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"Cold fusion" in U.S. patent, successful replication, re-evaluation is accelerating

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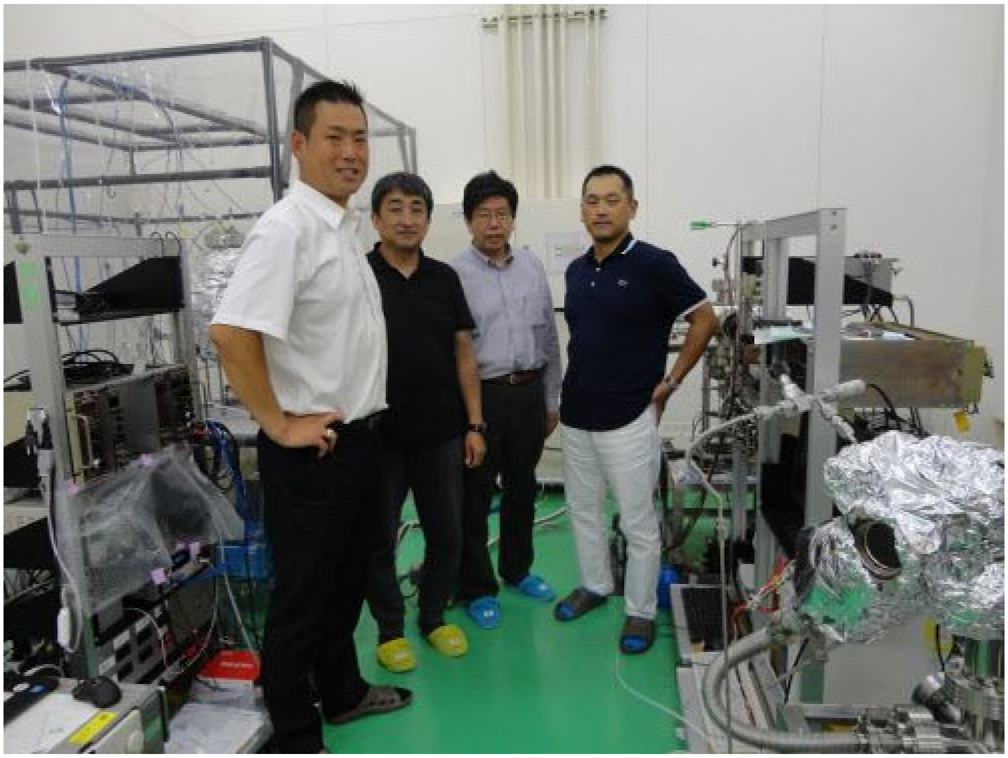
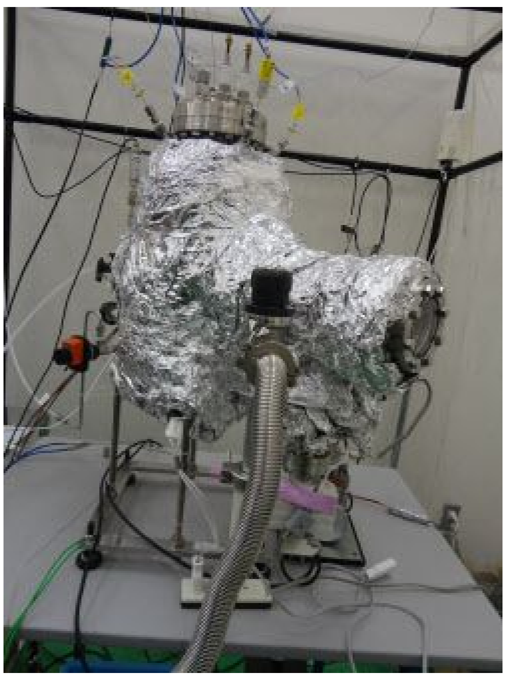
The Mikamine Park in Sendai City, Taihaku district, is known for having more than 500 cherry blossom trees. The "Research Center for Electron Photon Science, Tohoku University" is in the woods adjacent to the park. With two particle accelerators, for 50 years it has made history as a research center for nuclear physics.

■ Progress in a nuclear reaction that occurs at only a few hundred degrees

In April 2015, a joint research department "condensed matter nuclear science" (CMNS) was established in the center. [1] A "condensed matter nuclear reaction" occurs in a state of matter in which the atoms and electrons are present and integrated, as in a metal, and it refers to a phenomenon in which an element is converted into another element (transmuted).



Condensed Matter Nuclear Science (CMNS) research laboratory. From the left: Clean Planet president Yoshino, Tohoku University Visiting Associate Professor Ito, Professor Iwamura, Clean Planet director Masanao Hattori (photo: Nikkei BP)



CMNS science experimental apparatus in the laboratory of the nuclear reaction research department. A nuclear reaction occurs in this apparatus (photo: Nikkei BP)

In present day physics, it is considered common sense that in order to continuously transmute elements by nuclear fusion, you need a reaction in plasma at a temperature of 100 million degrees Celsius or more. This has promoted the construction of the “ITER (International Thermonuclear Experimental Reactor)” under international cooperation involving France, Japan and other nations. In this technique, plasma is confined at 100 million degrees Celsius in a magnetic field generated by a huge coil. However, compared to the initial planned target for this project, commercialization of this technique has been significantly delayed.

If a CMNS reaction occurs, atoms at low temperatures of several hundred degrees Celsius above room temperature undergo fusion, transmuting nuclides. Upon entering the new building constructed as part of the Tohoku University Electronic Light Science Research Center, you encounter a CMNS experimental apparatus wrapped in insulation.

The chamber (container) in which the nuclear reaction occurs is cylindrical. It is made of metal, so the inside is not visible, but the temperature is measured with a sensor. “The experimental project has only been underway for about a year, but it is going well and we already have excess heat.” said Yasuhiro Iwamura, research professor of the research department, while looking at the temperature log.

■ Researchers at Mitsubishi Heavy Industries moved to Tohoku U.

In the past, CMNS was referred to as “cold fusion.” This phenomenon was announced by two researchers at the U.S. University of Utah in March 1989, and it was in the limelight worldwide. [2] But, after the report was released from the University of Utah, additional tests that were performed, and as a result many leading institutions in the U.S. and Europe published negative opinions before the end of 1989. A verification project was also launched by the Ministry of Economy, Trade and Industry in Japan. In 1993 the Ministry expressed the view that “no excess heat has been demonstrated in cold fusion experiments.”

However, some researchers continue to believe that the reaction is possible, and they have steadily continued low profile research. They have gradually increased the reproducibility of the phenomenon. From around 2010, in places such as the United States, Italy and Israel, venture capital companies have been formed one after another for the purpose of developing cold fusion into a practical source of energy. The effect, called CMNS in Japan and “low energy nuclear reactions” (LENR) in the U.S., has been re-evaluated.

In fact, in April 2015 a newly established condensed nuclear reaction joint research department in Tohoku University was launched with by Clean Planet Co. (Tokyo, Minato-ku), which invests in ventures and laboratories in the clean energy field. Tohoku University provided the facilities and human resources.

Hideki Yoshino, president of Clean Planet, invested funds in the Tohoku University project. He believes that: “Enormous energy has been generated in stable reactions. A path to safe, low cost energy generation has been opened. Competing development projects in Europe and the U.S. have begun. Japanese researchers have a track record of leading in this field. As the research turns toward practical applications, we should apply the accumulated wisdom of the Japanese researchers.”

Research professor Iwamura of the Tohoku University Condensed Matter Nuclear Science Department, and visiting associate professor Takehiko Ito were both formerly involved in the study of CMNS at Mitsubishi Heavy Industries (MHI), and they moved to Tohoku University when the opportunity arose when this department was established. At MHI, they conducted low profile research with this as a technique to render harmless radioactive waste; research efforts under the name “new element conversion.” [3, 4] Their achievements in successful selective element conversion were cited worldwide.

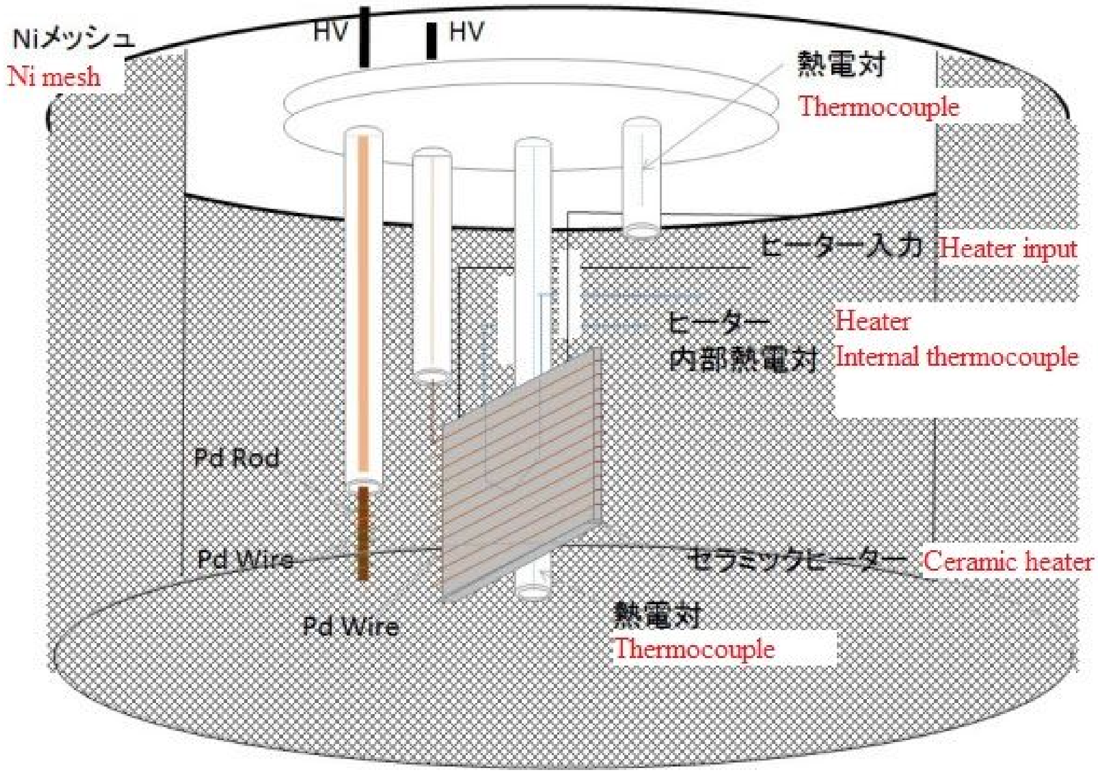
■ Observed “excess heat” after just one year

When Professor Iwamura moved to Tohoku University, he took this as an opportunity to switch the target of their research from the detoxification of radioactive waste to “heat generation.” The field of application of CMNS has two main directions: energy generation, and transmutation. The latter includes the detoxification of radioactive waste and the production of rare elements. The market value of a practical application for energy generation would be orders of magnitude larger than the market for transmutation, so companies such as Clean Planet and venture capitalists are concentrating on research to develop an energy source.

In fact, even with respect to “heat generation,” results from Japanese researchers have been cited worldwide. Pioneer researchers include Dr. Tadahiko Mizuno of Hokkaido University and Dr. Yoshiaki Arata, Professor Emeritus of Osaka University. Currently, in Japan, practical application research has been promoted based on the heat generation techniques of these two researchers.

Clean Planet has invested in joint research with Dr. Mizuno’s company Hydrogen Engineering Application and Development Company (Sapporo). Research professor of Tohoku University Iwamura and his colleagues’ first efforts were to reproduce the experiment devised by Dr. Mizuno, and they have made steady progress in observing “excess heat.”

The technique works like this. There are two wire-like palladium electrodes arranged in a cylindrical chamber, with the periphery surrounded by a nickel mesh. [5] High voltage is applied to the electrodes, causing glow discharge. After this treatment the electrodes are heated (baked) at 100 ~ 200°C. As a result, the surface of the palladium wire is covered with a film made up of a structure of nanoscale palladium and nickel particles.



A two-wire palladium electrode is placed in this experimental apparatus chamber, in surroundings enclosed by a nickel mesh (Source: Tohoku University Professor Iwamura)

After processing in this way to activate the palladium surface, the chamber is evacuated, while being heating up to several hundred degrees with a resistance heater. Deuterium gas is then introduced at high pressure (300 ~ 170 Pa), enough to sufficiently ensure contact between the palladium and deuterium. Then, "excess heat" exceeding the heat from the resistance heater input power is observed. When researchers introduce deuterium gas in the same apparatus under the same conditions but without doing the activation treatment first, excess heat is not observed. The excess heat causes a temperature difference ranging from about 70 ~ 100°C.

Iwamura describes the project with enthusiasm. "The experimental project has only been underway for about a year, but it is going better than we expected and we already have stable excess heat. We are applying the knowledge accumulated in our research at Mitsubishi Heavy Industries, demonstrating that highly reproducible element conversion techniques can also be applied to heat generation."

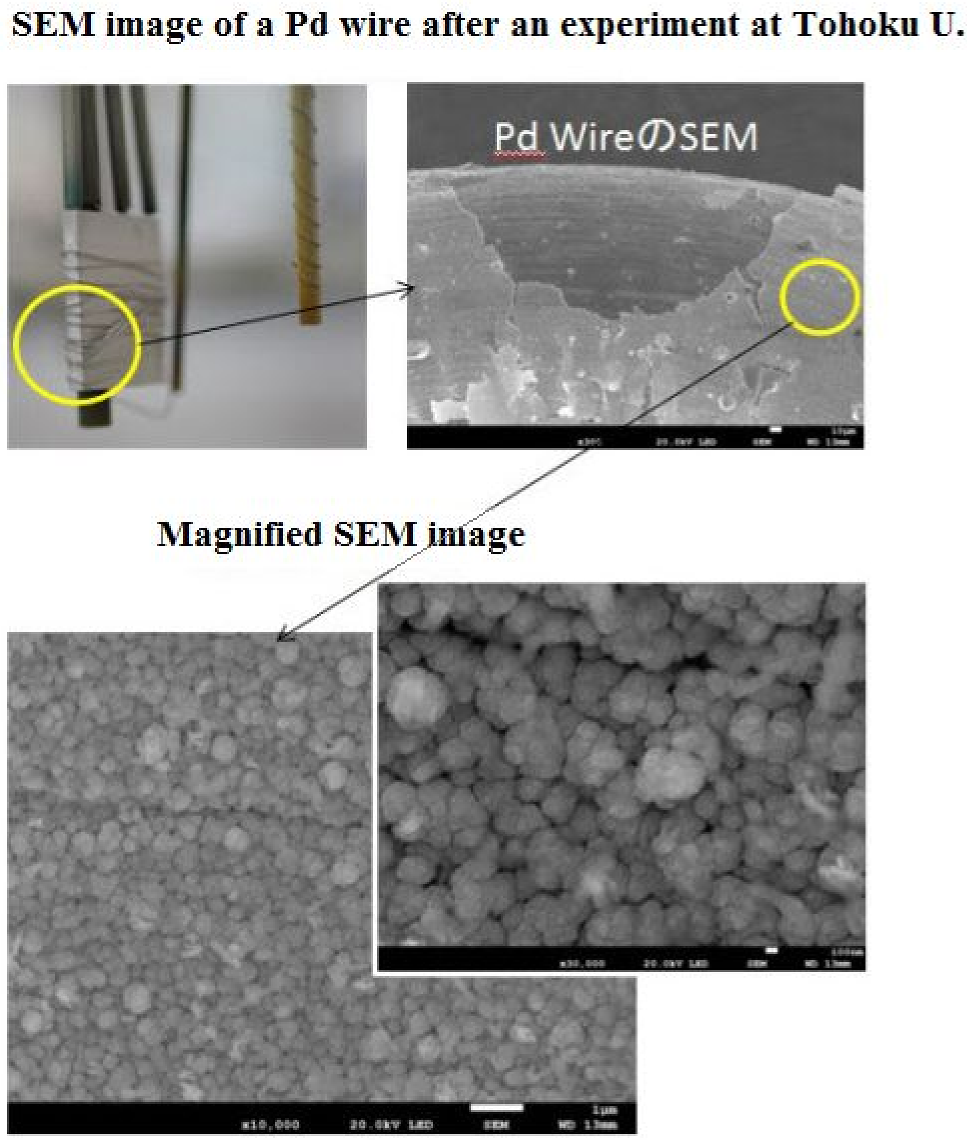
■ Nanostructures promote the nuclear reaction

Meanwhile, research in heat generation based on the method developed by professor emeritus Arata of Osaka University continues, with the technology-based think tank Technova (Tokyo Chiyoda-ku). Aisin Seiki Co. and Toyota Motor Corp. have invested in this company. Technova has welcomed as an advisors professor emeritus Akito Takahashi of Osaka University and professor emeritus Akira Kitamura of Kobe University, who have continued to research in collaboration with Kobe University.

In May 2008, Emeritus Professor Arata carried out a public experiment at Osaka University before news media. The technique he used at that time employed a zirconium oxide-palladium alloy in a nano-structure grid pattern, with deuterium gas forced into the structure under pressure. [6-8] He observed excess heat and helium production at room temperature. A Technova team forced light hydrogen into a nickel and copper-based nanoparticle structure based on Arata's. They succeeded in generating excess heat after a long waiting period of more than a month, by heating the sample up to about 300°C.

In 1989 at the U.S. University of Utah, when cold fusion attracted attention, the approach then used was electrolysis of a palladium electrode with heavy water (deuterium) in the solution. In subsequent studies, in addition to the electrolysis method, the gas loading method of injecting deuterium gas has been developed with increasing reproducibility. Nowadays, the gas loading system has become more mainstream than the electrolytic system. The Mizuno method being tested by Tohoku University and by Clean Planet, and also the Arata method being tested by Technova and Kobe University, both evolved from the gas loading technique.

In addition, "palladium and nickel nano-structures of the surface of the sample, deposited on a substrate such as copper, trigger the nuclear reaction; and this has been found to be a major key to excess heat generation," according to Professor Iwamura of Tohoku University.



After glow discharge treatment, the surface is covered with a film composed of nanoscale particles of palladium and nickel, etc. (Source: Tohoku University Professor Iwamura)

Qualitatively, 100% reproducibility has been established. The future research target is therefore: "how to increase heat generation, and how to use inexpensive materials such as nickel with light hydrogen, instead of palladium and deuterium" says Hideki Yoshino, president of Clean Planet.

■ First patent in the United States is granted

On October 2-7, 2016, the 20th International Conference on Condensed Matter Nuclear Science (ICCF20) will be held in Sendai. It will be hosted by the newly established CMNS research department of Tohoku University. The conference, held every year or two, is expected to attract more than 200 researchers in CMNS, who will announce their latest achievements. It is expected that the research results from the two groups of Japan will be highlighted.

Preparations for ICCF20 are progressing steadily, “In addition to researchers from the U.S. and Europe, researchers from China, Russia, etc., and about 30 countries overall are scheduled to participate, and it is likely there will be an increasing number of participants from corporations,” according to Appointed Professor Iwamura of Tohoku University. Beginning with the 17^{th} ICCF conference in 2012, there has been increasing participation by researchers from corporations. In the 18th meeting in July 2013, more than 40% of participants were from corporations promoting the development of “heat output devices” using CMNS.

Yoshino, president of Clean Planet, says that “75 companies engaged in CMNS research have surfaced, include leading electrical equipment and automobile manufacturers. Goaded by the participation of these companies, U.S. policy officials have been seen as beginning to position CMNS as an important technology for industrial policy.”

In November 2015, for the first time, the U.S. Patent Office granted a patent application from a U.S. researcher for a CMNS device. Previously, such patents were denied on the basis that a phenomenon that cannot be theoretically explained by current physics cannot be patented. The technical name of the patented process was “excess enthalpy by pressurized loading of deuterium into nano-sized metallic particles.” Again, the nanostructure is a key point of the technology.

■ Japan and Italy lead

In May 2016, the U.S. Congress ordered the Department of Defense (DoD) to assess the current status of CMNS from the point of view of national security. The DoD plans to report in September. A Member of Congress requested the DoD to determine, “if condensed matter nuclear science nuclear research has shifted to practical use, and whether it might become a revolutionary energy production and energy storage technology.” Also, the request showed recognition that “at present, Japan and Italy lead in the development, and Russia, China, Israel and India have also put some development resources into the field.”

Even though the name has been changed from “cold fusion” to “condensed matter nuclear science”, many researchers still view this field as “pseudoscience.” At the root of their view, there is a weakness that the phenomenon cannot be explained by current physics. In particular, there is really no theory that can explain how the reaction might overcome the repulsive force acting between protons (the Coulomb barrier), or how there could be a nuclear reaction which does not emit particles or radiation.

That said, some theories have been proposed to explain the reaction. Many theories have in common a focus not on a reaction between the two atoms, but rather between a collection of atoms in a phenomenon known as a “multi-body reaction” that occur simultaneously. This is proposed to occur in metals in which electrons and protons are densely packed and the Coulomb barrier is shielded by some principle, which gives rise to catalytic effects.

At Tohoku University, in parallel with the replication of the heat generation experiment, researchers plan to elucidate a theory to explain the reaction. In this way, as the theoretical study proceeds, if the new physical theory is built, the practical use of “revolutionary energy production” is likely to be further hastened.

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