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Letter to the Editor

Comment on the article 'Simulation of Crater Formation on LENR Cathodes Surfaces'

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Abstract

Formation of small craters on the surface of Pd cathode during electrolysis in electrolytes based on heavy water is sometimes interpreted as a consequence of low-temperature nuclear reactions. In this note we discuss the validity of these statements.
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Reference [1] discusses the processes of heat transfer which accompany the local emission of heat on the surface of Pd craters during the electrolytic hydrogenation (or deuteration). However, these notes are not about the model presented in the paper, or the corresponding results of the calculations. Reference [1] attracts the reader's attention with the bold assertion, accompanied by appropriate references, about nuclear reactions as a cause of formation of these craters. So, in the first sentence of the Abstract Ruer argues: "Many authors reported the presence of small-size craters on the surface of cathodes after Low-Energy Nuclear Reaction (LENR)". The author continues: "It is conjectured the craters result from violent reactions, perhaps of nuclear origin." Moreover, in the discussion following this, the author repeatedly reiterated this statement, without giving any arguments in its favor. It should be said that this statement about the probably nuclear origin of the craters is widespread in LENR literature. Interestingly, Mizuno, perhaps one of the first who found the craters on the surface of metals during electrolytic hydrogenation [2], does not say anything about its nuclear origin, but astutely points out the heterogeneity of the electric field on the cathode's surface and the possibility of local hydrogen recombination associated with this heterogeneity. In a comprehensive review [3], which discusses the morphological and energetic characteristics of the craters, Nagel made reasonable suggestions about the expediency of studies of the craters to understand LENR.

However, in a number of publications, some of which are cited in Ref. [1], the authors report on experimental results, which, in their opinion, are evidence of the localization of nuclear reactions in the craters. In some cases, this assertion is not supported by any experimental justification [4,5]. In others [6–8] the authors adduce the results

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of SEM-EDS analysis of the craters, which they say prove its nuclear nature. For example, Ref. [6] reported SEM detection of Ti, Mn, Fe, Cr and Ni on the surface of the cathode. The authors believe that the nuclear origin of these elements is proved by their absence in the starting metal. The weakness of this argument is that, as shown in numerous experiments, the cathode surface has always been contaminated by various metal and non-metal impurities during the process of electrolysis. This is particularly the case with experiments by Energetics Technologies [9]. The distribution of these elements over the cathode surface is very uneven. It replicates the non-uniformity of the electric field. In addition, metal elements as Ni, Na, K, Li (the latter found by XRD method in the form of lithium aluminate $LiAlO_2$) have been detected time and again after electrolysis experiments. Such contamination on the cathodes surface has been observed in open cells as well as in closed ones. Here is another typical example. Reference [7] reported the detection with EDS of Al, O, Ca, Mg and Si in the craters (or "blisters," in the terminology of the authors). The blisters formed on the surface of the Pd cathode during the co-deposition process. The authors believe that the detected elements are products of nuclear reactions. Interestingly, all the newly formed nuclei are stable. Anyway, there is no mention of the presence of any radiation sources of charged particles or photons, except for point sources of IR radiation. There are Al, Mg, Ca, Si, Zn at concentrations up to 20% revealed in the zone close to the blisters. Naturally, these impurities exist on the cathode surface not in elemental form, but in the form of binary and multicomponent high-enthalpy phases (oxides, oxycarbides, spinels, aluminates, etc.).

It is alleged that these impurities have a nuclear origin, because otherwise, according to the authors, they should be uniformly distributed over the cathode surface. This argument is incorrect because intensive surface diffusion of elements in the process of electrolysis occurs, due to strong heterogeneity of the electric field at the cathode surface[a]. Therefore, we cannot exclude the high probability of concentrated contaminants near the craters. Regarding the results of the EDS analysis of Pd cathodes reported in Ref. [8], the detection of the high concentration of Ag in the craters testifies only to rapid Ag migration, perhaps involving electro-capillary effect, from the lead wire to the cathode surface. This is likely because the authors have presented analytical data for the part of the cathode surface close to the contact zone. It should be borne in mind that reliable identification of Ag in Pd matrix with EDS method is possible only at very high concentrations of Ag due to the overlap Lβ1Pd and Lα1Ag spectral lines. The authors did not assess the amount of heat that would be generated by such a highly developed reaction of the nucleus of Pd with a proton (deuteron) and the formation of an Ag nucleus. A rough estimate shows that in this case the Pd sample must instantly evaporate, not to mention other, more dramatic consequences. A large number of analyses of the craters carried out by Energetics Technologies (Israel) with SEM and XRD methods. They can be summarized as follows:

(1) The craters arise on the Pd cathode during electrolysis with electrolytes made from light or heavy water.
(2) The craters appear when there is excess heat production, but they also appear when there is no excess heat.
(3) The crater areas usually do not contain impurities other than carbon and platinum.
(4) The concentration of Pt in the melted zone is increased, as compared with the rest of the cathode surface; that is easy to explain due to the phase transition of the first kind and by the higher melting point of Pt, as compared to that of Pd.
(5) The experimentally observed concentration of the craters is so low that the total amount of heat required for their formation is incomparably smaller than the experimentally measured excess heat, when heat is detected. Thus if we assume that all excess heat, e.g., 1 J is realized through formation of the craters, the craters have to cover the entire surface of the cathode with a mean density of $10^6 - 10^7$ cm^{-2}. The experimentally measured concentration of craters is just about 5–6 orders of magnitude less than this; hence, the corresponding amount of heat cannot be detected by any known calorimeter.

[a]This effect is caused, for example, by growth of the secondary and negative Pd crystals during the electrolytic process. Certainly, simultaneously with Pd, all other elements move onto the cathode surface. This is a very important circumstance that should not be overlooked.

The absence of radiation from LENR is usually explained by the dissipation of the energy in the lattice (e.g., by a change in its phonon or plasmon spectra). However, if we assume the craters are of nuclear origin, we must also assume that the zone of their thermal influence is very small, and has no effect on the energy spectrum of the metal as a whole.

Of course, the possibility that nuclear reactions form the craters cannot be excluded from consideration. However, this hypothesis should be substantiated only with detection products of such reactions located close to the crater area. On the other hand, searching for the nuclear products should be preceded by the search of the less exotic sources of heat as the cause of the phenomenon.

An example of such mundane sources may be, e.g., reaction of recombination of atomic deuterium (hydrogen):

$$2\mathrm{D} \rightarrow \mathrm{D}_2 + 221.7(\mathrm{kJ/g} - \mathrm{at.D}) \tag{1}$$

$$2\mathrm{H} \rightarrow \mathrm{H}_2 + 217(\mathrm{kJ/g} - \mathrm{at.H}) \tag{2}$$

Release of the heat of recombination due to a local fast desorption of D (H) at loading ≈ 1, is quite sufficient, as is evident from (1) and (2), to melt the corresponding mass of Pd(ΔH_mPd = 16.7 kJ/g –at.). This is true, as is easily seen, and for smaller ratios D/Pd, especially in view of the high probability of the oxidation reaction of deuterium (hydrogen):

$$\mathrm{D}_{2\mathrm{g}}(\mathrm{H}_{2\mathrm{g}}) + \frac{1}{2}\mathrm{O}_{2\mathrm{g}} \rightarrow \mathrm{D}_2(\mathrm{H}_2)\mathrm{O}_1 + 294.6(285.8)\mathrm{kJ/mol} \tag{3}$$

The high probability of reaction (3) is conditioned by the presence of dissolved oxygen in the electrolyte and free oxygen which is released at the anode, with vigorous stirring of the electrolyte in the inter-electrode space, especially at high current densities. The causes of the local sudden emission of an absorbed gas, the further scenario of the behavior of metal near the places of gas emission, rate of mass and heat transfer of the associated processes should be the subject of further research. By the way, the subject of the article, which was the reason for writing these notes, was research into one of the aspects of the phenomenon under discussion.

Of course,the simple conjecture offered here suffers from one significant “disadvantage” – it does not need in the excess heat effect (FP-effect) for the interpretation of the phenomenon.

From the above, it seems obvious that the assertion of the nuclear origin of the craters on the basis of the available experimental data is premature. Thus, the question of the nature of the craters, which appear during the electrolytic deuteration or hydrogenation of Pd remains open, and is a challenge for both theorists and experimentalists involved in the unraveling of the mysterious LENR phenomenon.

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