Condensed Matter Nuclear Reactions

P.A. Mosier-Boss
US Navy SPAWAR-Pacific, San Diego, CA

L.P. Forsley[1]
JWK Corporation, Annandale, VA
Global Energy Corporation, San Diego, CA
University of Texas, Austin, Austin, TX

[1]Contact: larryforsley@gmail.com +1-(703)-216-5566

Synopsis of Refereed Publications on Condensed Matter Nuclear Reactions[2]

Executive Summary

Pons & Fleischmann

In the 26 years since the ill-named, and ill-timed, announcement of "cold fusion" by Drs. Martin Fleischmann[3] and Stanley Pons at the University of Utah critics have consistently raised five concerns:

1. Fusion neutron production isn't commensurate with observed heat[4]
2. Lack of a theory
3. Counter to "all that's known in nuclear physics"
4. Irreproducibility
5. Lack of independent replication

It can be argued that the phenomenon is neither "cold" nor "fusion": *but it is nuclear*[5]. Neutrons are not easily produced, nor, are they produced by purely chemical means. Hence, neutrons are the hallmark of nuclear reactions. Although neutron production *isn't* commensurate with measured heat, several of our papers discuss neutron production.

There is an abundance of contradictory theories, and hence, we've shied away from theory until we had data. Although the mantra, "theory guides, data decides", doesn't preclude experimental data, several voices outside the field refuse to recognize the phenomena unless there is a theory. However, our modeling has provided guidance and suggests previously unrecognized magnetic and nuclear effects that clearly enable condensed matter nuclear reactions.

The major "cold fusion" criticism has been the need to overcome the Coulomb Barrier between two positively charged deuterons at room temperature, 0.025 eV, as opposed to the hot fusion ion temperature of 5 keV (55 million K). However, low energy accelerator experiments with metal deuteride targets demonstrate enhanced electron screening[6] that significantly raises the Gamow Factor thereby increasing the low temperature deuterium fusion cross-section. Other nuclear theories have been suggested to lower the Coulomb Barrier, though few of these are consistent with our data.

Most important, the co-deposition protocol discussed in these papers has shown independent reproducibility and replication across multiple laboratories in four countries negating two primary criticisms of Condensed Matter Nuclear Science (CMNS): irreproducibility and lack of independent replication.

The significance of condensed matter nuclear reactions cannot be overstated. *The successful commercialization of the technology would be paradigm shifting, to say the least.*

Our research and implementation is a few years ahead of what we have published. Contact us regarding our current work in hybrid fusion-fission reactors, energetics and compact power generation.

---

[2] Cover: Some select journals publishing a number of our papers: *Journal of Condensed Matter Nuclear Science:* 16; *European Physical Journal of Applied Physics*: 5; *Naturwissenschaften*: 3; *Radiation Measurements*: 1; ACS, *Low Energy Nuclear Source Books*, Vols. 1 and 2; with DT fusion tracks on cover, as did the Indian Journal, *Current Science*, with co-dep neutron induced recoil tracks on a cover, and now 2 papers in Volume 108.

[3] Fleischmann noted that the March 29, 1989 press conference was premature "by a couple years". The University was concerned about its intellectual property, given Dr. Steven Jones, Brigham Young University, had inferred similar nuclear reactions and reviewed Fleischmann's and Pons' DoE proposal to study the effect.

[4] "The Dead Graduate Student Problem", attributed to Dr. Robert McCrory, University of Rochester, UR/LLE, in 1989 was documented in Dr. John Huizenga's book, "Cold Fusion: The Scientific Fiasco of the Century". The hot fusion neutron flux necessary to produce the observed heat would result in a lethal neutron flux: hence, *no dead graduate students = no neutrons = no fusion*. Yet, in 2009, Dr. Johan Frenje, with the DoE NIF, UR/LLE and MIT, confirmed for the magazine, *New Scientist*, *that our Pd/D co-deposition triple tracks are from DT fusion neutrons*.

[5] P.A. Mosier-Boss, "It is Not Low Energy – But it is Nuclear", *J. Condensed Matter Nucl. Sci.* **13**.

[6] K. Czerski, A. Huke, P. Heide and G. Ruprecht,"The 2H(d, p)3H reaction in metallic media at very low energies", *Europhys. Lett.*, **68** (3), (2004) pp. 363–369

How and why we got here

Scientists at the US Navy Systems Center-Pacific (SSC-Pacific), and its predecessors, began this journey with the observation that an electrochemically-driven, deuterium-loaded, palladium cathode became anomalously hotter than the less conductive solution surrounding it. They, along with JWK Corporation, have had extraordinary success in publishing the results of condensed matter nuclear reaction research in peer-reviewed journals. This success hasn't come easily and is due to several factors. One key reason was the support of Dr. Frank Gordon, now retired SES and then Head of the Research and Applied Sciences Department. Because of his support, the SSC-Pacific upper management allowed scientists to conduct research and publish results in a controversial field from 1989 until 2012.

Co-deposition Protocol

By adopting the palladium-deuterium (Pd/D) electrolytic co-deposition protocol, invented by Dr. Stanislaw Szpak at the Naval Ocean Systems Center, we had a reliable and repeatable protocol for the high, fast loading of palladium with deuterium: *without cracking*. Both Drs. Martin Fleischmann and John Bockris, world-renowned electrochemists, contributed co-dep papers. As early as 1990 we began exploring nuclear effects, beginning with x-ray film, and later measuring tritium, elemental transmutation, then charged particles and neutrons using solid-state nuclear track detectors. We conducted thermal imaging. Colleagues, Dr. Mel Miles, and later, Dennis Letts, performed co-dep calorimetry. Miles observed the excess energy from the Pd/D co-deposition *surface* exceeded that of bulk palladium.

Other papers examined the effects of external fields on surface morphology, measurements of fast neutron and charged particle energy and the identification of their source. The nuclear fusion branching ratio was identified, as requested by Dr. Richard Garwin[7]. The majority of our work over the past two decades has dealt with nuclear effects in the Pd/D system. Eleven of the papers discuss modeling, 14 are on thermal effects and 31 with nuclear emissions. We have investigated magnetic interactions with the lattice and nuclei, and the relationship between superconductivity and condensed matter nuclear reactions.

Collaborative, International Effort

We have sought to identify, characterize and elucidate the underlying mechanisms. Ours has been a collaborative effort with colleagues around the globe. To date, the SSC-Pacific/JWK team and colleagues have published 48-refereed papers in 14 journals and book chapters, spanning 25 years. Our colleagues include 44 authors and co-authors from nine countries representing 33 institutions. We have given more than three times as many conference talks and briefings. *This is a well-represented, international effort*.

Several researchers have independently replicated our Pd/D co-deposition protocol, like Dr. Fran Tanzella *et al,* Dr. Kew-Ho Lee, *et al* and Pierre Carbonnelle; or modified it, including Dennis Letts and Dr. Mel Miles or, like Dr. Mitchell Swartz, independently developed their own. Drs. Peter Hagelstein and Dennis Cravens with Dennis Letts used co-deposition to create the gold-coated palladium structures they successfully laser irradiated. *Twelve of the papers are co-deposition replications, including researchers in the US, Belgium, Japan and South Korea.*

Perils of Publishing

The few journal editors and reviewers who had the fortitude to consider our work contributed to this success. Many reviewers from outside this field had to put aside their biases and look objectively at our data. In turn, their relentless concerns forced us to tenaciously address their issues. Unfortunately, US funding agencies ignored our peer-reviewed papers because they weren't published in the journals *Science* or *Nature.* Yet, neither of these journals will publish positive papers on this subject unless US funding agencies accept the phenomena: *Catch-22!* We explored this problem in a 2013 paper[8].

[7] Dr. Richard Garwin, a JASON member (who have a negative view of "cold fusion), was briefed on June 26, 2009.
[8] P.A. Mosier-Boss, L.P. Forsley and F.E. Gordon, "How the Flawed Journal Review Process Impedes Paradigm Shifting Discoveries", *J. Condensed Matter Nucl. Sci.* **12** (2013) 1-12.

However, *a patent is the most technologically significant publication*. It provides the means to capitalize upon a discovery and commercially exploit its impact. The first US co-deposition patent was published in 1999, but the second, in 2013, explicitly teaches the palladium co-deposition method as a means to generate energetic particles: *condensed matter nuclear reactions!*

Synopsis

This synopsis begins with two patents: #5,928,483, "Electrochemical Cell Having a Beryllium Compound Coated Electrode" and US #8,419,919, "System and Method for Generating Particles"[9]. It then lists:

- Journal, volume, and year with a brief description, and a categorization as:
  - Replication
  - Thermal measurements
  - Radiation measurements
  - Modeling
- In the Media
- Authors, co-authors and affiliations (identifying both US and non-US contributions)
- Author and co-author countries and number of papers
- US and non-US institutions
- Special thanks
- Journals and the number of papers published in each
- Number of papers published/year and the Journal the papers appeared in
- First pages of two papers on DT fusion:
  - The first[10] paper appeared on the 70th anniversary of the discovery of nuclear fission in the same Journal, *Naturwissenschaften*.[11]
  - The second paper[12] was conducted with a DoE laboratory and partially funded by DoE[13]
- Page from the US DoE Energy Citations Database, OSTI (Office of Science and Technology Information)
- Page from SciTech Connect replacing the DoE OSTI's Information Bridge
- Abstracts

The complete papers are available by request at the email address noted on the first page.

Conclusion

This comprehensive collection of peer-reviewed papers clearly defines the existence of, and many of the parameters associated with, condensed matter nuclear science. The palladium/deuterium co-deposition protocol has shown itself to be robust, replicable and repeatable. As such, it provides an accessible doorway to investigate this novel, nuclear phenomena. *It has the promise of controllable nuclear reactions without ionizing radiation; compact, green nuclear energy sources and a means to remediate existing nuclear waste. We ignore this new capability at our technological, environmental and commercial peril.*

---

[9] http://www.sciencechannel.com/tv-shows/brink/videos/brink-evidence-of-nuclear-fusion/
Beginning at 1 minute, 50 seconds, is a pictorial description of the co-deposition process.

[10] P.A. Mosier-Boss, S. Szpak, F.E. Gordon, and L.P.G. Forsley, **"**Triple Tracks in CR-39 as the Result of Pd/D Co-deposition: Evidence of Energetic Neutrons," *Naturwissenschaften*. **96** (January, 2009) 135-142.

[11] Hahn, O. and Strassmann, F., "Über den Nachweis und das Verhalten der bei der Bestrahlung des Urans mittels Neutronen entstehenden Erdalkalimetalle", *Die Naturwissenschaften* **27**, p. 11-15 (January 1939). Translated as, "Concerning the Existence of Alkaline Earth Metals Resulting from Neutron Irradiation of Uranium"

[12] P.A. Mosier-Boss, J.Y. Dea, L.P.G. Forsley, M.S. Morey, J.R. Tinsley, J.P. Hurley, and F.E. Gordon, "Comparison of Pd/D Co-Deposition and DT Neutron Generated Triple Tracks Observed in CR-39 Detectors," *Eur. Phys. J. Appl. Phys.* **51** (2010) 20901.

[13] The US Department of Energy has long disparaged "cold fusion", despite having produced two slightly neutral reports, in 1989 and 2004, that were interpreted as denying its existence.

US005928483A

United States Patent [19]

Szpak et al.

[11] Patent Number: 5,928,483

[45] Date of Patent: Jul. 27, 1999

[54] **ELECTROCHEMICAL CELL HAVING A BERYLLIUM COMPOUND COATED ELECTRODE**

[75] Inventors: **Stanislaw J. Szpak**; **Pamela A. Boss**, both of San Diego, Calif.

[73] Assignee: **The United States of America as represented by the Secretary of the Navy**, Washington, D.C.

[21] Appl. No.: **08/969,175**

[22] Filed: **Nov. 12, 1997**

[51] **Int. Cl.**[6] **C25B 11/00**

[52] **U.S. Cl.** .... **204/290 R**; 204/293; 204/272; 429/59; 429/101; 429/218.2; 429/231.6; 29/623.5; 29/746

[58] **Field of Search** .... 204/290 R, 293, 204/243.1, 272; 429/59, 101, 218.2, 231.6; 29/746, 623.5

[56] **References Cited**

U.S. PATENT DOCUMENTS

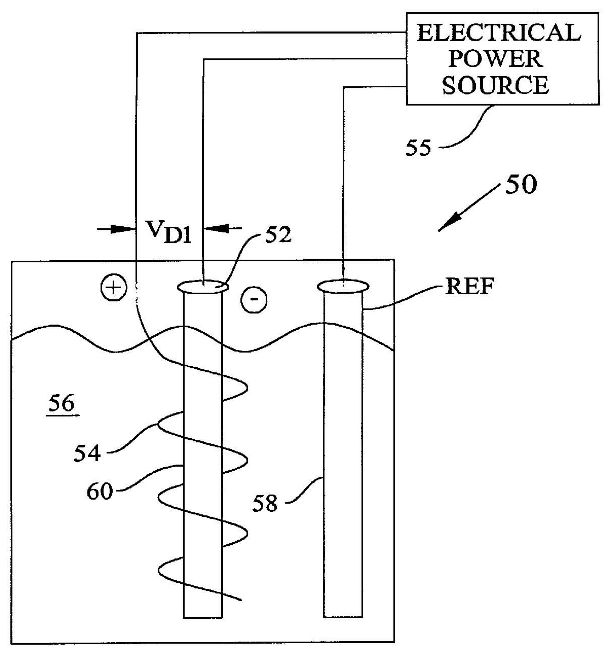
4,393,125 7/1983 Skarstad et al. .
4,528,084 7/1985 Beer et al. .
4,560,444 12/1985 Polak et al. .
4,585,579 4/1986 Bommaraju et al. 252/387
4,655,892 4/1987 Satta et al. .
4,677,041 6/1987 Specht .
4,795,533 1/1989 Young et al. .
5,032,474 7/1991 Hunter .
5,298,340 3/1994 Cocks et al. .
5,466,543 11/1995 Ikoma et al. 429/59
5,690,799 11/1997 Tsukahara et al. .... 204/290 R

Primary Examiner—Bruce F. Bell
Attorney, Agent, or Firm—Harvey Fendelman; Peter A. Lipovsky; Michael A. Kagan

[57] **ABSTRACT**

An electrochemical cell comprises a container; an electrolyte held within the container, a first electrode positioned in the electrolyte; and a second electrode having a beryllium compound coating. The second electrode is positioned in the electrolyte and generally centered within the first electrode. The second electrode is made of a material selected from the group that includes palladium, AB_2 alloys, and AB_5 alloys, where A represents magnesium, zirconium, and lanthanum, and B represents vanadium, chromium, manganese, or nickel. The beryllium compound coating is formed by charging the second electrode in the presence of a beryllium salt.

10 Claims, 2 Drawing Sheets



US008419919B1

(12) **United States Patent**
Boss et al.

(10) **Patent No.:** **US 8,419,919 B1**
(45) **Date of Patent:** **Apr. 16, 2013**

(54) **SYSTEM AND METHOD FOR GENERATING PARTICLES**

(75) Inventors: **Pamela A. Boss**, San Diego, CA (US); **Frank E. Gordon**, San Diego, CA (US); **Stanislaw Szpak**, Poway, CA (US); **Lawrence Parker Galloway Forsley**, San Diego, CA (US)

(73) Assignees: **JWK International Corporation**, Annandale, VA (US); **The United States of America as represented by the Secretary of the Navy**, Washington, DC (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1036 days.

(21) Appl. No.: **11/859,499**

(22) Filed: **Sep. 21, 2007**

Related U.S. Application Data

(60) Provisional application No. 60/919,190, filed on Mar. 14, 2007.

(51) **Int. Cl.**
C25D 5/48 (2006.01)
C25C 1/20 (2006.01)

(52) **U.S. Cl.**
USPC **205/220**; 205/102; 205/265; 205/627

(58) **Field of Classification Search** 204/229.4, 204/660, 663; 205/339, 340, 565, 627, 102, 205/220, 265, 441
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,248,221	B1	6/2001	Davis et al.	
6,379,512	B1 *	4/2002	Brown et al.	204/245
6,444,337	B1	9/2002	Iyer	
6,562,243	B2 *	5/2003	Sherman	205/745
2001/0019594	A1	9/2001	Swartz	
2002/0009173	A1	1/2002	Swartz	
2002/0018538	A1	2/2002	Swartz	
2002/0021777	A1	2/2002	Swartz	
2003/0112916	A1	6/2003	Keeney et al.	
2003/0213696	A1	11/2003	Dardik	
2005/0045482	A1	3/2005	Storms	
2005/0129160	A1	6/2005	Indech	

(Continued)

OTHER PUBLICATIONS

J. O'M. Bockris, R. Sundaresan, Z. Minevski, D. Letts. "Triggering of heat and sub-surface changes in Pd-D Systems." The Fourth International Conference on Cold Fusion. Transacations of Fusion Technology, Dec. 1994. vol. 25, No. 4T. p. 267.*

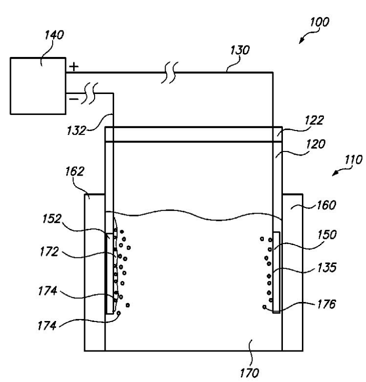
(Continued)

Primary Examiner — Keith Hendricks
Assistant Examiner — Steven A. Friday
(74) *Attorney, Agent, or Firm* — Ryan J. Friedl; Kyle Eppele

(57) **ABSTRACT**

A method may include the steps of supplying current to the electrodes of an electrochemical cell according to a first charging profile, wherein the electrochemical cell has an anode, cathode, and electrolytic solution; maintaining a generally constant current between the electrodes; exposing the cell to an external field either during or after the termination of the deposition of deuterium absorbing metal on the cathode; and supplying current to the electrodes according to a second charging profile during the exposure of the cell to the external field. The electrolytic solution may include a metallic salt including palladium, and a supporting electrolyte, each dissolved in heavy water. The cathode may comprise a second metal that does not substantially absorb deuterium, such as gold. The external field may be a magnetic field.

7 Claims, 10 Drawing Sheets



Condensed Matter Nuclear Reaction Peer-Reviewed Publications

#	Journal Volume	Year	Rep	Subject
1.	*J. Electroanalytical Chemistry* **302**	(1991a)		co-dep introduced, heat, tritium, x-rays observed
2.	*J. Electroanalytical Chemistry* **309**	(1991b)		modeling of D transport in bulk cathodes
3.	*J. Electroanalytical Chemistry* **337**	(1992)		modeling and experimental D transport obs.
4.	*J. Electroanalytical Chemistry* **353**	(1993)	√	co-dep and Tritium
5.	*J. Electroanalytical Chemistry* **365**	(1994a)		D modeling and Pd transport using XRD
6.	*J. Electroanalytical Chemistry* **373**	(1994b)		Tritium modeling and production in co-dep
7.	*J. Electroanalytical Chemistry* **379**	(1994c)		deuterium transport in co-dep
8.	*J. Electroanalytical Chemistry* **380**	(1995)		co-dep processes examined and discussed
9.	*Physics Letters A* **210**	(1996a)		co-dep x-ray spectroscopy, lines identified
10.	*Physics Letters A* **221**	(1996b)		Response to Vigier: thermal imaging
11.	*Fusion Technology* **33**	(1998a)		tritium production
12.	*Fusion Technology* **34**	(1998b)		tritium production and co-dep morphology
13.	*Nuovo Cim Soc Ital Fis A* **112**	(1999a)		thermal imaging, positive temp feedback
14.	*Fusion Technology* **36**	(1999b)	√	Co-dep calorimetry
15.	*Thermochimica Acta* **410**	(2004)	√	Co-dep calorimetry, excess heat exceeds bulk rate
16.	*J. Electroanalytical Chemistry* **580**	(2005a)		E-field manipulation of co-dep morphology
17.	*Naturwissenschaften* **92**	(2005b)		co-dep transmutation at ejecta sites
18.	*Naturwissenschaften* **94**	(2007a)		charged particle nuclear tracks using SSNTD
19.	*Eur Physics J. Appl Physics* **40**	(2007b)		SSNTD controls and nuclear particle distribution
21.	*Eur Physics J. Appl Physics* **44**	(2008b)		Response to Kowalski: co-dep nuclear tracks
22.	*Naturwissenschaften* **96**	(2009a)		co-dep triple-track, DT fusion observed
23.	*Eur Physics J. Appl Physics* **46**	(2009b)		co-dep nuclear particle specie and spectra
25.	*Eur Physics J. Appl Physics* **51**	(2010b)		comparison of co-dep and DT fusion tracks
26.	*J. Condensed Mat Nuclear Sci* **3**	(2010c)		Response to Kowalski: co-dep nuclear species
27.	*J. Condensed Mat Nuclear Sci* **3**	(2010d)		Two laser stimulation, THz difference frequency
28.	*J. Environ. Monitoring,* **12**	(2010e)		Response to Shanahan: LENR observations
29.	*Eur Physics J. Appl Physics* **51**	(2010f)		Theory of Co-Dep DT neutron production
30.	*J. Condensed Mat Nuclear Sci* **4**	(2011a)	√	Co-dep calorimetry
31.	*J. Condensed Mat Nuclear Sci* **4**	(2011b)	√	Co-dep calorimetry
32.	*J. Condensed Mat Nuclear Sci* **4**	(2011c)		Review of 20 years of Pd/D co-dep research
33.	*Detector Phys XIII, SPIE* **8142**	(2011d)		Optical and SEM analysis of DT & Pd/D tracks
34.	*Radiation Measurements* **47**	(2012a)		Comparison of optical and SEM DT tracks
35.	*J. Condensed Mat Nuclear Sci* **6**	(2012b)		Neutron detection and characterization
36.	*J. Condensed Mat Nucear Sci* **6**	(2012c)	√	Co-dep calorimetry
37.	*J. Condensed Mat Nuclear Sci* **6**	(2012d)		Review: LENR Nuclear Products
38.	*J. Condensed Mat Nuclear Sci* **8**	(2012e)	√	Co-dep calorimetry and absent shuttle reactions
39.	*Electrochimica Acta,* **88**	(2013a)		Gamma and alpha induced Pd x-ray fluorescence
40.	*J. Condensed Mat Nuclear Sci* **12**	(2013b)		Flawed review process and neutron detection
41.	*J. Condensed Mat Nuclear Sci* **13**	(2014a)	√	Co-dep, tritium production
42.	*J. Condensed Mat Nuclear Sci* **13**	(2014b)	√	Co-dep calorimetry, multiple metals
43.	*J. Condensed Mat Nuclear Sci* **13**	(2014c)		Charged particle specie and spectra
44.	*J. Condensed Mat Nuclear Sci* **14**	(2014d)		CR-39 in LENR
45.	*Current Science* **108**	(2015a)	√	Pd/D Co-deposition and nuclear reactions
46.	*Current Science* **108**	(2015b)	√	DD fusion branching ratio
47.	*J. Condensed Mat Nuclear Sci* **15**	(2015c)	√	Energetic Particles from Pd/D reactions
48.	*J. Condensed Mat Nuclear Sci* **17**	(2015d)		Strained Lattice Ferromagnetism

Brown indicates Nuclear or radiation effects: 31 papers   Red indicates thermal effects: 14 papers
Blue indicates modeling: 11 papers   √ indicates replications: 12 papers

Book Chapters

20. *Low Energy Nuclear Reactions Source Book*, American Chemical Society, (2008a)
Co-dep model system, SSNTD controls, nuclear species and DT fusion neutrons

24. *Low Energy Nuclear Reactions Source Book II*, American Chemical Society, (2010a)
Application of co-dep nuclear particles to RTG portable nuclear electric power

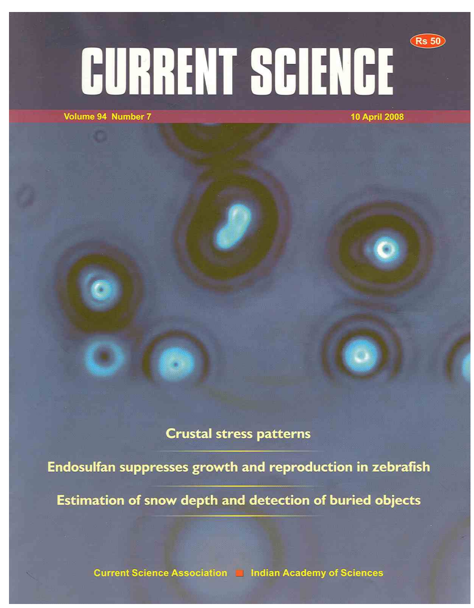
Brown indicates nuclear or radiation effects: 30 papers   Red indicates thermal effects: 14 papers

In the Media[14]

"Table-Top Fusion: The Beast That Would Not Die", *Economist*. Published after the SPAWAR announcement at the American Chemical Society in Salt Lake City, UT on the 20th anniversary of the March 23, 1989 press conference.

"Evidence of Nuclear Fusion", Discovery Science Channel, Brink segment on our protocol and DT fusion neutrons[15] broadcast in 2009. Beginning at 1:50 in the video is a pictorial representation of the protocol.

Université catholique de Louvain,
Louvain, Belgium



Indian Journal, *Current Science*, April, 2008 cover with Pd/D co-deposition neutron recoil tracks in Solid State Nuclear Track Detectors.

---

[14] Cartoon from the *Economist*, (May 26, 2009)
[15] http://www.sciencechannel.com/tv-shows/brink/videos/brink-evidence-of-nuclear-fusion/

US Authors, Co-authors (*alphabetically*) and Affiliations

Author	Affiliation	# papers	
1. Bao, J.	SRI International, *Menlo Park, CA*	1	
2. Bockris, J.O.M*	Texas A&M, *College Station, TX*	1	
3. Boss, R.D.	Naval Ocean Systems Center, *San Diego, CA*	2	
4. Cravens, D.	Ambridge University, *Cloudcroft, NM*	2	
5. Dash, J.	Portland State University, Portland, OR	1	
6. Dea, J.Y.	SPAWAR SSC, *San Diego, CA*	2	
7. DeChiaro, L.	Naval Surface Warfare Center, *Dahlgren, VA*	1	
8. Earle, B.	SRI International, *Menlo Park, CA*	1	
9. Forsley, L.P.	JWK Corporation, *Annandale, VA*	20	
	Global Energy Corporation, *San Diego, CA*		
	UT Austin, Nuclear Eng Teaching Lab, *Austin, TX*		
10. Gabriel, C.J.	Naval Ocean Systems Center, *San Diego, CA*	2	
11. Gordon, F.E.	SPAWAR Pacific, *San Diego, CA*	19	
	Global Energy Corporation, *San Diego, CA*		
	NAVY SES (retired), *San Diego, CA*		
12. Hagelstein, P.	MIT, *Cambridge, MA*	4	
13. Hodko, D.	Texas A&M, *College Station, TX*	1	
14. Hurley, J.P.	DoE National Security Technology, *Santa Barbara, CA*	3	
15. Kim, Y.	Purdue University, *West Lafayette, IN*	1	
16. Letts, D.	Letts Labs, *Austin, TX*	3	
17. McDaniel, P.J.	DoE Sandia National Lab. (retired), *Albuquerque, NM*	2	
	Univ. of New Mexico, *Albuquerque, NM*		
19. McKubre, M.C.H.	SRI International, *Menlo Park, CA*	2	
20. Miles, M.	Naval Air Warfare Center (retired), *China Lake, CA*	7	
	New Hydrogen Energy, *Sapporo, Japan*		1**
	Bates College, *Lewiston, ME*		
	Dixie State College, *St. George, UT*		
18. Morey, M.S.	DoE National Security Technology, *Santa Barbara, CA*	3	
19. Mosier-Boss, P.A.	Naval Ocean Systems Center, *San Diego, CA*	36	
	SPAWAR SSC, *San Diego, CA*		
	MIT, *Cambridge, MA*		
20. Nowak, R.J.	ONR, *Arlington, VA*	1	
21. Smith, J.J.	DoE, *Washington, DC*	8	
22. Scharber, S.R.	Naval Ocean Systems Center, *San Diego, CA*	2	
23. Storms, E.	KivaLabs, *Santa Fe, NM*	1	
24. Swartz, M.	JET Energy, Inc., *Wellesley, MA*	2	
25. Szpak, S.	Naval Ocean Systems Center, *San Diego, CA*	24	
	SPAWAR SSC (retired)		
26. Tanzella, F.L.	SRI International, *Menlo Park, CA*	3	
27. Tinsley, P	DoE National Security Technology, *Santa Barbara, CA*	3	
28. Young, C	SPAWAR SSC, *San Diego,* CA	2	
29. Zhou, D.Z.	NASA JSC, *Houston, TX*	1	
	National Space Center, Chinese Acad. of Sci, *Beijing, China*		1**

(*Deceased)
(**Papers listed on non-US list.)

Non-US Authors, Co-authors *(alphabetically)* and Affiliations

	Author	Affiliation	# papers	
1.	Carbonnelle, P	Université catholique de Louvain, *Louvain, Belgium*	2	
2.	Fleischmann, M.*	ENEA, *Frascati, Italy*	2	
		Tisbury, UK		
3.	Iwamura, Y.	Mitsubishi Heavy Industries, *Yokohama, Japan*	1	
4.	Jang, H.	Korea Research Institute of Chem Tech, *DaeJeon, South Korea*	1	
5.	Kim, S.	Korea Research Institute of Chem Tech, *DaeJeon, South Korea*	1	
6.	Lee, K.	Korea Research Institute of Chem Tech, *DaeJeon, South Korea*	1	
7.	Li, X.Z.	Tsinghua University, *Beijing, China*	1	
8.	Liang, J.B.	National Space Center, Chinese Acad. of Science, *Beijing, China*	1	
9.	Lipson, A.G.*	Frumkin Institute, Russian Academy of Sciences, *Moscow Russia*	1	
10.	Miles, M.	Naval Air Warfare Center (retired), *China Lake, CA*		7**
		New Hydrogen Energy, *Sapporo, Japan*	1	
		Bates College, *Lewiston, ME*		
		Dixie State College, *St. George, UT*		
11.	Marwan, J.	Dr. Marwan Chemie*, Berlin, German*y	1	
12.	Roussetski, A.	Lebedev Institute, Russian Academy of Sciences, *Moscow, Russia*	1	
13.	Saunin, E.I.	Frumkin Institute, Russian Academy of Sciences, *Moscow Russia*	1	
14.	Sun, Y.Q.	National Space Center, Chinese Acad. of Science, *Beijing, China*	1	
15.	Wang, C.	National Space Center, Chinese Acad. of Science, *Beijing, China*	1	
16.	Zhou, D.Z.	NASA JSC, *Houston, TX*		1**
		National Space Center, Chinese Acad. of Science, *Beijing, China*	1	
17.	Zhu, G.W.	National Space Center, Chinese Acad. of Science, *Beijing, China*	1	

(*Deceased)
(**Papers listed on US list.)

Country Breakdown

Country	# papers	# authors
Belgium	2	1
China	2	6
Germany	1	1
Italy	1	1
Japan	2	2
Russia	1	3
S. Korea	1	3
United Kingdom	2	1
United States	48	29

Special thanks

Dr. Jay W. Khim, JWK Corporation, *Annandale, VA*
Global Energy Corporation, *Annandale, VA*
Dr. Gary Phillips, Naval Research Laboratory, (retired) *Washington, DC*
Georgetown University, *Washington, DC*
Dr. William Wilson, DTRA, *Ft. Belvoir, VA*

Institutional Breakdown *(alphabetically)*

US Institutions (23)

1. Ambridge University, *Cloudcroft, NM*
2. Bates College, *Lewiston, ME*
3. Dixie State College, *St. George, UT*
4. Department of Energy, (DoE), National Security Technology, *Santa Barbara, CA*
5. Department of Energy, (DoE), Sandia National Laboratory*, Albuquerque, NM*
6. Department of Energy, (DoE), *Washington, DC*
7. Global Energy Corporation*, San Diego, CA*
8. JET Energy, Inc., *Wellesley, MA*
9. JWK Corporation, *Annandale, VA*
10. KivaLabs, *Santa Fe, NM*
11. Letts Labs, *Austin, TX*
12. MIT, *Cambridge, MA*
13. NASA Johnson Space Flight Center*, Houston, TX*
14. Naval Surface Warfare Center, *Dahlgren, VA*
15. Naval Air Warfare Center*, China Lake, CA*
16. Office of Naval Research (ONR), *Arlington, VA*
17. Portland State University*, Portland, OR*
18. Purdue University*, Lafayette, IN*
19. SPAWAR Pacific, *San Diego, CA*
    SPAWAR SSC, *San Diego, CA*
    Naval Ocean Systems Center, *San Diego, CA*
20. SRI International, *Menlo Park, CA*
21. Texas A&M, *College Station, TX*
22. University of New Mexico, *Albuquerque, NM*
23. University of Texas, Austin, Nuclear Engineering Teaching Lab, *Austin, TX*

Non-US Institutions (10)

1. Dr. Marwan Chemie*, Berlin, German*y
2. ENEA, *Frascati, Italy*
3. Frumkin Institute, Russian Academy of Sciences, *Moscow Russia*
4. Korea Research Institute of Chemical Technology, *DaeJeon, South Korea*
5. Lebedev Institute, Russian Academy of Sciences, *Moscow, Russia*
6. Mitsubishi Heavy Industries, *Yokohama, Japan*
7. National Space Science Center*,* Chinese Academy of Science, *Beijing, China*
8. New Hydrogen Energy*, Sapporo, Japan*
9. Tsinghua University, *Beijing, China*
10. Université catholique de Louvain, *Louvain, Belgium*

A total of 33 US and non-US institutions.

Journals, (*alphabetically)*

Journal/Book	**# papers/chapters**
1. *American Chemical Society, Low Energy Nuclear Reactions Source Books*	2
2. *Current Science*	2
3. *Detector Physics XIII, SPIE* (International Society for Optics & Photonics)	1
4. *Electrochimica Acta*	1
5. *European Physics Journal of Applied Physics*	5
6. *Fusion Technology*	3
7. *Journal of Condensed Matter Nuclear Science*	16
8. *Journal of Electroanalytic Chemistry*	9
9. *Journal of Environmental Monitoring*	1
10. *Naturwissenschaften*	3
11. *Nuovo Cimento della Società Italiana di Fisica, A*	1
12. *Physics Letters A*	2
13. *Radiation Measurements*	1
14. *Thermochimica Acta*	1
Total	**48**

Publications By Year

Year	**Count**	**Journal(s)**
1991	2	*J. Electroanal Chem*
1992	1	*J. Electroanal Chem*
1993	1	*J. Electroanal Chem*
1994	3	*J. Electroanal Chem*
1995	1	*J. Electroanal Chem*
1996	2	*Physics Letters A*
1997	0	
1998	2	*Fusion Technology*
1999	2	*Nuovo Cim. Soc. Ital. Fisica A, Fusion Technology*
2000	0	
2001	0	
2002	0	
2003	0	
2004	1	*Thermochimica Acta*
2005	2	*J. Electroanal Chem, Naturwissenschaften*
2006	0	
2007	2	*Naturwissenschaften, Eur. Physics J. Appl. Physics*
2008	2	*ACS, Eur. Phys. J. Appl. Physics*
2009	2	*Naturwissenschaften, Eur. Physics J. Appl. Physics*
2010	6	*ACS, Eur Physics J. Appl Physics,* *J. Con. Mat. Nucl. Sci, J. Environmental Monitoring*
2011	4	*J. Con. Mat. Nucl. Sci, Detector Phys XIII, SPIE*
2012	5	*Radiation Measurements, J. Con. Mat. Nucl. Sci*
2013	2	*Electrochimica Acta, J. Con. Mat. Nucl. Sci*
2014	4	*J. Con. Mat. Nucl. Sci*
2015	4	*Current Science, J. Con. Mat. Nucl. Sci*
Total	**48**	

DT Fusion Neutrons

Naturwissenschaften (2009) 96:135–142
DOI 10.1007/s00114-008-0449-x

SHORT COMMUNICATION

Triple tracks in CR-39 as the result of Pd–D Co-deposition: evidence of energetic neutrons

Pamela A. Mosier-Boss · Stanislaw Szpak · Frank E. Gordon · Lawrence P. G. Forsley

Received: 30 July 2008 / Revised: 3 September 2008 / Accepted: 14 September 2008 / Published online: 1 October 2008

Abstract Since the announcement by Fleischmann and Pons that the excess enthalpy generated in the negatively polarized Pd–D–D_2O system was attributable to nuclear reactions occurring inside the Pd lattice, there have been reports of other manifestations of nuclear activities in this system. In particular, there have been reports of tritium and helium-4 production; emission of energetic particles, gamma or X-rays, and neutrons; as well as the transmutation of elements. In this communication, the results of Pd–D co-deposition experiments conducted with the cathode in close contact with CR-39, a solid-state nuclear etch detector, are reported. Among the solitary tracks due to individual energetic particles, triple tracks are observed. Microscopic examination of the bottom of the triple track pit shows that the three lobes of the track are splitting apart from a center point. The presence of three α-particle tracks outgoing from a single point is diagnostic of the ^{12}C (n,n′)3α carbon breakup reaction and suggests that DT reactions that produce ≥9.6 MeV neutrons are occurring inside the Pd lattice. To our knowledge, this is the first report of the production of energetic (≥9.6 MeV) neutrons in the Pd–D system.

Electronic supplementary material The online version of this article (doi:10.1007/s00114-008-0449-x) contains supplementary material, which is available to authorized users.

P. A. Mosier-Boss (✉) · S. Szpak · F. E. Gordon
SPAWAR Systems Center Pacific,
Code 7173,
San Diego, CA 92152, USA
e-mail: pam.boss@navy.mil

L. P. G. Forsley
JWK International Corp.,
Annandale, VA 22003, USA

Keywords CR-39 · Palladium · Neutrons

Introduction

CR-39 is an allyl glycol carbonate plastic that has been widely used as a solid-state nuclear track detector. These detectors have been used extensively to detect and identify such fusion products as p, D, T, ^3He, and α particles resulting from inertial confinement fusion (ICF) experiments (Séguin et al. 2003). They have also been used to detect neutrons (Phillips et al. 2006). When a charged particle passes through the CR-39 detector, it leaves a trail of damage along its track inside the plastic in the form of broken molecular chains and free radicals (Frenje et al. 2002). After treatment with an etching agent, tracks remain as holes or pits. The size and shape of these pits provide information about the mass, charge, energy, and direction of motion of the particles (Nikezic and Yu 2004). Therefore, CR-39 detectors can semiqualitatively be used to distinguish the types and energies of individual particles. Advantages of CR-39 for ICF experiments include its insensitivity to electromagnetic noise; its resistance to mechanical damage; and its relative insensitivity to electrons, X-rays, and γ-rays. Consequently, CR-39 detectors can be placed close to the source without being damaged. Furthermore CR-39, like photographic film, is an example of a constantly integrating detector, which means that events are permanently stamped on the surface of the detector. As a result, CR-39 detectors can be used to detect events that occur either sporadically or at low fluxes.

Earlier, the use of CR-39 to detect the emission of energetic particles resulting from Pd–D electrolysis

Eur. Phys. J. Appl. Phys. 51, 20901 (2010)
DOI: 10.1051/epjap/2010087

THE EUROPEAN PHYSICAL JOURNAL
APPLIED PHYSICS

Regular Article

Comparison of Pd/D co-deposition and DT neutron generated triple tracks observed in CR-39 detectors

P.A. Mosier-Boss[1,*], J.Y. Dea[1], L.P.G. Forsley[2], M.S. Morey[3], J.R. Tinsley[3], J.P. Hurley[3], and F.E. Gordon[4]

[1] SPAWAR Systems Center Pacific, Code 71730, San Diego, CA 92152, USA
[2] JWK International Corp., Annandale, VA 22003, USA
[3] National Security Technologies, LLC, Special Technologies Laboratory, Santa Barbara, CA 93111, USA
[4] SPAWAR Systems Center Pacific, Retired, San Diego, CA 92122, USA

Received: 28 February 2010 / Received in final form: 5 May 2010 / Accepted: 20 May 2010
Published online: 7 July 2010 – © EDP Sciences

Abstract. Solid state nuclear track detectors (SSNTDs), such as CR-39, have been used to detect energetic charged particles and neutrons. Of the neutron and charged particle interactions that can occur in CR-39, the one that is the most easily identifiable is the carbon breakup reaction. The observation of a triple track, which appears as three alpha particle tracks breaking away from a center point, is diagnostic of the ^{12}C(n, n′)3α carbon breakup reaction. Such triple tracks have been observed in CR-39 detectors that have been used in Pd/D co-deposition experiments. In this communication, triple tracks in CR-39 detectors observed in Pd/D co-deposition experiments are compared with those generated upon exposure to a DT neutron source. It was found that both sets of tracks were indistinguishable. Both symmetric and asymmetric tracks were observed. Using linear energy transfer (LET) curves and track modeling, the energy of the neutron that created the triple track can be estimated.

1 Introduction

In 1978, Cartwright et al. [1] were the first to demonstrate that Columbia Resin 39 (CR-39), an optically clear, amorphous, thermoset plastic, could be used to detect nuclear particles. When an energetic, charged particle traverses through a solid state nuclear track detector (SSNTD) such as CR-39, it creates along its path an ionization trail that is more sensitive to chemical etching than the bulk material [1,2]. After treatment with a chemical etchant, tracks due to the energetic particles remain in the form of holes or pits which can be examined with the aid of an optical microscope. The size, depth of penetration, and shape of the track provides information about the mass, charge, energy, and direction of motion of the particle that created the track [3]. Besides detection of charged particles such as protons and alphas, CR-39 can also be used to detect neutrons [4].

Since its introduction as a detector for nuclear particles, CR-39 has found extensive use as a charged-particle spectrometer to study inertial-confinement-fusion (ICF) plasmas [4]. This is not surprising given the ability of CR-39 to detect both energetic charged particles and neutrons, which are products of the fusion reactions that occur in the plasma created upon laser-compression of the fuel capsule. Other advantages of CR-39 for use in the ICF field are its integrating capability, existence of a threshold for registration, ruggedness, and a degree of charge and energy discrimination [5]. SSNTDs can be used to record events cumulatively over long periods of time. This is particularly important for events that occur either sporadically or in bursts. The detectors are insensitive to electromagnetic noise and are resistant to mechanical damage. CR-39 detectors are relatively insensitive to gamma or X-ray emissions. Dielectric materials, such as CR-39, can register particles only if their charge and linear energy transfer (LET) value are above a minimum threshold that is dependent upon the composition and structure of the detector. A great deal of effort has been spent by a number of researchers to calibrate the SSNTDs using particle generators for speciation and energy determination [6]. While the size and shape of the track depends upon the energy and charge of the particle that created it, the ability of the detectors to discriminate particles is still poor and is dependent upon etching conditions and methodology. This is compounded by variability between the detectors caused by manufacturing procedures, the age of the detectors, as well as the temperature and storage history of the detectors.

The same advantages that make CR-39 useful in the ICF community also make it attractive for use in detecting particles in the Pd/D system. In addition, the

* e-mail: pam.boss@navy.mil

Article published by EDP Sciences

70 Years after the first paper on nuclear fission:

Hahn, O. and Strassmann, F., "Über den Nachweis und das Verhalten der bei der Bestrahlung des Urans mittels Neutronen entstehenden Erdalkalimetalle"[1], *Die Naturwissenschaften* **27**, p. 11-15 (January 1939).

[1] "Concerning the Existence of Alkaline Earth Metals Resulting from Neutron Irradiation of Uranium" translated, *American Journal of Physics*, January 1964, p. 9-15

DoE funded…

Under contract number DE-AC52-06NA25946. Listed on the DoE Energy Citations Database web-site. (next page)

About ECD
Site Map Help
ADOPT-A-DOC?

Energy Citations Database

Home • Basic Search • Fielded Search • Alerts • Document Availability

FAQ Widget
Contact Us

Comparison of Pd/D Co-Deposition and DT Neutron Generated Triple Tracks Observed in CR-39 Detectors

Description/Abstract

Solid state nuclear track detectors (SSNTDs), such as CR-39, have been used to detect energetic charged particles and neutrons. Of the neutron and charged particle interactions that can occur in CR-39, the one that is the most easily identifiable is the carbon breakup reaction. The observation of a triple track, which appears as three alpha particle tracks breaking away from a center point, is diagnostic of the 12C(n, n')3α carbon breakup reaction. Such triple tracks have been observed in CR-39 detectors that have been used in Pd/D co-deposition experiments. In this communication, triple tracks in CR-39 detectors observed in Pd/D co-deposition experiments are compared with those generated upon exposure to a DT neutron source. It was found that both sets of tracks were indistinguishable. Both symmetric and asymmetric tracks were observed. Using linear energy transfer (LET) curves and track modeling, the energy of the neutron that created the triple track can be estimated.

Authors:	P.A. Mosier-Boss, J.Y. Dea, L.P.G. Forsley, M.S. Morey, J.R. Tinsley, J.P. Hurley, F.E. Gordon
Publication Date:	2010 Aug 01
OSTI Identifier:	982908
Report Number(s):	DOE/NV/25946--815
DOE Contract Number:	DE-AC52-06NA25946
Resource Type:	Journal Article
Resource Relation:	Journal Name: European Physical Journal Applied Physics; Journal Volume: 51; Journal Issue: 2; Related Information: Published online July 7, 2010
Research Org:	National Security Technologies, LLC (United States)
Sponsoring Org:	USDOE; USDOE National Nuclear Security Administration (NA)
Country of Publication:	United States
Language:	English
Format:	Size: 20901-1-20901-10
Other Number(s):	TRN: US201014%%301
Subject:	46 INSTRUMENTATION RELATED TO NUCLEAR SCIENCE AND TECHNOLOGY; A CENTERS; ALPHA PARTICLES; BREAKUP REACTIONS; CARBON; CHARGED PARTICLES; LET; NEUTRON SOURCES; NEUTRONS; SIMULATION
Related Subject:	Pd/D co-deposition, DT neutron triple tracks, CR-39 detector
Publisher:	Eur. Phys. J. Appl. Phys.
Update Date:	2010 Aug 05

Top

Full Text

Journal Articles

DOI 10.1051/epjap/2010087

To obtain a copy of this Journal Article, link to the DOI if present for specific Publisher information. Library patrons may click here to search WorldCat to identify libraries that hold this journal title; check beforehand to verify the library holds the volume needed.

Cite

EndNote Excel

Select a citation type above to copy/paste or download the reference.

Return to Search Results
Return to Original Search Page

This page from the US DoE Energy Citations Database on the Office of Science and Technology Information website references both the journal and the DoE NNSA funding document. DoE has changed the OSTI site to now search via the SciTech Connect (see next page).

SciTech Connect (/scitech/) / Search Results / Journal Article: *Comparison of SEM and Optical Analysis of DT Neutron Tracks in CR-39 Detectors*

Comparison of SEM and Optical Analysis of DT Neutron Tracks in CR-39 Detectors

Citation Details | In-Document Search

A solid state nuclear track detector, CR-39, was exposed to DT neutrons. After etching, the resultant tracks were analyzed using both an optical microscope and a scanning electron microscope (SEM). In this communication, both methods of analyzing DT neutron tracks are discussed.

Authors:	P.A. **Mosier-Boss**, L.P.G. Forsley, P. Carbonnelle, M.S. Morey, J.R. Tinsley, J. P. Hurley, F.E. Gordon
Publication Date:	2012-01-01
OSTI Identifier:	OSTI ID: 1055514
Report Number(s):	DOE/NV/25946--1151
DOE Contract Number:	DE-AC52-06NA25946
Resource Type:	Journal Article
Resource Relation:	Journal Name: Radiation Measurements; Journal Volume: 47; Journal Issue: 1
Research Org:	Nevada Test Site/National Security Technologies, LLC (United States)
Sponsoring Org:	USDOE National Nuclear Security Administration (NNSA)
Country of Publication:	United States
Language:	English
Subject:	46 INSTRUMENTATION RELATED TO NUCLEAR SCIENCE AND TECHNOLOGY SEM, Optical, DT Neutron Tracks, CR-39 Detector;

FULL TEXT

Journal Articles

DOI:
10.1016/j.radmeas.2011.10.004
(http://dx.doi.org/10.1016/j.radmeas.2011.10.004)

To obtain a copy of this Journal Article, link to the DOI if present for specific Publisher information. Library patrons may click here to search WorldCat (http://www.worldcat.org/search?q=Journal%20Name%3A%20Radiation%20Measurements to identify libraries that hold this journal title; check beforehand to verify the library holds the volume needed.

CITATION FORMATS

MLA
APA
Chicago
Bibtex

EXPORT METADATA

EndNote (/scitech/endnote?osti_id=1055514)
Excel (/scitech/excel.jsp?export_ids=1055514)

SAVE / SHARE THIS RECORD

Save to My Library
Send to Email

Some links on this page may take you to non-federal websites. Their policies may differ from this site.

DoE has expanded the database search capability, noting "SciTech Connect consolidates the contents of OSTI's Information Bridge and Energy Citations Database". Searches are conducted via:

http://www.osti.gov/scitech/

Abstracts

1. S. Szpak, P.A. Mosier-Boss, and J.J. Smith, "On the Behavior of Pd Deposited in the Presence of Evolving Deuterium," *J. Electroanal. Chem*., **302** (1991) 255-260

http://www.sciencedirect.com/science/article/pii/002207289185044P

This was a preliminary note introducing the Pd/D co-deposition protocol as an alternative experimental approach to initiate LENR. Temperature measurements using thermocouples placed in the cathode and solution show that the cathode was hotter than the solution. This indicates that the observed heat is not due to Joule heating. A ten-fold increase in tritium content in the solution was observed. Experiments were conducted with photographic film in close proximity of the cathode. After development, the film showed a grid pattern due to the Ni screen cathode and was attributable to the emission of soft X-rays.

2. S. Szpak, C.J. Gabriel, and R. J. Nowak, "Electrochemical Charging of Pd Rods," *J. Electroanal. Chem*., **309** (1991) 273-292

http://www.sciencedirect.com/science/article/pii/002207289187019Z

A model was developed to describe the electrochemical charging of palladium rods. This model coupled the interfacial processes with the transport of interstitials in the electrode interior. It was shown that boundary conditions arise from the solution of equations governing the elementary adsorption-desorption and adsorption-absorption steps as well as the symmetry of the electrode.

3. S. Szpak, P.A. Mosier-Boss, S.R. Scharber, and J.J. Smith, "Charging of the Pd/^{n}H System: Role of the Interphase," *J. Electroanal. Chem*., **337** (1992) 147-163.

http://www.sciencedirect.com/science/article/pii/002207289280534B

Slow scan cyclic voltammetric studies of Au/Pd/^{n}H were conducted to examine the dynamics of transport of electrochemically deuterium/hydrogen across the electrode/electrolyte interphase. It was found that a coupled, two-layer model of the interphase describes the observed behavior as a function of scan rate and electrolyte composition. The effect of chemisorbing species, thiourea, and pH on the transport across the interphase was also investigated.

4. Hodko, D. and Bockris, J.O.M., "Possible excess tritium production on Pd codeposited with deuterium", *J. Electroanal. Chem.*, **353***, Issues 1–2*, *(1993*) *33-41.*

http://www.sciencedirect.com/science/article/pii/002207289380284O

Tritium production was measured in the liquid and gas phases on Pd codeposited with deuterium from $PdCl_2$ + LiCl + D_2O solutions. During two weeks of electrolysis, in four out of six cells, average excess tritium levels of 1.9 times in the gas phase and 1.6 times in the liquid phase were found over those expected from the separation factor. The largest excess of tritium found was three times that calculated theoretically from the separation factor. The excess tritium observed exhibited a 'burst' nature, both in the gas and liquid phases. On two occasions, where tritium production was within classical limits, no bursts were observed. A separation factor of 1.6 was measured in these two cells. This method has the advantage that the tritium concentration in the bulk of Pd was measured in solution before the Pd was deposited on an Au substrate.

5. S. Szpak, P.A. Mosier-Boss, C.J. Gabriel, and J.J. Smith, "Absorption of Deuterium in Palladium Rods: Model vs. Experiment," *J. Electroanal. Chem*., **365** (1994) 275-286.

http://www.sciencedirect.com/science/article/pii/002207289303051P

A model that incorporates variables such as electrochemical rate constants, bulk diffusion coefficient, and charging current has been developed. Such a model can be used to predict the overpotential, surface coverage, and bulk loading of the electrode during charging. The computed time dependence of the bulk loading has been compared with published experimental charging curves. Microscopic examination of a charging Pd cathode using Nomarski optics has shown that, even within a single grain, there are preferred sites of absorption. *In-situ* XRD measurements of the charging Pd cathode shows that deuterium preferentially enters the Pd lattice through the 111 sites. With additional charging, a broadening and a shift to lower 2θ angles was observed which suggested the presence of a supercharged layer.

6. S. Szpak, P.A. Mosier-Boss, R.D. Boss, and J.J. Smith, "Comments on the Analysis of Tritium Content in Electrochemical Cells," *J. Electroanal. Chem*., **373** (1994) 1-9.

http://www.sciencedirect.com/science/article/pii/0022072894033021

The time dependence of tritium content of an open cell operating galvanostatically with intermittent sampling has been derived and is given by the following expression:

$$f(t) = f(0)\left(\frac{m(0) - r(i)t}{m(0)}\right)^{S-1} + \frac{q}{(S-1)r(i)} \bullet \left\{1 - \left[\frac{m(0) - r(i)t}{m(0)}\right]^{S-1}\right\}$$

where f is the tritium mass fraction, m is the mass of the electrolyte phase, r(i) denoted the rate of change associated with the cell current, q is the rate at which tritium is added/removed, and s is the isotopic separation factor. It was concluded that a complete mass balance between the liquid and gas phases was necessary in order to determine that tritium was produced in the Pd/D system.

7. S. Szpak, P.A. Mosier-Boss, and J.J. Smith, "Deuterium Uptake During Pd-D Codeposition," *J. Electroanal. Chem*., **379** (1994) 121-127.

http://www.sciencedirect.com/science/article/pii/0022072894871302

Deuterium uptake during Pd-D co-deposition was examined using galvanostatic perturbation techniques. The resultant potential relaxation curves exhibit four distinct potential-time intervals where the relaxation process is controlled by the interaction between the transport of deuterium from inside the lattice to the surface to form adsorbed deuterium and the reduction of palladium from solution.

8. S. Szpak, P.A. Mosier-Boss, S.R. Scharber, and J.J. Smith, "Cyclic Voltammetry of Pd + D Codeposition," *J. Electroanal. Chem*., 3**80** (1995) 1-6.

http://www.sciencedirect.com/science/article/pii/002207289403332W

Processes associated with the Pd + D alloy codeposition were examined by cyclic voltammetry. The dynamics of the interphase region are discussed.

9. S. Szpak, P.A. Mosier-Boss, and J.J. Smith, "On the Behavior of the Cathodically Polarized Pd/D System: Search for Emanating Radiation," *Phys. Lett. A*. **210** (1996) 382-390.

http://www.sciencedirect.com/science/article/pii/0375960195009159

Pd/D co-deposition experiments were conducted inside lead caves while measuring gamma and X-rays, as a function of time, using a HPGe detector with an Al window and a Si(Li) detector with a Be window. The cathodically polarized Pd/D system was observed to emit X-rays with a broad energy distribution and with an occasional emergence of recognizable peaks attributable to the Pd K_α and Pt L lines. The emission of X-rays is sporadic and of limited duration.

10. S. Szpak and P.A. Mosier-Boss, "On the Behavior of the Cathodically Polarized Pd/D System: A Response to Vigier's Comments," *Phys. Lett. A*. **221** (1996) 141-143.

http://www.sciencedirect.com/science/article/pii/0375960196004501

Preliminary results of thermal imaging of the Pd/D cathode prepared using the co-deposition technique are presented. Hot spots are observed that appear/disappear chaotically. With time these hot spots merge into larger islands that exhibit oscillatory behavior. SEM images of a Pd/D cathode that had melted during electrolysis are shown.

11. S. Szpak, P.A. Mosier-Boss, R.D. Boss, and J.J. Smith, "On the Behavior of the Pd/D System: Evidence for Tritium Production," *Fus. Technol*., **33** (1998) 38-51.

http://www.new.ans.org/pubs/journals/fst/a_14

In these experiments, the D_2 and O_2 gases were recombined in a separate chamber. The tritium content in the liquid and gas phases were measured daily using a liquid scintillation. The measured data were analyzed using the mass balance expression that was derived earlier. It was observed that tritium production occurred in bursts and sporadically. During a burst, the rate of tritium production was estimated to be 10^3 to 10^4 atoms s^{-1}. Tritium produced during prolonged electrolysis was transported out of the electrode interior by two distinct paths. One path results in enrichment of tritium in both the electrolyte and gas phases. The second results in enhancement only in the gas phase.

12. S. Szpak and P.A. Mosier-Boss, "On the Release of ${}^{n}_{1}H$ from cathodically polarized Palladium Electrodes," *Fus. Technol*. **34** (1998) 273-278.

http://www.ans.org/pubs/journals/fst/a_71

The release paths for tritium produced during electrochemical compression of deuterium in a Pd lattice were examined. The results indicate that tritium production requires high D/Pd atomic ratios. This requirement is met if there are no channels reaching the contact surface. The electrogenerated tritium is distributed among the voids and bulk material. Gas evolution promotes a continuous exchange between the atoms residing in the subsurface layer and with those in the adsorbed state. Atoms in the adsorbed state exchange with the molecules of the contacting electrolyte phase or gaseous phase, leading to two distinct transfer paths.

13. P.A. Mosier-Boss and S. Szpak, "The Pd/^{n}H System: Transport Processes and Development of Thermal Instabilities," *Nuovo Cimento Soc. Ital. Fis. A*, **112** (1999) 577-587.

http://link.springer.com/article/10.1007%2FBF03035869

The surface temperature distribution of the cathode prepared by Pd/D co-deposition on a Ni screen was measured using an infrared camera. It was observed that, unlike joule heating, excess enthalpy generation occurs in the form of localized events in close proximity to the contact surface. It was also observed that, the higher the electrolyte temperature, the more frequent the events. In the limit, these events overlap to produce oscillating islands.

14. S. Szpak, P.A. Mosier-Boss, and M. H. Miles, "Calorimetry of the Pd + D Codeposition," *Fus. Technol*., **36** (1999) 234-241.

http://www.ans.org/pubs/journals/fst/a_105

Calorimetric measurements indicate that the excess enthalpy generated in cells using cathodes prepared by the co-deposition process is, on average, higher than that produced in cells using solid Pd rods. Infrared imaging of the cathodes prepared by Pd/D co-deposition shows that the heat sources are highly localized. The steepness of the temperature gradients indicates that the heat sources are located in close proximity to the electrode-solution contact surface.

15. S. Szpak, P.A. Mosier-Boss, M. H. Miles, and M. Fleischmann, "Thermal Behavior of Polarized Pd/D Electrodes Prepared by Co-deposition," *Thermochimica Acta*, **410** (2004) 101-107.

http://www.sciencedirect.com/science/article/pii/S0040603103004015

The thermal behavior of Pd/D electrodes, prepared by the co-deposition technique, was examined using a Dewar-type electrochemical cell calorimeter. Results indicated that excess enthalpy is generated during and after the completion of the co-deposition process. The rates of excess enthalpy generated using the co-deposition technique were higher than those obtained using Pd wires or other forms of Pd electrodes. Positive feedback and heat-after-death effects were observed. The rates of excess power generation were found to increase with an increase in both cell current and cell temperature.

16. S. Szpak, P.A. Mosier-Boss, C. Young, and F.E. Gordon, "The Effect of an External Electric Field on Surface Morphology of Co-deposited Pd/D Films," *J. Electroanal. Chem*., **580** (2005) 284-290.

http://www.sciencedirect.com/science/article/pii/S0022072805001890

After plating out the Pd on a Au foil, the cell current was increased and an external electric field was applied across the cell. The experiment was terminated after 48 h. The cell was disassembled and the cathode was subjected to analysis using an SEM. In the absence of an external electric field, the Pd deposit exhibits a cauliflower structure. After exposure to an external electric field, significant changes in the morphology of the Pd/D deposit were observed. Fractal features were observed as well as dendritic growths, rods, wires, and craters. Considerable work is needed to account for the variety of shapes. The process of shape change is driven by energy transferred from the electrostatic field and directed by the field.

17. S. Szpak, P.A. Mosier-Boss, C. Young, and F.E. Gordon, "Evidence of Nuclear Reactions in the Pd Lattice," *Naturwissenschaften*, **92** (2005) 394-397.

http://link.springer.com/article/10.1007/s00114-005-0008-7

When a cathode prepared by Pd/D co-deposition is subjected to an external electrostatic field, SEM analysis of the deposit shows discrete sites exhibiting molten-like features. Such features require substantial energy expenditure in order to form. EDX analysis of these features shows the presence of new elements (Al, Mg, Ca, Si, Zn,…) that could not be extracted from cell components.

18. S. Szpak, P.A. Mosier-Boss, and F.E. Gordon, "Further Evidence of Nuclear Reactions in the Pd/D Lattice: Emission of Charged Particles," *Naturwissenschaften*, **94** (2007) 511-514.

http://link.springer.com/article/10.1007%2Fs00114-007-0221-7

CR-39 is a solid state nuclear track detector that is used to detect energetic particles such as alphas, protons, tritons, and helium-3. Pd/D co-deposition was done, in the presence of an external electric or magnetic field, with the cathode in direct contact with a CR-39 detector. Tracks on the CR-39 detector were observed where the cathode was in contact with the plastic indicating that the source of the tracks is the cathode. The features of these tracks (optical contrast, shape, and bright spot in the center of the pit) are consistent with those observed for pits in CR-39 that are of a nuclear origin. The emission of the energetic particles is sporadic and occurs in bursts.

19. P.A. Mosier-Boss, S. Szpak, F.E. Gordon, and L.P.G. Forsley, "Use of CR-39 in Pd/D Co-deposition Experiments," *Eur. Phys. J. Appl. Phys.,* **40** (2007) 293-303.

http://dx.doi.org/10.1051/epjap:2007152

A series of control experiments were conducted. It was shown that the tracks observed in CR-39 detectors subjected to Pd/D co-deposition were not due to radioactive contamination of the cell components. No tracks were observed when Cu was electrochemically plated on the surface of the CR-39 detectors. This indicates that the pits cannot be attributed to chemical attack of the surface of the CR-39 by either D_2, O_2, or Cl_2 present in the electrolyte. Nor can the pits be attributed to the metal dendrites piercing into the surface of the detectors. Additional experiments showed that LiCl is not essential for the production of pits and that the density of pits significantly decreases when light water is substituted for D_2O. Quantitative analysis using an automated scanner shows that there are three populations of tracks (0.1-0.5 μm, 0.9-4.0 μm, and 4.1-12 μm) and that the pits can be either perfectly circular or elliptical in shape.

20. P.A. Mosier-Boss, S. Szpak, F.E. Gordon, and L.P.G. Forsley, **"**Detection of Energetic Particles and Neutrons Emitted during Pd:D Co-deposition," *Low Energy Nuclear Reactions Source Book*, American Chemical Society , Chapter 14, (2008) 311-334.

http://dx.doi.org/10.1021/bk-2008-0998.ch014

Co-deposition procedures and control experiments specifically identified the conditions under which nuclear particles were observed, and ruled out chemical means of mimicking nuclear tracks. The nuclear tracks are quantitatively examined and are consistent with neutron knock-ons. Triple tracks are presented as evidence of $^{12}C(n,n')3\alpha$ indicative of DT fusion.

21. P.A. Mosier-Boss, S. Szpak, F.E. Gordon, and L.P.G. Forsley, "Use of CR-39 in Pd/D Co-deposition Experiments: A Response to Kowalski," *Eur. Phys. J. Appl. Phys.,* **44** (2008) 291-295.

http://dx.doi.org/10.1051/epjap:2008182

Earlier we reported that the pits generated in CR-39 detectors during Pd/D co-deposition experiments are consistent with those observed for pits that are of a nuclear origin. Recently, that interpretation has been challenged. In this communication, additional experimental data and further analysis of our earlier results are provided that support our original conclusions.

22. P.A. Mosier-Boss, S. Szpak, F.E. Gordon, and L.P.G. Forsley, **"**Triple Tracks in CR-39 as the Result of Pd/D Co-deposition: Evidence of Energetic Neutrons," *Naturwissenschaften*, **96** (2009) 135-142.

http://link.springer.com/article/10.1007%2Fs00114-008-0449-x

Triple tracks have been observed in CR-39 detectors used in Pd/D co-deposition experiments. Microscopic examination of the bottom of the triple track pit shows that the three lobes of the track are splitting apart from a center point. The presence of three α-particle tracks outgoing from a single point is diagnostic of the $^{12}C(n,n')3\alpha$ carbon break up reaction and is easily differentiated from other neutron interactions occurring within the CR-39 detector. The presence of triple tracks suggests that DT reactions that produce ≥9.6 MeV neutrons are occurring inside the Pd lattice.

23. P.A. Mosier-Boss, S. Szpak, F.E. Gordon, and L.P.G. Forsley, **"**Characterization of Tracks in CR-39 Detectors Obtained as a Result of Pd/D Co-deposition," *Eur. Phys. J. Appl. Phys.,* **46** (2009) 30901 p-12.

http://dx.doi.org/10.1051/epjap/2009067

Spacer experiments and track modeling have been done to characterize the properties of the particles that generated the tracks in CR-39 detectors used in Pd/D co-deposition experiments. By placing a 6 μm thick Mylar film between the cathode and the detector, it was observed that ~90% of the energetic particles were blocked. Using LET curves, a 6 μm thick Mylar film cuts off < 0.45 MeV protons, < 0.55 MeV tritons, < 1.40 MeV ^{3}He, and < 1.45 MeV alphas. However, this is the energy of the particle when it reaches the CR-39 detector. It does not take into account the water layer the particle needs to traverse before it reaches the Mylar film. The Pd deposit exhibits a cauliflower like structure. Because of this structure, the particles need to traverse a water layer of varying thickness. Assuming water thicknesses varying between 0 and 10 μm, it is estimated that the majority of the particles formed as a result of Pd/D co-deposition are <0.45-0.97 MeV protons, < 0.55-1.25 MeV tritons, < 1.40-3.15 MeV ^{3}He, and < 1.45-3.30 MeV alphas. The estimated energies of the alpha particles are supported by computer modeling of the tracks using the TRACK_ETCH program developed by Nikezic and Yu. The energies of the particles formed as a result of Pd/D co-deposition are consistent with DD primary and secondary fusion reactions.

24. P.A. Mosier-Boss, F.E. Gordon, and L.P.G. Forsley, **"**Characterization of Energetic Particles Emitted During Pd/D Co-Deposition for Use in a Radioisotope Thermoelectric Generator (RTG)," *Low Energy Nuclear Reactions Source Book II*, American Chemical Society, (2010).

http://dx.doi.org/10.1021/bk-2009-1029.ch007

Use of the particles generated as the result of Pd/D co-deposition as a source to power RTGs was evaluated. It was observed that the production of these particles occurs in bursts and their generation is sporadic. Experiments conducted by placing a 6 μm thick Mylar film between the cathode and the CR-39 detector indicate that the majority of the particles have energies on the order of 1 MeV. This conclusion is supported by track modeling of the pits. Low energy radiation emission has been observed in Pd/D co-deposition. The cathodically polarized Pd/D system emits X-rays with a broad energy distribution (Bremsstrauhlung) with the occasional emergence of recognizable peaks (20 keV due to Pd Kα and 8-12 keV due to either Ni or Pt). Like the particle emissions, the emission of radiation is sporadic and of limited duration. On the back surface of the CR-39 detectors, tracks are observed. The size distribution and ellipticity of the tracks suggest that the tracks were caused by knock-ons due to neutrons. Triple tracks, diagnostic of the carbon break-up reaction, have been observed in the CR-39 detectors. The threshold energy of the neutron to initiate the carbon break-up reaction is 9.6 MeV. These results indicate that, for use to power an RTG, the Pd/D co-deposition operational parameters need to be optimized for particle generation. In particular, the flux of particles needs to be increased and the radiation/neutron emissions need to be minimized.

25. P.A. Mosier-Boss, J.Y. Dea, L.P.G. Forsley, M.S. Morey, J.R. Tinsley, J.P. Hurley, and F.E. Gordon, "Comparison of Pd/D Co-Deposition and DT Neutron Generated Triple Tracks Observed in CR-39 Detectors," *Eur. Phys. J. Appl. Phys.* **51** (2010) 20901

http://dx.doi.org/10.1051/epjap/2010087

Solid state nuclear track detectors (SSNTDs), such as CR-39, have been used to detect energetic charged particles and neutrons. Of the neutron and charged particle interactions that can occur in CR-39, the one that is the most easily identifiable is the carbon breakup reaction. The observation of a triple track, which appears as three alpha particle tracks breaking away from a center point, is diagnostic of the $^{12}C(n,n') 3\alpha$ carbon breakup reaction. Such triple tracks have been observed in CR-39 detectors that have been used in Pd/D co-deposition experiments. In this communication, triple tracks in CR-39 detectors observed in Pd/D co-deposition experiments are compared with those generated upon exposure to a DT neutron source. It was found that both sets of tracks were indistinguishable. Both symmetric and asymmetric tracks were observed. Using linear energy transfer (LET) curves and track modeling, the energy of the neutron that created the triple track can be estimated.

Acknowledgements: This work was funded by the SPAWAR Systems Center Pacific ILIR and S&T Initiatives Programs, the Defense Threat Reduction Agency (DTRA), and JWK Corporation. The authors would also like to thank Dr. G. Phillips, nuclear physicist, retired from the Naval Research Laboratory, US Navy, Radiation Effects Branch, and P. Carbonnelle from *Université catholique de Louvain* for valuable discussions in interpreting the optical data. It was G. Phillips who first pointed out the existence of triple tracks in our CR-39 photomicrographs. The authors acknowledge the contributions of Dr. S. Szpak, retired from SPAWAR Systems Center Pacific, who pioneered the Pd/D co-deposition process. This manuscript has been co-authored by National Security Technologies, LLC, under Contract No. DE-AC52-06NA25946 with the US Department of Energy. The United States Government retains and the publisher, by accepting the article for publication, acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, worldwide license to publish or reproduce the published form of this manuscript, or allow others to do so, for United States Government purposes.

26. P.A. Mosier-Boss, L.P.G. Forsley, and F.E. Gordon, "Comments on Co-deposition Electrolysis Results: A Response to Kowalski," *J. Condensed Matter Nucl. Sci.* **3** (2010) 4–8

http://www.iscmns.org/CMNS/JCMNS-Vol3.pdf

In 2009, it was reported that the tracks observed on the front surface of CR-39 detectors as a result of co-deposition were due to 0.45–0.97 MeV protons, 0.55–1.25 MeV tritons, 1.40–3.15 MeV ^{3}He, and/or 1.45–3.30 MeV alphas. Recently those conclusions have been challenged. In this communication, additional experimental data and further analysis of our earlier results are provided that support our original conclusions.

27. Hagelstein, P.L., Letts, D., and Cravens, D. "Terahertz difference frequency response of PdD in two-laser experiments", *J. Condensed Matter Nucl. Sci.* **3** *(2010) 4–8*

http://www.iscmns.org/CMNS/JCMNS-Vol3.pdf

The cell responded to three difference frequencies in the THz range at 8.2 THz, at 15.1 THz, and at 20.8 THz. The first two of these frequencies can be associated with optical phonon frequencies of PdD with zero velocity. We examine the conjectures that the response at 20.8 THz is due to deuterium in vacancies in the gold coating, or due to hydrogen contamination.

28. J. Marwan, M. C. H. McKubre, F. L. Tanzella, P. L. Hagelstein, M. H. Miles, M. R. Swartz, Edmund Storms, Y. Iwamura, P. A. Mosier-Boss and L. P. G. Forsley, "A new look at low-energy nuclear reaction (LENR) research: a response to Shanahan", *J. Environ. Monit.,* **12,** (2010), 1765-1770.

http://dspace.mit.edu/handle/1721.1/71632

In his criticisms of the review article on LENR by Krivit and Marwan, Shanahan has raised a number of issues in the areas of calorimetry, heat after death, elemental transmutation, energetic particle detection using CR-39, and the temporal correlation between heat and helium-4. These issues are addressed by the researchers who conducted the original work discussed in the Krivit and Marwan (K&M) review paper.

29. Y. E. Kim, "Theoretical interpretation of anomalous tritium and neutron productions during Pd/D co-deposition experiments", *Eur. Phys. J. Appl. Phys.*, **46** 3 (2010) 31101

http://dx.doi.org/10.1051/epjap/2010161

The recent experimental observations of triple tracks in solid-state nuclear track detectors, CR-39, during Pd/D co-deposition experiments indicate that the triple tracks are due to ~14 MeV neutrons, which appear to originate from "hot" fusion reaction $D(t,n)^4He$. Nuclear theory interpretation of the origin of ~14 MeV neutrons is presented in terms of a sub-threshold resonance reaction involving (T + p) resonance state of $^4He^*$ ($J^\pi = 0^+$) at 20.21 MeV, which produces 1.01 MeV T. An upper limit of the branching ratio, $R(n)/R(T)$, between neutron production rate and tritium production rate is calculated to be $R(n)/R(T) < 10^{-4}$. Experimental tests of the proposed theoretical interpretation are proposed.

30. Miles, M.H., Fleischmann, M.,"Measurements of Excess Power Effects In Pd/D2O Systems Using a New Isoperibolic Calorimeter", *J. Condensed Matter Nucl. Sci.* **4** (2011) 45-55

http://www.iscmns.org/CMNS/JCMNS-Vol4.pdf

Relatively inexpensive isoperibolic calorimeters have been designed and constructed with the goal of obtaining a constant heat transfer coefficient that is insensitive to normal changes in the electrolyte level during electrolysis. Four prototypes were constructed from copper tubing and used different insulating materials. Preliminary tests on two of these new calorimeters show excellent stability for the cell temperature measurements, stable heat transfer coefficients during electrolysis, and precise power measurements. Initial applications include nitrate electrolytes and co-deposition systems. There was no evidence for any shuttle reactions in these experiments.

31. D. Letts, "Codeposition Methods: A Search for Enabling Factors", *J. Condensed Matter Nucl. Sci.* **4** (2011) 81-92.

http://www.iscmns.org/CMNS/JCMNS-Vol4.pdf

This paper is a preliminary report on results obtained from a series of experiments conducted April–September 2009. The experiments were designed to test for excess power using the basic methods disclosed in 1991 by Szpak, Mossier-Boss and Smith. A large and repeatable excess power signal was observed and the efforts to test mundane explanations for the signal are described. The design, fabrication and calibration methods of a new type of Seebeck calorimeter used for these experiments are also disclosed.

32. P.A. Mosier-Boss, J.Y. Dea, F.E. Gordon, L.P. Forsley, M.H. Miles, "Review of Twenty Years of LENR Research Using Pd/D Co-deposition", *J. Condensed Matter Nucl. Sci.* **4** (2011) 173–187.

http://www.iscmns.org/CMNS/JCMNS-Vol4.pdf

In the Pd/D co-deposition process, working and counter electrodes are immersed in a solution of palladium chloride and lithium chloride in deuterated water. Palladium is then electrochemically reduced onto the surface of the working electrode in the presence of evolving deuterium gas. Electrodes prepared by Pd/D co-deposition exhibit highly expanded surfaces consisting of small spherical nodules. Because of this high surface area and electroplating in the presence of deuterium gas, the incubation time to achieve high D/Pd loadings necessary to initiate LENR is orders of magnitude less than required for bulk electrodes. Besides heat, the following nuclear emanations have been detected using Pd/D co-deposition: X-ray emission, tritium production, transmutation, and particle emission. Experimental details and results obtained over a twenty year period of research are discussed.

33. P.A. Mosier-Boss, L.P.G. Forsley, P. Carbonnelle, M.S. Morey, J.R. Tinsley, J. P. Hurley, F.E. Gordon, "Comparison of SEM and Optical Analysis of DT Neutron Tracks in CR-39 Detectors", *Hard X-Ray, Gamma-Ray, and Neutron Detector Physics XIII*, edited by Franks, James, and Burger, **Proc. of SPIE Vol. 8142**, (2011) pp K1 – K8

http://proceedings.spiedigitallibrary.org/article.aspx?articleid=1342027

CR-39 detectors were exposed to DT neutrons generated by a Thermo Fisher model A290 neutron generator. Afterwards, the etched tracks were examined both optically and by scanning electron microscopy (SEM). The purpose of the analysis was to compare the two techniques and to determine whether additional information on track geometry could be obtained by SEM analysis. The use of these techniques to examine triple tracks, diagnostic of ≥9.6 MeV neutrons, observed in CR-39 used in Pd/D co-deposition experiments is discussed.

34. P.A. Mosier-Boss, L.P.G. Forsley, P. Carbonnelle, M.S. Morey, J.R. Tinsley, J. P. Hurley, F.E. Gordon, "Comparison of SEM and Optical Analysis of DT Neutron Tracks in CR-39 Detectors", *Radiation Measurements*, **47**, (2012) pp 57-66.

http://dx.doi.org/10.1016/j.radmeas.2011.10.004

A solid-state nuclear track detector, CR-39, was exposed to DT neutrons. After etching, the resultant tracks were analyzed using both optical and a scanning electron microscopy (SEM). Both complimentary methods of analyzing DT neutron tracks are discussed.

35. P.A. Mosier-Boss, L.P.G. Forsley and F.E. Gordon, "Characterization of Neutrons Emitted during Pd/D Co-deposition", *J. Condensed Matter Nucl. Sci.* **6** (2012) 13–23.

http://www.iscmns.org/CMNS/JCMNS-Vol6.pdf

Experiments using CR-39 detectors have shown that energetic particles and neutrons are emitted during Pd/D co-deposition. Using 6 μm Mylar between the CR-39 and the cathode, it has been shown that the majority of the tracks formed have energies on the order of 1–3 MeV. This conclusion was supported by computer analysis of the pits using the 'TrackTest' program developed by Nikezic and Yu. In this communication, additional analysis of the detectors will be discussed. In particular, it will be shown that the size distribution of the neutron-generated tracks on the backside of the CR-39 detectors are consistent with the occurrence of DD and DT fusion reactions. This is supported by the presence of triple tracks in the CR-39 as well as the energies of the charged particles as determined in the Mylar experiments.

36. Letts, D. and Hagelstein, P., "Modified Szpak Protocol for Excess Heat", *J. Condensed Matter Nucl. Sci.* **6** (2012) 44-54.

http://www.iscmns.org/CMNS/JCMNS-Vol6.pdf

In recent theoretical work, vacancies in PdD have been shown to be able to host molecular D2, which is conjectured to be necessary for excess heat in Fleischmann–Pons experiments. Vacancies in the original Fleischmann–Pons experiment are proposed to be created through inadvertent codeposition at high loading. This suggests that a better approach should be to focus on experiments in which Pd codeposition is controlled, such as in the Szpak experiment. Unfortunately, the Szpak experiment has proven difficult to replicate, and we conjecture that this is due to low D/Pd loading. A modified protocol has been tested in which codeposition is carried out at higher current density with a lower PdCl2 concentration. Positive results have been obtained in all of the tests done with this protocol so far.

37. P.A. Mosier-Boss, "A Review on Nuclear Products Generated During Low-Energy Nuclear Reactions (LENR)", *J. Condensed Matter Nucl. Sci.* **6** (2012) 135–148.

http://www.iscmns.org/CMNS/JCMNS-Vol6.pdf

Given the response to the Fleischmann–Pons news conference in 1989, it became clear to many researchers in the field that excess heat was not convincing enough evidence to prove that nuclear processes were occurring inside a metal lattice. Skeptics attributed the excess heat to recombination of deuterium and oxygen gases and/or poor calorimetry, despite the fact that control experiments showed that this was not the case. Consequently, a number of researchers redirected their efforts from measuring heat to looking for nuclear products such as neutrons, charged particles, X- and gamma rays, and transmutation. The results of these efforts are discussed in this communication.

38. M. H. Miles, "Investigations of Possible Shuttle Reactions in Co-deposition Systems", *J. Condensed Matter Nucl. Sci*. **8** (2012) 12–22

http://www.iscmns.org/CMNS/JCMNS-Vol8.pdf

Experiments in the 0.025 M $PdCl_2$ + 0.15 M ND_4Cl + 0.15 M ND_2OD/D_2O co-deposition system produced anomalous excess power in three out of three prior experiments in Japan. Completely new experiments have produced even larger excess power effects for this deuterated co-deposition system. The largest excess power effect in D_2O produced 1.7 W or about 13 W/g of palladium ($160 W/cm^3$). These large excess power effects were absent in extensive studies of H_2O controls. Excess power was also absent in various experiments involving the co-deposition of ruthenium (Ru), rhenium (Re), and nickel (Ni) in both H_2O and D_2O ammonia solutions. The statistical analysis of all 18 co-deposition experiments yields a probability of greater than 99.9989 % that the co-deposition excess power effect requires both palladium metal and D_2O. Shuttle reactions have been proposed to explain the reproducible excess power effect in this ammonia co-deposition system. However, various electrochemical studies show no evidence for any shuttle reactions in this ammonia system. Nevertheless, the initial chemistry for the Pd system is complex leading to large pH changes, chlorine (Cl_2) evolution, and the formation of nitrogen trichloride (NCl_3) during the first few days. However, the large excess power effects are observed later in the experiments after this chemistry is completed. A better understanding of the chemistry should be helpful in the reproduction of anomalous excess power in co-deposition systems

39. L.P.G. Forsley, P.A. Mosier-Boss, P.K. McDaniel and F.E. Gordon, "Charged Particle Detection in the Pd/D System: CR-39 SSNTD vs. Real-Time Measurement of Charged Particle Stimulated Pd K Shell X-rays", *Electrochimica Acta* **88** (2013) 373-383.

http://dx.doi.org/10.1016/j.electacta.2012.10.084

There have been a number of efforts to measure charged particle emissions in the Pd/D system. In general, two approaches have been employed. One approach was to indirectly detect charged particles by measuring Pd K-shell X-rays that should be created as charged particles traverse through the Pd lattice. The other approach ultilized CR-39, a solid state nuclear track detector (SSNTD). With these detectors, a charged particle creates an ionization trail in the plastic that, upon etching, leaves a symmetric pit. The size, depth of penetration, and shape of the pits provides information about the mass, charge, energy, and direction of motion of the particles. While experiments done using CR-39 solid state nuclear track detectors have shown the presence of these charged particles, X-ray measurements of the Pd K-shell X-rays have not. The most significant difference between the two measurement techniques is that CR-39 is a constantly integrating detector and the X-ray measurements are done in real time. In this communication, this apparent discrepancy between the two charged particle measurement techniques is examined using known alpha sources.

40. P.A. Mosier-Boss, L.P. Forsley and F.E. Gordon, "How the Flawed Journal Review Process Impedes Paradigm Shifting Discoveries", *J. Condensed Matter Nucl. Sci.* **12** (2013) 1-12.

http://www.iscmns.org/CMNS/JCMNS-Vol12.pdf

The purpose of scientific journals is to review papers for scientific validity and to disseminate new theoretical and experimental results. This requires that the editors and reviewers be impartial. Our attempt to publish novel experimental results in a renowned physics journal shows that in some cases editors and reviewers are not impartial; they are biased and closed-minded. Although our subject matter was technical, its rejection was not: it was emotionally charged. It was an agenda-laden rejection of legitimate experiments that were conducted in US DoD and DoE laboratories. This paper describes the flawed journal review process, detailing our own case and citing others. The behavior of editors and reviewers has a stifling effect on innovation and the diffusion of knowledge.

41. K. Lee, H. Jang and S. Kim, "A Change of Tritium Content in D_2O Solutions during Pd/D Co-deposition", *J. Condensed Matter Nucl. Sci.* **13** (2014) 294–298.

http://www.iscmns.org/CMNS/JCMNS-Vol13.pdf

In this study electrochemical co-deposition of Pd/D on nickel electrodes was performed to determine whether a nuclear fusion reaction occurs in the palladium deposit. Co-deposition was performed with a palladium salt/D_2O solution. The content of tritium in D_2O solution was varied depending on the electrolysis procedure during co-deposition. A comparison between the co-deposition of Pd/D and the simple electrolysis of D_2O was performed to investigate the change of tritium concentration in the D_2O solution.

42. M. H. Miles, "Co-deposition of Palladium and other Transition Metals in H2O and D2O Solutions", *J. Condensed Matter Nucl. Sci.* **13** (2014) 401-410.

http://www.iscmns.org/CMNS/JCMNS-Vol13.pdf

The co-deposition of palladium, ruthenium, rhenium, nickel, and iridium were investigated in H2O and D2O ammonia systems (NH4Cl/NH3). Significant amounts of excess power were observed only in the deuterated Pd/D2O system. There was no anomalous excess power observed for the co-deposition of ruthenium, rhenium or nickel in any H2O or D2O experiment.

43. P.A. Mosier-Boss, "It is Not Low Energy – But it is Nuclear", *J. Condensed Matter Nucl. Sci.* **13** (2014) 432-441.

http://www.iscmns.org/CMNS/JCMNS-Vol13.pdf

In this communication, CR-39 track results obtained as a result of Pd/D co-deposition are discussed and criticisms of those results are addressed. Implications of the CR-39 results with reports of transmutation are explored.

44. P.A. Mosier-Boss, L.P. Forsley, and P.J. McDaniel, "The Use of CR-39 Detectors in LENR Experiments", *J. Condensed Matter Nucl. Sci.* **14** (2014) 29-49.

http://www.iscmns.org/CMNS/JCMNS-Vol14.pdf

In this communication, the use of CR-39 detectors to detect energetic charged particles and neutrons in LENR experiments is discussed. The main advantages of these detectors over real-time electronic detectors are its integration capability and its ability to speciate energetic particles. Unlike real-time detectors, CR-39 can be placed in close proximity to the cathode and can be used for both electrolysis experiments and gas loading. These advantages of CR-39 detectors over real time, electronic detectors are particularly important when energetic particle emissions occur either sporadically in bursts or at a low flux.

45. P.A. Mosier-Boss, L.P. Forsley, A.S. Roussetski, A.G. Lipson, F. Tanzella, E.I. Saunin, M. McKubre, B. Earle, and D. Zhou, "The Use of CR-39 Detectors to Determine the Branching Ratio in Pd/D Co-deposition", *Current Science*, **108,** No. 4, pp. 585-588. (2015)

http://www.currentscience.ac.in/Volumes/108/04/0585.pdf

Columbia Resin-39 (CR-39) detectors used in Pd/D co-deposition experiments were examined using an optical microscope, scanned using an automated scanner, and underwent both sequential etching analysis as well as LET spectrum analysis. These analyses identified and quantified the energetic particles responsible for the tracks observed in the CR-39 detectors and made it possible to estimate the branching ratios of the primary and secondary reactions.

46. P.A. Mosier-Boss, L.P. Forsley, F.E. Gordon, D. Letts, D. Cravens, M.H. Miles, M. Swartz, J. Dash, F. Tanzella, P. Hagelstein, M. McKubre, and J. Bao, "Condensed Matter Nuclear Reaction Products Observed in Pd/D Co-Deposition Experiments", *Current Science*, **108,** No 4, pp. 656-659. (2015)

http://www.currentscience.ac.in/Volumes/108/04/0656.pdf

Pd/D co-deposition has been used by a number of researchers to explore the condensed matter nuclear reactions occurring within the Pd lattice by generating highly loaded layers of lattice over the cathode. Reaction products that have been observed include heat, transmutation, tritium, energetic charged particles, and neutrons. The results of these experiments are discussed in this communication

47. D.Z. Zhou, L.P. Forsley, X.Z. Li, P.A. Mosier-Boss, F.E. Gordon, C. Wang, Y.Q. Sun, J.B. Liang, and G.W. Zhu, "Energetic Particles Generated in Pd+D Nuclear Reactions", *J. Condensed Matter Nucl. Sci.* **15,** pp. 33-43. (2015).

http://www.iscmns.org/CMNS/JCMNS-Vol15.pdf

Low energy nuclear reactions (LENRs) may be one of the best sustainable, safe and clean energy sources. CR-39 plastic nuclear track detectors (PNTDs) are widely used in physics research where one of its important properties is the linear energy transfer (LET) function. LET analysis measures the energy lost by charged particles as they traverse matter, providing the means to distinguish among different charged particle species and their energy spectra. We apply the LET spectrum method using CR-39 detectors to Pd-D co-deposition as described in US Patent 8,419,919, "System and Method for Generating Particles". The LET spectra, energy distributions and triple alphas obtained by LET analysis agree well with the D+D and Pd+D proposed reactions. This provides strong evidence of Low Energy Nuclear Reactions.

48. L. F. DeChiaro, L. P. Forsley, and P.A. Mosier-Boss, “Strained Layer Ferromagnetism in Transition Metals and its Impact Upon Low Energy Nuclear Reactions”, *J. Condensed Matter Nucl. Sci.* **17,** pp. 1-26. (2015)

http://www.iscmns.org/CMNS/JCMNS-Vol17.pdf

Spin-polarized Density Functional Theory (DFT) calculations have been performed to model the lattice structures for the Transition Metal Group, Columns I and II, and a number of sp elements in the Periodic Table. Our results suggest that most of the transition metals can exhibit ferromagnetic ordering if the lattice is placed in sufficiently high tensile stress. These results are applied to the study of some layered structures employed by a number of Low Energy Nuclear Reaction (LENR) research teams and may help to explain some of the anomalous results and the difficulty in reproduction of those results.