1. Can a Solid-State Nuclear Fusion Reactor Be the Ultimate Green Energy Solution?

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1. Introduction

We all know that palladium (Pd) is an ideal material to study hydrogen storage kinetics because its bulk hydride properties are well characterized. Pd absorbs hydrogen gas up to 900 times its volume. Furthermore, recent investigations have shown that the rate of hydrogen trapping inside Pd is even higher in the case of Pd nanoparticles. Hydrogen atoms are strongly trapped and stabilized in the lattice of Pd nanoparticles, compared to bulk Pd. The benefit of studying and modifying the surface of nanoparticle Pd and other large surface area nanoparticles can lead to better understanding of nuclear transmutation reactions in solids heavily loaded with H, D or both. The phenomenon is known as Low Energy Nuclear Reactions (LENR).

Since 1989 and particularly in the last two years, differentresearch groups around the world have reported undisputable evidence on the presence of nuclear reactions in the Pd/D lattice. It was unfortunate that Fleischmann and Pons, who were the first to observe LENR in 1989, made mistakes and added wild extrapolations; nevertheless, they were not wrong with regard to their finding of excess heat, which has now been validated by so many research groups worldwide,like the valuable results that have been achieved by U.S.Navy researchers, Yasuhiro Iwamura of Mitsubishi Heavy Industries, and especially the results of Yoshiaki Arata and Yue Chang Zhang. However, by comparing the results and methods of these experiments, it seems that there is a better experimental approach to increase the reaction rates of this process and obtain clear and sound results. LENR is a surface-dependent phenomena. Thus, in order to increase the reaction rate and have a suitable process from a practical point of view, one has to focus on the surface area and try to create the right environment. Better results can be obtained by comparing the surface reactivity of different materials anddifferent size nanoparticles in a new experimental configuration called “laser-driven solid-state nuclear reactor.” In addition to the above, better experimental results can lead to formulating a theoretical model for nuclear transmutation reactions in solids. I believe there are certain conditions that can be created which might bring the ions of H/D isotopes at distances of a few Fermi so the spontaneous fusion rate would increase considerably.

2. Evaluations of the Research Activities

Experiments show that when deuterium (or at times even hydrogen) atoms are inserted (or loaded) inside a metal — such as palladium, titanium, nickel, etc. — occupying interstitial lattice positions in sufficiently large numbers and if the right “active environment” is created, a variety of nuclear reactions are found to occur involving not only the deuterium nuclei but also the host metal atoms. In this process “excess energy” is often found to be produced and in some cases nuclear particles such as neutrons, X-rays and even charged particles are released. But increasingly it has been observed that new “transmutation” elements not present prior to the commencement of the experiments have been detected. Most of those stunning experiments demonstrating low energy nuclear transmutations are readily available for sincere skeptics in the website www.lenr-canr.org. LENR was first observed in 1989 by Fleischmann and Pons. Their work got embroiled in a worldwide controversy. Now there are hundreds of researchers in several countries working on this field to unravel the mystery behind what has now come to be also known as Condensed Matter Nuclear Science (CMNS).

Some of the leading researchers in this field are or were employed at well known research institutes such as Los Alamos National Laboratory. Dr. Igor Goryachev from the famous Kurchatov Institute, for example, is expecting to demonstrate his 100 KW “alchemical reactor” in the very near future.

In 2007 researchers from the Navy’s Space and Naval Warfare Systems Center in San Diego, California threw cold water on skeptics of LENR. They achieved “direct and undisputable evidence” of LENR in the Pd lattice and successfully detected the passage of atomic particles emitted from the reactions using CR-39 detectors. They say their method can be replicated and verified by the scientific community. The results were published in the respected journal *Naturwissenschaften*. Yasuhiro Iwamura of Mitsubishi Heavy Industries designed a flawless experiment that demonstrated 100% reproducibility. On May 22, 2009, Osaka University physicist Yoshiaki Arata and his associate Yue Chang Zhang continuously generated excess energy in the form of heat and also produced helium particles. “The demonstration showed their method was highly reproducible,” said physicist Akito Takahashi, one of the 60 persons from industry and universities who witnessed it. Arata, who is the recipient of Japan’s highest award, the Emperor’s Prize, is the first person to have performed thermonuclear fusion research in Japan. Arata and Zhang have been reporting their work on cold fusion at various conferences and in Japanese journals for the last ten years. The details of their work are available at the above website.

The experiments of these groups are very promising, because if their methods and results can be easily reproduced and verified by other institutions, then widespread acceptance would become the norm.

Even though there is still a lack of strong neutron emissions and also a lack of strong emission of gamma or X-rays, most of the experiments have demonstrated the production of neutrons, He3, He4, tritium, gamma rays and other end products, of nuclear transmutation reactions. This is in spite of the fact that those experiments use very small electrodes and small cells, compared with large size experiments which can show undisputable proof of the number of neutrons or radioactivity produced from this process. But even if the rate increases considerably, this type of reaction would still have low radiation emissions compared to fission or hot fusion reactions. This process seems to represent a new nuclear mechanism, maybe we can call it low radiation nuclear fusion.

There are important areas where we have to concentrate and learn how to make the right environment for these reactions. Investigating the lattice structure and its rearrangement when hydrogen, deuterium or mixed gas is absorbed in palladium or other alloys would allow us to learn how to reduce the internuclear distances in such lattices. Nanoparticles with very high trapping rate of H/D are the bases to understand the right environments. They are vital in understanding how to increase the reaction rate of this process (better nuclear fuel) and how this could be used either to produce energy directly or to produce neutrons and tritium in a sustained manner. In other words, if the necessary environment can be properly identified—which is a realistic possibility—then the reaction rate can be made to occur at potentially useful rates, where it can be produced in large quantity and standard engineering methods can be applied.

3. Improving the Surface Area

How do we find the best conditions to induce high rate nuclear fusion by dense-deuterium formed within the surface area of those nanoparticles? It has been reported by Arata and Zhang that both the volume of the surface zone of Pd black and the amount of D/H atoms are easily absorbed inside the Pd black-intense solid-state nuclear fusion. This means the surface area plays an important role in solid-state nuclear fusion (SSNF) and, therefore, it is crucial to have small particle size, as small as possible.

I believe there is a much better nanostructured material than what Arata and Zhang used that can form abundant dense-deuterium (pycnodeuterium) and induce a high rate of solid-state nuclear fusion. This material will be characterized by long incubation periods.

4. The Importance of the Working Gas

The best working gas and the best stimulation energy system are still dark areas in this field of research. Arata and Zhang have concluded from their experimental work that the use of a mixed working gas D_2 + He compared with pure D_2 gas has greater expectation for generating strong pycnodeuterium nuclear fusion. But is this mixing the best working gas?

5. Advantages of Solid-State Nuclear Fusion

Up to now research in the field of SSNF has been conducted by very few researchers with a lack of funding and amidst the criticism of a very hostile hot fusion community. Despite these facts, experimental evidence has shown that solid pycnodeuterium is by far the most excellent fuel for nuclear fusion, as compared with gaseous deuterium which is used in thermonuclear fusion. Furthermore, SSNF requires a very low stimulation energy system. For instance, the laser welding nuclear fusion used by Arata and Zhang was only 300 watts and generated about 10^{19} to 10^{20} particles per 10 seconds.

These results should increase the research interest and funding of this field because this new energy source has the greatest potential for the ultimate green energy solution here on earth and also the greatest potential and advantage for space application and exploration. However, this important field is still facing the same treatment that superconductivity (or the disappearance of electrical resistance at very low temperatures) faced when it was first proposed. It was angrily dismissed by the absolute majority of mainstream scientists in the field, who considered it pseudoscience, and well known scientific journals refused to publish any research about it. Now, of course, superconducting magnets are used in magnetic resonance imaging (MRI) machines in our hospitals and magnetic levitation transport is considered as the future of rail travel. In fact, today there are full-scale prototypes in Japan and the U.S. and even a commercial high speed maglev train in service in China. But we must not forget that superconductivity earned its scientific acceptance when it started to produce results replicable in any laboratory with the proper equipment. LENR or SSNF is starting to do the same, but the progress is very slow. In order for this field to develop rapidly, international organizations concerned with the peaceful development of mankind, the environment and the energy crisis should immediately endorse and encourage the research and development of this field.

There can be no doubt that these experiments reveal the existence of a new way nuclei of atoms can interact, which present nuclear theory cannot explain. Still these results are viewed by mainstream scientists as pseudoscience. But can the absence of theoretical explanations be used to dismiss experimental evidence? Are these findings contrary to the understanding that we have gained in the last 60 years in the field of nuclear reactions, as some critics claim? Are we going to seriously look into these new experimental findings and modify, add to or change our present theories or are we going to cling to our age old theories and refuse to face facts?

Based on the history of science, there has always been an immense resistance to accepting a paradigm shift in mainstream science. Nevertheless, there is mounting evidence from this fascinating and emerging area of research that a third route to produce nuclear energy is possible. This route is cheaper and cleaner than the other two.

At this time in human history, we are teetering on the brink of the most serious disasters ever to face us in our long history—global warming, pollution (air, sea, land), higher energy costs (rising price of energy), crisis in global food prices, partly caused by the increasing use of crops for energy generation, looming global conflicts among powerful nations as fossil fuels reserves are depleting, a population increase and a lack of energy for economic development in developing countries. These are serious issues threatening global stability and the future of the planet. Thus, the time to invest in and encourage the research of this field is long overdue, but the decision will remain in the hand of the political establishment of the developed world.

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