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# Finding Out Active Site of Carbon Electrode Catalyst to Replace Platinum

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1. Local Governmental Measures

(1) Kobe City

A project will start to import hydrogen to distribute in Japan in order to realize hydrogen society. Kawasaki Heavy Industries, KHI, and Iwatani plan to build a new import base at the Port of Kobe in cooperation with Kobe City to operate it from 2020. Although hydrogen as a by-product from steelworks is supplied to the market, this supply may not meet the demand in the 2020's when hydrogen is expected to be used more as fuel for fuel cell vehicles, FCVs, and power stations. Being estimated with an over ¥10 billion budget project, the import base will be built on a piece of land owned by the city on the artificial island where the Kobe Airport is situated, and the area will be approximately 1 ha. Hydrogen will be liquefied at a low temperature and high pressure, and then imported in a special tanker ship. The base will store hydrogen, and lorries will distribute hydrogen from it. The capacity will be a commercial model of a couple of 1,000 $m^3$ level. KHI plans to build a tanker ship for transporting from oversea, a landing facility and a storage tank. The loading facility from the tank to lorries is planned to be prepared by Iwatani. These two firms are leading in the technological development of this area, and the construction cost is supported by a subsidy of the New Energy and Industrial Technology Development Organization, NEDO. The most likely plan is to produce hydrogen from low-grade cheap lignite in Australia which is rich in the resource and import hydrogen to Japan. J-Power will help on coal power generation technology. Liquefied natural gas, LNG, has a relatively smaller impact to the environment. However, Japanese firms lost their bargaining power at negotiations on import price after the accident of Fukushima Daiichi Power Station of Tokyo Electric Power Company, Incorporated, TEPCO. To diversify power supply, the Ministry of Economy, Trade and Industry, METI, aims to establish a hydrogen market by 2030. (The Nikkei, January 26, 2016)

On January 26th, Kobe City announced that an import base would be built at the Port of Kobe for hydrogen which is drawing attention as next generation energy in cooperation of KHI and Iwatani. This base will be a center to lead the world in hydrogen supply chain. The city is seeking business to develop as a core following the healthcare industry, and hydrogen business is a good candidate to expand in the future. On the day, Mayor Kizo Hisamoto said at the press conference that we were glad to have the center for the governmental key project in the city. The base will be located in a piece of approximately 1 ha land owned by the city in north eastern part of the island where the Kobe Airport is situated. This experimental plant will be used to unload liquid hydrogen from tanker ship, to store and to distribute the material nationwide, which is to be the first facility in Japan. Once hydrogen becomes fully used in the future, the domestic production is estimated to be insufficient. "Hydrogen/FC Strategic Road Map" set by METI shows the plan to fully use the technology to extract hydrogen from unused energy by 2030. "Many local governments are committed to hydrogen related projects nationwide, and we can take a lead in this area." An executive officer from the Kobe Chamber of Commerce and Industry appraised. (The Nikkei, January 27, 2016)

(2) Arakawa-ku, Tokyo

Arakawa-ku of Tokyo will start an experiment of commercial FCs from February. The plan is to examine reduction in $CO_2$ emissions in cooperation of

Tokyo Gas in order to use the system fully from FY2017. Hydrogen is expected to be the next generation clean energy for 2020. The city wants to advertise itself as an advanced town by using hydrogen at the 2020 Tokyo Olympics by supporting the commercialization of commercial level FCs which is required to output more power than those for homes. The experiment use solid oxide fuel cells, SOFCs, produced by Miura which has a higher efficiency and outputs 5 kW. The local government and Tokyo Gas signed an agreement, and mainly the gas supplier will carry out the experiment. The local government will not pay any costs, but will provide a location to install the system as the cooperation. The experimental system will be installed at Arakawa Sogo Sports Center near Minami-Senju Station. The FCs will produce power for lighting and heat for showers. A monitor will be installed to show how energy is produced, and a washbasin will be provided to let the facility users try hot water heated by the system. (The Nikkei, January 19, 2015)

(3) Yokohama City

Yokohama City, Tokyo Gas and Mitsubishi Hitachi Power Systems, MHPS, have started working on creating multi-energy using sewage biogas. This project is to separate methane from sewage digestion gas by a membrane to use hydrogen produced from methane gas and to generate power and heat. Methane is estimated to produce heat at the same level as natural gas. A study group has been already launched to realize hydrogen/low-carbon society, and the project is seeking more businesses to join to develop usage of the system. Sewage biogas is carbon-neutral energy consisting of approximately 60% of methane and 40% $CO_2$, and attracts attention as a counter global warming measure. Refining biogas increases the quantity of heat, and gives a variety of use. The city has used unrefined digestion gas as supplemental fuel of power generation and garbage incinerator. The production of digestion gas changes depending on seasons and this gives a small amount of excess gas some time. In order to find out usage of excess gas, the city signed an agreement of joint research with Tokyo Gas in 2013 which was researching a highly efficient membrane separation method for a small amount of biogas at low cost. Furthermore, MHPS joined, and a study group was launched to produce hydrogen, heat and electricity using a portion of refined gas as application development in 2015. The research target is a stable supply of natural gas which is concentrated methane produced using a membrane to remove $CO_2$ from sewage biogas. Refined gas is also to be used as fuel of FC cogeneration under development to create heat and electricity as well as hydrogen production. In this project, methane is concentrated by removing $CO_2$ from biogas which is carbon neutral. Because of this, $CO_2$ that comes out from the system is not counted as emission. The highly concentrated methane has a similar quantity of heat to natural gas, and is used as non-fossil fuel derived natural gas. The project intends to use this energy for stationary/mobile hydrogen refueling stations, natural gas refueling stations, EV chargers, FCVs, natural gas vehicles, EVs and heat use in community. Mainly feasibility studies have been carried out in FY2015. From FY2016, they will decide the direction of actual projects and budgets, and ask businesses to join them to develop new technologies. MHPS is developing commercial use FCs to be the highest efficiency in the world planning to be commercialized in FY2017. Exploring the business, Tokyo Gas is introducing its membrane separation system for sewage treatment works to other local governments to expand business opportunities. There are 2,000 sewage treatment works in Japan, and 300 facilities are trying or able to use digestion gas. These facilities are business opportunities, and biomass from food waste is a new promising area for MHPS. They also intend to expand their business to overseas in the future. The 2020 Tokyo Olympics and Paralympics are considered to be a trigger to realize hydrogen/low-carbon society, and the research group is expected to produce an achievement as early as possible. (The Chemical Daily, January 21, 2016)

## 2. FC Element Technology Development & Business Plans

(1) Honda

UK-based FC producer Ceres Power will research FC power generator for homes in cooperation with Honda. Although Honda sells a gas cogeneration using gas engine to produce electricity and heat for domestic use, and will add a FC generator, which is

highly energy efficient and has better environmental performance, to their research. Next generation generator is aimed for with Ceres' material technologies. Ceres produces a SOFC which has high generation efficiency, and is a core component to convert fuel into electricity. This firm is listed on AIM, formally known as alternative investment market, of the London Stock Exchange. Honda has already developed a FCV, and will start the sales of commercial FCV in March 2016. Because FC uses different technology and production method for automobile and power generator, Honda decided the joint research with Ceres. Used for domestic generator, SOFCs operate at high temperatures of over 700°C, and uses ceramic, a heat resistant cell material. This causes a cost issue. Ceres has a technology to operate the cells at 500 to 600°C, which can reduce material for cells. As well as cost reduction, generation efficiency is expected to increase. Honda will research on next generation generator through the joint research with Ceres. (The Nikkei, January 18, 2016)

(2) University of Tsukuba

A research group of Prof. Junji Nakamura, Associate Prof. Takahiro Kondo, and Dr. Donghui Guo of the Graduate School of Pure and Applied Sciences of University of Tsukuba, has elucidated the nitrogen species which constitutes the oxygen reduction reaction site where catalytic reactions occur in nitrogen-doped carbon material for FC catalyst. The study results are expected to accelerate development of cheaper catalysts by giving a design guide to increase performance of nitrogen-doped catalyst to replace platinum, a rare metal. The finding was published on Science, a scientific journal. Cost saving allows FCs to be more widely used. Platinum is commonly used, but expensive. For this reason, replacement materials are sought at cheaper cost. A nitrogen-doped carbon material is reported to exhibit the same catalytic performance as platinum. However, the active catalytic sites were not known enough to increase catalytic performance. The group created model catalysts with controlled doping of nitrogen species to examine by applying X-rays or using chemical reaction to compare and analyze catalytic performance. The results show that "pyridinic nitrogen" is the nitrogen species to constitute the active sites. This made clear that doping pyridinic nitrogen increases catalytic performance. (The Nikkan Kogyo Shimbun & The Chemical Daily, January 22, 2016)

3. Technology Development for Infrastructure Element of Hydrogen Society

(1) Toyota

Toyota Motor will develop a next generation production line with no $CO_2$ emissions using hydrogen as the energy source. The experiment will start in 2020, and the manufacturer wants to "hybrid plant" combining photovoltaic generator and hydrogen power generation using technologies developed through the FCV development globally spread. The experiment will be carried out at Motomachi Plant which assembles the world's first commercial FCV "MIRAI" in Toyota City, Aichi Prefecture. Hydrogen will be used for air conditioning and as heat source of a drying furnace at a painting work in the plant. FCs will be installed to supply plant with electricity, and the plant will also use renewable energy. Solar panels will be installed on the premises. Also, Tahara Plant is planning to install wind turbines by 2020, and excess power is to be sent to Motomachi Plant. Hydrogen will be produced by water electrolysis. For common example, steelworks burn hydrogen which comes out from the manufacturing process as a by-product. However, it is unusual to use hydrogen for production line of commercial products. (The Yomiuri Shimbun, January 16, 2016)

(4) Shizuoka University

A team of Associate Prof. Hiroyuki Kimura at Shizuoka University has developed a basic technology to produce methane and hydrogen for fuel by feeding food waste to microbes living in hot water from the ground. The technology was tested in a small incubator. The team aims to commercialize the technology in two to three years by increasing the production. Accretionary wedges lie underneath of Tokai and Minamikyushu, and are formed by scraped bedrock of the Philippine Sea Plate which goes under another plate from south east. This layer has plenty of organisms and degrading bacteria stored at the bottom of the sea. Hotter bath operators have been digging deep in the accretionary wedge to pump up hot water. The team added sugar to pumped hot water for fermentation, and the bacteria produced 400

ml of methane per liter each day. Hydrogen of 1,200 ml was produced each day per liter by adding a chemical to inhibit the methane producing bacteria. Furthermore, bacteria produced methane and hydrogen from old rice. The team will test the production by feeding the bacteria with various substances including food waste. (The Nikkei, January 18, 2016)

4. ENE-FARM Business Plans

(1) Toray

On January 23rd, Toray Construction will start the sales of condominium "Chalier Nagaizumi-cho Grand Marks" under construction in Nagaizumi-cho. With Shizuoka Gas's cooperation in the latest energy saving technology, electricity from ENE-FARMs will be shared among the units, and utility use including electricity will be made "visible". The two firms will develop highly value-added condominiums in other areas highlighting the environmental performance. The condominium is located 25 minute walk from the Mishima Station, and 15 minute walk from the closest Nagaizumi-Nameri Station. This 12-story building is to have a total 190 units, and applications have been taken for 39 units to be sold by drawing in the first phase. The range of exclusively-owned area is 71 to 89 $m^2$, and the price is from ¥30 to 47.5 million. Delivery will start in March 2017. Shizuoka Gas granted joint patent for a sharing system of electricity with Panasonic. Excess electricity will be sold to the gas supplier to provide households which are short in electricity. The gas supplier will charge for the electricity and gas in a same bill. Other key features are preparation for disasters and substantial common facilities. (The Nikkei Business Daily, January 18, 2016)

(2) Shinshowa

On January 16, Shinshowa started the sales of the first six houses of "Withearth Garden Sodenoura" which has a total of 51 houses in the land readjustment area in Narawa, Sodenoura City, Chiba Prefecture, in the first phase. The development is in an exclusive area for the first low-rise dwelling. Framing two story houses come with home energy management systems (HEMS), ENE-FARMs, hot water floor heating and home security constituting a smart and eco town. The delivery will be in March. (Jutaku Shimpo, January 19, 2016)

5. Cutting Edge Technology of FCVs & EVs

(1) North American International Auto Show

On January 11th, Toyota Motor, Nissan Motor and Honda all revealed new cars at the North American International Auto Show started on the day. "The top end coupe "LC500" will be released from the luxury brand Lexus. Also, this brand plans to add FCV in its range by 2020." Mr. Akio Toyoda, the president of Toyota, said. Additionally, he shows an intention to expand FCV range which is only MIRAI at the moment. (The Nikkei, January 12, 2016)

While large vehicles attract more consumers due to cheap oil price, European and American automakers are expanding their range of eco cars in the US. General Motors, GM, has started commercial production of new EVs, and Ford Motors will increase its budget for EV development. Although large vehicles are currently the source of earnings, the government is tightening the regulations on fuel towards 2025. The automakers have been working on their mid- and long-term growth strategy while keeping short-term gain. North American International Auto Show is being held in Detroit. Ms. Mary Barra, the CEO of GM showed up in an EV Bolt of which the driving range is 200 miles, approximately 322 km, in the exhibition. The price is about $30,000, about ¥3.54 million. "This is the first EV affordable for everyone and can drive a long distance." she said. The driving range is 15% greater than that of Nissan "LEAF". Ford announced that $4.5 billion would be invested in EV development towards 2020. By that year, 40% of their global sales will be electric powered. FCAUS, formally known as Chrysler, revealed plug-in hybrid vehicle (PHV) version of minivan which drives 129 km on approximately 3.8 L of gasoline. This PHV will be introduced into the market by the end of the year. From the European side, German-based Audi is displaying a concept FCV run on hydrogen as a highlight. This FCV can be refueled with hydrogen in four minutes, and drives maximum 600 km. German-based Volkswagen, VW, brought out a new PHV. These manufacturers need the balance between the strong sellers and the regulations, which made this mixed range of display of large and eco cars at the auto show this year. Being left behind in fuel efficiency

comparing to Japanese automakers, American car manufacturers are trying hard to catch up in this area by developing EVs which are easier than hybrid vehicle, HV. This movement can promote technological innovation from manufacturers of materials such as batteries. GM uses a secondary battery of South Korean-based LG Chem for "Bolt". LG also provides batteries for Ford's EV. As technology advances for elements, automakers which use the elements will improve their technology. This time, Japanese car producers focus on large and luxury cars, but no eco cars. "We should concentrate the sales of normal cars while gasoline price is low leaving eco car sales aside for now.", Toyota's executive said. However, they know that they need to work on accommodating the tightening regulations. (The Nikkei, January 13, 2016)

(2) Tesla

US-based Tesla Motors has got the top place in the EV market in the US for 2015 overtaking Nissan Motor. Being damaged by falling oil price, the sales of EVs are 116,548 vehicles, a 5% decrease of that of previous year. Nevertheless, Tesla has established itself as a luxury brand, and is competing well against the auto giants. Tesla's sales has significantly increased, which gives the firm a 22% share in the market. Inside EVs, a US-based research firm, has published an EV sales trend including PHVs. Tesla's EV sedan "Model S" increased its sales to 25,700 vehicles, a 49% rise while Nissan's small EV "LEAF" lost the sales to 17,269 vehicles, a 43% decrease. Model S outran LEAF. Well branded European car producers are now enthusiastic about small EVs such as German-based BMW's "i3" and Italian-based Fiat's "500e", which is causing more competition in the market. This is another reason Nissan lost its share. US-based GM's Bolt and Toyota's Prius PHV are losing their sales, which is a sign of the last phase of product lifecycle. (The Nikkei, January 13, 2016)

Providing hot topics such as development of rocket and space technology, US-based Tesla is snapping at Toyota which was a partner in development. Tesla says that "FCV that Toyota is developing is Mind-Bogglingly Stupid." Why do they think so? Being led by Mr. Elon Musk, the CEO, they are developing an EV at a crazy speed and scale. Musk appears young and fresh at press conferences. We want to get closer to the other side of him at his office. (The Nikkei, January 18 and 24, 2016)

(3) Great Wall Motors

Great Wall Motors, a Chinese-based automaker, has opened Great Wall Japan Technologies, a research and development center in Yokohama City. The center will research advanced technologies on EV, FCV and automatic driving system and human resources as well as building connections with component manufacturers. Great Wall Motors has been expanding its sales in developing countries in Africa and Central and South America. Their newly opened Japanese arm aims for improvement of their brand value and technology. (The Nikkei Business Daily, January 13, 2016)

(4) Yokohama National University

Kanagawa Toyota Motor Sales has delivered FCV "MIRAI" to the Center for Creation of Symbiosis Society with Risk of Yokohama National University. This is the first delivery for Kanagawa Toyota to University. Their Hodogaya Branch near the university will provide post-sales service. The delivery ceremony was held at the Yokohama Campus, Mr. Hiroshi Daibo, a managing officer of Kanagawa Toyota, handed the commemorative key over to Mr. Yuichi Hasebe, the president of the university, in front of MIRAI with university's original sticker on it. The Center for Creation of Symbiosis Society with Risk works on "safety evaluation of energy carriers" which comprehensively studies stable supply and operation of energy carrier such as liquid hydrogen and the risks derived from these. This research is selected as a "Cross-ministerial Strategic Innovation Promotion Program (SIP)" led by the Cabinet. (Nikkan Jidosha Shimbun, January 13, 2016)

(5) Meitetsu Kotsu & Tsubame-Taxi

Tsubame-Taxi, a large taxi operator in Nagoya City and Meitetsu Kotsu will introduce three FCVs each of Toyota's MIRAI. On five year lease, these vehicles will operate as taxis from January 22nd. Both firms will use two of the vehicles for normal taxi operation by mileage and the other is for hire by hours. Booking is required by prior day for FCV taxi, and ¥200 will be charged for picking-up. However, Meitetsu Kotsu will not charge for picking-up at two places including Nagoya Lucent Tower near Nagoya Station. The taxi rate is the same as a medium sized taxi. (The Nikkei

Business Daily, January 19, 2016)

(6) Yamagata University

Having prepared in Iide-cho, Yamagata Prefecture, and Yamagata University finished construction of a pilot plant which aims for development and commercialization of a lithium-ion battery, LIB, of the most advanced high performance in the world. This facility will function as a core of "Iida Battery Valley Concept" that the town is aiming to form an industrial complex of storage battery. The plant will operate from May. The participants of the project are 47 businesses including automakers, battery manufactures and chemical producers. The town invested ¥700 million to build the facility, and will rent it out to the university. The university spent ¥800 million for the machinery. (The Nikkei, January 20, 2016)

(7) Honda

On January 22nd, Mr. Takahiro Hachigo, the president of Honda, showed an intention to expand the partnership with US-based GM. He said that we want to add artificial intelligence, AI, and automatic driving technology to the current partnership for FCVs. Once signed, this expansive partnership will cover core automobile technologies from environment to safety areas. Mr. Hachigo told the Nikkei in Arizona, USA. "Environmental and automatic driving technologies will be keys for automobile development. We hope that this partnership will bring both GM and Honda good results," he said. He picked up "information technology, IT, and AI" to be the core technologies for automatic driving. Honda has been working on the development of core technology for FCV together with GM since 2013, and now wants broader cooperation. The FCV tie-up with GM started from research and development, and is now investigating commercial production. He emphasized the smooth progress. Both firms plan to introduce the jointly developed FCV into the market by 2020. (The Nikkei, January 23, 2016)

Honda will triple the current driving range on electricity of its new PHV to be released in the US in 2018. The US is tightening the environmental regulations, and California, a large market, will strengthen the Zero Emission Vehicle (ZEV) regulation in the same year. The automaker will add high performance eco cars in 2016 as well as FCV to accommodate the regulations. PHV can be charged at home, and drive a certain distance without using gasoline. The automaker plans to extend the driving range of its new PHV to be released in 2018 solely on electricity to 39 miles, approximately 63 km in the test mode set by the United States Environmental Protection Agency, EPA. This range will be over triple of that of medium size sedan "Accord PHV" currently sold in the US. The new PHV will be able to drive on highways solely on electricity. The car producer is also considering introducing this PHV into the Japanese market. The electric driving range of current Accord is 37.6 km in the standards set by the Ministry of Land, Infrastructure, Transport and Tourism, MLIT. However, the new PHV is expected to go over 110 km. For example, Mitsubishi's sport utility vehicle (SUV) "Outlander PHEV" drives over 60 km on electricity. Toyota's current "Prius PHV" droves 26.4 km on electricity, but the new version to be released in this year will offer an extended electric driving range of over double. (The Nikkei, January 23, 2016)

(8) Taiwanese-based Gogoro

Gogoro is a venture of an electric scooter founded by former officers of HTC Corporation which is a major smart phone manufacturer, and going strong in Taiwan. As well as its sophisticated look, the scooter offers a battery replacement system at charging stations. This is grabbing consumers responsive to trends. Will Gogoro grow into a global brand, and bring benefit to the Taiwanese industry which is suffering economic stagnation as a "savior"? Taiwanese roads are filled with scooters. An eye-catching streamline scooter stopped at a roadside, to call in a charging station. The station has 24 slots to charge cylindrical batteries which are slightly larger than two liter plastic bottle. When a battery which is low in power is inserted in a slot, a charged battery pops up from a slot. Then, the scooter can drive again on full charge. These charging stations are installed at over 100 locations mainly in the northern urban area such as Taipei, New Taipei City and Taoyuan. Drivers can search and book the closest station on their smartphone. The scooter was released in June 2015, and sold over 2,500 vehicles in six months. This figure is small in the Taiwanese motorbike market where

about 600,000 vehicles are sold each year. The motorbike market is growing at an annual rate of nearly 30%, a 7,000 to 8,000 vehicle increase each year. The scooter has made a good start. (The Nikkei, January 27, 2016)

(9) Terra Motors & Resc

The Asian motorbike market is dominated by Honda, the global leader in the area, and Yamaha Motor in the second place. However, the electric motorbike market shows a completely different face. Electric motorbikes have a lower barrier to enter for ventures compered to gasoline ones, and many businesses are aiming at the top. As an example of Japanese business, Terra Motors, a venture in Shibuya of Tokyo, are entering the Indian and Bangladeshi markets. Developing countries have a problem of serious air pollution, and electric motorbikes are in high demand there due to their clean nature. Resc, Shinagawa of Tokyo, operates business combining sales of electric motorbikes and charging infrastructure preparation in Kawasaki City, and receives potential clients from many countries. (The Nikkei, January 27, 2016)

6. FCV Element Development & Business Plans

Honda and US-based GM are jointly developing a FC system for FCV, and they will investigate a mutual production in the future. In March, Honda will release a commercial FCV with its own system. A FC system is being jointly developed by Honda and GM for the next generation FCV to be introduced by 2020. Honda and GM will investigate a way to share production and component supply of the FC system. On January 18th, "Mr. Toshihiro Mibe who is an executive in charge of powertrain of Honda showed a possible joint production of the FC system by saying that we will discuss to find mutually measurable benefit for 2020." (The Nikkei, January 19, 2016)

7. Hydrogen Refueling Station Technology Development & Business Plans

(1) Tokyo Gas

On January 12th, Tokyo Gas announced that its "Senju Hydrogen Station" had been operated as a part of research and development and test facility, and was changing to a commercial station. This is the second commercial station after "Nerima Hydrogen Station" in Yahara, Tokyo, and the first station to shift from research and test to commercial facility for the firm. Senju Station produces hydrogen from natural gas on site, and can supply 100 $m^3$/h of hydrogen. Refueling time for MIRAI is about three minutes per vehicle. After the operation for research and experiment from 2003 to August 2015, the station had construction to change into commercial facility using a subsidy of the Ministry of Economy, Trade and Industry, METI. Tokyo Gas will open the third commercial hydrogen refueling station in Saitama City by the end of March. (The Nikkan Kogyo Shimbun, January 13, 2016)

(2) Iwatani

Iwatani finished the construction of "Iwatani Hydrogen Station Otsu", and the operation has started. The facility uses liquid hydrogen produced off-site. The fuel will be transported from its liquid hydrogen plant "HydroEdge" in Sakai City, Osaka Prefecture, by lorries. Iwatani operates 11 hydrogen refueling stations mainly in four urban areas, and the new one is the 12th. Their plan is to prepare stations at 20 locations in FY2015, the remaining eight stations are still in progress. (The Chemical Daily, January 18, 2016)

―This edition is made up as of January 27, 2016―

## *A POSTER COLUMN*

Futuristic Technology 2020; Hydrogen Refueling Station Development

Hydrogen refueling stations are essential for FCV, a next generation eco car. In the Kansai area, the Japan's first commercial station started its operation in Amagasaki City, Hyogo Prefecture, in 2014. The preparation of this infrastructure will progress this year. The station construction used original technologies of many businesses in Kansai. Here are stories of four men who are developing technologies to realize hydrogen society.

"It was just a chance." Mr. Hideyuki Takaishi, the president of Takaishi Industry which produces plumbing rubber packing in Ibaraki City, Osaka Prefecture, said with a smile. Takaishi Industry produces O-rings, rubber packings, for connection of dispensers and compressors for hydrogen for refueling stations for FCVs.

The chance came in eight years ago. A professor at Kyushu University rang them. He was looking for rubber pieces for an experiment using hydrogen. "We will do it" Mr. Takaishi immediately replied.

Hydrogen molecules are very small, and characteristically make rubber and metal weak by getting into gaps of the material structures. Although Mr. Takaishi worked on the development with a couple of young employees, a number of trials turned out failures. They tried over 50 types of rubber materials. Finally, they found the current product which can stand the temperature range from -40 to +180°C. This product is used in a couple of dozen of hydrogen refueling station.

This packing is used and most appreciated by Mr. Toshiyuki Nakatsuka, the production manager of Kaji Technology, a compressor manufacturer. This firm produces compressors to increase pressure for dispensing hydrogen for FCVs. Their share is over 70% in the compressor market for natural gas refueling stations. However, hydrogen is another story. A hairline scratch can make products defective.

While their competitors were selling compressors for hydrogen refueling stations, Kaji Technology just made deliveries of three compressors in FY2014. Mr. Nakatsuka still shows worries. He feels huge pressure that one failure can completely ruin future sales. Irrespective of the pressure, the sales are going strong, and the number of deliveries increased to eight for FY2015.

In cooperation of Mr. Nakatsuka, Mr. Yoshiki Sakaguchi, the managing director of Samtech in Kashiwara City of Osaka Prefecture, produces small cylinders to store pressurized hydrogen gas. Samtech started the development of hydrogen cylinders in 2002; even though, it already made one for a rocket. Mr. Sakaguchi thinks that they might not have tried if they had known it would take 10 years.

Their product is used in over 80% of hydrogen refueling stations in Japan. "At the end of 2015, we had no days off to meet the deadlines for deliveries." he says.

Sumitomo Precision Products produces heat exchangers. It started by an inquiry from Iwatani which operates hydrogen refueling stations. Mr. Yasuhiro Fujita, the leader of high temperature heat exchanger group said "we did not expect this high pressure".

Because hydrogen increases temperature as pressure goes up, it needs to be refrigerated beforehand. The pressure used for hydrogen refueling station is about 80 MPa which is triple to four times of what the firm was expecting. Their experience of a product development for high pressure gas furnace helped this. They achieved the commercialization of the new product in two years by using a method to bond stainless steel plates without using glue.

These four people still have doubt in the current anticipated upsurge for hydrogen. In early 2000's, FCVs were in the spotlight, and then went out. Mr. Sakaguchi thinks that FCV may go out of fashion again due to many issues such as high costs. However, they want to keep their dream future of FCV, the ultimate eco car. "Technology will keep developing in any circumstances", they all say. Hydrogen society will be opened up by this strong devotion. (The Nikkei, January 13, 2016)

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