Coupled Calorimetry and Resistivity Measurements, in Conjunction with an Emended and More Complete Phase Diagram of the Palladium - Isotopic Hydrogen System

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Results of a calorimetric study established the energy produced, over and above the input energy, from electrolytic loading of deuterium into Pd was 150 MJ/cc of Pd (14000 eV/Pd atom) for a 46 day period. High fugacity of deuterium was developed in unalloyed palladium via electrolysis (0.5 molar electrolytic solution of lithium deteroxide, LiOD) and the use of an independent electromigration current. In situ resistivity measurements of the Pd were used to assay the activity of D in the Pd lattice (ratio of D/Pd) and employed as an indicator of phase changes. In addition, during this period, two run-away events were triggered by suddenly increasing the current density resulting in 100 percent excess power (2.4 watts output with only 1.2 watts input) necessitating a temporary cut back in the electrolysis current. The average excess power (excluding run-away) ranged from 4.7 +/- 0.15 to 9.6 +/- 0.30 percent of input power while the input power ranged from 2.000 to 3.450 watts, confirming the Fleischmann-Pons effect. The precision was: Power In = +/-.0005 W; ΔT = +/- .05^{o}C; Power Out = +/-.015 W giving an overall precision of +/- 0.5%. High fugacity was required to produce these results, and the triggered run-away events required even higher fugacity. Using thermodynamic energy balance, it was found that the energy release was of such magnitude that the source of the energy is from a nuclear source, however the exact reaction was not determined in this work. X-ray diffraction results from the recent literature, rules for phase diagram construction, and thermodynamic stability requirements necessitate revisions of the phase diagram, with the addition of three *thermodynamically stable* phases of the superabundant vacancy (SAV) type. These stable phases, each requiring high fugacity, are: γ ($Pd_7VacD_{6\text{-}8}$), δ phase (Pd_3VacD_4 - octahedral), δ' phase (Pd_3VacD_4 - tetrahedral). The emended Palladium – Isotopic Hydrogen phase diagram is presented here. The excess heat condition supports portions of the cathode being in the ordered δ phase (Pd_3VacD_4 - octahedral), while the drop in resistance of the Pd cathode during increasing temperature and excess heat production strongly indicates portions of the cathode also transformed to the ordered δ' phase (Pd_3VacD_4 - tetrahedral). These phases were encouraged by the used of an electromigration current causing the D+ ions (trapped to vacancies) to pull the vacancies along and aid the formation of the SAV phases. The heat increases with increasing volume fraction of the new phase. Extending these basic unit cells to the larger lattice epiphanates the nuclear active state as the δ and δ' phases. The decreased resistance phase, δ', is modeled in the same way by extending the unit cell to the entire lattice revealing extensive pathways of low resistance. A potential connection of these phases to the superconductivity phase of PdH / PdD is offered.