ISSN 0910-6170

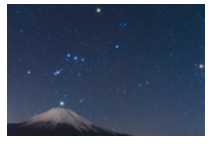
Ultimate in Vacuum

ULVAC

A Community Magazine of ULVAC Group

No. 66

ULVAC



Cover Photo: "Orion and Mt. Fuji"
Photographed by: Isao Kimura,
Global Market & Technology Strategy,
Management Planning Division, ULVAC, Inc.
"Mt. Fuji is the highest mountain in Japan
and was registered as a World Heritage site
in June, 2013.
This photograph was taken 1 hour before sunrise,
from Lake Yamanaka locating at the foot of Mt. Fuji."

PICTURES:
p.4-5, 7-8 JAXA, Akihiro Ikeshita

PRODUCTION ASSISTANCE: Adopa Corp.

PUBLISHER: ULVAC, Inc.
Head Office / Plant: 2500 Hagisono, Chigasaki, Kanagawa, 253-8543, Japan, Phone: 81-467-89-2033
EDITING: Public Relations Magazine Editors, Corporate Communications & IR Team, Management Planning Department
ULVAC WEBSITE: http://www.ulvac.co.jp/en/

*Names of companies, organizations, and job titles appearing in all articles are current as of the time they were written.
Printed in Japan (June 2016)

EXECUTIVE GUEST

“Inferiority” Provides Opportunities for Innovation

—— Working with Private Enterprises Based on Space Technologies and the Lessons Learned from Hayabusa

Guest: **Dr. Hitoshi Kuninaka**

Professor at the Department of Space Flight Systems,
Institute of Space and Astronautical Science
Director of the Space Exploration Innovation Hub Center,
Japan Aerospace Exploration Agency (JAXA)

Interviewer: **Hisaharu Obinata**

President and CEO, ULVAC, Inc.

On June 13, 2010, the first asteroid explorer Hayabusa returned to Earth safely. Having made a great impression on not only the Japanese public but also many other people around the world as well, this event is still fresh in the memory. It was so impressive that a film featuring this project was produced. Following on from this success, Hayabusa 2 was launched on December 3, 2014. Just one year later, on December 3, 2015, Hayabusa 2 used a method known as an Earth swing-by to change its path and accelerate towards its destination asteroid —called Ryugu— with the aim of bringing new results back to Earth. Japan’s space research and development projects, including Hayabusa and Hayabusa 2, are supported by the Japan Aerospace Exploration Agency (JAXA). For this issue’s “Executive Guest”, Hisaharu Obinata, President and CEO of ULVAC, Inc., visited Dr. Hitoshi Kuninaka, a professor at the Department of Space Flight Systems, Institute of Space and Astronomical Science, JAXA (director of the Space Exploration Innovation Hub Center), who developed the ion engine, one of Hayabusa’s core technologies, and asked him about his valuable experience with a focus on space research and development.

On June 13, 2010, the first Hayabusa returned to Earth in a blazing ball of fire (Courtesy of JAXA)

Introduction

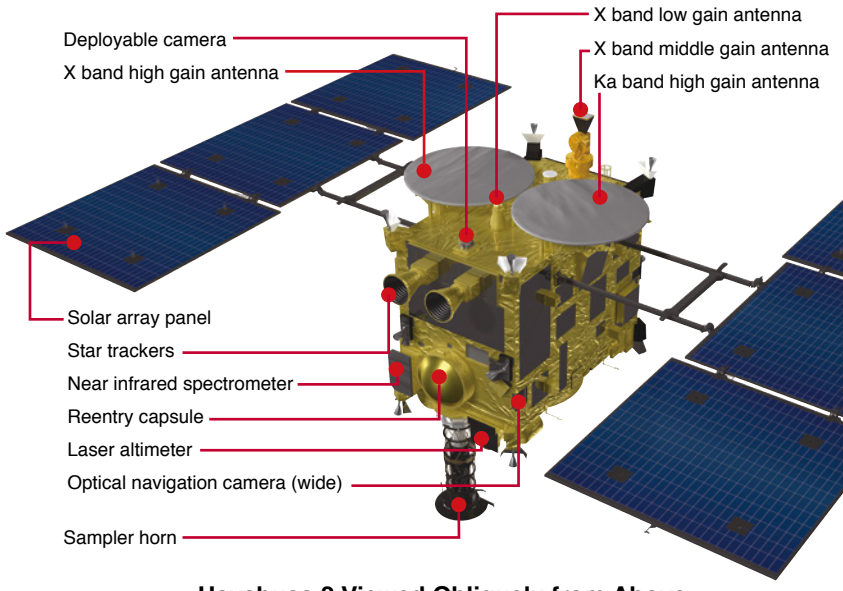
Planetary exploration technologies that employ an unmanned space probe have been developed in stages, as described below.

The first stage was the "fly-by," which involved the unmanned space probe observing a target celestial body while passing near to it. The second stage was the "rendezvous," which involved the probe approaching the target celestial body and observing it while adjusting speed and traveling along the same orbit as the target. The third stage was "landing," which involved the probe descending to the surface of the target celestial body to conduct observations. The most recent stage is the "sample return," which involves the probe bringing substances collected from the target celestial body back to Earth for analysis.

Hayabusa left a lasting impression on people around the world and attracted considerable attention by returning to Earth safely despite having to overcome a number of problems. In terms of its significance in the development of asteroid exploration technologies, it was the world's first explorer to successfully return a sample from a difficult to approach asteroid. It is said that the ion engine made a significant contribution to the Hayabusa's long journey through outer space and its eventual successful return to Earth.

Being able to return many samples from an asteroid, as Hayabusa succeeded in doing, fulfills the purpose of space research and development by helping to clarify the unknown —such as the origin of life, the structure of the universe, and the beginning of the solar system— and to get closer to learn about life, including humanity, and nature on Earth.

A return capsule containing minute particles collected from the Itokawa asteroid lands safely in Australia (Courtesy of JAXA)



Hayabusa 2 Viewed Obliquely from Above
(Courtesy of JAXA)

■ Table 1: Characteristics of the Ryugu and Itokawa Asteroids

	Ryugu	Itokawa
Date of discovery	May 10, 1999	September 26, 1998
Size and shape	Approx. 900 m in diameter; almost spherical	535 m x 294 m x 209 m; shaped like a sea otter
Rotation period	Approx. 7 hours and 38 minutes	Approx. 12 hours and 8 minutes
Orbital period	Approx. 1.3 years	Approx. 1.52 years
Orbital radius	Approx. 180 million km	Approx. 198 million km
Light reflectance	Approx. 0.05	0.25 on average
Color	Blackish	Gray (portions that have not suffered space weathering appear whiter than the surrounding portions)
Spectral type	C-type (it is presumed to contain water, organic substances and minerals)	S-type (minerals such as olivine, pyroxene, plagioclase, troilite, taenite, and chromite)

The Role of the Project Manager: To Encourage All Individual Project Members to Display Their Abilities to the Full and Make Decisions by the Deadline

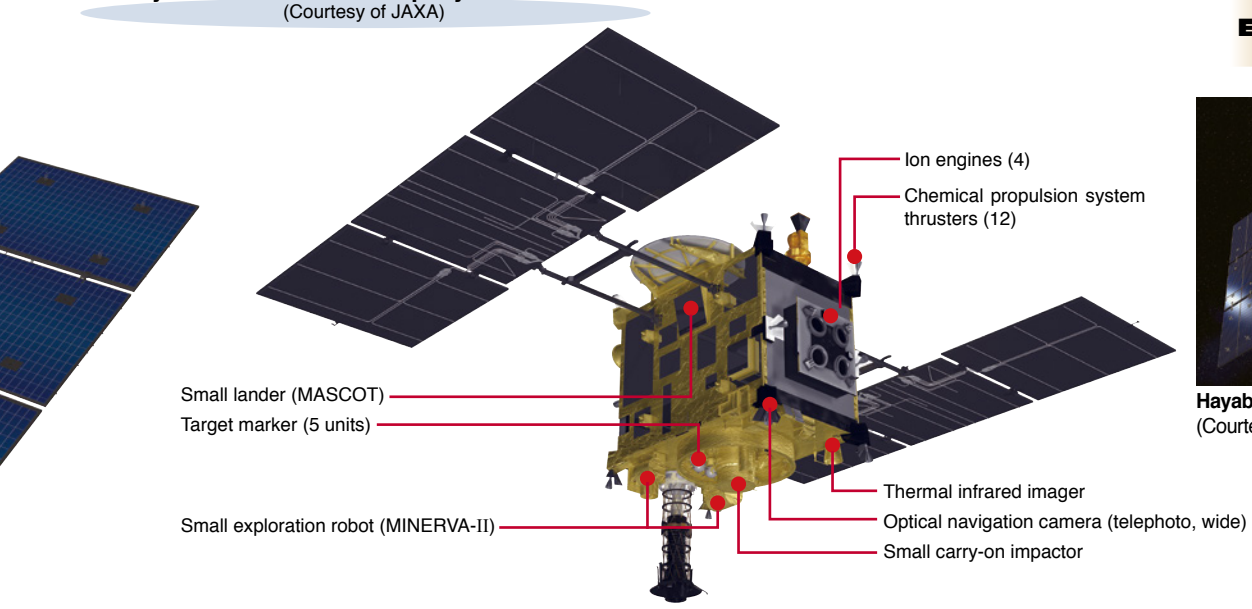
Obinata: The Hayabusa project brings together a wide range of specialized technologies. Since the project integrates such wide-ranging technologies, I imagine that many of them are not necessarily your specialty. Can you explain what you try to do when leading such a project team?

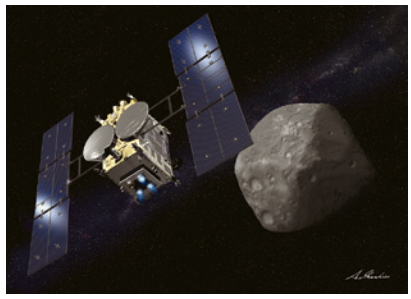
Kuninaka: It's true that there are many things I don't know (laugh).

What I try to do is to remind myself that first of all there are no supermen that are familiar with absolutely everything and that I am no superman myself. Given this, I tried to respect the judgment of those working at the project site as much as possible. I listened to their opinions in order to create an environment that would allow individual project members with specialized knowledge to display their abilities to the full.

Obinata: When I assumed the presidency of ULVAC, its employees were not very driven. Feeling the need to vitalize them, I strove to delegate authority in order to draw out their independence. I was extremely encouraged when I learnt that

Hayabusa 2 Viewed Obliquely from Below
(Courtesy of JAXA)





Hayabusa 2 approaching the Ryugu asteroid
(Courtesy of JAXA / Courtesy of Akihiro Ikeshita)

■ Table 2: Comparison of the Hayabusa 2 Asteroid Probe and the First Hayabusa Asteroid Probe

	Hayabusa 2	First Hayabusa
Dimensions of the main body without solar panels	1 m (width) × 1.6 m (length) × 1.25 m (height)	1 m (width) × 1.6 m (length) × 1.1 m (height)
Mass	Approx. 600 kg (including fuel)	510 kg (including fuel)
Date of launch	December 3, 2014	May 9, 2003
Carrier rocket	H-IIA rocket No. 26	M-V rocket No. 5
Communication frequency band	X band (7 to 8 GHz) Ka band (32 GHz)	X band (7 to 8 GHz)
Main exploration devices	Near infrared spectrometer, thermal infrared imager, optical navigation camera, laser altimeter, deployable camera, small carry-on impactor, sampler horn, MINERVA-II, and MASCOT	Near infrared spectrometer, fluorescent X-ray spectrometer, multiband, spectroscopic camera, laser altimeter, sampler horn, and MINERVA
Period of asteroid exploration	Approx. 18 months	Approx. 3 months
Collection of stone and sand	Twice on the surface and once below the surface	Twice on the surface
Return to Earth	November to December 2020 (scheduled)	June 13, 2010

your policy as the leader of this project was to draw out the abilities of individual members to the maximum extent possible.

By the way, project managers have to decide a lot of things in a short period of time, don't they?

Kuninaka: The duration of the Hayabusa 2 project was fixed, and its team members faced a mountain of tasks that needed to be completed at the climax of the project. Since nothing moved forward unless I made a decision, my job as the project manager was to make decisions quickly each day. This has something in common with corporate management. Corporate managers have to make decisions over a long period of time every time a problem arises. They have to examine all of the resources —including the time, personnel, and budget available— and all of the parameters closely, and then select the best of them.

In this project, however, the launch was scheduled for December 2014, so we had to create something acceptable by that deadline. Given this, we had to choose a maximum of one or two options from among the many candidates, put all of our resources into them, and solve any problems as inexpensively as possible in a short period of time. I could not place responsibility for the results on the project members, so I felt that my job was to make the final decision. In this sense, the job always put me in a tense situation.

Obinata: A company also employs many capable experts in fields such as accounting, finance, and development. If these experts are unsure what to do despite having considered the issue long and hard, the president should make the decision. In all other circumstances, I generally have no worries about leaving everything else to them.

I presume that it is extremely difficult for you to make a final decision on complicated issues if there are many stakeholders involved, and that this can put you in a difficult position.

Kuninaka: That's right. Since we had only three and half years before the rocket's launch for the Hayabusa 2 project, I had to make decisions on many things during that period. It proved difficult to obtain the budget we requested for the Hayabusa 2 project. In particular, we had a hard time because projects promoting science and technology faced difficulties in those days. In any event, we were not allowed to work slowly.

For the first Hayabusa project, I worked purely as an engineer, but for the Hayabusa 2 mission, I ended up taking on a managerial position.

Dr. **Hitoshi Kuninaka**

Professor at the Department of Space Flight Systems,
Institute of Space and Astronomical Science
Director of the Space Exploration Innovation Hub Center,
Japan Aerospace Exploration Agency (JAXA)

Born in 1960, Dr. Hitoshi Kuninaka graduated from Kyoto University in 1983 with a bachelor's degree in engineering. In 1988, he obtained his ph.D of Engineering from the University of Tokyo, and then went on to join the Institute of Space and Astronomical Science. In 2005, he became a professor at the Institute of Space and Astronomical Science. He also worked for the Department of Aeronautics and Astronautics, Graduate School of Engineering, University of Tokyo. In 2011, he became director of the JAXA Space Exploration Center, and in 2012, he was appointed program manager of the Hayabusa 2 project. In 2015, he took office as director of the Space Exploration Innovation Hub, a post that he holds to this day.

[Awards received]

2004 Technology Award for the microwave-discharge ion engine, Japan Society for Aeronautical and Space Sciences
2006 Space Pioneer Award to the Hayabusa Project Team, National Space Society
2007 Technology Award for the Hayabusa asteroid exploration mission, Japan Society for Aeronautical and Space Sciences
Best Paper Award for the paper on the ion engine, American Institute of Aeronautics and Astronautics
Best Paper Award for the paper on the ion engine, Electric Rocket Propulsion Society
2010 Electric Propulsion Outstanding Technical Achievement Award for the ion engine, American Institute of Aeronautics and Astronautics
58th Kikuchi-Kan Prize for the Hayabusa Project
Asahi Prize for the Hayabusa Project
Special Prize for the establishment of round-trip space technology in the Hayabusa asteroid mission, Minister of Education, Culture, Sports, Science and Technology
2011 Von Braun Award to the Hayabusa Project Team, National Space Society
Laurels for Team Achievement for the Hayabusa Project Team, International Academy of Astronautics
2012 Fellowship of the American Institute of Aeronautics and Astronautics
International SpaceOps Award for Outstanding Achievement to Hayabusa Operations Team, SpaceOps Organization
2013 Stuhlinger Medal, Electric Rocket Propulsion Society

Exploration of an S-type Asteroid by Hayabusa and a C-type Asteroid by Hayabusa 2

Obinata: The first Hayabusa targeted the Itokawa asteroid, while Hayabusa 2, which is currently still in outer space, is targeting the Ryugu asteroid. How did you decide on these targets?

Kuninaka: There are actually several types of asteroids. Those close to Earth are classified into two major categories: S-type asteroids and C-type asteroids. The "S" in "S-type" stands for "stone." These stony asteroids consist mainly of substances such as iron silicate and magnesium silicate. The "C" in "C-type" stands for "carbon," which also includes organic substances and water, so C-type asteroids are carbonaceous. The first Hayabusa was sent to Itokawa, an S-type asteroid, while the target of Hayabusa 2 is a C type asteroid.

The mission of the first Hayabusa was to prove whether Japan was capable of performing a round-trip asteroid exploration using only its own technology, so the target could be anything as long as it was an asteroid. Most of the asteroids that are easily accessible from Earth are of the S-type, so we selected an S-type one. The current mission, however, is to send a probe to a C-type asteroid. In fact, C-type asteroids that are close to and easily accessible from Earth are extremely rare, but one of these is called "Ryugu." The United States and the European Union are planning to reach other carbonaceous asteroids.

Obinata: When did you decide on the current target?

Kuninaka: The project was launched in 2011.

Saito: That was one year after the first Hayabusa returned to Earth, wasn't it?

Kuninaka: Yes. The work of finding new asteroids is also underway throughout the rest of the world, and if a new one is discovered, it is immediately analyzed to identify what type it is. At its own expense, JAXA has astronomical observatories observe asteroids that have just been discovered but have not yet been analyzed. For the current project, we started searching for C-type asteroids as long as ten years ago.

Following the Success of the First Hayabusa, Hayabusa 2 Has Attracted a Great Deal of Attention

Obinata: This type of project probably has a large budget, but in order to ensure the success of a project that involves a large number of people, it is important to set a goal or mission that is ambitious enough to unite them, isn't it?

Kuninaka: I think so. The target of the current project is extremely difficult to achieve and very challenging, but it's certainly an interesting mission that inspires everyone and makes people want to take part in it.

People in this field will already be aware of this, but it is important to get a place in the line for rocket launches. You cannot launch a satellite unless you have a place in the queue. This is a matter of great concern to us. If a problem occurs during development, the order of launches is adjusted. For the Hayabusa project, other missions said that they would be willing to give up their place for us —such was the appeal of the mission. Everyone knew that Hayabusa was an attractive project, but it was probably only Dr. Junichiro Kawaguchi, the then project manager, who envisaged that the project would succeed.

Since the first Hayabusa succeeded in returning to Earth in 2010 despite a number of twists and turns, the entire world has come to realize the objectives, significance, and value of asteroid

explorations. The reason we succeeded in getting the Hayabusa 2 project underway in such a short period of time under these circumstances, despite facing a mountain of problems, was that the success of the first Hayabusa mission was shared among stakeholders in Japan and the rest of the world. This eliminated the need to explain the objectives and other details of the project, which spared us a great deal of trouble.

Obinata: The success of the Hayabusa mission was a particularly impressive achievement. But given the considerable reputation acquired by the first Hayabusa, wasn't it all the more difficult to handle the Hayabusa 2 project because people had such great expectations for it?

Kuninaka: I'm exaggerating a little, but it is true that we did become the focus of public attention when we carried out the project (laugh). We felt as if our every move was being carefully watched by the public.

Obinata: Since this is a matter of concern to the general public as well, the entire nation is watching you closely. But when I visited some of your research and development facilities and offices a while ago, it was clear that the project members were not enjoying any luxuries (laugh).

Kuninaka: The Space Simulation Chamber was especially built to be used in the durability tests for the first Hayabusa's ion engine. It was constructed within one or two years, but we had visited ion engine research institutes throughout the world during the preceding decade in order to observe chambers made specifically for conducting ion engine durability tests. We prepared so carefully that we were able to build JAXA's Space Simulation Chamber quickly. In case you didn't know, the cryopump we use to create an ultra-high vacuum is manufactured by ULVAC.

Obinata: Yes, I found that out at the laboratory a short while ago. Thank you very much for using our product (laugh).

The Space Simulation Chamber Helped Facilitate Durability Tests for the Ion Engine

Saito: When someone mentions outer space, we tend to think of an ultra-low temperature, a dark expanse of space or an extremely harsh expanse of space with powerful solar radiation. How do you cope with the heat balance required to ensure that satellites work in the harsh environment of space?

Kuninaka: Heat management in space is extremely difficult. In a satellite, heat is transported via heat pipes, thermal conduction, and the like, but in the end, all of the heat is converted into infrared rays and released throughout a large area. The service life of semiconductors and other electronic components will be shortened if their temperature rises, and they will break if it rises too high. The higher the temperature becomes, the easier it is to discharge heat because, according to the Stefan-Boltzmann law, heat is released in proportion to the fourth power of the absolute temperature. Fortunately, the ion engine uses practically no electronic components, so there are few problems if it is operated at high temperature. However, the engine uses a magnet that is resistant to high temperatures so that it will not fail under such conditions.

JAXA Sagamihara Campus (Courtesy of JAXA)

Overview (as of April 1, 2015)

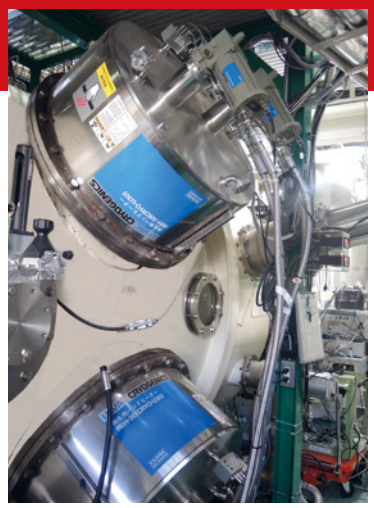
Japan Aerospace Exploration Agency, a national research and development agency

Location: 44-1, Jindaiji Higashimachi 7-chome, Chofu-shi, Tokyo
Established: October 1, 2003
Budget: ¥154.1 billion
Number of employees: 1,527 (as of April 1, 2015)
President: Naoki Okumura
Predecessors:
Institute of Space and Astronautical Science (ISAS)
National Aerospace Laboratory of Japan (NAL)
National Space Development Agency of Japan (NASDA)
Major bases:
Chofu (head office), Sagamihara (campus), Tsukuba, Tanegashima, and Kakuda (space centers), etc.
Profile:
The Japan Aerospace Exploration Agency (JAXA) is a national research and development agency that is responsible for Japan's aerospace development policy. Supervised jointly by the Cabinet Office, the Ministry of Internal Affairs and Communications, the Ministry of Education, Culture, Sports, Science and Technology, and the Ministry of Economy, Trade and Industry, JAXA is the largest of all Japan's national research and development agencies. It was formed in October 1, 2003 by combining the following organizations: t Institute of Space and Astronautical Science (ISAS); the National Aerospace Laboratory of Japan (NAL); and a the National Space Development Agency of Japan (NASDA). Its head office is located in Chofu City, Tokyo, where NAL was formerly situated.

Saito: At ULVAC, we use microwaves when we process something in a vacuum, but unlike with satellites, we do not operate machinery in a vacuum continuously for days or years. For your satellite, didn't you have great difficulty in terms of ensuring durability?

Kuninaka: Well, we conducted thorough durability tests for the first Hayabusa. The chamber was actually installed for that purpose. We conducted two-year durability tests twice. We continued the trial operation of the chamber except when its operation was suspended for maintenance. We spent about five years conducting durability tests, so we were able to observe the chamber's true capabilities. Our project is special; we develop the ideas ourselves, produce the prototypes ourselves, deliver them to ourselves, and use them ourselves. Manufacturers like ULVAC design and manufacture products that are subsequently used not by themselves but by the customer, so your responsibility is greater. Since we completed 20,000 hours of durability

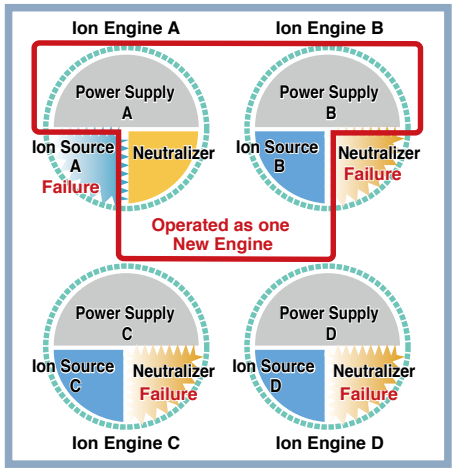
The four circular portions are ion engines (Courtesy of JAXA)



The cryopump incorporated in the space chamber, which played an important role in the durability tests (manufactured by ULVAC CRYOGENICS INCORPORATED)

A Cross-Networked Circuitry in the Ion Engines Helped Hayabusa Return to Earth.

An ion engine consists of three components: a power supply, an ion source, and a neutralizer.



As seen in the figure on the left, the cross operation combines the three undamaged components of ion engines A and B to enable them to operate as a new engine. As a result, the first Hayabusa was able to successfully return to Earth.

tests, we believe that we have created something that is more or less acceptable. We have satisfied ourselves that sufficient durability tests have been conducted. If you don't have confidence in your products, you cannot deliver them to your customers, can you?

Leading Hayabusa to Success by Leveraging a Uniquely Japanese Approach That Differs from That Employed by the United States

Obinata: Despite so many durability tests having been conducted, the first Hayabusa met with an unexpected accident when it landed on Itokawa. When we design equipment, we do everything possible to ensure success by taking additional measures in case the original idea fails. But this can make things overly complicated, thereby causing further problems. With limited weight and limited space in the Hayabusa project, you took various measures to prepare for unexpected events, didn't you?

Kuninaka: Since a satellite does not carry humans, we employ a design method that will enable it to cope with one failure. For example, if we have 100 items, we devise countermeasures on the assumption that one of them will suffer a failure (defect). If we assume that two failures will occur, we have to envisage 100 × 99 = 9,900 cases, and there is no way we can cope with such a large number of cases. The basic policy for space technologies used in unmanned spacecraft is for them to be able to cope with one failure. A policy known as "three inhibits" is used for manned spacecrafts. It aims to solve all possible problems by taking three measures. Therefore, different approaches are taken for manned and unmanned missions. Since it is an unmanned explorer, Hayabusa is operated using three ion engines with another installed as a backup on the assumption that one failure may occur.

Obinata: So that's why Hayabusa has four ion engines.

Kuninaka: Such sizing is an important issue that requires engineering insight. For example, if we are to structure the propulsion system for a satellite using one engine, we have to carry 200% because we need one more engine as a backup. If we cover the required propulsion with three engines, we need to carry only 133% in total even if a backup engine is added. The result is a lighter, smaller satellite. For this reason, how the satellite is sized is an important matter that requires engineering insight. Setting a satellite to a small size reduces the scale of the ground tests, allowing us to manage with a relatively small chamber.

At that time, the United States emerged as a rival by attempting to conduct space exploration using an ion engine. Starting later, the Americans were able to complete in just three years what it took Japan five to six years to achieve, and their launch took place earlier than the Japanese one did. We got angry (laugh).

Since American-built ion engines are large, their artificial satellites are equipped with only one. In Japan, we covered the propulsion needs with four small engines. In terms of scale, American-built ion engines are unquestionably superior, but we felt that we could use a different approach to that used by the Americans because we had as many as four engines. The ion engine works with a set made up of an ion source and a neutralizer. Since the Japanese satellite has four engines —each of which carries such a set— we firmly believed that ours would be superior because each of the neutralizers could be combined with other engines.

Obinata: That was what you refer to as a "cross-networked circuitry in the ion engine," which was a great achievement that led to the first Hayabusa being successful in the end.

Kuninaka: Such an innovative idea came about precisely because the United States emerged as our rival, prompting us to work harder.

Developing Highly Reliable Data Through Repeated Simulations

Obinata: At ULVAC, I always tell our developers that they must perform simulations properly in the design stage without fail when they develop new products. In the case of Hayabusa, engineers had to employ a combination of many specialized technologies, so the number of simulations that had to be performed was enormous. I imagine you had to make effective use of data obtained from many areas. How did you get on?

Kuninaka: The techniques used to build satellites have been

established to a certain extent, and they are assembled in stages. At first, fairly broad specifications are given, and as the detailed design progresses, various profiles become more real. Something real and concrete —rather than ambiguous figures— emerges. This process is repeated so as to put together the whole picture of the satellite.

Obinata: At our company, too, an unexpected result is sometimes obtained as we proceed with development, and this forces us to make a decision based on that result. What is important is to clarify whether such an outcome was obtained as a result of our best efforts. The reason is that the results of half measures may be meaningless.

Kuninaka: That's right. We have some students, and I check the results of their research every week. Some results include some very dubious figures, but I encourage them to develop more reliable data by letting them repeat the experiment several times while I offer them some ideas.

Evolving the Ion Engine Further by Rejuvenating the Research Teams

Saito: In the first Hayabusa project, you performed exhaustive durability tests for the ion engines and incorporated Japan's own unique ideas into them. Did you make any new attempts or introduce any new initiatives for Hayabusa 2?

Kuninaka: We were able to obtain a clear understanding of various space phenomena through our first ion engines and get various data through field activities. Based on these results, we decided that we wanted to create much better engines. I also made that a research assignment for our students.

Rejuvenating the research staff is another important issue that needs to be addressed. Since, just like other researchers, I am getting older, I want to rejuvenate the research organization. Even though we would like to hire young researchers, JAXA's budget is tight, so we have to make the most of external funds from NEDO and other organizations to recruit research personnel. Furthermore, since that was still not enough, we also encouraged companies that were willing to manufacture ion engines. This is also part of our indirect efforts to strengthen our human resources. At the same time, since it is a waste of resources to make such companies operate only in the Japanese market, we travelled overseas with their personnel to conduct sales activities.

Obinata: Are ion engines used in commercial rockets?

Kuninaka: American ion engines are used in commercial rockets, but the microwave-discharge iron engine I developed hasn't been yet. My ambition is to have it mounted on geostationary satellites. That would generate a large volume of sales. If it is used for commercial satellites, it will be mass-produced.

Hayabusa 2's Ion Engine Applies the Lessons Learned from the First Hayabusa

Kuninaka: In the past, there were three space-related organizations in Japan —the National Space Development Agency of Japan (NASDA), the Institute of Space and Astronautical Science (ISAS), and the National Aerospace Laboratory of Japan (NAL)— but these were all integrated to form JAXA in 2003. I was affiliated with ISAS, which worked on scientific satellites only, not commercial ones. Since NASDA developed many commercial satellites, I envied the organization, thinking that if I was working there, many of the ion engines I had developed would be used. In 2003, the three organizations were combined to form JAXA, which resulted in my field of activity expanding suddenly about 100 fold. The reorganization of the three organizations into JAXA was really beneficial to me.

Hisaharu Obinata,
President and CEO,
ULVAC, Inc.

Kazuya Saito,
Executive Officer and Manager of the Research & Development Planning Department, ULVAC, Inc.

Saito: Doesn't that also mean that you became the manager of the Hayabusa 2 project, and that such a change in position allowed you to look at things in new ways?

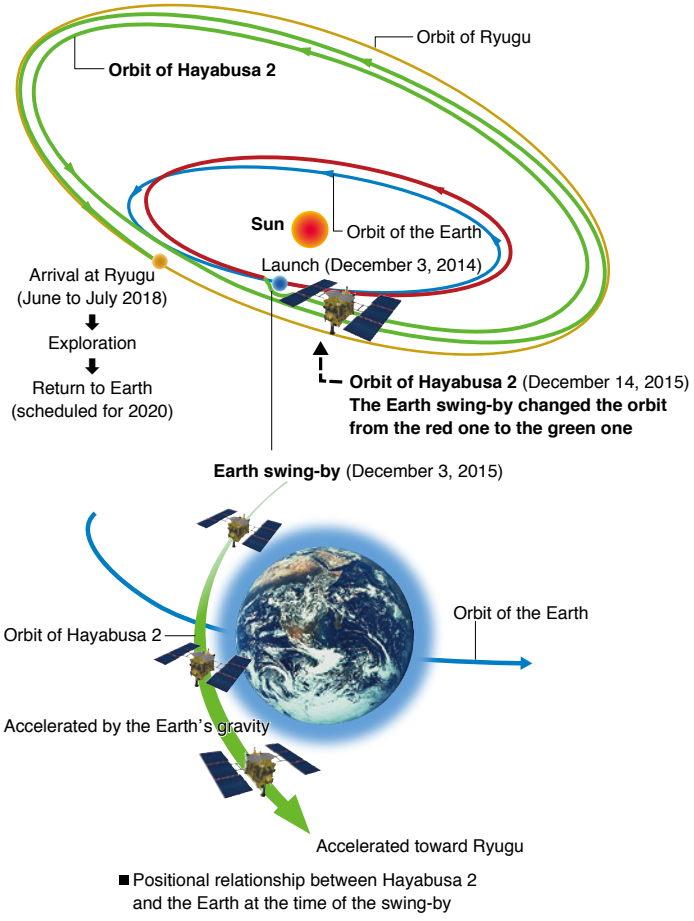
Kuninaka: The challenge we face for the Hayabusa 2 project is the number of things we can concentrate on creating in a short period of time. The situation forced me to make decision after decision after decision. It was a rather restricted life (laugh).

On reflection, the ion engines used on the first Hayabusa were not perfect. If they had been perfect, we would have been able to make advance preparations more easily, but since the explorer's return —which had initially been scheduled for June 2006— was postponed to 2010, we were concerned about whether the postponement might affect the project or not. We took several measures based on such assumptions, but we still didn't know whether these measures would really work. The delay meant that more tasks were assigned to the ion engines. Attitude control, which was originally performed without using the ion engines, now had to be performed using the engines, and this forced Hayabusa to employ a cross-networked circuitry in the ion engine in order to return to Earth.

We had tried employing a cross-networked circuitry in the ion engine using an experimental model, but we had not done so using an actual model to confirm whether it worked.

Obinata: In various kinds of development competition scenarios, even if our competitor clearly exceeds us, we still

■ **Overview of a Swing-by Using the Earth's Gravity**



■ Positional relationship between Hayabusa 2 and the Earth at the time of the swing-by

rack our brains to try and develop something that will rival or surpass them. That was how you developed the idea of a cross-networked circuitry in the ion engine, wasn't it?

Kuninaka: I also think it's important to work hard together —after all, the grass is always greener on the other side of the fence. Inferiority does, in a sense, provide us with opportunities to develop such new technologies. When we announced that we would use a microwave-discharge ion engine for the first Hayabusa, overseas researchers said that we would never be able to do so. Even lecturers at Japanese universities said the same. It may sound a bit paradoxical, but if saying "You can if you try" is a form of positive encouragement, then saying "There is no way you can" is a form of negative encouragement. If you use negative encouragement in a clever way, employ the feeling of vexation as a springboard, and do your best, you will be able to achieve what you previously considered to be impossible.

Hayabusa 2 was based on the obstacles that the first Hayabusa overcame, so as the December 2014 launch approached, we proceeded with its development with plenty of confidence. Since this is also a science and technology project, however, we can't be sure that we will be able to find solutions in real time. The only thing we can do is to apply the best scientific and technological knowledge that is available at the time. New knowledge may emerge five or ten years later that makes us realize that the decisions we made five or ten years before were wrong. This often occurs in the field of science and technology, and it is unavoidable. The reason for this is that what we were trying to clarify was beyond human knowledge at the time.

Demonstrating to Young Children How Attractive Space Development is While Giving Them a Glimpse of the Future

Obinata: Recently, ULVAC established the new Future Technology Research Laboratory (for details, see pages 18 and 19 of this magazine). Our aim is to consider what we will, or should be able to, achieve in 10 to 20 years' time and to identify now what will sustain our future growth. I'm sure you're developing various visions based on a close look at what things will be like in 10 or 20 years from now, but what inspires you to envision what will be needed in the future?

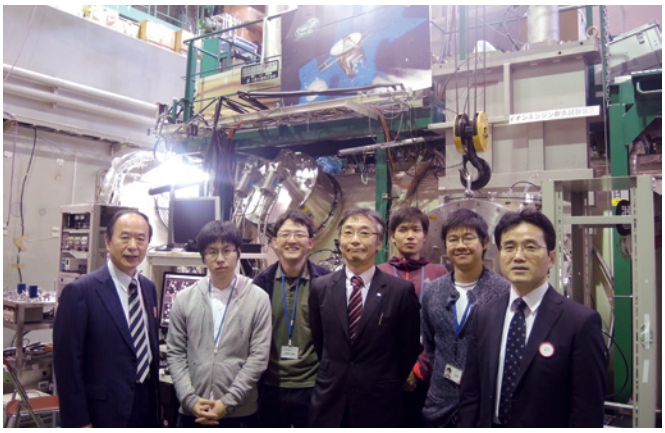
Kuninaka: It comes from considering what I will be doing in my job in the immediate future or in 3, 5, or 10 years from now. What inspires me is that this process may take 20 years or it may be realized very quickly. In addition to research and development, my job includes education in the form of instructing postgraduate students. I am constantly thinking about what research assignments I should give to new students, and I always come up with such assignments —including a more in-depth study of technologies that are close at hand— from flashes of inspiration and ideas that spring to mind.

Obinata: What kind of environment should persons in higher positions try to provide, or what should they do, to encourage engineers to have flashes of inspiration?

Kuninaka: They should give them opportunities to envisage what technologies should be available in the future. Everybody is probably very busy, so if you are told by your superior to do a particular job, you will think only about that job at all times because you are required to deliver results within one or two weeks. Of course, their immediate jobs need to be done, but what is important is to encourage your subordinates to think and envision what things will be like in 10 to 20 years' time.

Space projects must be implemented over a long period of 10 to 20 years. I often have the opportunity to give lectures to children, who may go on to become researchers themselves in the future. On such occasions, I always use a chronological table as a visual aid to show what JAXA currently plans to achieve in its space development projects within the next 10, 20, or 30 years. Junior high school students and high school students will graduate from university and find a job 10 years from now, and 10 years after that, they will be working at the frontline of their organizations. At that time, the space development projects that I explain will be underway, so they should develop their talents in order to be able to contribute to such projects. If they are interested in space development, they should start to prepare themselves now.

I always speak to children in this way in order to inspire them.



With the Space Chamber in the background, Dr. Kuninaka (center) poses for a group photo with students involved in the development of ion engines.

Obinata: I see. The idea is to encourage young engineers to come up with ideas on their own initiative by showing them what space development will be like 10 or 20 years from now.

Creating New Technologies Jointly with Private Enterprises with Outer Space as the Keyword

Saito: Having served as manager of the Hayabusa 2 project, what exactly are you doing now?

Kuninaka: We recently established a new department called the Space Exploration Innovation Hub Center, and I am working there with the support of the Japan Science and Technology Agency. I am chiefly in charge of joint technology research and development projects with private enterprises. Our primary objective is to promote technological developments that will contribute to the commercial activities of private enterprises. Since this is part of JAXA's business, we do, of course, select technologies that can be used in space when we undertake joint development.

Saito: You must have trouble making arrangements for technology development.

Kuninaka: We have to find projects that will serve the purpose of the business. Fortunately, I believe that JAXA is delivering satisfactory results as a national research and development agency. The government's intention is that JAXA should share with private enterprises the schemes, expertise, knowledge, and equipment that it has developed through its space development projects.

A few decades ago, innovations often occurred, which resulted in things changing rapidly. Today, however, research and development has reached a saturation point worldwide in that we have an environment that prevents new innovations from being created easily. Old customs and inflexible ways of thinking do not lead to the creation of new innovations. Conversely, new ideas may emerge if we ask private enterprises to come up with something new using outer space as the keyword. If we think in this way, some unconventional ideas may emerge that can be used effectively in business. This is what is meant by JAXA's call for the joint idea development that I described earlier.

Obinata: If we develop new ideas in earnest by linking our business with space projects, JAXA may be able to make use of them.

Kuninaka: I sincerely hope that you will propose something new to the Space Exploration Innovation Hub Center. If you propose something that is suitable for your business model and it meets JAXA's vision for the future of space development, it will certainly be used.

Saito: Satellites float in the vacuum of space, but ULVAC provides a variety of technologies by creating vacuums on Earth. We do not have any specific ideas at the moment, but we would certainly like to submit some proposals to JAXA in the future.

Our Next Vision: Using Jupiter's Gravity to Explore Planets Farther Away

Obinata: Finally, can you tell us about your vision for the future?

Kuninaka: Given that I am involved in space development, my next target is Jupiter. The gravity of Jupiter is strong because it is the largest planet in the solar system, which would allow us to use a maneuver known as a "gravity assist" or a "Jupiter swing-by." The United States has sent Voyager and other explorers to Saturn and Pluto, but when they send probes beyond Jupiter, the probes always travel via Jupiter to make use of its gravity to achieve a stronger swing-by. If explorers are launched to go farther out into the solar system, they always need to go via Jupiter. Being able to reach Jupiter using Japanese technologies would provide us with opportunities to go beyond it. Developing routes to Jupiter independently will open up the way to going farther afield, in much the same way as European navigators discovering the Cape of Good Hope did during the Age of Discovery.

Obinata: If so, you will need ion engines with an even higher level of performance, won't you?

Kuninaka: We will have to create more fuel-efficient ion engines. We have already started research and development into this. In addition to ion engines, we are steadily preparing new technologies that will allow us to reach Jupiter.

Obinata: How many years will it take before such technologies are available?

Kuninaka: That will depend on whether a budget is appropriated for this project, but we would like to realize them in the 2020s.

Obinata: It would be absolutely wonderful if the return of Hayabusa 2 and the launch of the next Jupiter mission would coincide with the Tokyo Olympics and Paralympics.

Kuninaka: I will have retired by then (laugh). I am currently interested in how I can interest young children in space projects. That is another job of mine. For space projects, successors cannot be produced unless their development starts during their childhood.

Obinata: That is truly a cosmic vision full of dreams, isn't it? I sincerely hope that you will enjoy great success as you aim to reach Jupiter. Thank you for taking the time to talk to us today.

PROLAYER

Outstanding Vinyl Record

Quality and High Sound Quality Realized by Using Sputtering Film

— Reduced Abrasion, Good Heat Conductivity, and Static Electricity Prevention Through the Use of Vacuum Film Technologies

Interview with: ULVAC TAIWAN INC.

A PROLAYER™ record produced using sputtering film and its sleeve

LIVING & ULVAC

Vinyl records quickly lost their long-held dominant position in the music publishing market when digital CDs made their debut at the beginning of the 1980s, and in just a few short years they had been relegated to a small corner of the music publishing market. Vinyl records did not completely disappear, however; they were still produced for a small number of audio fans. In recent years, demand for vinyl records has tended to increase, mainly among the younger generation who were brought up listening to CDs. The main reasons behind this trend include the fact that CD sleeves don't have the same dynamic feel as vinyl record sleeves do and that the high sound quality that is unique to analog recording is only reproducible with today's high performance audio sets. Although the performance of acoustic products has been increasingly enhanced, the original quality of polyvinyl chloride (PVC) —or "vinyl"— LP records has not been modified or improved since they made their debut in the latter half of the 1940s. For this issue of LIVING & ULVAC directs a spotlight on the high-quality PROLAYER records created by ULVAC TAIWAN INC. PROLAYER records are produced by leveraging vacuum technologies to eliminate the weakness of vinyl records, thereby providing even higher sound quality.

PROLAYER Records Produced Using Vacuum Technologies

ULVAC TAIWAN INC. (UTI; head office: Hsinchu city, Taiwan) was founded in 1981. It is a core overseas member of the group of companies that act as ULVAC's global production base. A more detailed description of the company is provided on pages 15 to 17 of this magazine in the VISITING ULVAC section.

UTI's main line of business is the manufacture of vacuum equipment for the electronics industry, which produces devices such as semiconductors and LCD televisions, and it also provides field supports for this industry. As part of its unique range of activities, the company has recently developed PROLAYER, a groundbreaking sputtering film record that is made using a type of thin-film deposition equipment called a sputtering system.

Universal Resurgence of Interest in Vinyl Records

The world's first vinyl record was the 78 rpm shellac record. It had a recording time of about five minutes on one side. Some time later, the use of high-density polyvinyl chloride (PVC) allowed extremely narrow grooves to be formed in records to act as the sound source. As a result, the long-playing (LP) record, which can hold 30 minutes or more of music on one side, became the principal type of vinyl record.

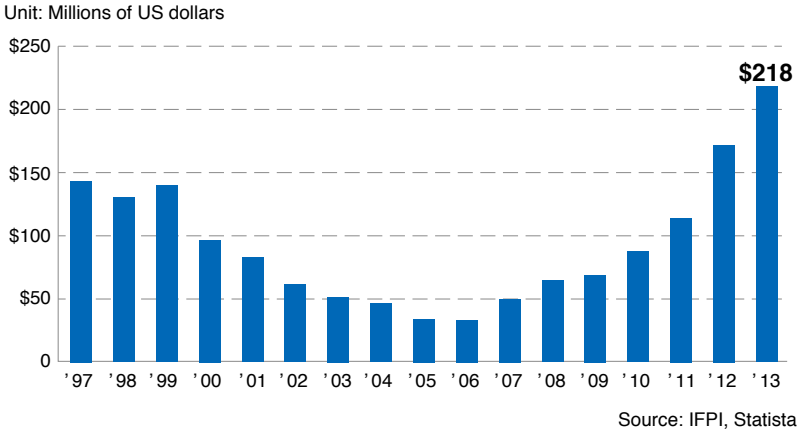
The LP record was developed in the latter half of the 1940s, and it replaced conventional 78 rpm records from the 1950s onwards. Until the digital CD appeared in the early 1980s, LP records were the main form of music media for about half a century. In the 1990s, vinyl records became temporarily obsolete. Since the mid-2000s, however, LP record production has been gradually increasing, and they have regained some of their popularity through support from not only vinyl fans, but also the younger generation.

A Radical Measure to Improve Previously Unchanged Vinyl Records

Throughout the vinyl record age and the digital CD age, audio electronic devices —such as record players, CD players, amplifiers, and speakers— have undergone an amazing evolution, thereby contributing to the high-quality sound we now enjoy. In contrast, the materials and production process used for vinyl records have remained unchanged, so vinyl records have not evolved in the same way as audio devices have.

So, is the vinyl record a perfect product? No. Vinyl records

■ Global Trends in Sales of Vinyl Records



Source: IFPI, Statista

From the left: Stanley Wu (UTI Vice President), Chiang-Yao Chen, Ellie Chen (in charge of development and project), and Clare Wei (Vice President) in front of the sputtering system

have a lot of problems. The main problems are as follows. A record differs from a CD in that sound is produced by a phonograph needle tracing the record's grooves. The heat generated on the side in contact with the needle causes the record's shape to change, which eventually results in damage to the grooves. Consequently, the service life of a record is limited. Another crucial issue is a problem with the material PVC. PVC tends to generate static electricity, which results in dust accumulating on the record. This dust generates noise and disturbs the comfortable sound of the music.

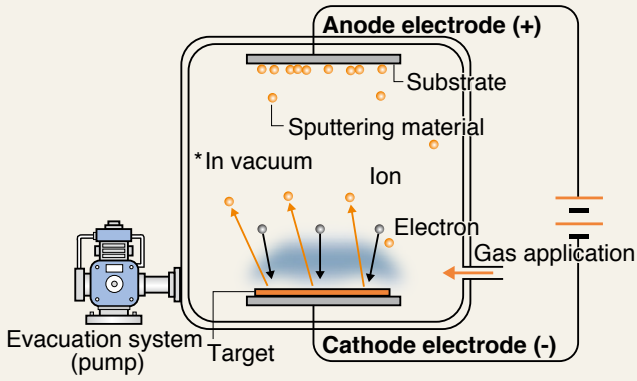
Eliminating Problems with Records through the Use of Sputtering Film

Vinyl records have the following drawbacks: they are inferior in terms of abrasion; they have very low heat conductivity; and they tend to generate static electricity. As a fan of vinyl, Clare Wei (UTI Vice president) wondered whether vacuum technologies could be leveraged to eliminate these problems. He then had a flash of inspiration when he came up with the idea of applying a vacuum thin film to the surface of a phonographic record.

Various different methods can be used to form a thin film with the aid of a vacuum. The following are the three most commonly used ones: the evaporation method, which is relatively easy to use for a wide variety of applications; the sputtering method, which is suitable for large homogeneous areas; and the vapor phase growth method, which forms a high-performance chemical thin film through vaporization. After some trial and error, it was finally determined that a molybdenum sputtering film formed with a sputtering system would eliminate the problems.

Stanley Wu (UTI Vice President) unveils the PROLAYER record at the TAA Taipei Yuen-shan Audio Show

The Principle of Sputtering Film Deposition



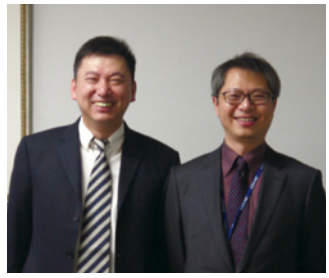
The target is positioned opposite the substrate. In an argon atmosphere under a pressure of between a fraction of 1 pascal and several pascals, an electric discharge is generated by applying a negative high voltage of several kilovolts to the target. This discharge creates plasma in which argon atoms become positive ions that collide with the target. The atoms ejected by this collision reach the substrate and form a deposition thin film on it. This thin film deposition method is called the sputtering method.

This sputtering film enhances vinyl records by molybdenum'se melting point up to more than 2,500°C, thereby increasing the surface hardness to about 30 times greater than conventional vinyl records material, PVC, and increasing the heat conductivity to about 1,300 times greater. In addition, since the sputtering film produces a smooth surface, the friction force is reduced by 50% or more, and the damage caused by the pressure that the stylus exerts on the grooves is markedly reduced. It has been demonstrated that the sputtering film contributes to an increased service life for records.

In the spring of 2015, Clare Wei approached Mr. Yu-Chang Huang, a chief member of the Kaohsiung Electrical Commercial Association, with his idea, and together they launched a joint development project. In August 2015, the sputtering film record was exhibited at the TAA Taipei Yuen-shan Audio Show. An audio commentator was invited to attend the show, and Ms. Artemis H.R. Yen who granted the Post-Graduated diploma in piano Performance from the famed Moscow State conservatory, performed one of Tchaikovsky's piano pieces live. After that, an event was held where those attending listened to the same piece of music being played using a conventional vinyl record and a sputtering film record to compare the sound quality. The sputtering film record received such a favorable review from the audio commentator that it actually is our expectations.

We are now in the process of trademarking the sputtering film record, and the mass production of sputtering film is almost within sight. Going forward, we will develop concrete approaches for promoting sales of the PROLAYER record by selecting target artists and album music for its world debut.

As ULVAC's base in Taiwan, ULVAC TAIWAN INC. (UTI; Chairman: Mitsuru Motoyoshi [Director and Senior Managing Executive Officer of ULVAC, Inc.] President: Yu-Jer Tsai) has delivered more than 1,000 ULVAC systems, thereby supporting Taiwan's electronic industry. In recent years, manufacturing in Taiwan has been decreasing, but ULVAC TAIWAN INC. is endeavoring to enhance its services, undertake unique research and development, and pursue market development. This edition's VISITING ULVAC section has an interview with Yu-Jer Tsai (UTI President) and Stanley Wu (Vice President).



Left: Yu-Jer Tsai (President)
Right: Stanley Wu (Vice President)

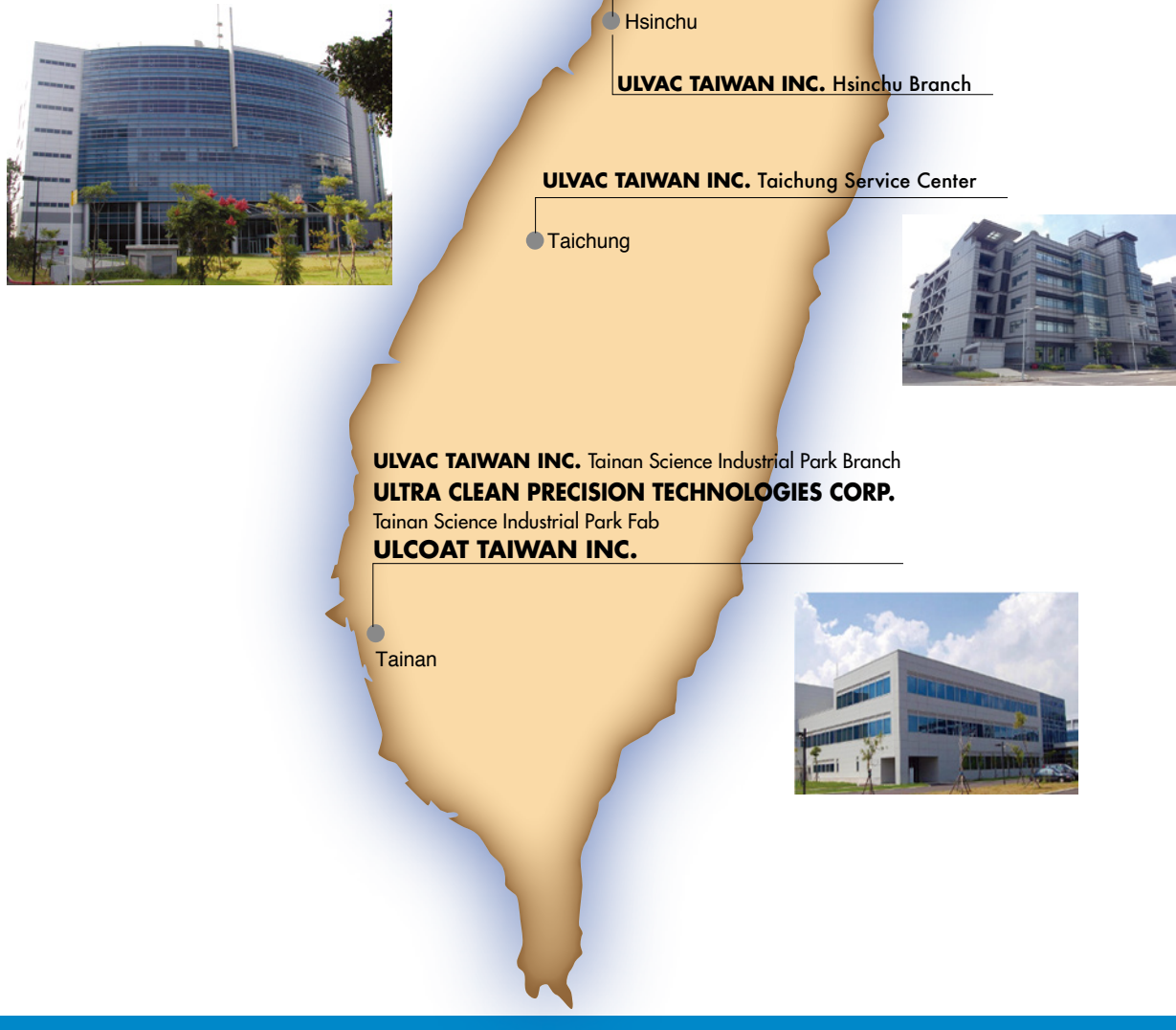
VISITING ULVAC

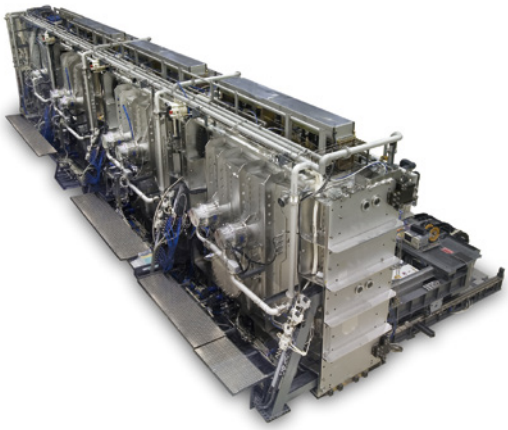
ULVAC TAIWAN INC.

Head office: Hsinchu City, Taiwan

Aiming to Expand the Market as an ULVAC Production Base in Taiwan

—Unique Research and Market Development Created by Diverse Sensitivity





SMD-2400 sputtering system

ENTRON™ EX2 W300 sputtering system

NA-1300 ashing system

Introduction

UTI was founded in 1982 with the aim of delivering sales and service operations for vacuum equipment. Initially, its sales and service operations were for components and small research systems. Until the mid-1980s, its main products included industrial equipment such as vacuum evaporation roll coaters and vacuum heat treatment furnaces.

In the 1990s, industries in Taiwan shifted to electronic parts and semiconductors in response to increased technical cooperation with Japanese-owned businesses and the start of a foundry business. After 1998, investment related to flat panel displays (FPDs) increased rapidly, resulting in Taiwanese industries playing an active role as the base of production for the world's semiconductors and LCDs.

UTI not only installed ULVAC systems, but also started its own production in Taiwan. It constructed a factory in Tainan, from which it manufactured and delivered many systems.

Recently, however, the electronics industry in Taiwan has seen an increase in the number of company mergers and business start-ups overseas, and domestic opportunities for manufacturing have been decreasing.

Against this backdrop, UTI has been enhancing its manufacturing and production skills and actively pursuing initiatives such as enhancing its field services, undertaking unique research and development, and developing an organization that takes full advantage of diversity.

Enhancing Our Customer Support Business

UTI cannot succeed and survive in today's increasingly intense global competition simply by delivering conventional customer services, such as repairing broken products and selling the necessary parts. UTI not only performs any necessary repairs, but also pays due attention to the customer's needs at all times by proposing useful improvements and enhancements for them in a variety of ways.

UTI also works in cooperation with ULTRA CLEAN PRECISION TECHNOLOGIES CORP., a group company that delivers manufacturing, cleaning, surface treatment, and customer support services for vacuum system units and their parts. As a result, UTI's customer support business in Taiwan is now essential to the Taiwan group.

Unique Research and Development

UTI mainly conducts its business in cooperation with large companies in major industries. However, it also focuses on small-scale projects that could easily be overlooked, and keeps a close eye on various new possibilities by actively working to identify new lines of business ahead of its competitors.

In addition, UTI is aggressively developing businesses in new areas that are directly linked to our everyday lives. Its employees contribute ideas for discussion, and these are eventually raised at a directors' meeting. Under this system, one idea is adopted every six months as a new research and development theme.

PROLAYER, the recording technology introduced in LIVING & ULVAC (p. 12 to 14), is one of these themes.

Wu says, "We experienced a countless number of unsuccessful trials, but successful trials —even if they are few in number— raise the morale and motivation of employees. With themes that are deeply linked to our everyday lives, we are moved by being able to experience ULVAC's technologies directly. The most important thing is develop your sensitivity —in other words, what inspires you. It is essential to enjoy development."

We expect new areas of business to be increasingly created through the enjoyable development that is realized by fully demonstrating your sensitivity and experiencing things through your five senses.

Inter-Group Cooperation

Taiwan is a geographically compact island, so it is easy to provide support among the various different business areas, and

PROLAYER record

members of the company's upper management can visit domestic sites easily. UTI takes full advantage of these geographical advantages. Rather than dividing its head office, business offices, factories, and group companies into different frameworks, the company prioritizes the maintaining of a close network, cooperation, communication, and operational agility.

UTI also cooperates with ULVAC group companies in China to support its Taiwanese customers with China-based factories. It regularly provides on-site support for such customers when necessary.

Tsai says, "Even if the work is undertaken by a different company, base, or department, it will always be ULVAC for our customers. It is important for us to integrate to be One ULVAC."

Developing an Organization That Takes Full Advantage of Diversity

In recent years, an increasing number of women have entered Taiwan's business society, and UTI employs many women too. Women are now playing important roles at our company, particularly in the business departments for materials and parts.

Since UTI originally focused on selling technologies, it mainly employed graduates with a science or engineering background or individuals with experience as engineers. UTI now actively employs graduates from humanities programs and persons in non technical areas as well, since they have high-level communication skills and a rich sensitivity that inspires others. UTI will continue responding to the dramatically changing business environment and diversifying customer needs by not only respecting and accepting differences, but actually making active use of them.

Deepening Communication through Recreation

To promote a sense of unity within the company, UTI is proactive in its efforts to hold a large number of events that provide an opportunity for its employees to get together. Such events include year-end parties, company trips, and CSR activities. In 2013, UTI held a sports day that boasted full attendance for the first time.

This event had been planned from scratch, but several hundred employees prepared and practiced for the holding of the event in a cooperative manner. Many employees said that this process helped to improve their sense of unity, and that the solidarity of the organization was enhanced by sharing feelings of joy and sorrow in a sympathetic environment. In March 2015, employees donated clothes to Corning Education Center, which supports an independent lifestyle for senior citizens, low-income individuals, and people with disabilities. In return, they received a letter of appreciation.

Future Vision

Creating Unique Groundbreaking Technologies without Sticking to Conventional Business Frameworks

Yu-Jer Tsai
President
ULVAC TAIWAN INC.

I took up the post of president in 2006, so this is my tenth year in this role.

In UTI's operations, we channel all of our energy into establishing a system for accomplishing our work as organization. Under this system, if one of the people in charge is absent, another person will support the project to ensure that the business operations continue smoothly.

To establish such a system, it is important that you support flexible activities by delegating authority and that you promote solidarity among the company's employees. Given this, we believe that the holding of various company events and activities will also contribute to the establishment of such a system. Consequently, we will continue holding such events and activities.

We will make full use of the ULVAC group network, which covers not only Taiwan, but also the rest of the world. In doing so, we will continue creating unique groundbreaking technologies in Taiwan without sticking to conventional business frameworks. We hope that we can continue to count on the support of our stakeholders.

Employee solidarity was enhanced at our sports day

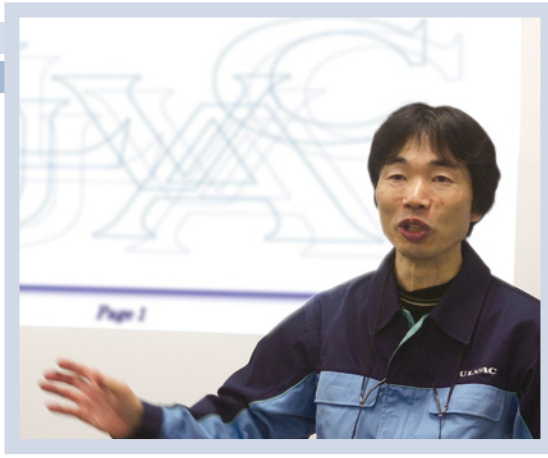
A letter of appreciation was given for the donation to Corning Education Center

ASK

Hirohiko Murakami (General Manager of the Future Technology Research Laboratory of ULVAC)

Establishment of the Future Technology Research Laboratory

—— Toward Creating Future Core Competence



On July 1, 2015, ULVAC established the Future Technology Research Laboratory in Tsukuba, Ibaraki (headed by Hirohiko Murakami) to create next-generation business. The Laboratory aims to create innovation by researching "future technology," as its name indicates, to further leverage ULVAC's strengths of developing devices and researching materials.

Introduction

ULVAC was founded in 1952 with the determination to contribute to Japan's industrial recovery with vacuum technology. Since vacuum technology was not widely used at that time, we established a vacuum technology research department ahead of other Japanese companies, starting to tackle challenges of the industry using all of our intellectual powers.

As a result, the research department has contributed to the industry representing each postwar period with our advanced technology, giving priority to research and development and cooperating with our production department. These industries include heavy industry from 1955, secondary industry, such as home electronic appliances, automobiles, and foods, from 1965, and the electronics industry, such as semiconductors, between 1975 and 1990.

Vacuum technology is now considered a promising key technology essential to the fields of information equipment related to IoT (Internet of Things), energy, and advanced medical treatment.

In recent years, it has become important to promote research and development from a long-range perspective to conduct stable and continuous corporate activities in the industry, which keeps changing and making progress. That is why the Future Technology Research Laboratory was established under our management policy of creating innovative business with an overwhelming competitive edge, or core competence.

For What Purposes Was the Laboratory Established?

The Future Technology Research Laboratory aims to create innovation that surpasses existing technology by researching "future technology," as its name indicates.

As conditions surrounding us have changed significantly, the challenges we should solve have also become diversified and increased. In this situation, we believe that researchers need to always have challenging research themes of creating something new with the originality of creating one from zero.

It is no exaggeration to say that R&D-oriented companies, like ULVAC, are obligated to create new technology and new social value. We will keep proposing new technology leading the company's management and business strategies to make every possible contribution to the company's future.

What Are the Research Themes of the Laboratory?

We started our operations with the Surface Treatment Development Center and three research fields (next-generation energy, electronics, and materials). With a basic policy of "open innovation and an open research laboratory," we will search for valuable research themes leading to in-house ventures together with other R&D departments and work on such themes.

Our research themes, unlike those of university and public research laboratories, will focus not only on academic contributions of accumulating scientific knowledge, but also on contributions to creating future business and core competence.

What Social Contributions Does the Laboratory Make?

Energy is an important global issue. We wish to bring a sustainable future to society and companies by developing technology that can explore the energy frontier.

To achieve this goal, we find it effective to research ultimate storage batteries for expanded use of renewable energy and energy harvesting, which reuses waste heat as energy. We will put extra focus on next-generation secondary batteries, which use CNT (carbon nanotubes) and are one of the materials we have researched, for electrodes.

What is the Research Policy of the Laboratory?

A department whose performance directly influences the company's performance needs to create business models with the selection and concentration of its operations because failure is unacceptable. On the other hand, a research laboratory should conduct free-minded and flexible activities without the selection and concentration of its operations. In fact, failure can be considered a role of a research laboratory. Failure is classified into two types: mere failure and failure opening the way to the future. Many failures in research activities are achievements opening the way to the future.

To make failures in research activities useful ones, it is important to realize the visions and concepts of research themes one by one. For this reason, I believe that we should not easily reject proposed research themes only because they seem difficult or unacceptable. I hope that each researcher has enough vitality to take the initiative and leadership in his research theme.

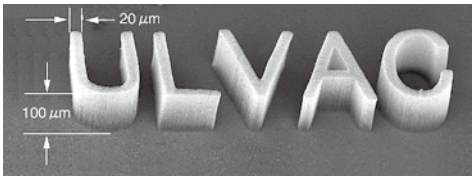
What Are the Necessary Qualifications of Researchers?

I believe that innovations emerge from interdisciplinary exchanges. It is generally not difficult to find an opportunity to participate in such exchanges, but to be able to come up with new ideas also requires you to incorporate the knowledge of different disciplines. Merely gathering to socialize and sip on beverages may foster exchange of information, such as research topics, among organizations, but will never lead to breakthroughs.

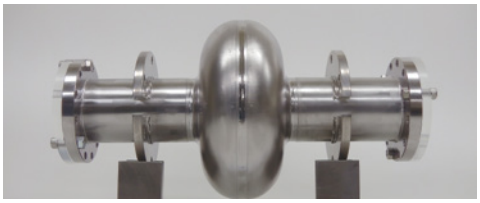
A good example of exploring different fields is how Watson and Crick discovered the double helix structure of DNA in 1953. They found a clue to this discovery in X-ray diffraction used to analyze crystallographic structures. When they analyzed the structure of DNA with this technique, they found that DNA has a double helix structure. In this example, biological experts began a new phase of science by applying a physiological technique. This is the type of interaction among different fields that I want to see in the Laboratory.

Workshop

At the Future Technology Research Laboratory, one of the qualities we look for in a researcher is a daring attitude. We aim to train researchers who not only have such an attitude but also show spirit in competing with other researchers and pioneering in new fields. We welcome those who aspire to be such researchers.



Letters of ULVAC made from CNT
(The width of each line is about 20 μm and the height of each letter is 100 μm.)



High-purity niobium materials for superconducting accelerators

Awarded "100 million dollar Export Tower Award" for Contributing to Korea's Export Earnings

— ULVAC KOREA, Ltd.

In December 2015, ULVAC KOREA, Ltd. (hereinafter referred to as "UK") was awarded the "100 million dollar Export Tower Award," sponsored by the Korea International Trade Association and supported by the Ministry of Trade, Industry and Energy of South Korea.

The "100 million dollar Export Tower Award" is an award aimed at companies the accumulate export value of which exceeds 100 million US dollars. South Korea holds a ceremony to recognize the outstanding export performance of companies on December 7 each year, which is celebrated as "Annual Trade Day" in the country. The ceremony was conducted on a grand scale again this year, with the attendance of President Park Geunhye and those representing the companies to be honored.

This was the third time UK has been awarded an Export Tower Award, following the "10 million dollar Export Tower Award" in 2005 and "70 million dollar Export Tower Award" in 2012, showing that the company has made steady progress.

Paik Choong Ryul , President of ULVAC KOREA, Ltd., with the "tower" in his hands

●Contact Information
ULVAC KOREA, Ltd.
TEL:+82-31-683-2922
URL: http://www.ulvackorea.co.kr/

New Web Pages

ULVAC, Inc. runs a website to provide its stakeholders with information about its business activities, IR, products, and so on. As part of its efforts to further increase customer satisfaction, new feature pages on five different areas of products have been launched to offer even more helpful information to customers. The five product areas are: "MEMS System" "HELIOT 900 (leak detector)," "UNECS (high-speed spectroscopic ellipsometer)," "Power Generator" and "Advanced Package (packaging technology)." There are plans to add more areas in the future. For further information, please visit the respective pages.

●Contact Information
ULVAC, Inc.
TEL:+81-467-89-2033
URL: https://www.ulvac.co.jp/en/

New Products

* Please visit our website for further information.

ULVAC, Inc.

World's first*,
Low Temperature PZT Sputtering Technology in Mass Production Scale Developed for Piezoelectric MEMS Device Integrated on CMOS.

Sputtering system model SME-200

ULVAC, Inc. announced industry's first low temperature PZT sputtering technology in mass production scale enabling future advanced MEMS device integrated on CMOS which will be the mainstream of next generation MEMS devices.

Today many sensors such as accelerometers, gyros, and pressure sensors are widely used inside high performance smart phones, tablet PCs, and automobiles enabling the "Smart society" representing the IoT world.

The increasing demand and the key element to enable this functionality, is the piezoelectric MEMS (Micro Electro Mechanical Systems) device, using a piezoelectric thin film material called PZT (lead zirconate titanate, Pb (Zr,Ti) O_3).

The future holds that, higher performance, multi - functional and smaller piezoelectric MEMS devices for the next generation of advanced sensor technology is rapidly expanding its applications by the integration with CMOS (Complementary Metal Oxide Semiconductor) devices.

PZT, Piezoelectric MEMS is one of the most practical MEMS devices available today, however, the process temperature was an obstacle, to integrate the MEMS device directly onto a CMOS device. A CMOS device due to its nature, can only withstand a process temperature of 500 degreesC or lower. A typical crystallization temperature for a PZT thin film is 600degreesC for sputtering and 700 degreesC for Sol-Gel.

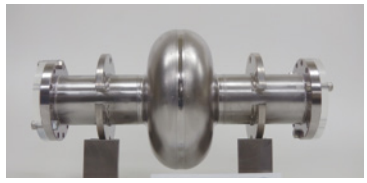
ULVAC has developed world's first unique innovative technology allowing integration of the piezoelectric MEMS device onto a CMOS device, thus achieving highest level piezoelectric performance, withstand voltage reliability, and cycle performance. This is accomplished by utilizing unique sputtering technology with process temperature below 500 degreesC.

The piezoelectric device, using thin film PZT, is formed by five (5) layers which are: an adhesion layer, a lower electrode layer, a buffer layer, a piezoelectric (PZT) layer, and upper electrode layer. All the accumulated layers are formed sequentially, through one single sputtering system developed by ULVAC. This multi-chamber type sputtering system (model SME-200) allows for consistent process flow, optimizing each individual layer inside each process chamber respectively, achieving highly stable repeatability of the stacked layer performance, and also improving throughput, to that which is that is very suitable for mass production purposes.

●Contact Information
ULVAC, Inc.
Advanced Electronics Equipment Division
TEL:+81-467-89-2139
URL: https://www.ulvac.co.jp/information/20150325/

ULVAC, Inc.

Launching High-purity Niobium Material for Superconducting Accelerators



Single-cell accelerating cavity manufactured by KEK from ULVAC's material

ULVAC, Inc. has developed niobium material of high purity for superconducting accelerators and started selling the material.

Superconducting accelerators are expected to be used in a wide variety of areas, including researching the origin of the universe by International Linear Colliders (ILC) in particle physics, analyzing the structure of proteins in medicine, and partitioning and transmuting of

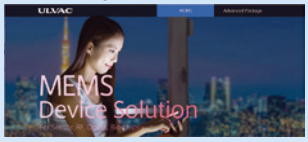
Launched to Feature Five Product Areas

— ULVAC, Inc.

▶ **Power Generator**

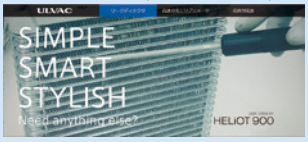
http://www.ulvac.co.jp/special/powersupply/

▶ **MEMS System**



http://www.ulvac.co.jp/special/mems/mems/

▶ **HELIOT 900** (leak detector)



http://www.ulvac.co.jp/special/heliot900/

▶ **UNECS**
(high-speed spectroscopic ellipsometer)

http://www.ulvac.co.jp/special/ellipsometer/

▶ **Advanced Package**
(packaging technology)

http://www.ulvac.co.jp/special/advanced-package/

Vacuum Magazine —Think Beyond Vacuum—

A New Digital Medium Launched to Explore Possibilities of Vacuum

ULVAC, Inc. has launched a new website entitled Vacuum Magazine specializing in exploring new possibilities of vacuum. It is a vacuum-themed blog-based website that provides information on topics like "relationship between vacuum and industry," "latest vacuum-related technological trends" and "the history of vacuum" as the world's only comprehensive vacuum manufacturer.

This website is compatible with smartphones and tablet PCs. For further information, please visit the following website: https://www.ulvac.co.jp/wiki/

●Contact Information
ULVAC, Inc.
TEL:+81-467-89-2033 URL: https://www.ulvac.co.jp/en/

high-level radioactive waste using nuclear transmutation (ADS: Accelerator Driven System) in environmental and energy sciences.

Superconducting accelerators are used to accelerate charged particles (such as electrons, positrons, protons and ionized atoms). Niobium (Nb), which becomes superconductive at the highest temperature (9.25 K) among pure metals, is used as material for accelerating cavities. Niobium material for accelerating cavities must have a Residual Resistance Ratio (RRR) that exceeds 250.

To increase the purity of niobium, ULVAC optimized multiple conditions, including the selection of raw materials, the degree of vacuum, and melting speed by using a 600 kW EB melting furnace that was newly constructed at our group company ULVAC TOHOKU, Inc. (Hachinohe, Aomori), thereby successfully producing niobium ingots with an RRR exceeding 250.

We requested the High Energy Accelerator Research Organization (KEK) —an inter-university research institution with which we conduct joint research— to manufacture a single-cell accelerating cavity by using plates produced from these ingots and to conduct an electric field performance test. Consequently, we achieved a maximum accelerating electric field gradient of 41 MV/m (performance required for ILCs: at least 35 MV/m).

●Contact Information
ULVAC, Inc. Material Division
TEL:+81-467-89-0246
URL: https://www.ulvac.co.jp/information/20150625/

ULVAC, Inc.

Launching Precise Microplate Paddle Mixer "MICROPADDLE", Enabling Direct Mixing for 96 Well Microplate

MICROPADDLE (maximum 12 units controllable by 1 PC)

ULVAC, Inc. has developed Precise Microplate Paddle Mixer "MICROPADDLE" and started selling the product.

Precise Microplate Paddle Mixer "MICROPADDLE" is the mixer for 96 well microplate that is used in biotechnology experiments. It has been pointed out that the conventional mixer has the disadvantages, such as "Mixing can be done accurately, but it needs large volumes of chemical solution and it cannot process large number of the simultaneous mixing", "It does not needs large volumes of chemical solution and it can process large number of simultaneous mixing, but mixing cannot be done accurately.", etc.

To meet those demands, ULVAC has developed and started selling the mixer "MICROPADDLE" that enables mixing with high precision, accuracy, and efficiency.

[Feature]

- Low volume mixing:
  Reduce sample consumption by mixing with 96 well microplate (50 - 300 μL)
- High efficiency mixing:
  Direct paddle mixing and high rotation speed enable high efficiency mixing.
- Highly accuracy and precision mixing:
  Rotation speed from 1 to 3000min^{-1}(1min^{-1} increment) with ± 1% precision.
- Low rotation speed mixing:
  Available highly precise gentle mixing below 300 min^{-1}
- Multiple rotation speed setting simultaneously:
  12 Independent rotation speed setting in 1 microplate facilitates your optimum rotation setting search.

The use of the "MICROPADDLE" in wide range of market of Mixer with microplate, is highly expected, such as Basic research at Universities, Government Research laboratory of Medical, Pharmaceutics, and Agricultural Science, and Evaluation of products and prototypes at pharmaceutical manufacturer and diagnostic pharmaceutical manufacturer.

●Contact Information
ULVAC, Inc. Component Division
TEL:+81-467-68-4212
URL: https://www.ulvac.co.jp/information/20150901/

Awarded "Encouragement Award" in the Mukaidono Safety Awards for Product Safety Assurance Efforts

— ULVAC, Inc.

ULVAC, Inc. was awarded the "Encouragement Award" in the Mukaidono Safety Awards in December 2016 for its product safety assurance efforts.

The Mukaidono Safety Awards was established in 2015, when Dr. Masao Mukaidono, Professor Emeritus of Meiji University and one of the leading figures in the area of product safety, was awarded the Prime Minister's Commendations on Contributors to Public Safety. The purpose of the Awards is to recognize the achievements of individuals and organizations that have contributed to improving, advancing and proliferating safety in the Japanese manufacturing industry.

The reason for the Encouragement Award was that the entire ULVAC Group had 35 employees who had qualified as Safety Assessors, had carried out risk assessments against an appropriate set of safety design standards from an in-the-field point of view, and had made group-wide contributions to enhancing product safety.

●Contact Information
ULVAC, Inc.
TEL:+81-467-89-2033
URL: https://www.ulvac.co.jp/en/

Reception of the certificate of commendation

CLOSE UP Awarded Life

ULVAC TOHOKU, Inc. (hereinafter referred to as "ULVAC TOHOKU")was awarded the "Life Innovation Award 2015 (AOMORI)" by Aomori Prefecture.

Aomori Prefecture has established the Life Innovation Awards to recognize innovative, creative and challenging initiatives that contribute to creating industries in the prefecture in life-related fields (medicine, health and welfare), in the three categories of "medicine-engineering collaboration," "service" and "product." ULVAC TOHOKU was awarded the award in the "medicine-engineering collaboration" category.

[Reason for the honor]

ULVAC TOHOKU, Inc. has been promoting medicine-engineering collaboration by working in partnership with local medical institutions to contribute to medical safety through developing and improving peripheral equipment. The main products the company has developed include a mobile power cable checker that allows for easy and advanced measurements on 3P power cables and an oxygen flow meter checker that can periodically check the precision of oxygen flow meters in an efficient manner.

[Mobile power cable checker]

ULVAC TOHOKU's mobile power cable checker can easily measure three wires —namely power

New Products

* Please visit our website for further information.

ULVAC, Inc.

Launching G-TRAN Series Multi Ionization Gauge ST2 Enabling a Long Product Life That Maintains High Precision Even Under Harsh Conditions

G-TRAN Series Multi Ionization Gauge ST2

ULVAC, Inc. has developed G-TRAN series multi ionization gauge ST2, a transducer-type ionization vacuum gauge with a long product life that maintains high measurement accuracy even under harsh conditions, and started selling the product.

A variety of gas molecules may exist in a vacuum space under certain conditions.

Therefore, it is not uncommon that vacuum measurements are performed under conditions that are severe for a vacuum gauge.

As a result, we often hear that users encounter problems regarding lifetime of vacuum gauges (a short product life due to contamination, problems in electrical discharge, an increase in sensor head replacement frequency, etc.) and measurement accuracy (variation in sensitivity, errors, etc.).

To avoid such problems, it is necessary to replace sensor heads periodically. More frequent replacement of sensor heads leads to:

— An increase in running costs for sensor heads, which are consumables
— Losses caused by suspension of production lines (systems) during replacement of sensor heads
— An increase in time and effort required to replace them

To resolve these difficulties, ULVAC has developed an ionization vacuum gauge with a structure designed to lighten the load on ion collectors by reducing the ion current value per area and to make electric potential in ionized space uniform. This gauge enables the performance of accurate measurements (±10%) for a longer period of time (more than 30 times longer compared to our conventional models) even under harsh conditions for ionization vacuum gauges.

●Contact Information
ULVAC, Inc. Component Division
TEL:+81-467-89-2410
URL: https://www.ulvac.co.jp/information/20150903-2/

ULVAC, Inc.

Launching the Revolutionary Dry Vacuum Pump Accessory ECO-SHOCK ES4A Substantially Reduce Power Consumption by Attaching to the Dry Vacuum Pump Exhaust Line

ECO-SHOCK ES4A

ULVAC, Inc. has recently developed and started selling the ECO-SHOCK ES4A, a power saving accessory for dry vacuum pumps that can reduce power consumption substantially by attaching to the dry vacuum pump exhaust line.

Dry vacuum pumps consume particularly large amounts of electricity in production lines. Therefore, it is of crucial importance to reduce their power consumption. ULVAC has already released the ECO-SHOCK ES10, which reduces power consumption when attached to a dry vacuum pump exhaust line. However, it has been difficult to reduce power consumption of dry vacuum pumps that are used for frequent pumping down of loading/unloading chambers of vacuum systems and use large amounts of sealing gas

This new product, "ECO-SHOCK ES4A", enables a reduction in power consumption of dry vacuum pumps that are used for frequent pumping down of loading/unloading chambers of large vacuum system and use large amounts of sealing gas.

[Features]

— The ECO-SHOCK ES4A makes possible a substantial reduction in power consumption of dry vacuum pumps used for the following purposes.
  (1) Dry vacuum pumps that are used for frequent pumping down of loading/unloading chambers
  (2) Dry vacuum pumps that use large amounts of sealed gas
— There is no degradation of pumping speed because any control such as rotation speed

Innovation Award 2015 (AOMORI) — *ULVAC TOHOKU, Inc.*

wires and a protective earth— at the same time, and can even measure the low-value resistance of the protective earth stipulated by JIS.

In recent years, increasing numbers of highly-functional electric medical instruments have been used in operating rooms, intensive care units (ICUs) and other medical environments. However, patients are at risk of suffering electrical discharges known as "micro-shocks" that can be caused by electricity leaking from these instruments even if it is so minute that conventional measuring equipment cannot detect it.

To prevent risks from these micro-shocks, the JIS standards for medical electrical equipment set a standard for the resistance of protective earth conductors of medical instruments (0.1 to 0.2 Ω). As this resistance range stipulated by JIS is too low to be measured with general-purpose measuring equipment, the resistance value is normally measured by electricians using a special measuring system.

In response to Aomori Prefecture's policy for promoting collaboration between medicine and engineering, ULVAC TOHOKU set about a few years ago to tackle this issue to meet the demand of the local Hachinohe City Hospital and other stakeholders. After about two years of efforts and hard work, the company has finally succeeded in developing an easy-to-measure mobile power cable checker.

This mobile power cable checker does not require any specialist knowledge or special equipment and allows the user to quickly measure the "JIS safety standards" level of resistance simply by inserting the 3P plug of the power code of the target medical equipment. ULVAC TOHOKU sees this award as a good trigger for making further progress into new areas of business.

Takeo Kato, President of ULVAC TOHOKU, Inc., giving a speech at the awards ceremony


Mobile power cable checker

●Contact Information
ULVAC TOHOKU, Inc.
TEL:+81-178-28-7839
URL: http://www.ulvac-tohoku.com

adjustment is not required when attaching it to dry vacuum pump. Also, even if the ES4A was broken down, there is no decrease in performance of dry vacuum pump.

— The ECO-SHOCK ES4A can be attached to dry pump exhaust lines that have already been installed.

●Contact Information
ULVAC, Inc. Component Division
TEL:+81-467-89-2185
URL: https://www.ulvac.co.jp/information/20150903-1/

ULVAC, Inc.

ULVAC started selling KLA-Tencor's Stylus Profiler and Optical Surface Profiler


Stylus Profiler P-17

ULVAC, Inc. started the domestic sales of Stylus Profiler/ Optical Surface Profiler made by KLA-Tencor Corporation (Headquater: California, USA).

Those profilers have the capability to measure the fine shape and the roughness of various sample surface with high precision, and measure a various applications from R&D to production, in many area like Semiconductors, Displays, Electronics, Optical Components, MEMS etc.

[Product Range]

1. Stylus Profiler (4 models)
   - Alpha-Step D-500: ø150mm manual stage
   - Alpha-Step D-600: ø200mm auto stage
   - P-7: ø150mm auto stage
   - P-17, P-17 OF: ø200mm (P-17 OF: 300mm) auto stage
2. Optical Surface Profiler (2 models)
   - MicroXAM-100: 100 × 100mm manual stage
   - MicroXAM-800: ø150mm auto stage

●Contact Information
ULVAC, Inc. Component Division
TEL:+81-467-89-2185
URL: https://www.ulvac.co.jp/information/20150930/

ULVAC Group

■ Japan
ULVAC, Inc.
ULVAC TECHNO, Ltd.
ULVAC KYUSHU CORPORATION
ULVAC TOHOKU, Inc.
ULVAC KIKO, Inc.
ULVAC EQUIPMENT SALES, Inc.
ULVAC CRYOGENICS INCORPORATED
ULVAC-PHI, Inc.
TIGOLD CORPORATION
ULVAC COATING CORPORATION
Nisshin Seigyo Co., LTD
ULVAC Human Relations, Ltd.
SHINKU CERAMICS CO., LTD.
FINE SURFACE TECHNOLOGY CO., LTD.
Reliance Electric Limited
SHOWA SHINKU CO., LTD.

■ China
ULVAC (China) Holding Co., Ltd.
ULVAC (NINGBO) Co., Ltd.
ULVAC (SUZHOU) CO. LTD.
ULVAC Orient (Chengdu) Co., Ltd.
ULVAC Automation Technology (Shanghai) Corporation
ULVAC Tianma Electric (Jingjiang) Co., Ltd.
ULVAC Vacuum Furnace (Shenyang) Co., Ltd.
ULVAC (Shanghai) Trading Co., Ltd.
ULVAC Materials (Suzhou) CO., LTD
ULVAC Opto-electronics Thin Film Technology (Shenzhen) Co., Ltd.
ULVAC CRYOGENICS (NINGBO) INCORPORATED
ULVAC NONFERROUS METALS (NINGBO) CO., LTD.
ULVAC Research Center SUZHOU Co., Ltd.
Luoyang Xinyou Magnesium Co., LTD
Hong Kong ULVAC Co., Ltd.
ULVAC VACUUM EQUIPMENT (SHANGHAI) CO.,LTD.

■ Taiwan
ULVAC TAIWAN INC.
ULTRA CLEAN PRECISION TECHNOLOGIES CORP.
ULCOAT TAIWAN, Inc.
ULVAC AUTOMATION TAIWAN Inc.
ULVAC SOFTWARE CREATIVE TECHNOLOGY, CO.,LTD.
ULVAC Materials Taiwan, Inc.

■ South Korea
ULVAC KOREA, Ltd.
Ulvac Korea Precision,Ltd.
Pure Surface Technology, Ltd.
ULVAC CRYOGENICS KOREA INCORPORATED
ULVAC Materials Korea, Ltd.
UF TECH, Ltd.

■ Southeast Asia
ULVAC SINGAPORE PTE LTD
ULVAC MALAYSIA SDN. BHD.
ULVAC (THAILAND) LTD.

■ North America
ULVAC Technologies, Inc.
Physical Electronics USA, Inc.

■ Europe
ULVAC GmbH

ULVAC WEB SITE:
https://www.ulvac.co.jp/en/