Simulation of the Formation of Craters in LENR Cathode Materials

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Many electrochemical Low Energy Nuclear Reactions (LENR) experiments have resulted in the observations of micro-craters in the surfaces of the cathode metals (Pd, Au and others) [1]. Such craters are not known to form in ordinary electrochemical experiments, that is, without the possibility of LENR [2]. Small craters are of interest for scientific reasons. They indicate the fast and local (high power density) release of energy, much faster than can be captured by calorimeters. Knowing crater formation dynamics might contribute to the understanding of LENR, and also constrain theories about mechanisms and locations of LENR. Cratering might also be practically important, since is erodes the cathode material.

No way is known to measure directly the dynamics of crater formation to determine the formation (energy release) time, a key parameter scientifically. Hence, we are using simulations to attempt to learn about the energy production time, the amount of energy liberated, and both the shape and the location of the volume into which energy is released by LENR. There are several commercial software packages, which might be used for the simulations, including ANSYS, ComSol and SolidWorks. We are employing SolidWorks, which permits the initialization of the simulation by designating the cathode material, the release time and total energy, and the geometry of the problem. All of these factors can be varied parametrically in an attempt to produce post-simulation structures similar to those seen in micrographs after LENR experiments. The simulations yield both temporal and spatial distributions of the temperatures that follow from the LENR energy release.

Our initial simulations were done for Pd, using its known heat capacity and thermal conductivity. For one early run, a sub-micron heated volume was positioned 1 micrometer below the surface. For this simulation, 1 microjoule was released into that volume during 0.1 microsecond. Figure 1(left) gives the time history at three points within the 25 micrometer diameter model volume. Figure 1 (right) is a spatial cross section of the heated and nearby region. For this set of parameters, the central energy-release region exceeds the melting temperature of Pd (1828K) early during the energy release time. The region that is melted at the end of 0.1 microsecond is 6.0 micrometers in diameter. We will present the results of simulations of energy releases of 1 nJ to 1 mJ in times from less than 1 nsec to greater than 10 μsec, with a wide range of geometries for the energized volume and its depth below the surface. Estimates of the energy release time and depths are expected to result from the simulation results and their comparisons with experimental micrographs.

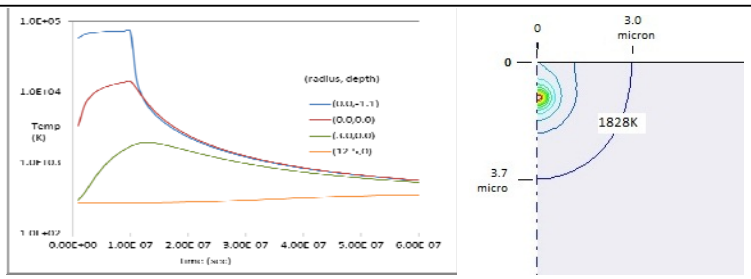

Figure 1. Left: Computed time history of the sample temperatures at (radius, depth) micrometers. Right: Spatial distribution of the temperatures after 1 microsecond.

[1] References are given in D. J. Nagel, "Characteristics and Energetics of Craters in LENR Experimental Materials," J. Condensed Matter Nuclear Science, 10, pp.1-14, 2013
[2] M. C. H. McKubre, private communication