Products and Technology of the HORIBA Group: Origin, Evolution, and the Future

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Abstract

HORIBA, Ltd., established on January 26, 1953, marked its golden anniversary this year (2003). With our motto of "HORIBA, pursuing technology to an ultimate degree," we have made independent progresses as a manufacturer specializes in unique analytical technologies and products. HORIBA has been moved aggressively into overseas market from the very beginning and founded many significant subsidiaries. Most notably, the joining of Jobin Yvon and ABX in HORIBA Group expanded the range of it's products and technologies. Today, the products of HORIBA group are comprised over 1000 different models, which are strongly supported by multiple technologies. This article refers to such products and technologies, the path that HORIBA has been following through the history of fifty years, and for the coming years.

1 Introduction

Beginning from its "Big Bang" origin, the Universe continues to expand into the future. The HORIBA Group, which began as the tiny private HORIBA Radio Laboratory in October 1945, has also persistently grown as a unique global corporate group in the field of analysis and measurement, now boasting 3700 professional Horibarians from 39 companies in 25 countries.

HORIBA's current technology and products allow the analysis of an element in levels as low as a nanometer as well as analysis of the entire earth in mega meters to determine various characteristics such as composition and physical volume. These products and technologies, however, do not stem from separate roots, they are instead, small sprouts from a technology seed that correlate with each other and grow into large, advanced products. It is exactly like a seed that first grows into a small sapling and eventually into a gigantic tree.

In this article, we shall review the history of fifty years along the path of HORIBA products and technology, and provide a bird's-eye view of its future.

2 Three Analysis Trees: Liquid, Gas, and Solid

2.1 Before Dawn – from Electrolytic Condensers to pH Meters (Liquid Analysis)

In August 1945, faced with defeat in World War II, all of Japan fell into a state of lethargy. People were suffering from hunger and looking for scraps of food to survive day by day. Amid such extreme conditions, Dr. Masao Horiba (current chairman of HORIBA, Ltd.) established the HORIBA Radio Laboratory, which offered prototype manufacturing and maintenance of special electronic machinery from his graduate school, Faculty of Science, Kyoto University. This was quite the "Student's Venture."

Dr. Horiba encountered many difficulties troubleshooting electronic products, especially electrolytic condensers, and this inspired him to start the business of developing high-quality condensers. However, the hard work and efforts invested in establishing the new company took a heavy blow due to the Korean War and his first business plan was unfortunately terminated.

In the meantime, the Japanese chemical industry was under strong political promotion to spur economic recovery after the war. One possible solution was the need for industrial measurement instruments of high quality at low cost. Dr. HORIBA had already made a prototype pH meter in preparing for the condenser business, and this

was a perfect opening to another business opportunity. It was not long before he turned his attention towards launching a new business in pH measurement.

There were two technical problems to overcome in developing pH meters at that time: a glass electrode with low alkaline sensitivity, and an amplifier with input impedance over 10^{12} ohms. The glass electrode was elaborately developed with the advice of Professor Tasuke Nishitomo of Kyoto University (current Emeritus Professor). For the amplifiers, vacuum tubes were carefully chosen from "surplus materials" disposed of by the U.S. Army in electrical shops in Akihabara, Tokyo. With these problems resolved, the first domestic glass electrode pH meter, Model N, was completed in 1951. Fig.1 shows the high-quality type pH meter, Model H (restored in May 2003). This model was developed soon after Model N. The vacuum tube as seen through the transparent cover reveals the challenges and efforts required of the engineers of those days. Fig.2 shows latest pH meter, the F-50 Series. This model was created on the concept of providing easy and entertaining professional measurement system for world wide users.

On January 28, 1953, Dr. Horiba established HORIBA, Ltd. This venture was supported by the pH meters for which at that time, had reached monthly sales of one million yen.

2.2 The Path from Non-Dispersive Infrared (NDIR) to Automotive Emission Gas Analysis (Gas Analysis)

Although HORIBA held a strong position in pH meters, it was not enough for further business expansion. The next development target was an alkali halide single crystal. Crystal development is also the result of industry-university collaboration nurtured through the close relationship between HORIBA and Kyoto University.

HORIBA pursued R&D of the single crystal, and at the same time, launched the application of this technology resulting in the development of Non-dispersive Infrared (NDIR) gas analyzers. Initially, there was great criticism of the analyzer due to the fluctuation caused by surrounding interference, but each technical problem was overcome and the analyzer was improved until it was eventually released as the GA-1, the first HORIBA gas analyzer.

The gas analysis field in those days consisted mainly of supporters of the gas chromatography technique, and NDIR was unheard of. The foresight of the young HORIBA executives to apply the capabilities of NDIR as a continuous gas analysis method was an innovative solution. This selection, more than anything, was the key to realizing today's HORIBA Group.

Today, NDIR is continuously used in HORIBA through various application processes such as aspiration gas analysis, automotive emission gas analysis, as well as air pollution monitoring, to establish a steady position with core technology that results in high-sensitivity, continuous gas analysis instruments.

Fig.1 First pH meter Model "H", Restored in May 2003

Fig.2 Latest pH Meter Model "F-50 Series", Developed in May 2003

2.3 From the NaI Scintillator to X-ray Elemental Analysis (Solid Analysis)

HORIBA started developing a Sodium Iodide (NaI) scintillator in the latter half of the 1950's, along with its typical instrument application of radiation measurement with the intention of building yet another business.

The NaI scintillator, as well as the infrared optical crystal, continued to excel as one of the significant foundation technologies of HORIBA. In 2002, a super large single crystal of 31 inches in diameter was grown in the HORIBA Crystal Product (HCP) facility in Tempe, Arizona, U.S.A. This success has evoked the prospect of using HORIBA's scintillator in gamma cameras throughout the world in the very near future.

At the same time, development of radiation measurement instruments has slowed down due to the negative image of nuclear applications that has historically prevailed in Japan. The turning point for HORIBA radiation technology was the discovery of an alternate application of a semiconductor X-ray detector, and the X-ray elemental analysis system (EDX).

HORIBA initiated the development of the semiconductor radiation detector with high-energy resolution (SSD) in the middle of the 1960's. Combined with an imported multi-channel analyzer, the detector was integrated as a radiation measurement system that provided a rather modest amount of sales.

At the beginning of the 1970's, the HORIBA R&D team developed an X-ray detector (Si(Li)) originating from lithium dispersion on a single silicon crystal and in 1976, the first Energy Dispersive X-ray elemental analysis system (EMAX), was produced by HORIBA. With the progress in electronics and new material industries, the EMAX market expanded rapidly in the 1980's, particularly for quality management application in factories.

It is significant to note that HORIBA converted technology to digital software technology entirely during the development of the EMAX. In the 1980's, computerization greatly advanced, and the starter role of EMAX during this period is highly valued.

Another accomplishment during that time was the establishment of a system that allowed development and production of sensors within the company. In the field of measurement instruments where many companies follow the way of outsourcing certain components, HORIBA pursued the unique policy of developing and producing its own sensors, which is obviously one of HORIBA's immeasurable advantages. This provides a single source to the market.

Thus, liquid analysis originated from pH meters, gas analysis was formed by NDIR, and solid analysis was led by EDX; these three technology trees were planted in the middle of the 1970's.

3 World Automotive Emission Gas Analysis Advances during the Environmental Boom

3.1 Branching Out to the U.S.A. with MEXA

The Automotive Emission Gas Analysis System (MEXA) utilizing medical gas analyzer technology with 0.1 second in response time, steadily marked huge sales, favored by a society focused on pollution issues in the late half of Japan's economic boom. Two milestones in particular, the 1970 CO-emission regulation for used cars and the large demand for gas analyzers for car inspection (small MEXA) in 1975, determined HORIBA's position in Japan.

HORIBA was also committed to becoming number one in this market globally; in the mid 1960's, the company had already embarked into the global market. The first entry was MEXA, into the giant and growing automobile empire in the U.S.A. In 1970, HORIBA and Olson Laboratories, a manufacturer of automobile emission measuring equipment in the state of Michigan, set up the venture company "Olson HORIBA." Three years later, this became the foundation of a HORIBA fully owned subsidiary in the U.S.A., HORIBA Instruments Incorporated (HII).

HII incorporated a tactical sales style in which the analyzing unit sent from Japan was assembled with the sampling unit exclusively for the U.S.A. market. This was a significant business strategy in the emission gas analysis field having the ability to provide diverse specifications depending on customer requirements.

MEXA's debut in the U.S.A. market had two significant results for HORIBA: First, was obtaining a basic patent

for the Critical Flow Venturi type Constant Volume Dilution Sampling System (CFV-CVS) purchased from Philco-Ford. CFV-CVS technology was then evaluated by the Environmental Protection Agency (EPA) as a potential application for automotive emission gas tests, and is presently a global standard in this field. Secondly, was the creation of a software development site, HORIBA Automotive Division (HAD), outside of Detroit, Michigan. Emission analysis cannot be realized without complete system configuration incorporating peripheral devices such as a chassis dynamometer or data logger, analyzing and sampling units. By arranging such essential functions as software development and system engineering in Detroit, the birthplace of cutting-edge automotive technologies, HORIBA had a great advantage in increasing the growth of its engine measurement business.

3.2 Environmental Monitoring System Delivered to Kuwait

In 1980, HORIBA received an order from the government of Kuwait for an environmental monitoring system for seawater and air pollution. This super-large environmental monitoring system connected water quality monitoring instruments for pH, dissolved oxygen, conductivity, oil content, and Chemical Oxygen Demand (COD) and air monitoring analyzers for Sulfur Oxides (SOx), Nitrogen Oxides (NOx), and Hydrocarbons (HC) by telemeter, and then provided data processing of the obtained results.

The “Kuwait Project” was enabled by active joint operations between the Japanese team led by Mr. Atsushi Horiba (current president of HORIBA, Ltd.), the Overseas Technical Manager at the time, and all the overseas companies based in HORIBA Instruments, Limited (HIL), UK. In spite of the harsh environment of daytime temperatures reaching 55 ºC, an elaborate high quality installation was established satisfying the local service engineers and the government. During the 1990 Gulf War, when the monitoring station delivered by this project was destroyed, HORIBA’s response was fast; immediately repairing and recovering the system to full operation, receiving much gratitude from Kuwait.

3.3 Dry-type Air Pollution Monitor Highly Valued in Europe

HORIBA started doing business with Europe when it opened a HORIBA Instruments Corporation (HIC) liaison office in Frankfurt, Germany in 1971. The first sales target, the MEXA, had a slow start due to late entry into the market and advanced competition.

However, when Dr. Kraeft, a market thought leader of Mercedes-Benz, performed an extensive evaluation, resulting in the purchase of the newly released MEXA-8000 series in 1976, the situation changed rapidly. News spread throughout Europe and inquiries from European automotive manufacturers increased day by day. Backed by this success, HORIBA started construction of such group companies as HORIBA Instruments Limited (HIL) in England, and HORIBA Instruments in Switzerland. But the end of the 1980’s, an extensive marketing network covering all of Europe was established.

Through this technology and market expansion in Europe, HORIBA introduced its dry-type air monitoring method into the Japanese market. HORIBA developed dry-type air monitoring systems applying such technologies as Chemiluminescence Detection (CLD) and Flame Ionization Detection (FID) developed mainly for automotive emission gas analysis. These products were widely used for air-pollution monitoring in various European countries. In Japan, however, wet-type systems such as the Salzman method or Iodine Coulometry were still very popular because of traditional attitude. At the end of the 1990’s the dry-type systems were finally officially recognized in Japan, a market to which HORIBA has greatly contributed.

As we can see, the 1970’s to the 1980’s was the era in which HORIBA to entered the world market with two additional significant products: automotive emission gas analysis systems and air-pollution monitoring systems.

4 HORIBA in Japan Focuses on a Global HORIBA Group

4.1 ABX Participation

HORIBA has been involved in medical analysis since its company foundation. In 1983, the SERA-200 electrolyte analyzer system analyzing Sodium (Na), Potassium (K) and Chlorine (Cl) in blood or urine using ion specific electrodes was released attaining impressive sales with orders for more than 500 units.

With this background, HORIBA chose to expand its efforts in the medical analysis field. In 1987, an agreement was signed between HORIBA and ABX, a French manufacturer of blood cell counters, for HORIBA's distributorship and the right to manufacture ABX's blood cell counters in Japan. ABX was established in 1983 as a venture company exclusively for blood cell counters, and expanded its business quickly to seek partners in the global market.

HORIBA concentrated on sales of ABX's small blood cell counters, and at the same time continued to develop a nationalized version of the product. In 1990, this effort was realized with the LC-360, an automated blood cell counter manufactured in Kyoto. Believing "Life Science" to be one of the biggest business targets in the 21st century, President HORIBA determined in 1996 that ABX join the core companies in the HORIBA Group and the ABX-HORIBA Medical Group was born.

With the collaboration of ABX's marketing and development power and HORIBA's production technology, this unique medical group has continuously expanded its sales based on small- and medium-sized blood cell counters, and presently is one of the world market leaders in this field.

The notable products realized by the ABX-HORIBA Medical Group are the LC-360 CRP, an Automated Blood Cell Counter Plus C-Reactive Protein (CRP), and the Pentra 400, a Clinical Chemistry Analyzer. The LC-360 CRP is an innovative product that incorporates both blood cell counting and CRP concentration measurement in a single compact unit, and is used with convenience in small hospitals. This product was developed by HORIBA and is now being sold in the European market under the name "Micros CRP" after small specification changes by ABX.

The Pentra 400 (Fig.3) is a desktop clinical chemistry analyzer that covers a wide range of assays from routine clinical chemistry tests to more advanced, professional assays such as Hemoglobin A1c (HbAlc), Drugs of Abuse (DAT), and Therapeutic Drug Monitoring (TDM).

These products are a few of the collective achievements of the HORIBA Group, based on the knowledge of ABX on blood diagnostic systems with HORIBA's ion sensor technology and the recently acquired optical technology of Jobin Yvon. The HORIBA Medical/Diagnostic Segment is planning on further expansion into the ever growing clinical laboratory market.

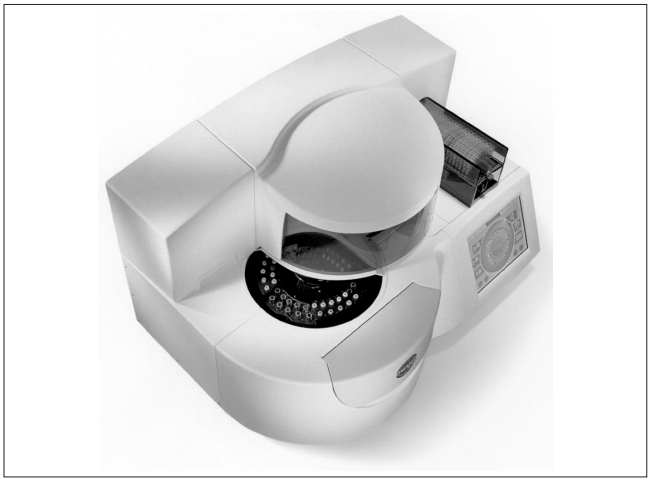

Fig.3 Clinical Chemistry System Pentra 400

4.2 Jobin Yvon, Leader in Optical Technology, Joins in

Jobin Yvon (JY) and HORIBA first met when HORIBA acquired Instruments S.A. (the previous company name of JY) in 1997. The JY technology was required to complete the spectral range for HORIBA core technology. JY's history goes back more than 180 years. The company was involved in collaborative research and development of various optical products with prestigious scientists such as Augustin Fresnel. Since that JY has been recognized worldwide as a leader in optical measurement systems. Starting in the 1970's, JY shifted to manufacturing and development of spectroscopy systems for laboratory use, such as emission spectrochemical analysis systems and Raman systems, through alliances with European and American manufacturers.

HORIBA's endless development antenna had expanded to the fields of infrared and X-ray. Completing the spectrum, JY has had an outstanding career in the field of visible and ultraviolet rays. Their target customers were also quite different; HORIBA focused on general industries, while JY had a strong network in universities and research institutes. With this background, JY's inclusion into the HORIBA Group dramatically expanded the group's potential from a customer and detection perspective, thereby providing even greater business opportunities to both companies. This was definitely a win-win relationship.

Two products, among many, typically explain this relationship: an elemental analysis system for steel, and the UT-300, an automatic thin-film measurement system. The former is a typical product of the JY and HORIBA alliance. HORIBA has extensive experience in analysis systems for measuring Carbon, Oxygen, Nitrogen and Sulfur in steel using NDIR for quality management. Researchers steadily support JY's high-quality Inductive Coupled Plasma (ICP) and Glow Discharge Spectrometry (GDS) emission spectrochemical systems to enable multi-element analysis. Full Automatic Spectroscopic Ellipsometer UT-300 (Fig.4) was also realized by the collective effort of JY ellipsometric technology, HORIBA mechatronics, and the application knowledge provided by Atago Bussan, a JY (currently HORIBA) Sales Company in Japan. UT-300 is highly anticipated as an inline evaluation system for nano-sized semiconductor devices.

With the advanced, unique technologies now combined into our core technology in the late 1990's, HORIBA was now fully prepared to leap from HORIBA Japan to the global HORIBA Group. Globalization now becomes a driving force for the HORIBA Group.

Fig.4 Full Automatic Spectroscopic Ellipsometer, UT-300

5 Explore the Future

HORIBA celebrated its fiftieth anniversary on January 26, 2003. This memorial day is even more meaningful when we consider that it is also the day for the HORIBA Group to begin another fifty years.

The strategic business direction that the HORIBA Group is pressing forward can be roughly expressed with the keywords "Environmental Analysis." The words "Environmental Analysis," however, do not merely mean what is typically interpreted as pollutant monitoring in air and water, or as continuous monitoring of carbon dioxide causing global warming. Instead, it indicates a wide-ranging analysis that includes our total global environment. It includes organic environmental analysis for biological composition and temperatures required at the sites of daily health and medical care. Furthermore, it includes inorganic environmental analysis that allows the measurement of physical and chemical content of materials, required in factories and laboratories.

This attitude is well described in Fig.5. The horizontal axis shows the sizes of measurement targets, from nano particles to the entire globe. The vertical axis depicts the measurement object along which nature as well as humanity is marked as the origin point. The higher the vertical axis goes, the more complex is the artifact created by human production activities.

The HORIBA Group business scope covers four areas. The first area is human health and the environment we live in. Recent social and political requirements are increasingly demanding in quality for daily life environment and medical sites. The HORIBA Group is applying its core technologies to both the Medical/Diagnostic and Analytical Segment resulting in a contribution to each individual's health as well as to our entire environment. The products in this area include various diagnostic systems for blood and infectious diseases in the Medical/Diagnostic Segment, and those in the Analytical Segment such as monitoring devices for food quality control, pH measurement devices for water quality, indoor toxic gas detection monitors, and infrared automatic switches.

The second area is the use of environmental measurement and control systems in factory production and energy supply facilities such as power plants. Supported by the Semiconductor and Analytical Segment, this area covers the control systems required during the production process to the environmental monitoring instruments that monitor stack gas or waste water. The typical products are mass flow controllers developed by the Semiconductor Segment, and X-ray analysis systems with various industry applications, stack gas and water monitoring instruments developed by the Analytical Segment.

The third area covers research and development, a significant investment made by government and industry to promote human health and industrial improvement. This area consistently pursues protection of the environment and technological innovation. It consists of the Engine Measurement Segment aimed mainly at automotive emission gas measurement systems for research objectives, and the Analytical Segment supplying necessary instruments promoting new material research and

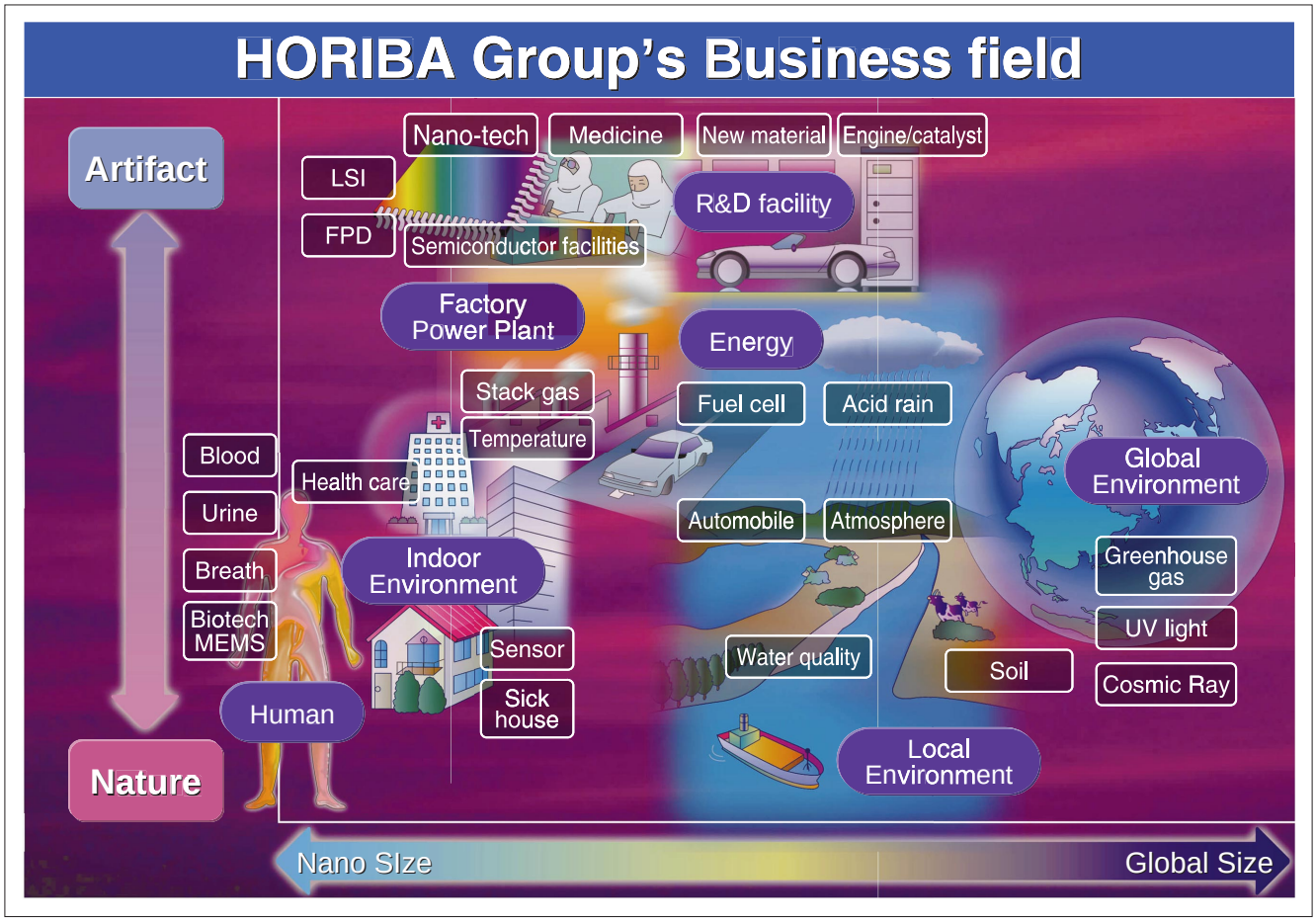

Fig.5 HORIBA Group's Business Field

development fields including life science, pharmaceutical composition, and nanoparticle analysis.

The fourth area is environmental analysis at the local and global levels. Specifically, it is the monitoring concentration of regulated substances in air, water, and soil, of water quality, as well as of stack gas and exhausted gas from vehicles and other engines. Supplying equipment to continuously measure and monitor the toxic substances emitted into the natural world is one of the most important goals of the HORIBA Group business. Through this goal, the HORIBA products can assure that a safe and healthy environmental condition is maintained. HORIBA also promotes environmental analysis technology on a global level through technology transfer projects to developing countries. This area is tightly connected to the Analytical and Engine Measurement businesses.

The HORIBA business group, with the keywords of "Environmental Analysis," thus covers many diverse markets from natural to artificial materials. It contributes to every industry from the aspect of analysis and measurement. Based on a long history of measurement, its application of core technology, and with new technology realized by original, flexible alliance power, and future acquisitions, HORIBA will continue to contribute to new technology development to meet the environmental measurement and monitoring needs of today, and of tomorrow.

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