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# Why Cold Fusion Has Been So Hard to Explain and Duplicate

Edmund Storms
Energy K. Systems, Inc.
Santa Fe, NM

## INTRODUCTION

Cold fusion (LENR) has been difficult to duplicate and many proposed explanations have not helped to solve this problem. I suggest the difficulty is caused by an erroneous assumption.

LENR reactions obviously do not occur everywhere in nature. Painful experience has shown that they occur only in special and difficult to create materials, the so-called NUCLEAR ACTIVE ENVIRONMENT. In the past, people have assumed that the NAE is in the bulk of a Pons-Fleischmann (P-F) palladium cathode. The surface of the cathode is assumed to be inert and only serves to modify the composition of the underlying beta-PdD. In contrast, I'm proposing that the surface layer itself is the NAE.

The concept of NAE is difficult for people trained in physics to accept because phenomenon studied by physics, particularly nuclear physics, are independent of chemical form. For example, when sufficient plutonium is brought together in one place, the resulting nuclear reaction does not depend on whether the material is the carbide, nitride or oxide. However, in the case of LENR the environment is very important. When the proper environment is achieved, the nuclear reaction occurs spontaneously, with no additional effort required. A person does not have to understand the mechanism of the process. Unfortunately, most theories have focused on the mechanism rather than on the environment. To make matters worse, the mechanisms are applied to ideal, imagined materials, not to those existing in the real world. As a result, little useful progress has been achieved.

## DISCUSSION

To discover the properties of the NAE, it's location on the cathode must be determined. The following observations suggest that it is located in the surface region of the cathode.

### 1. Helium generated by LENR is found in the surrounding gas rather than in the palladium deuteride.

When helium is placed in palladium using decay of dissolved tritium, the resulting $^{3}He$ can be removed only by heating near the melting point [1]. Only helium located near the surface is able to leave the material without this treatment. Therefore, the observed anomalous $^{4}He$ must have been generated very near the surface of a P-F cathode to be observed in the surrounding gas.

### 2. Anomalous tritium is detected in the electrolyte rather than in evolving gas.

Tritium that is known to be present within the cathode can be displaced by deuterium during electrolysis. This tritium is found to leave with the evolving deuterium gas [2]. However, tritium produced during a cold fusion reaction is found in the electrolyte, provided a recombining catalyst is not present in the cell. Tritium is able to enter the electrolyte as $T^+$ because it is able to exchange with $D^+$ at the cathode surface before it has a chance to form DT molecules, which would leave as gas.

## 3. Anomalous heat is observed to be generated on the cathode surface.

Szpak et al. [3, 4], using an IR camera, observed hot spots that turned on and off in rapid secession on an active cathode . The generated energy was claimed to come from just below the surface.

## 4. Transmutation products are located only in the surface region.

A number of studies have detected transmutation products located within the surface region of P-F cathodes. These elements do not exist within the bulk material[5-9].

## 5. Melted regions are observed on the cathode surface.

Microscopic examination of the surface shows many melted regions after anomalous energy has been generated[10].

## 6. Large amounts of anomalous energy can be generated using thin films on an inert substrate.

Significant anomalous energy has been generated using very thin films of material[11-13]. If a large amount of palladium were required, as would be present in bulk material, these thin films would have produced very little anomalous energy.

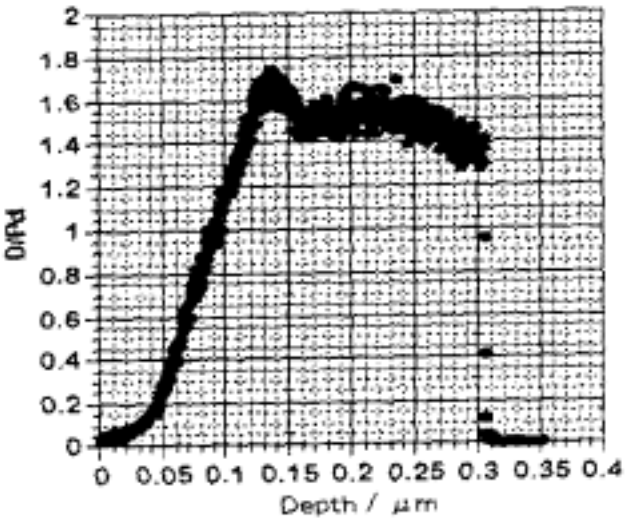


**FIGURE 1.** Deuterium concentration in Pd after electrolysis based on ERDA. [14] Some deloading from the surface is evident.

Next, the deuterium content of the NAE needs to be discovered. Unfortunately, this property is difficult to measure. Reported values are always based on the average composition, not the composition of the surface. Two efforts to measure the composition near the surface are shown in Figs. 1 and 2. The D/Pd ratio of the NAE will be greater than these values.

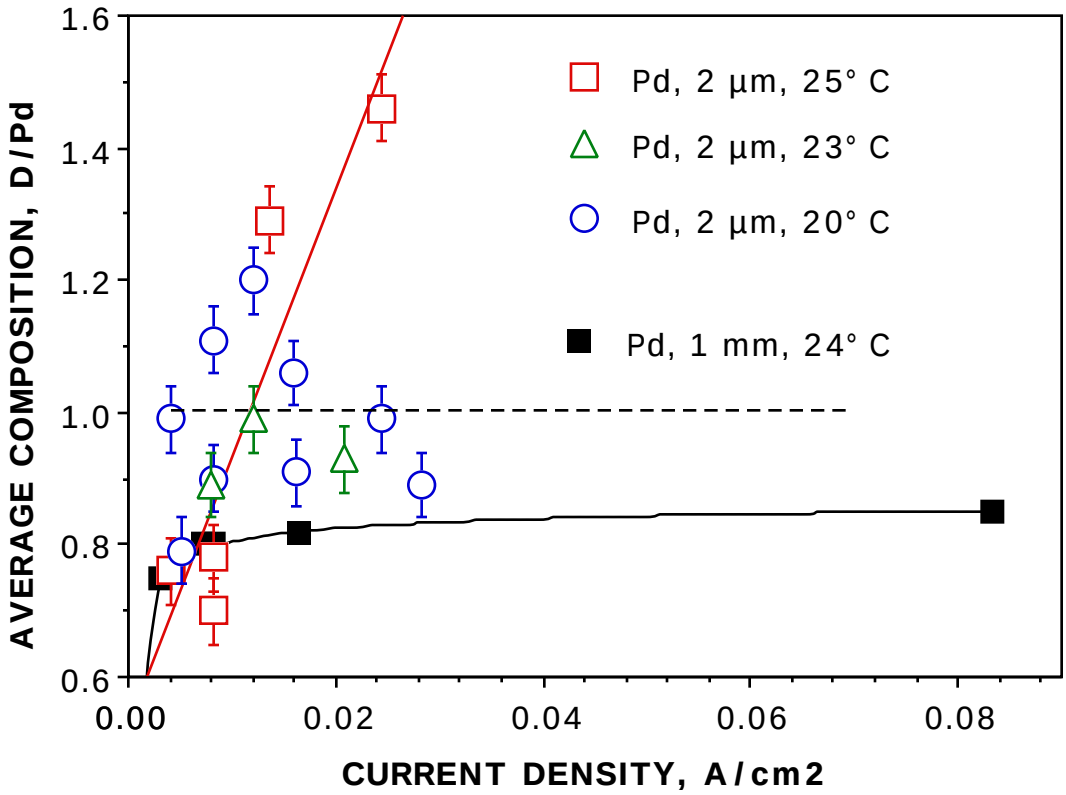


**FIGURE 2.** Deuterium content in Pd films plated on Pt after electrolysis based on orphaned oxygen. [15] Film thickness and temperature are indicated.

These measurements indicate that the NAE has a composition in excess of $PdD_{1.7}$. The beta phase has a limiting composition of $PdD_{1.0}$. Therefore, the NAE can not be beta-PdD. Of course, some people will argue that the additional D+ goes into tetrahedral sites. However, no evidence exists for occupancy of this site. In fact, if this site were occupied, a change in crystal structure would be expected as experienced by hydrides formed by other metals.

For example, other metals form hydrides having a limiting composition of $MH_2$, in addition to MH. An example is shown in Fig. 3 for the Zr-H system. The $ZrH_2$ structure is fcc tetragonal, as would be expected if D+ occupied both tetrahedral and octahedral sites and had an ordered arrangement. If tetrahedral sites were occupied, it is safe to conclude that they would be present in $PdD_2$ not in beta-PdD. Also, such structures have the potential for the presence of deuterium dimers.

Besides having a very high D/Pd ratio, the surface also contains a high concentration of Li, Pt and Si, along with many other elements[8, 16, 17]. Consequently, the surface is a complex mixture of many elements with a very high D/M ratio and an unknown structure.

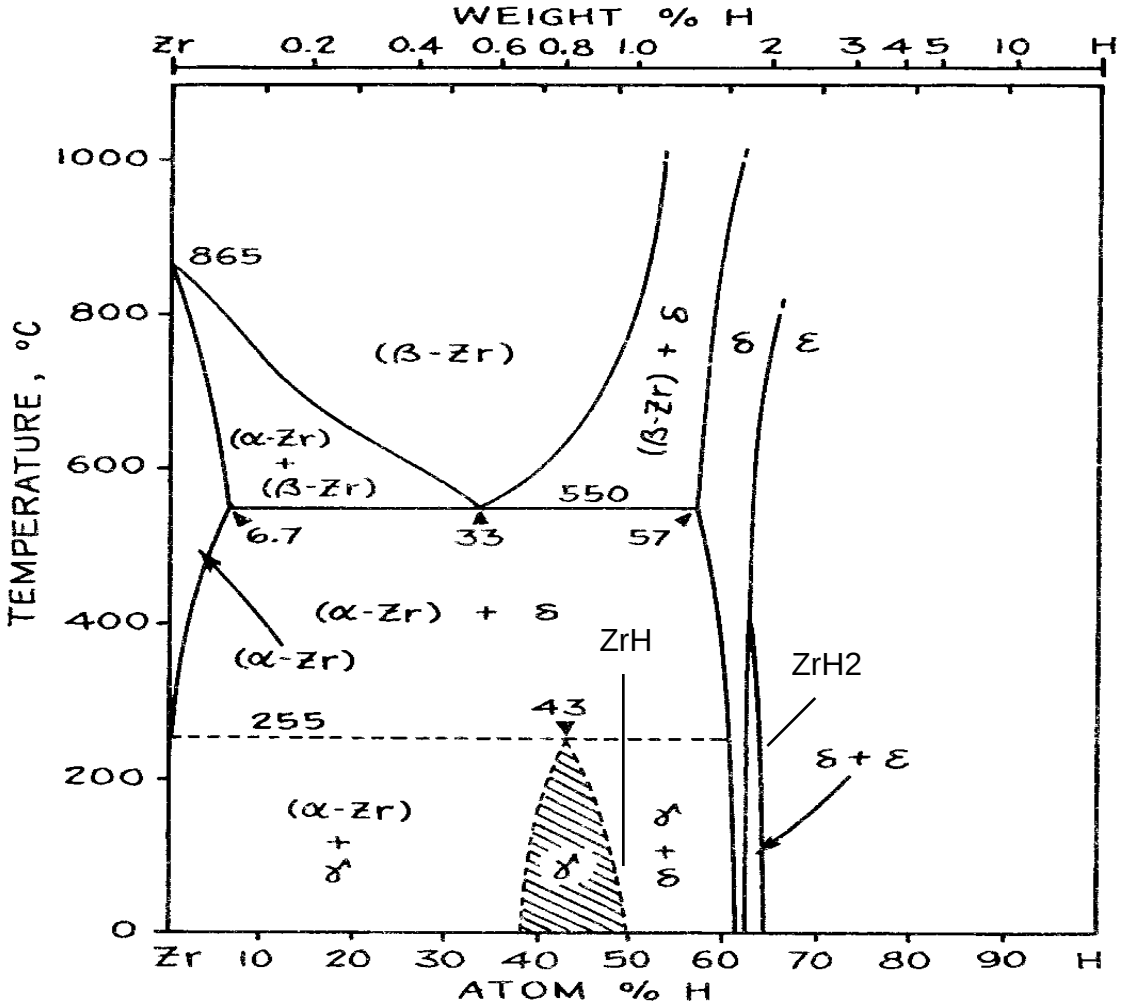


**FIGURE 3.** Zr-H system at 1 atm $H_2$ pressure. (GE Handbook of Phase Diagrams).

What other characteristics might the surface layer have? LENR has been produced from finely divided palladium using palladium-black [18, 19] or fine powder attached to charcoal[20]. Even microparticles of other substances imbedded in palladium are found to be active[21]. Examinations of cathode surfaces show the presence of similar microstructures as a result of the electrodeposition process. In addition, successful thin films, as mentioned previously, also contain this type of microstructure. Apparently, structures in the nanometer range of size are frequently associated with anomalous energy production.

## CONCLUSION

1. Pure beta-PdD, regardless of its deuterium content, is not the environment in which LENR occurs during the Pons-Fleischmann effect. In addition, the complex alloy in which the effect occurs in this case apparently requires a very high deuterium content.

2. Nearly pure beta-PdD, when it is used as small particles, appears to be active at a relatively low deuterium content.

3. LENR requires nanosized particles and can involve various complex materials, not just palladium.

4. Most theories, mechanisms, and explanations are inadequate because they have not taken these factors into account.

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