interlayer copper foil thickness) were generated. Polyimide multilayer board is devoid of smear generation, and it is evident that high connection reliability can be expected. At the same time, the burrs on the copper foil made by the drill blade, which is a measure of the wear on the blade, was determined. It was found that this was of the same order as with epoxy resin, indicating that there is no problem.

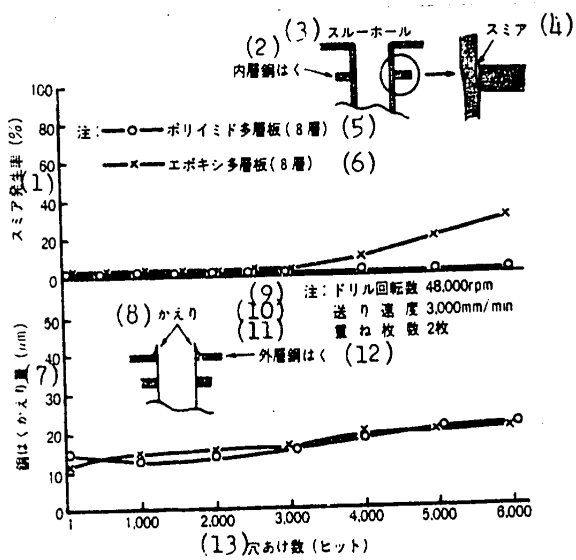

Figure 12. Workability for Hole Drilling

Polyimide multilayer board suffers no smear formation and has superior connection reliability

Key:
(1) Smear incidence rate
(2) Inner layer copper foil
(3) Through-hole
(4) Smear
(5) Note: polyimide multilayer board (8 layers)
(6) Epoxy multilayer board (8 layers)
(7) Copper foil burrs (μm)
(8) Burr
(9) Note: drill rpm
(10) Feed rate 3,000 mm/min
(11) Number of stacked layers 2 sheets
(12) Outer layer copper foil
(13) Number of holes (hit)

6.4 Connection Reliability

The connection reliability of multilayer board was tested at the MIL temperature cycle (MIL-STD-202E 107D Cond. B). The results are shown in Figure 13. In the case of epoxy multilayer board, damage at the through-hole occurred after 130 cycles and gradually increased. No damage was seen in polyimide multilayer board even after 200 cycles, which is indicative of its high stability.

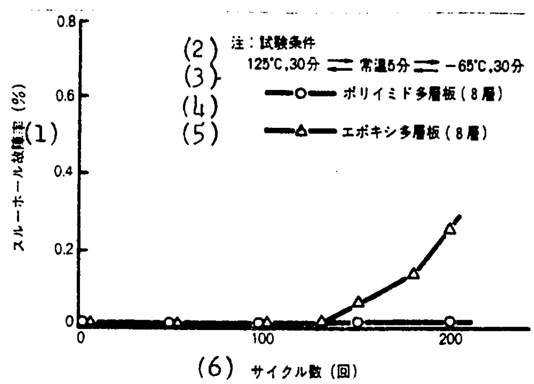

Figure 13. Through-Hole Connection Reliability

Polyimide multilayer board suffered no cracks around its through-holes even after 200 cycles and has superior reliability

Key:
(1) Through-hole damage rate (percent)
(2) Note: Test conditions
(3) 125°C, 30 min ⇄ 5 min room temperature ⇄ -65°C, 30 min
(4) Polyimide multilayer board (8 layers)
(5) Epoxy multilayer board (8 layers)
(6) Number of cycles (cycles)

7. Conclusions

New heat resistant polyimide resin "HI-L" and a copper clad multilayer board using resin MCL-I-67 along with prepreg GIA-67N were developed. "HI-L" dissolves in low boiling point solvents, and the workability of MCL, prepreg, and multilayer board during manufacture was improved. At the same time, the multilayer board obtained in this manner possessed superior circuit position precision as well as high through-hole reliability, making it the best for high density multilayer board material application.

We express our gratitude to the many concerned people of this company who gave us countless advice and assistance during the course of this development.

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ECONOMIC

ENTERPRISES FIND WELCOME IN MIDDLE EAST COUNTRIES

Tokyo BUSINESS JAPAN in English Vol 26, No 8 Aug 81 31-38

[Article by Yasufumi Sugiyama, Western Europe, Africa and Middle East Section, Trade Policy Bureau, Ministry of International Trade and Industry]

[Text]

THE history of exchanges between Japan and Middle Eastern countries can be traced back more than 5,000 years, but the progress of such exchanges, initially over the Silk Road, the ancient trade route between the East and the West, has been extremely slow.

Japan, opening its door to foreign intercourse through the Meiji Restoration in 1868, promoted an industrialization policy on a rapid pace with the target of enriching itself and strengthening its military power. The industry that became the first driving force in the large flow of establishing private enterprises in the 1880s was the cotton spinning industry. Modern industries using steam power were established one after another and Japan had to depend on foreign countries for a large amount of raw cotton as raw material for such industries. Japan first imported raw cotton from China and gradually expanded the sources of raw cotton supply to the United States and India. It was in 1892 that Egyptian raw cotton was first imported to Japan. This seems to have been Japan's first modern contact with the Middle East, but the advance into the Middle East by Japanese enterprises was considerably later than this event. This advance, too, was related to raw cotton. The first Middle East Office of a Japanese trading company – these companies take the initiative in Japan's trade with foreign countries – was established in Alexandria in 1933 by Toyo Menka (currently Tomen), which had become independent from Mitsui & Co. The office was established for the purpose of purchasing raw cotton in Egypt. It was after this event that Japan started to directly import materials from the Middle East

Table 1. Amounts of Contracts for Development Projects by Country in the Middle East

1979		1980	
1. Saudi Arabia	$16,720 million	1. Saudi Arabia	$15,710 million
2. Iraq	5,910 "	2. Iraq	12,650 "
3. Egypt	3,480 "	3. Kuwait	3,520 "
4. Algeria	2,440 "	4. Libya	3,460 "
5. Libya	2,220 "	5. UAE	1,720 "
6. Kuwait	1,710 "	6. Egypt	1,710 "
7. UAE	1,670 "	7. Morocco	1,180 "
8. Iran	1,240 "	8. Algeria	1,080 "
9. Jordan	990 "	9. Syria	750 "
10. Tunisia	600 "	10. Lebanon	630 "
Total*	40,040 "	Total*	46,270 "

Note: The total includes those in other countries also.
Source: MEED (The Middle East Economic Digest)

without trading companies in third countries serving as intermediaries.

But Japanese enterprises were still not ready to move forcefully into the Middle East. However, during World War I (1914 - 1918), Japan's exports to the Middle East rapidly increased as Europe, the main supplier of industrial products to the Middle East, had become a battlefield. But with the termination of the conflict and the rehabilitation of Europe, Japan's exports drastically decreased.

Japan's relations with the Middle East, suspended during World War II, were resumed through Japan's oil imports after the war and in the 1950s, when private trade became possible, Japanese trading companies established branches in the Middle East. In December 1956, the first Japanese local corporation, Marubeni Iran Co., was set up. In July 1958, Arabian Oil Co., which was established through the concerted efforts of Japanese financial circles, obtained oil concessions from both the Saudi Arabian government and the Kuwaiti government. The fact that the company started oil production in the Middle East as the first Japanese company after the war facilitated Japanese enterprises' advance into the Middle East. Japan was then in the process of high-paced economic growth, but its exports of industrial plants, barometer for any full-fledged advance into a market, were still very few.

Table 2. Amounts of Contracts for Development Projects by Industry in the Middle East

1979		1980	
1. Housing	$6,550 million	1. Defense	$6,390 million
2. Communication	5,510 "	2. Transportation	5,390 "
3. Transportation	4,210 "	3. Waterworks, sewerage & deslinization	5,270 "
4. Waterworks, sewerage & desalinization	3,760 "	4. Housing	4,930 "
5. Aircraft	3,650 "	5. Industry	3,540 "
6. Electric power	3,020 "	6. Electric power	3,310 "
7. Industry	3,010 "	7. Aircraft	3,220 "
8. Hydrocarbon/ petrochemical	3,010 "	8. Foods/farming	3,210 "
9. Foods/farming	1,900 "	9. Hydrocarbon/ petrochemical	2,610 "
10. Ocean	1,880 "	10. Education	2,440 "
11. Education	1,350 "	11. Ocean	2,180 "
12. Hospitals/health care	950 "	12. Communication	2,040 "
13. Tourism	940 "	13. Hospitals/health care	1,230 "
14. Computers	260 "	14. Tourism	460 "

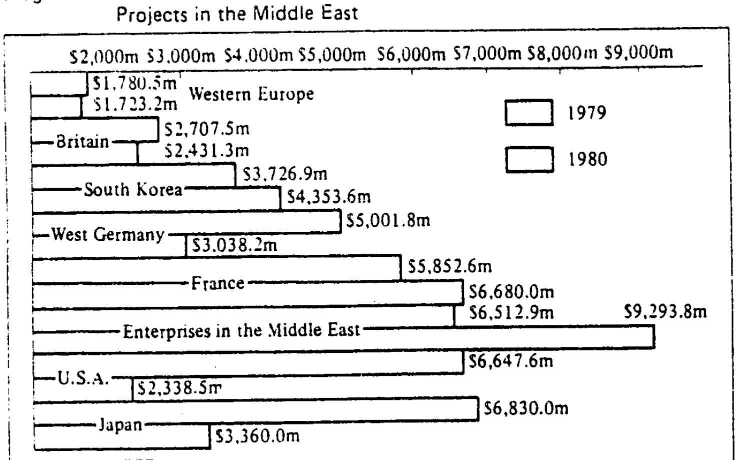
Today, many seawater desalinization plants are exported to the Middle East. The first such plant was established by the Arabian Oil Co. at its mining station in Kafji. As a result of Arabian Oil's successful ventures in Saudi Arabia and Kuwait, Japanese products began to be widely used in both countries. The Arabia people, who had known only European and American commodities, began to show interest in both Japanese goods and technology. In 1958, 15 Japanese engineers were dispatched to Kuwait to work at auto repair shops. When the Nippon Telegraph and Telephone Corp. (NTT) received a contract in 1965 for consultation concerning Kuwait's plan to expand telephone services. the Kuwaiti people's interest in Japan increased even further. In September 1959, Iran Yasa Tire & Rubber Corp., the first joint venture in a manufacturing field in the Middle East, was established by Inouye Rubber Industry Co. Nine years before this, the International Bank of Iran & Japan was established by the Bank of Tokyo and eight trading companies as the first joint venture in Iran. It was about that time that Japan's exports to the Middle East began to show a sizable increase and gradually replaced products from Europe and America in that market. Even before the first oil crisis in 1973, Japanese products assumed top place in the list of imports among many Middle East countries.

The first oil crisis in 1973 rapidly expanded the arena of activities for Japanese enterprises and remarkably enhanced the importance of the Middle East as a market for Japanese products.

On the basis of the huge inflow of oil money, Middle East countries have worked out extremely large-scale plans to develop their economies and societies and have begun to promote their nation building on a rapid scale. In the case of Saudi Arabia, for instance, its second national development plan worked out in 1974 for the period from 1975 through 1980 has a scale nearly 10 times larger than its first development plan covering the period from 1970 to 1975.

The marked increase in oil dollars as a result of the sharp rise in crude oil prices resulted in expanded purchases of consumer goods that raised considerably the standard of living of the people in the oil producing countries. In addition, much of the money flowed into machines and equipment designed to develop their economies. Japanese enterprises gradually moved into these fields. Consequently, their operations in Arabic countries gradually expanded from basic commodity export to the exports of industrial plants, ranging from partial contracts for industrial plants to full-scale contracts for exporting industrial plants as a whole including those on a full turn-key basis. Finally, Japanese enterprises are now establishing joint ventures in the Middle East with local corporations. Japanese enterprises have gradually moved into the Middle East market as the needs for its products and services have developed.

Diagram 1. Countries That Have Received Contracts for Development Projects in the Middle East



Source: MEED

One of the reasons why many Japanese enterprises have advanced into the Middle East is that it is an area where business can be conducted more easily than in many other regions of the world because of the huge inflow of foreign currencies and because there is no notable modern industry. Japanese enterprises which have moved into this market range from souvenir shops to large companies engaged in the construction of huge industrial plants. Today there are about 13,000 Japanese working in the Middle East (as of October 1978). The more the Middle East countries become industrialized, the more Japanese enterprises will establish business operations there. Such expansion is assured because the Japanese ways of management and technological guidance as well as Japan's modern production technology are regarded highly by the people of Middle East countries.

Table 3. Approved Exports of Industrial Plants by Region

(Unit: $1,000)

	FY1976			FY1977			FY1978			FY1979			FY1980		
	No. of items	Value	Share	No. of items	Value	Share	No. of items	Value	Share	No. of items	Value	Share	No. of items	Value	Share
Southeast Asia	216	1,260,919	15.8	238	1,848,456	21.5	226	2,406,975	27.6	187	1,878,143	16.0	196	2,435,917	27.3
Middle and Near East	88	2,906,572	36.3	94	1,851,440	21.5	87	1,420,434	16.3	118	3,624,232	31.0	124	1,743,771	19.5
West Europe and North America	79	326,869	4.1	72	492,642	5.7	68	215,304	2.5	95	458,535	3.9	105	772,999	8.6
Central and South America	127	1 178,392	14.7	140	830,446	9.6	167	2,021,404	23.2	120	594,834	5.0	81	791,105	8.9
Africa	54	818,491	10.2	42	1,951,114	22.7	46	640,589	7.3	41	863,245	7.1	41	1,647,845	18.4
Oceania	12	64,307	0.8	13	122,140	1.4	13	329,382	3.7	12	48,284	0.4	26	263,757	3.0
Communist bloc	104	1,449,985	18.1	137	1,511,136	17.6	146	1,695,086	19.4	170	4,317,708	36.6	104	1,276,602	14.3
Total	680	8,005,535	100	736	8,607,374	100	753	8,729,174	100	743	11,784,981	100	677	8,931,996	100

(Source: Ministry of International Trade & Industry)

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