Lattice Energy LLC

LENRs: revolutionary new source of safe, radiation-free nuclear energy

Japan now funding R&D in LENR technology for use in power generation applications. Quietly threw down gauntlet to oil industry

January 2018: terse project report summarizing progress in Japanese government NEDO-funded R&D in LENRs for Oct. 2015 thru Oct. 2017 released by Technova Inc. on ResearchGate

Herein we will review and discuss NEDO project's progress

Project scientists reported significant R&D progress toward developing LENR devices that serve as powerful heat sources.

Reproducibility of device fabrication techniques and excess heat output were improved. Certain nanocomposite, multi-metal LENR test devices with mass <140 grams cumulatively produced up to ~85 megajoules (MJ) of excess heat per mole (MJ/mol) of absorbed Hydrogen (H) or Deuterium (D); some: duration of heat > 1 month. By contrast, complete combustion of Hydrogen releases ~0.286 MJ/mol of H. Chemical processes cannot explain these results.

Japan, Inc. appears to be developing LENR technology to someday replace the internal combustion engine

Japan's beloved Mt. Fuji at dawn

“What is needed is a commitment to change”

“The only certainty is that the chances of succeeding in the unprecedented quest to create a new energy system compatible with the survival of high-energy civilization remain uncertain. Given our degree of understanding, the challenge may not be relatively more forbidding than overcoming a number of barriers we have surmounted in the past. But understanding, no matter how impressive, will not be enough. What is needed is a commitment to change, so we could say with Senancour (1770 - 1846),”

“Man perisheth. That may be, but let us struggle even though we perish; and if the nothing is to be our portion, let it not come to us as a just reward.” (1901)

Prof. Vaclav Smil
“Energy and Civilization: A History”
MIT Press page 441 of 564 pp. (2017)

Ultralow energy neutron reactions (LENRs)

Under the radar technology: little mentioned in media or science press

Could potentially replace internal combustion engine if it can be commercialized

- New type of very disruptive green nuclear power generation technology
- Radically different from fission and fusion nuclear energy technologies:
  - No emission of deadly energetic neutron or gamma radiation
  - No production of dangerous long-lived radioactive wastes
  - No necessity for $$$ radiation shielding or containment systems
  - Many-body reactions instead of simple 2-body nuclear reactions
  - Key steps rely on electroweak force rather than strong force
  - Reactions triggered at moderate temperatures and pressures
  - Spent LENR devices could be disposed of in ordinary landfills
- Cost of producing energy could be vastly lower versus fission or fusion
- LENR devices could someday be mass-produced --- much like batteries
- Physics of processes fully explained by Widom-Larsen theory of LENRs

Comparison of LENRs to fission and fusion

Fission, fusion, and LENRs all involve controlled release of nuclear binding energy (heat) for power generation: no CO_2 emissions; scale of energy release is MeVs (nuclear regime) > 1,000,000x energy density of chemical energy power sources

Heavy element fission: involves shattering heavy nuclei to release stored nuclear binding energy; requires massive shielding and containment structures to handle radiation; major radioactive waste clean-up issues and costs; limited sources of fuel: today, almost entirely Uranium; Thorium-based fuel cycles now under development; heavy element U-235 (fissile isotope fuel) + neutrons → complex array of lower-mass fission products (some are very long-lived radioisotopes) + energetic gamma radiation + energetic neutron radiation + heat

Fusion of light nuclei: involves smashing light nuclei together to release stored nuclear binding energy; present multi-billion $ development efforts (e.g., ITER, NIF, other Tokamaks) focusing mainly on D+T fusion reaction; requires massive shielding/containment structures to handle 14 MeV neutron radiation; minor radioactive waste clean-up $ costs vs. fission

Two key sources of fuel: Deuterium and Tritium (both are heavy isotopes of Hydrogen)

Most likely to be developed commercial fusion reaction involves the following:

D + T → He-4 (helium) + neutron + heat (total energy yield 17.6 MeV; ~14.1 MeV in neutron)

Ultralow energy neutron reactions (LENRs): distinguishing feature is neutron production via electroweak reaction; neutron capture on fuel + gamma conversion to IR + decays [β^-, α] releases nuclear binding energy; early-stage technology; no emission of energetic neutron or gamma radiation and no long-lived radioactive waste products; LENR systems would not require massive, expensive radiation shielding or containment structures → much lower $$$ cost; many possible fuels --- any element/isotope that can capture LENR neutrons; involves neutron-catalyzed transmutation of fuels into heavier stable elements; process creates heat

Many-body collective reactions with Q-M entangled particles

Protons, deuterons, or tritons react with *sp* electrons to make neutrons

Many-body e_n + p_n reaction triggers at moderate temperatures and pressures

Three isotopes of Hydrogen (p^+, d^+, t^+) react to create ultralow energy neutrons

Input energy: provided from coherent infrared IR and/or visible light using lasers; or infrared blackbody radiation from reaction vessel walls, or from DC electric currents

Many-body electroweak reactions

$$\text{Energy}_{\text{E-field}} + e^-_{n\,sp} \rightarrow e^{-*}_{n\,sp} + p^+_n \rightarrow 1n^0 + \nu_e$$

$$\text{Energy}_{\text{E-field}} + e^-_{n\,sp} \rightarrow e^{-*}_{n\,sp} + d^+_n \rightarrow 2n^0 + \nu_e$$

$$\text{Energy}_{\text{E-field}} + e^-_{n\,sp} \rightarrow e^{-*}_{n\,sp} + t^+_n \rightarrow 3n^0 + \nu_e$$

ν_e neutrinos: ghostly unreactive particles that fly-off into space; n^0 neutrons capture on target atoms

sp indicates that electron in these three electroweak reactions is what is called a surface plasmon

Ultralow energy neutrons are captured and catalyze safe hard-radiation-free nuclear transmutations of elements along rows of Periodic Table

Neutron capture process releases heat transmutes targets to other elements

Neutrons + target atoms → heavier elements + decay products

Neutron capture $\quad n + (Z, A) \rightarrow (Z, A+1)$

Beta decay $\quad (Z, A+1) \rightarrow (Z+1, A+1) + e^-_\beta + \bar{\nu}_e$

Neutron capture-driven transmutation of isotopes and elements

Appropriate input energy is required to produce neutrons

Reaction vessels serve as blackbody resonant electromagnetic cavities

Input energy is required to trigger LENRs: to create non-equilibrium conditions that enable nuclear-strength local E-fields which produce populations of heavy-mass $e^{-}*$ electrons that react with many-body surface patches of p^{+}, d^{+}, or t^{+} to produce neutrons via $e^{-}* + p^{+} \rightarrow 1\ n$ or $e^{-}* + d^{+} \rightarrow 2\ n$, $e^{-}* + t^{+} \rightarrow 3\ n$ (energy cost = 0.78 MeV/neutron for H; 0.39 for D; 0.26 for T); includes (can combine sources):

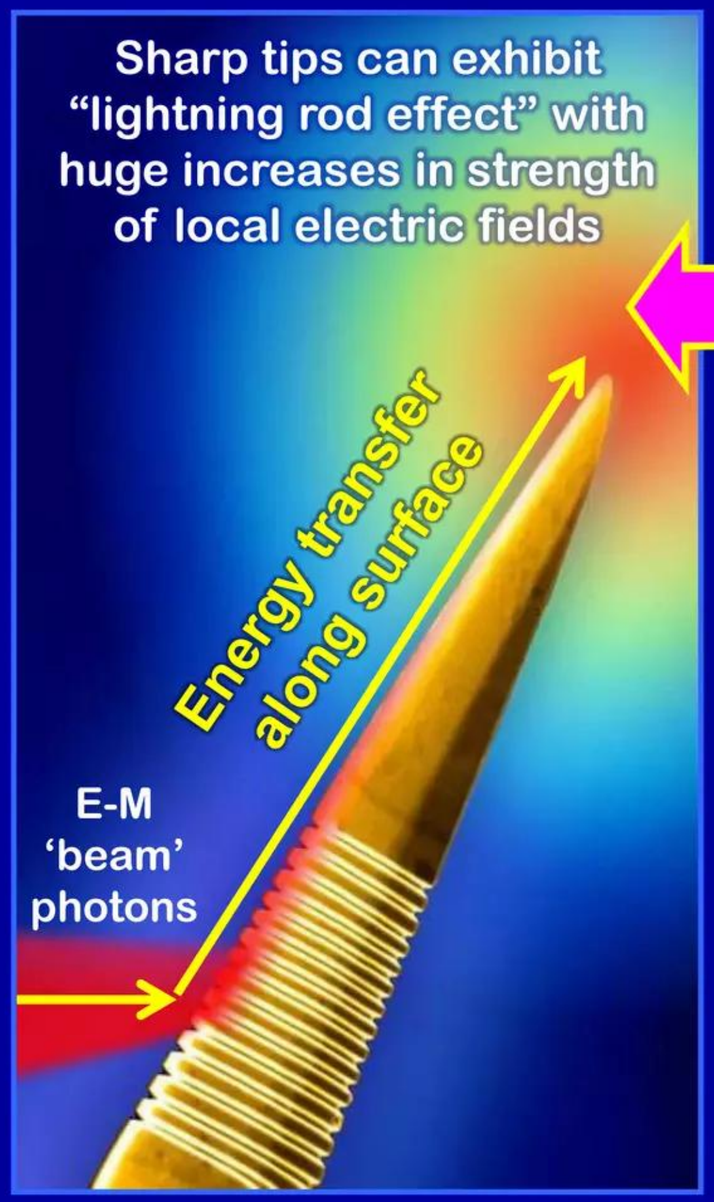
- **Electrical currents:** i.e., an electron 'beam' of one sort or another can serve as a source of input energy for producing neutrons via $e + p$ electroweak reaction
- **Ion currents:** passing across a surface or an interface where SP electrons reside (i.e., an ion beam that can be comprised of protons, deuterons, tritons, and/or other types of charged ions); one method used for inputting energy is an ion flux caused by imposing a modest pressure gradient (Iwamura *et al.* 2002)
- **Incoherent and coherent electromagnetic (E-M) photon fluxes:** can be provided via incoherent blackbody infrared radiation found in resonant electromagnetic cavities; with proper momentum coupling, SP electrons can be energized with coherent laser beams emitting photons at appropriate resonant wavelengths
- **Organized magnetic fields with cylindrical geometries:** many-body collective magnetic LENR regime with direct acceleration of particles operates at very high electron/proton currents; includes organized and so-called dusty plasmas; scales-up to stellar flux tubes on stars with dimensions measured in kilometers

Electromagnetic radiation provides energy to create neutrons

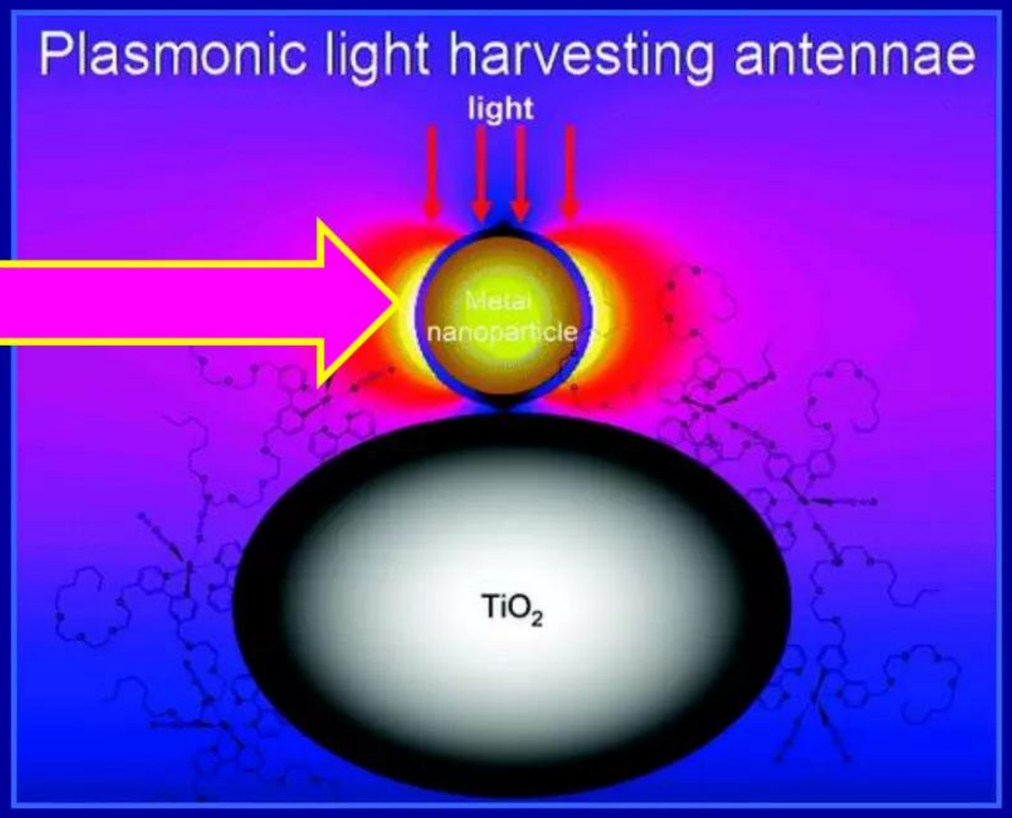
Nanostructures can act as tiny antennas that absorb E-M input energy

Surface plasmons can greatly intensify local electric fields on nanoparticles

Graphics show capture of E-M photons and energy transfer via surface plasmons



Regions of increased electric fields



http://people.ccmr.cornell.edu/~uli/res_optics.htm

Source of above image is Wiesner Group at Cornell University:

"Plasmonic dye-sensitized solar cells using core-shell metal-insulator nanoparticles" M. Brown *et al.*, *Nano Letters* 11 pp. 438 - 445 (2011)

http://pubs.acs.org/doi/abs/10.1021/nl1031106

Neutrons charge-neutral so target atoms readily absorb them

Capture of neutrons by atoms will transmute them into other isotopes

$$n + \text{target atom } (Z, A) \rightarrow (Z, A+1)$$

$$(Z, A+1) \rightarrow (Z+1, A+1) + e_{\beta}^{-} + \overline{\nu}_{e}$$

LENR transmutation processes typically proceed from left to right across rows of the Periodic Table of chemical elements

1 H Hydrogen 1.00794																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012182											5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine 18.9984032	10 Ne Neon 20.1797
11 Na Sodium 22.989770	12 Mg Magnesium 24.305											13 Al Aluminum 26.9815	14 Si Silicon 28.085	15 P Phosphorus 30.973761	16 S Sulfur 32.066	17 Cl Chlorine 35.4527	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.955910	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn 54.9	26 Fe Iron 55.8	27	28	29 Cu Copper 63.546	30	31 Ga Gallium 69.723	32 Ge Germanium 72.61	33 As Arsenic 74.92160	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.94	43 Tc	44	45	46	47	48	49 In Indium 114.818	50 Sn Tin 118.710	51 Sb Antimony 121.760	52 Te Tellurium 127.60	53 I Iodine 126.90447	54 Xe Xenon 131.29
55 Cs Cesium 132.90545	56 Ba Barium 137.327	57 La Lanthanum 138.9055	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.84	75	76	77	78	79	80	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98038	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	104 Rf Rutherfordium (261)	105 Db Dubnium (262)	106 Sg Seaborgium (263)	107 Bh (262)	108 Hs (265)	109	110	111	112	113	114				

58 Ce Cerium 140.116	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92534	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93032	68 Er Erbium 167.26	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
90 Th Thorium 232.0381	91 Pa Protactinium 231.03588	92 U Uranium 238.0289	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)

Mitsubishi Heavy Industries and Toyota involved since 1989

Japanese government (NEDO) resumed funding of R&D in LENRs in 2015

- Since 1989, Mitsubishi Heavy Industries and Toyota have quietly supported R&D in LENRs out of their own budgets with little funding from Japanese government
- Keiretsu: is a Japanese term which describes a loose association of different companies that share one or more common interests and work closely together to achieve mutually agreed-upon key business and technological objectives. They may or may not have some degree of mutual ownership and are tied to banks. Mitsubishi and Toyota are members of their own respective keiretsu. Toyota is presently considered the largest vertical corporate conglomeration in Japan
- Under Team Leader Dr. Yasuhiro Iwamura, Mitsubishi Heavy Industries (MHI) has conducted and reported important experimental results on basic science LENR transmutation measurements for over 20 years. Heretofore, MHI did not focus on trying to produce substantial amounts of excess heat to generate thermal power
- In 2013, Toyota published paper in peer-reviewed *Japanese Journal of Applied Physics* (JJAP) which confirmed paradigm-shifting experimental results that MHI's Iwamura et al. first published in JJAP back in 2002. Mitsubishi's proprietary Hydrogen permeation method is capable of triggering safe, radiation-free LENR nuclear transmutation reactions at low rates using modest temperatures and pressures; at higher rates, such reactions produce substantial amounts of heat

Mitsubishi has published reports on LENR R&D since 1990

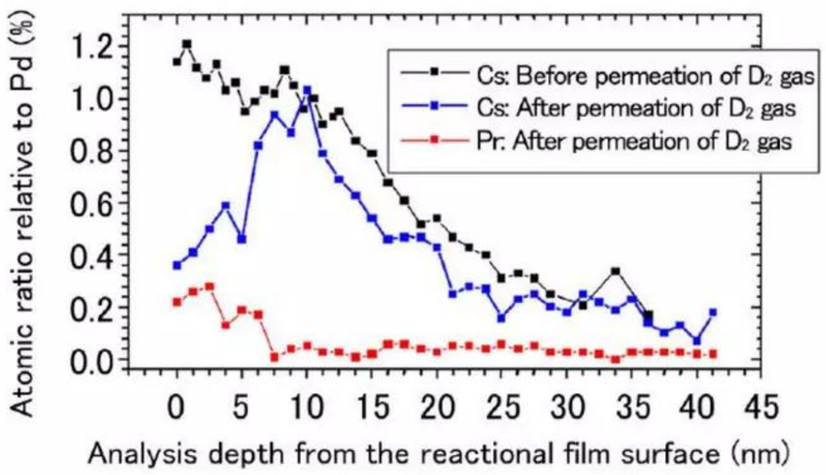
Dr. Yasuhiro Iwamura served as MHI Team Leader for much of that period

Transmutation Reaction Induced by Deuterium Permeation Through Nanostructured Multi-layer Thin Film

Vol. 52 No. 4 (2015) New Products & Technologies

MITSUBISHI HEAVY INDUSTRIES TECHNICAL REVIEW

MITSUBISHI HEAVY INDUSTRIES



"The new method of nuclear transmutation is a simple method of nuclear transmutation that uses Mitsubishi Heavy Industries, Ltd.'s (MHI) original nanostructure multi-layer reactional film (hereinafter, reactional film) to transmute elements at low energy cost. So far, transmutation from cesium (Cs) to praseodymium (Pr), from barium (Ba) to samarium (Sm), from strontium (Sr) to molybdenum (Mo), etc., has been observed. If this technology is established, it is expected to contribute to society in the field of detoxification treatment of radioactive waste including the transmutation of radioactive cesium into a harmless nonradioactive element in the future."

https://www.mhi.com/company/technology/review/Vol.52No.4/abstracte-52-4-106.html

https://www.mhi.com/company/technology/review/pdf/e524/e524106.pdf

Mitsubishi's experimental method can transmute elements

Proof-of-concept: Cesium (Cs), Barium (Ba) & Strontium (Sr) transmuted

Transmutation Reaction Induced by Deuterium Permeation Through Nanostructured Multi-layer Thin Film

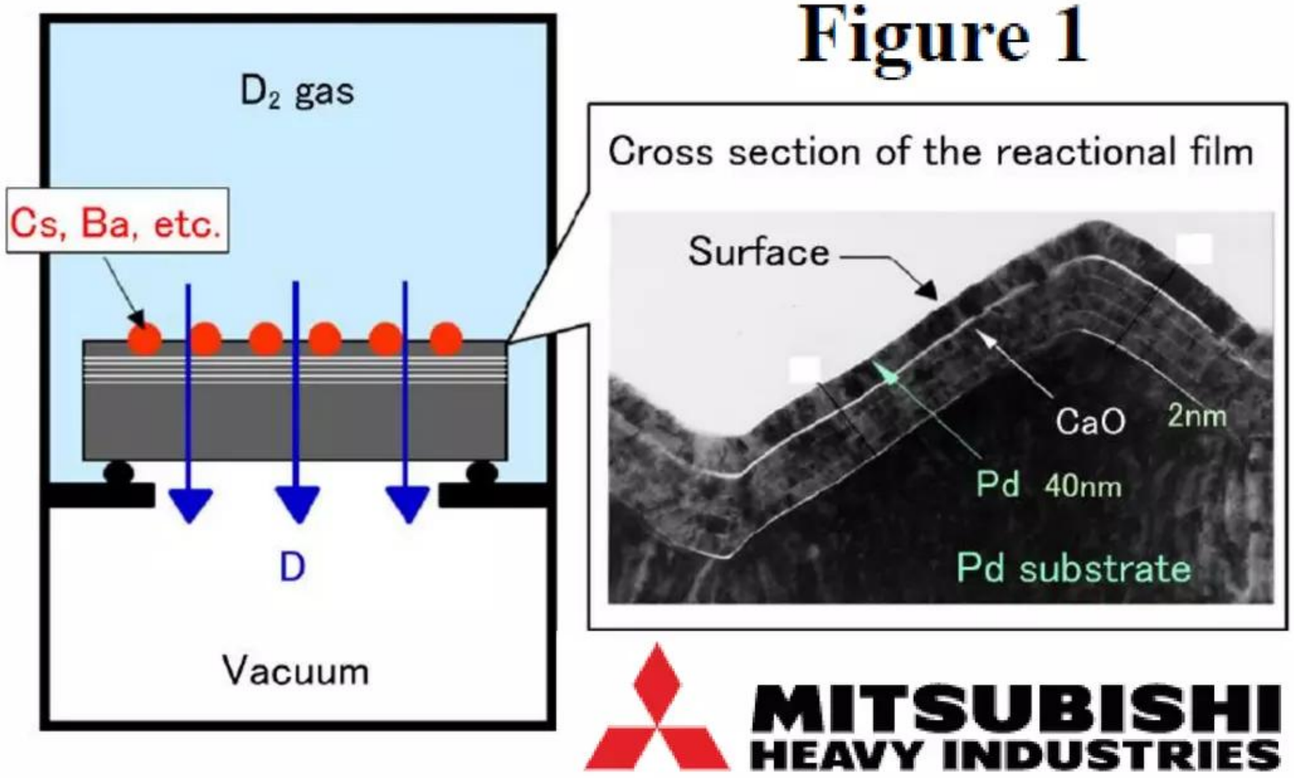


Table 1 Example of transmutation phenomenon observed

Element	Assumed reaction					
Cs	$^{133}_{55}Cs$	→	$^{141}_{59}Pr$			
Ba	$^{137}_{56}Ba$	→	$^{149}_{62}Sm$	$^{138}_{56}Ba$	→	$^{150}_{62}Sm$
Sr	$^{88}_{38}Sr$	→	$^{96}_{42}Mo$			

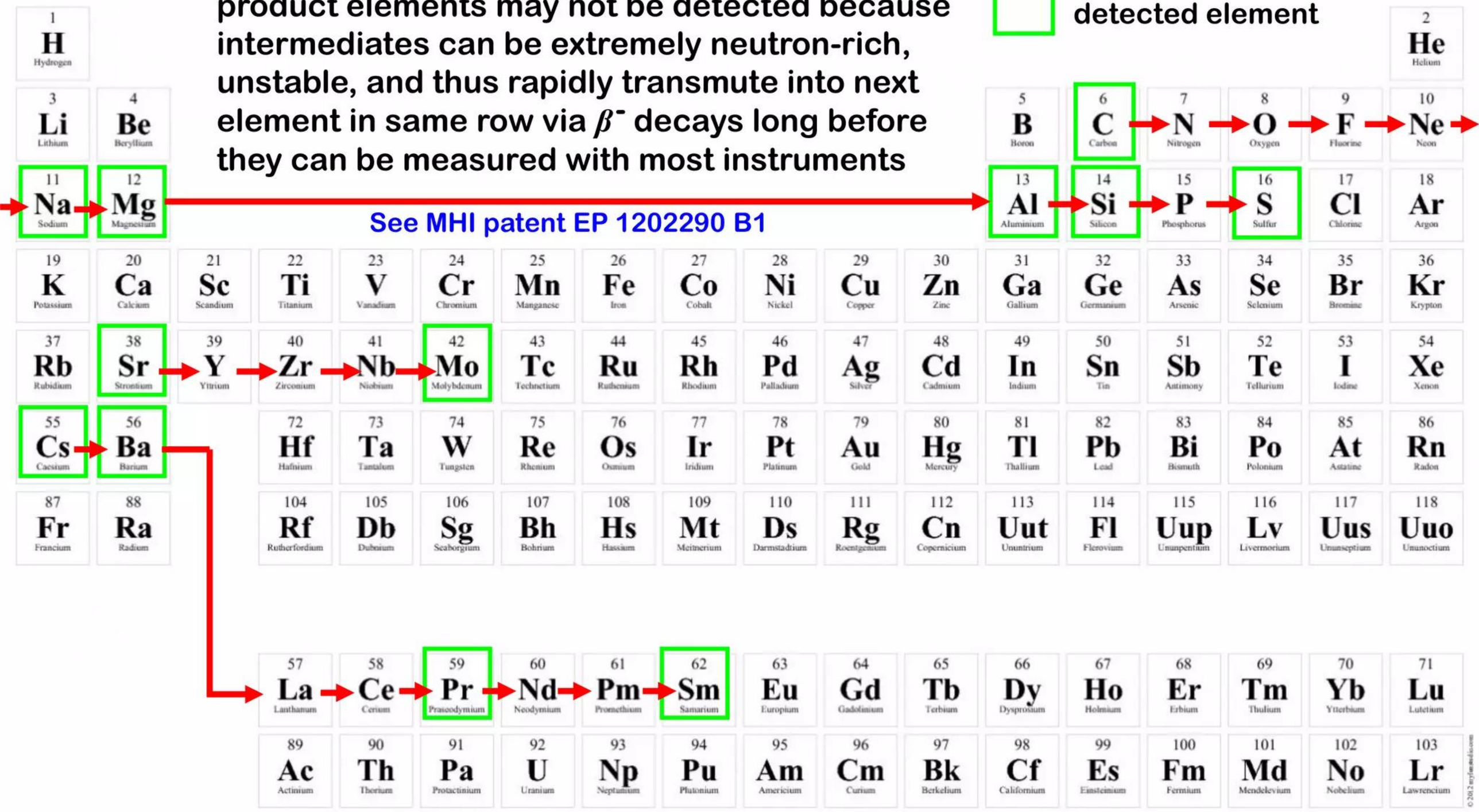
MHI's transmutation pathways follow rows of Periodic Table

This key feature specifically predicted by Widom-Larsen theory of LENRs

Intermediate products along rows to stable end-product elements may not be detected because intermediates can be extremely neutron-rich, unstable, and thus rapidly transmute into next element in same row via β^- decays long before they can be measured with most instruments

Green box indicates detected element

See MHI patent EP 1202290 B1



Widom-Larsen theory: neutrons catalyze LENR transmutation

Patent EP 1202290 B1 for Mitsubishi Heavy Industries issued Dec. 4, 2013

Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 1 202 290 B1**

EUROPEAN PATENT SPECIFICATION

Date of publication and mention of the grant of the patent:
04.12.2013 Bulletin 2013/49

Application number: **01402812.0**

Date of filing: **30.10.2001**

(51) Int Cl.:
G21B 3/00 *(2006.01)* ***G21G 1/04*** *(2006.01)*

Nuclide transmutation device and nuclide transmutation method

Inventors:
Iwamura, Yasuhiro
Yokohama,
Kanagawa-ken (JP)
Itoh, Takehiko
Yokohama,
Kanagawa-ken (JP)

"[0001] The present invention relates to a nuclide transmutation device and a nuclide transmutation method associated, for example, with disposal processes in which long-lived radioactive waste is transmuted into short-lived radioactive nuclides or stable nuclides, and technologies that generate rare earth elements from abundant elements found in the natural world."

https://www.google.com/patents/EP1202290B1?cl=en

No physics in MHI's EINR theory; Widom-Larsen is rigorous

Mitsubishi invoked neutron-catalyzed transmutations in EP 1 202 290 B1

Produced ultralow energy neutrons via electroweak *e* + *d* reaction

[0077] lines 30 - 34
on patent page 9

$$^{2}_{1}\mathrm{d} + ^{0}_{-1}\mathrm{e} \rightarrow ^{2}_{0}\mathrm{n} + \nu \qquad (2)$$

Transmuted stable Cesium (Cs) into stable Praseodymium (Pr)

[0077] lines 35 - 39
on patent page 9

$$^{133}_{55}\mathrm{Cs} + 4^{2}_{0}\mathrm{n} \rightarrow ^{141}_{59}\mathrm{Pr} \qquad (3)$$

Transmuted stable Carbon (C) into stable Sulfur (S)

[0095] lines 32 - 39
on patent page 10

$$^{12}_{6}\mathrm{C} \xrightarrow{6^{2}_{0}\mathrm{n}} ^{24}_{12}\mathrm{Mg} \xrightarrow{2^{2}_{0}\mathrm{n}} ^{28}_{14}\mathrm{Si} \xrightarrow{2^{2}_{0}\mathrm{n}} ^{32}_{16}\mathrm{S} \qquad (4)$$

Transmuted stable Strontium (Sr) into stable Molybdenum (Mo)

[0116] lines 1 - 8
on patent page 12

$$^{88}_{38}\mathrm{Sr} + 4^{2}_{0}\mathrm{n} \rightarrow ^{96}_{42}\mathrm{Mo} \qquad (6)$$

Transmuted stable Sodium (Na) into stable Aluminum (Al)

[0163] lines 50 - 55
on patent page 14

$$^{23}_{11}\mathrm{Na} + 2^{2}_{0}\mathrm{n} \rightarrow ^{27}_{11}\mathrm{Na} \xrightarrow{\beta^{-}} ^{27}_{12}\mathrm{Mg} \xrightarrow{\beta^{-}} ^{27}_{13}\mathrm{Al} \qquad (7)$$

August 2015: Japanese government resumed funding LENRs

NEDO organized and funded LENR R&D project with industry & academia

Lattice Energy LLC

Commercializing a next-generation source of safe CO_2-free nuclear energy

New Energy Times reports Japan funding R&D in LENRs

After hiatus of ~20 years government issued RFP that includes LENRs

Ultralow energy neutron reactions could be strategic to Japan's energy security

Lewis Larsen

President and CEO

August 25, 2015

"Japan has little domestic fossil fuel which plays a center role of energy source, and has the vulnerability to depend on import from abroad. It causes Japan to have the energy structure which is easily affected from domestic/international situation of energy. It is essential for security of states to secure stable supply of energy as blood vessel, and this always remains a big issue for Japan. Besides … under … situation where international geopolitical structure faces a big change … circumstance surrounding Japan's energy security becomes severer."

Japan's National Strategic Energy Plan (English translation - April 2014)

Contact: 1-312-861-0115 Chicago, Illinois USA lewisglarsen@gmail.com

http://www.slideshare.net/lewisglarsen/presentations

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-japanese-government-resumes-funding-lenr-research-after-20-year-hiatus-august-25-2015

March 2017: Nissan openly joined NEDO LENR R&D project

NEDO revealed Japan pursuing LENR R&D to develop new energy source

Japanese NEDO confirms Nissan now involved in government-funded LENR research
This is a very significant development

Lewis Larsen, President and CEO, Lattice Energy LLC, March 15, 2017
1-312-861-0115 lewisglarsen@gmail.com

"Lattice commentary: official confirmation by Japanese government's New Energy and Industrial Technology Development Organization (NEDO) that Nissan Group is now jointly involved with Toyota and 4 well-respected Japanese universities in a multi-year Japanese government-sponsored research program about developing ultralow energy neutron reactions (LENRs) for "realization of commercial energy devices" is a very significant development. Note that, for whatever reason, NEDO uses the wordy but innocuous sobriquet "new exothermic reaction between metal and hydrogen" to refer to LENRs." … "As of 2017, NEDO has dropped the mask as to the true intent of Japan's government and corporate LENR R&D programs: it is not just to help clean-up radioactive fission wastes. Its additional, even more important goal is an attempt to develop LENRs as a new type of truly 'green', CO_2-free nuclear energy source."

https://www.slideshare.net/lewisglarsen/lattice-energy-llc-japanese-nedo-confirms-nissan-involved-in-government-funded-lenr-research-march-15-2017

Japan's government targeting commercialization of LENRs

NEDO organized and funded LENR project with industry and academia

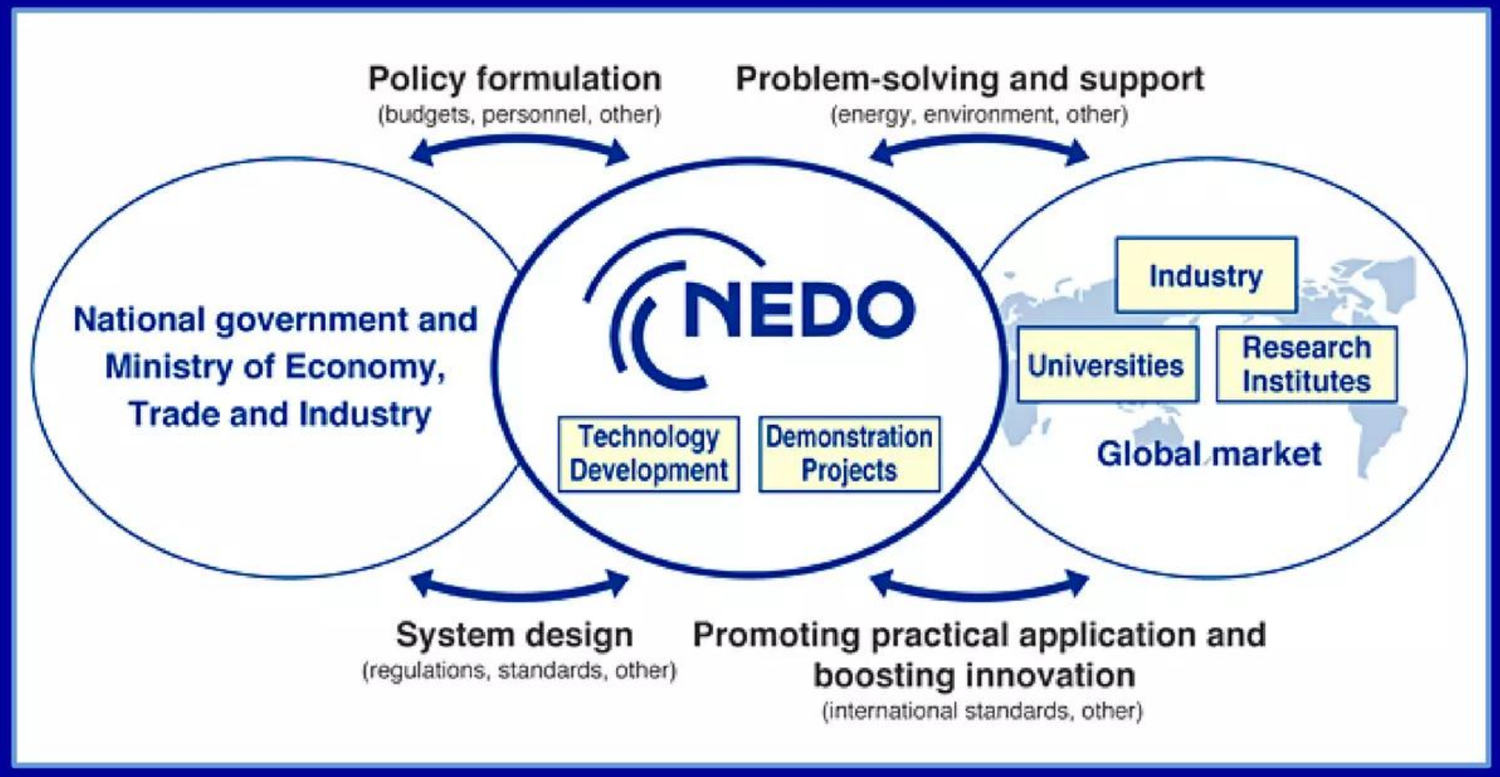
NEDO New Energy and Industrial Technology Development Organization

Combining the efforts of industry, government and academia and leveraging established international research networks, NEDO is committed to contributing to the resolution of energy and global environmental problems and further enhancing Japan's industrial competitiveness

http://www.nedo.go.jp/english/

NEDO's mode of operation – graphic copied from home page of NEDO website

経済産業省 Ministry of Economy, Trade and Industry



MITSUBISHI

TOYOTA

NISSAN

Toyota Motor Co. is principal shareholder of Technova, Inc.

Key area of focus is "… energy for power generation and transportation"

Technova | Inc. 株式会社テクノバ

Technova is a research management organization specialized in research, consulting, and promotional services in the fields of energy & environment, transportation, and advanced technologies.

Name	Technova Inc.
Location	The Imperial Hotel Tower, 13F, 1-1 Uchisaiwaicho 1-chome, Chiyoda-ku, Tokyo, 100-0011, Japan
TEL	+81-3-3508-2280
FAX	+81-3-3508-7578
Established	May 1,1978
Capital	160 million JPY
Principal shareholder	AISIN SEIKI CO., LTD AISIN AW CO., LTD TOYOTA MOTOR CORPORATION

Energy & Environment

We are engaged in topics relevant to primary and secondary energy for power generation and transportation. Our past and ongoing experiences include research on fossil resources, renewable resources, cold fusion, superconductivity technologies, hydrogen energy technologies, and hydrate technologies. In addition to hands-on research, we also have years of experience in project management.

Link to the list of Research Papers on Condensed Matter NuclearScience

http://www.technova.co.jp/english/about/profile.html

http://www.technova.co.jp/pdf/ListofResearchPapersonCondensedMatterNuclear.pdf

Members of NEDO project now working on LENR technology

Technova helps manage and coordinate activities of project for NEDO

NEDO

Technova Inc.

MITSUBISHI

TOYOTA

NISSAN

TOHOKU UNIVERSITY

NAGOYA UNIVERSITY

KOBE UNIVERSITY

KYUSHU UNIVERSITY

Project Leader Akito Takahashi affiliated with Technova Inc.

Posted public information about NEDO LENR project on ResearchGate

Project

ResearchGate

Leading the Japanese Gvt NEDO project on anomalous heat effect of nano-metal and hydrogen gas interaction

Akito Takahashi · · Akira Kitamura · Show all 11 collaborators

Goal: To confirm non-chemical (namely nuclear origin-like) high energy-density heat genration by nano-metal and hydrogen gas inetraction at elevated temperature and to extend R&D program for new hydrogen energy devices.

Akito Takahashi

Technova Inc

Location
Tokyo, Japan

Department
Thermal Energy Technology Group

Position
Prof. Emeritus Osaka University, Senior Advisor

Goal: ”To confirm non-chemical (namely nuclear origin-like) high energy-density heat generation by nano-metal and hydrogen gas interaction at elevated temperature and to extend R&D program for new hydrogen energy devices.”

https://www.researchgate.net/project/Leading-the-Japanese-Gvt-NEDO-project-on-anomalous-heat-effect-of-nano-metal-and-hydrogen-gas-interaction

January 4, 2018: Takahashi posted update on ResearchGate

English summary only 8 pages; Project Report in Japanese is 169 pages

Akito Takahashi
added an **update**

ResearchGate Jan 4

Brief Summary of Final Report on Project 2015-2017

Final formal report of the project 2015-2017 has written in 169 pages text (in Japanese) and sent to NEDO in the end of December 2017. Hopefully, it will be disclosed in near future.

Brief summary in English is uploaded in RG on New Year Day of 2018, as you see below.

See next slide for screenshots of first report page, URL to pdf copy, and Lattice's discussion of its contents

Jan. 2018: Technova posted NEDO project summary report

Trying to obscure clear connection to LENRs by calling it something else

Technical Report | Full-text available

ResearchGate

Brief Summary Report of MHE Project Phenomenology and Controllability of New Exothermic Reaction between Metal and Hydrogen

January 2017 **Date should be January 2018**

DOI · 10.13140/RG.2.2.31393.92006

Projects · Leading the Japanese Gvt NEDO project on anomalous heat effect of nano-metal and hydrogen gas interaction

Akito Takahashi · Akira Kitamura · Koh Takahashi · Show 13 more authors · Hideki Matsune

Abstract: "Project Aim: to verify the existence of new exothermic reaction between nano-metals and hydrogen which will be applicable for future new clean energy source, and to study the controllability of generated thermal energy. In the following, brief summary of implementation and results by MHE-group Japan is described in designated R&D issues for two years project period of 2015 October to 2017 October."

https://www.researchgate.net/publication/322160963_Brief_Summary_Report_of_MHE_Project_Phenomenology_and_Controllability_of_New_Exothermic_Reaction_between_Metal_and_Hydrogen

These scientists working at least part-time on LENR project

Yasuhiro Iwamura, formerly at MHI, now affiliated with Tohoku University

Brief Summary Report of MHE Project Japan for 2015 October - 2017 October ResearchGate

Phenomenology and Controllability of New Exothermic Reaction between Metal and Hydrogen

Akito Takahashi[1], Akira Kitamura[1], Koh Takahashi[1], Reiko Seto[1], Yuki Matsuda[1],
Yasuhiro Iwamura[4], Takehiko Itoh[4], Jirohta Kasagi[4],
Masanori Nakamura[2], Masanobu Uchimura[2], Shunsuke Sumitomo[2], Hidekazu Takahashi[2],
Tatsumi Hioki[5], Tomoyoshi Motohiro[5],
Yuichi Furuyama[6],
Masahiro Kishida[3], Hideki Matsune[3]

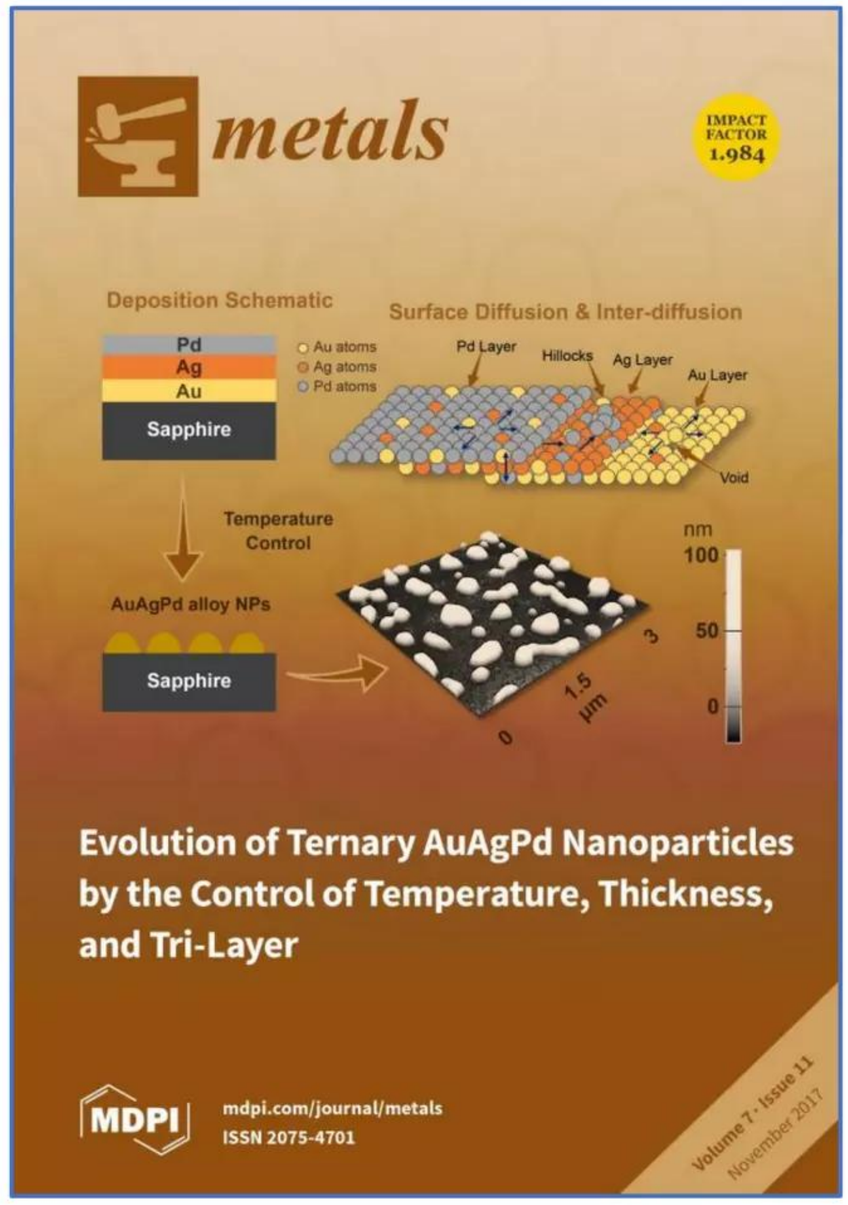
[1]Technova Inc., [2]Nissan Motors Co., [3]Kyushu University, [4]Tohoku University, [5]Nagoya University and [6]Kobe University

NEDO project utilizes standardized experimental methods

LENR test devices: nanocomposite structures with varied compositions

Overview of NEDO project LENR device materials composition and fabrication

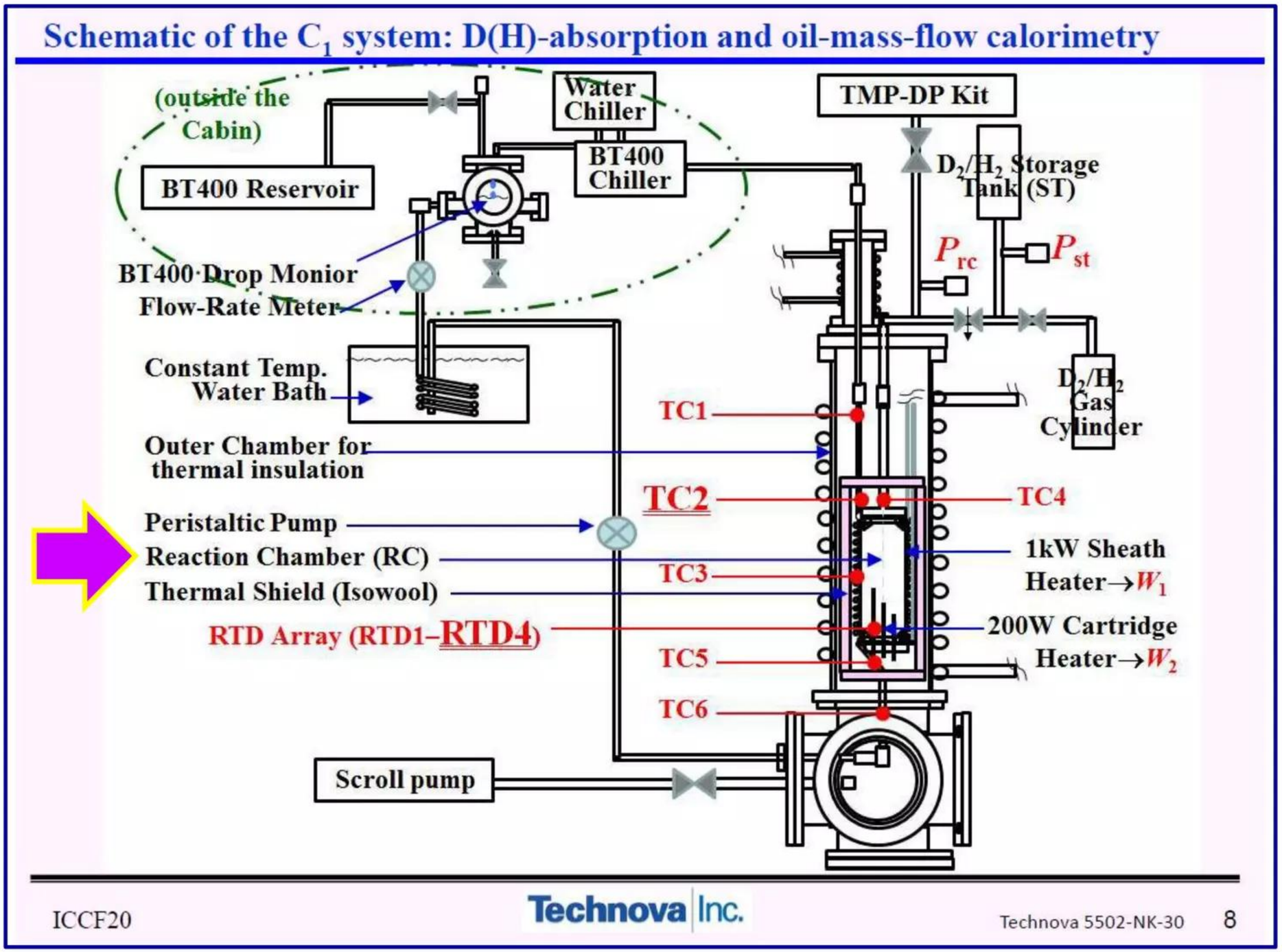
- Designed multi-metallic, nanocomposite LENR test devices comprising alloys of metallic Ni, Pd, Zr, and Cu, with metal-oxide support substrates; fabricated via several well-established methods
- Solid-state LENR devices were amorphous. Had nanometer-scale domains consisting of alloyed metals with various molar ratios. Ni, Pd, Zr will form good hydrides when exposed to Hydrogen
- LENR device types tested: PS (Pd-SiO_2), CNS (Cu-Ni-SiO_2), PNZ (Pd-Ni-Zr), or CNZ (Cu-Ni-Zr) used with either SiO_2 or ZrO_2 support substrates
- LENR test devices were carefully analyzed and characterized before-and-after experimental runs with some or all of following techniques: XRD, SOR-XRD, SOR-XAFS, TEM, STEM/EDS, ERDA, and ICP-MS, among others



NEDO project utilizes standardized experimental apparatus

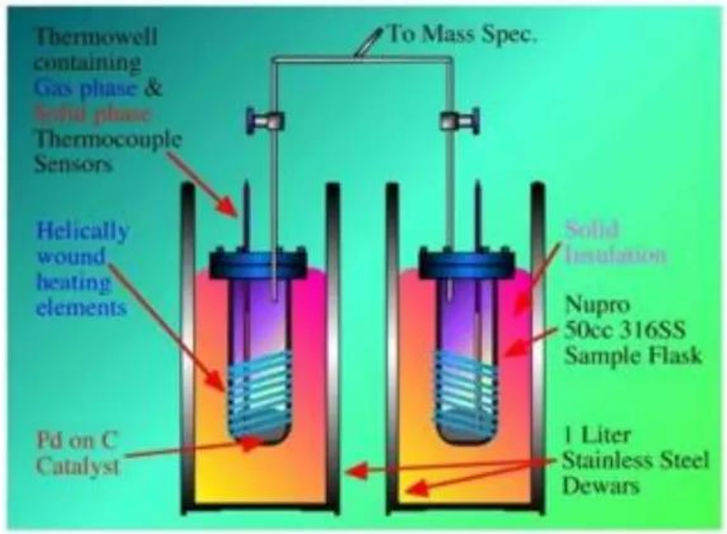
Reaction chamber (RC): capacity 500 cc of D_2 or H_2 gas + LENR materials

Heat gas in RC to working temp; calorimetry measures excess heat output of LENR devices

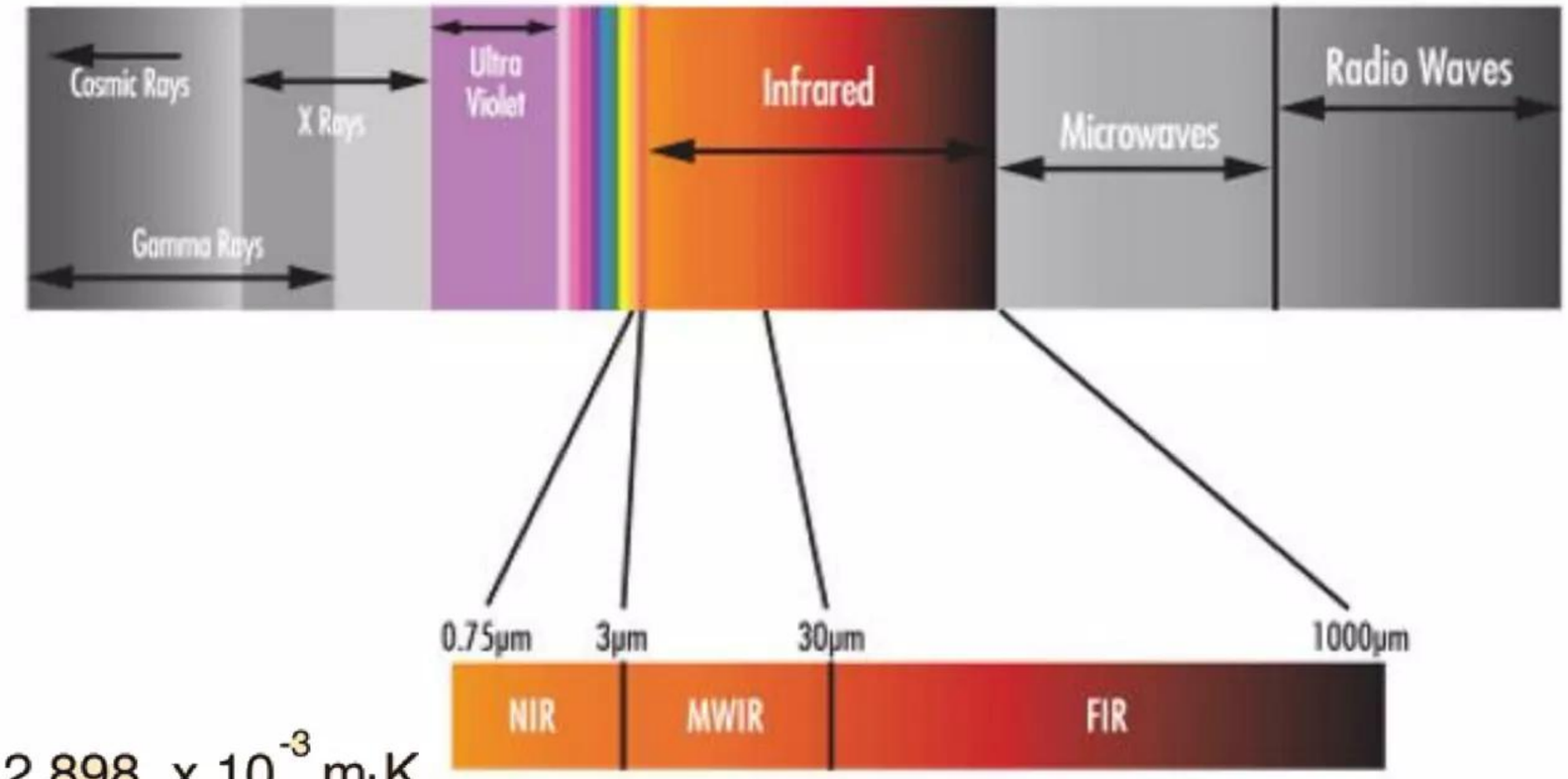


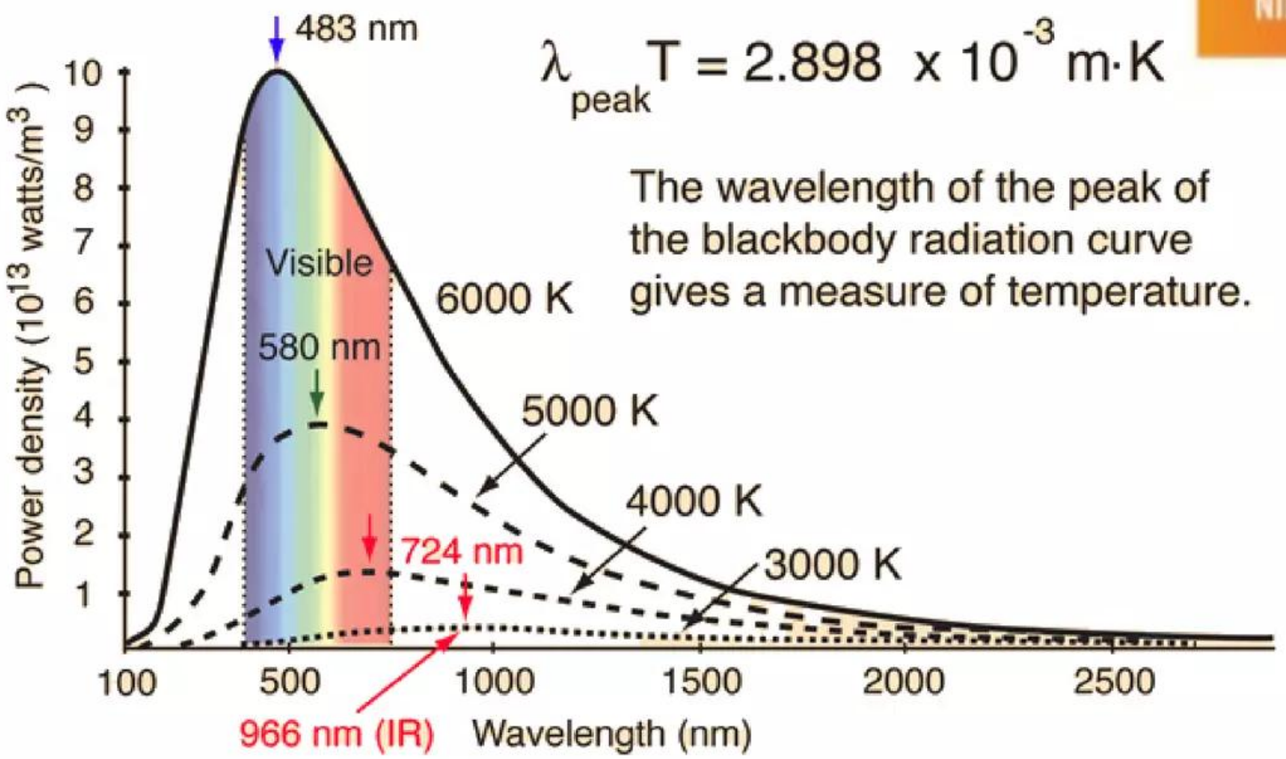
Blackbody radiation inside reaction chamber mainly infrared

Power density of spectral peak for blackbody radiation changes with temp



Source: M. McKubre - SRI International





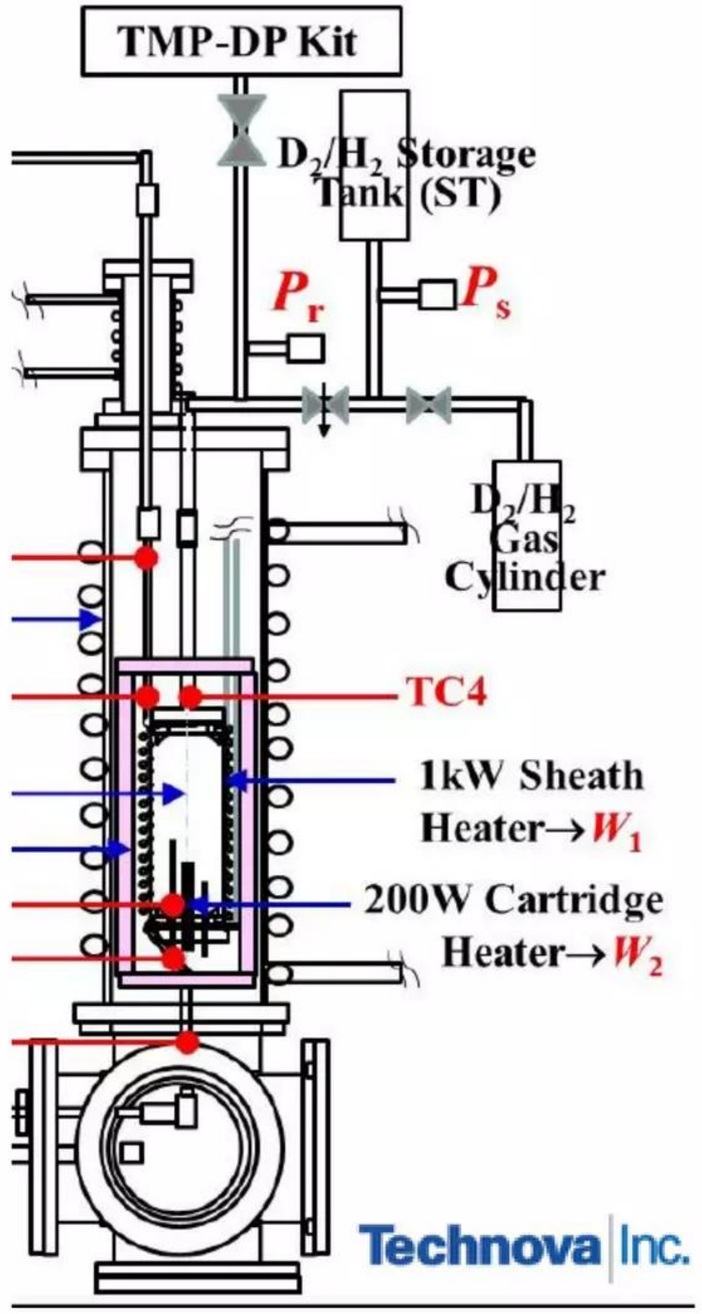
Source: T. Mizuno – Hokkaido University

NEDO project utilizes standardized experimental methods

Apparatus designed to accurately measure excess heat production in RC

Generic overview of experimental run after LENR device materials fabrication

- Non-destructively characterize LENR device materials
- Place LENR device materials in reaction chamber (RC)
- Open valve: admit either 99^{+}%-pure D_2 or H_2 gas into reaction chamber at ~1 atm pressure and room temp; then close valve (RC is sealed); measure excess heat production via calorimetry (tiny values @ room temp)
- Use external heaters to heat reaction chamber up to desired initial working temperature and pressure
- Conduct experimental run for planned period of time: continuously measure excess heat production inside RC via calorimetry (excess heat ≈ measured total thermal output from RC minus total thermal input into RC) for remaining duration of given experimental run
- Stop experiment; remove device materials from RC
- Post-experiment: analyze LENR test device materials



Duplicate experimental apparatus located at two universities

PS-, CNS-, PNZ-, and CNZ-type nanocomposite LENR devices were tested

Quoting directly from page 3 in English version of Jan. 2018 project summary:

"Two MHE facilities at Kobe University and Tohoku University and a DSC (differential scanning calorimetry) apparatus at Kyushu University have been used for excess-heat generation tests with various multi-metal nano-composite samples. Members from 6 participating institutions have joined in planned 16 times test experiments in two years (2016-2017). We have accumulated data for heat generation and related physical quantities at room-temperature and elevated-temperature conditions, in collaboration. Cross-checking-style data analyses were made in each party and compared results for consistency. **Used nano-metal composite samples were PS (Pd-SiO_2)-type ones and CNS(Cu-Ni-SiO_2)-type ones, fabricated by wet-methods, as well as PNZ (d-Ni-Zr)-type ones and CNZ (Cu-Ni-Zr)-type ones, fabricated by melt-spinning and oxidation method."**

Quoting directly from page 5 in English version of Jan. 2018 project summary:

"At the managing office Technova Inc. of this project, 9 R&D discussion/managing meetings were held in 2016-2017. In every meeting, the joint-team members from 6 institutions, MHE-project members and external science advisors have participated for reporting, discussing on latest-obtained results, next experimental plans and tactics towards national project. **For starting national project class R&D activity, the joint team concept with 5 sub-groups of increment of excess heat level, material development, mechanism study, substantial industrial application study and managing/strategy."**

Measured excess heat production of as much as 85 MJ/mol-D

Heat NOT from chemical process: total combustion of D_2 only .286 MJ/mol

Quoting directly from page 3 and 4 in English version of Jan. 2018 project summary:

"Results for elevated-temperature condition: **Significant level excess-heat evolution data were obtained for PNZ-type, CNZ-type CNS-type samples at 200-400°C of RC (reaction chamber) temperature,** while no excess heat power data were obtained for single nano-metal samples as PS-type and NZ-type. By using binary-nano-metal/ceramics-supported samples as melt-span **PNZ-type** and CNZ-type and wet-fabricated CNS-type, **we observed excess heat data of maximum 26,000 MJ per mol-H(D)-transferred or 85 MJ per mol-D of total absorption in sample, which cleared much over the aimed target value of 2 MJ per mol-H(D) required by NEDO.** Excess heat generation with **PNZ-type** samples has been also confirmed by DSC experiments, at Kyushu University, using very small (0.04 to 0.1 g) samples at 200 to 500°C condition. Optimum conditions for running temperature (around 400 degree C) and Pd/Ni ratio (around 1/7-1/10) were obtained by the DSC experiments at Kyushu University to get highest heat flow (power). **We also observed that the excess power generation was sustainable with power level of 10-24 W for more than one month period, using PNZ6 (Pd_1Ni_{10}/ZrO_2) sample of 120 g at around 300°C."**

"Reproducibility at different laboratories: Providing two divided sample powders of **PNZ-type** from same-batch fabricated powder, independent parallel test runs were carried out at Kobe University and Tohoku University. **Results of excess heat generation data from both laboratories were very reproducible for room-temperature and elevated-temperature conditions.** Thus, the existence and reproducibility of new exothermic phenomenon by interaction of nano-metal composite samples and H(D)-gas have been confirmed."

Lattice comments re NEDO January 2018 summary report

Excess heat measurements of MJ/mol of absorbed H / D probably correct

- After review of NEDO project's experimental apparatus and methods, having closely followed prior experimental work of number of its scientists for years, and even knowing some of them personally, Lattice has little doubt about the veracity of their reported results which claim that megajoules of excess heat per mole of H or D were produced in certain experiments. Their published data is therefore believable and was very likely measured with acceptable accuracy
- Two university laboratories, Kobe and Tohoku, produced very similar results using duplicate LENR devices, duplicate experimental apparatus & very same methods of quantitative heat measurement and experimental protocols. In our opinion, this suggests they have achieved reasonable degree of reproducibility
- Complex nanocomposite alloys used in NEDO's LENR test devices relatively well-characterized from materials science perspective; provide exceptionally high surface to volume ratio compared to bulk metals (this is advantageous to maximize Hydrogen loading and hydride formation). They are an improvement over Mitsubishi's metal-oxide fabricated thin-film heterostructures and major advance beyond 99^{+}% chemically pure, single-element, bulk-metallic Pd or Ni LENR cm-scale devices used for decades in many types of LENR experiments
- Technova has uploaded assortment of public documents about NEDO project results to ResearchGate; Lattice will now make note of several selected items

Excess heat production in nanocomposite PNZ-type devices

Palladium (Pd), Nickel (Ni), Zirconium (Zr) - PNZ (Pd-Ni-Zr) and ZrO_2 filler

Presentation | File available

Comparison of excess heat evolution from zirconia-supported Pd-Ni nanocomposite samples with different Pd/Ni ratio under exposure to hydrogen isotope gases

November 2017

DOI · 10.13140/RG.2.2.36364.00644

Conference: JCF18 Meeting, JCFRS

Projects · Leading the Japanese Gvt NEDO project on anomalous heat effect of nano-metal and hydrogen gas interaction

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Akira Kitamura · Akito Takahashi · Koh Takahashi · Show all 17 authors · H Matsune

https://www.researchgate.net/publication/321295906_Comparison_of_excess_heat_evolution_from_zirconia-supported_Pd-Ni_nanocomposite_samples_with_different_PdNi_ratio_under_exposure_to_hydrogen_isotope_gases

Excess heat production in nanocomposite PNZ-type devices

Palladium (Pd), Nickel (Ni), Zirconium (Zr) - PNZ (Pd-Ni-Zr) and ZrO_2 filler

Comparison of excess heat evolution from zirconia-supported Pd-Ni nanocomposite samples with different Pd/Ni ratio under exposure to hydrogen isotope gases

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JCF18 (2017.11.24-25, Sendai)

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Excess heat production in nanocomposite PNZ-type devices

Palladium (Pd), Nickel (Ni), Zirconium (Zr) - PNZ (Pd-Ni-Zr) and ZrO_2 filler

Atomic composition for Pd_1Ni_{10}/ZrO_2 (PNZ6, PNZ6r) and Pd_1Ni_7/ZrO_2 (PNZ7k)

November 2017
DOI · 10.13140/RG.2.2.36364.00644
Conference: JCF18 Meeting, JCFRS

Sample	Mass (g)	Molar ratio				ZrO_2 filler mass (g)
		Ni	Pd	Zr	O	
PNZ6	124.2	**0.318**	**0.032**	**0.650**	0.240	1377
calcined at 450°C·60h		10 : 1				
PNZ6r	131.9	**0.318**	**0.032**	**0.650**	1.03	1378
recalcined at 450°C·60h		10 : 1				
PNZ7k	99.8	**0.306**	**0.044**	**0.650**	0.274	1531
calcined at 450°C·60h		7 : 1				

95% of 500-cc RC was filled with ZrO_2 filler

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Excess heat production in nanocomposite PNZ-type devices

Too much heat for chemistry: behaves as "radiation-free nuclear process"

Summary

Hydrogen isotope absorption and heat evolution have been examined for three kinds of ZrO_2-supported Pd·Ni nanocomposites, PNZ6, PNZ6r, and PNZ7k

- Excess power of 3~24W at elevated temperature of 200~300°C continued for several weeks.
- PNZ6 and PNZ6r samples with Pd/Ni=1/10 generated much higher excess power than PNZ7k with Pd/Ni=1/7
  : Pd/Ni ratio is one of the keys to increase the excess power.
- Maximum specific energy η_{av} > 16 keV/D (1.6 GJ/mol-D), Integrated excess energy = 1 keV/Ni (100 MJ/mol-Ni)
- Impossible to attribute to any chemical reaction, possibly radiation-free nuclear process

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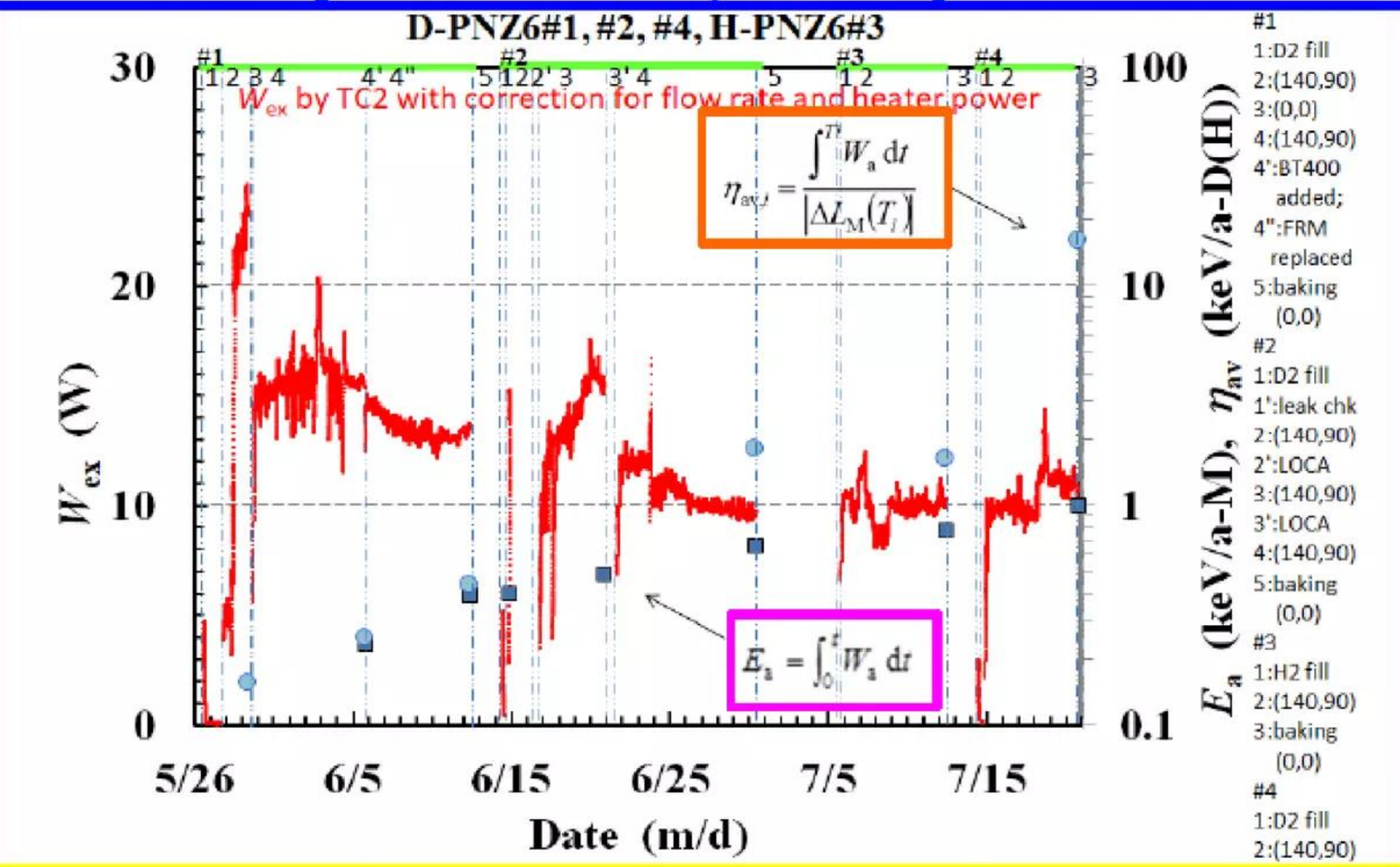
Excess heat production in nanocomposite PNZ-type devices

Excess power > 10 Watts continued for 45 days in one PNZ LENR device

Excess power, W_{ex}, integrated excess heat per metal atom, E_a (keV/a-M), and excess energy per hydrogen isotope atom absorbed/desorbed, $\eta_{av,j}$ (keV/a-D(H)), in RT and ET phases evaluated by TC2 temperature.



- **Excess power W_{ex} exceeding 10 W continued 45 days**
- **$\eta_{av,j}$ exceeded 10 keV/a-D, and E_a reached 1 keV/a-M.**

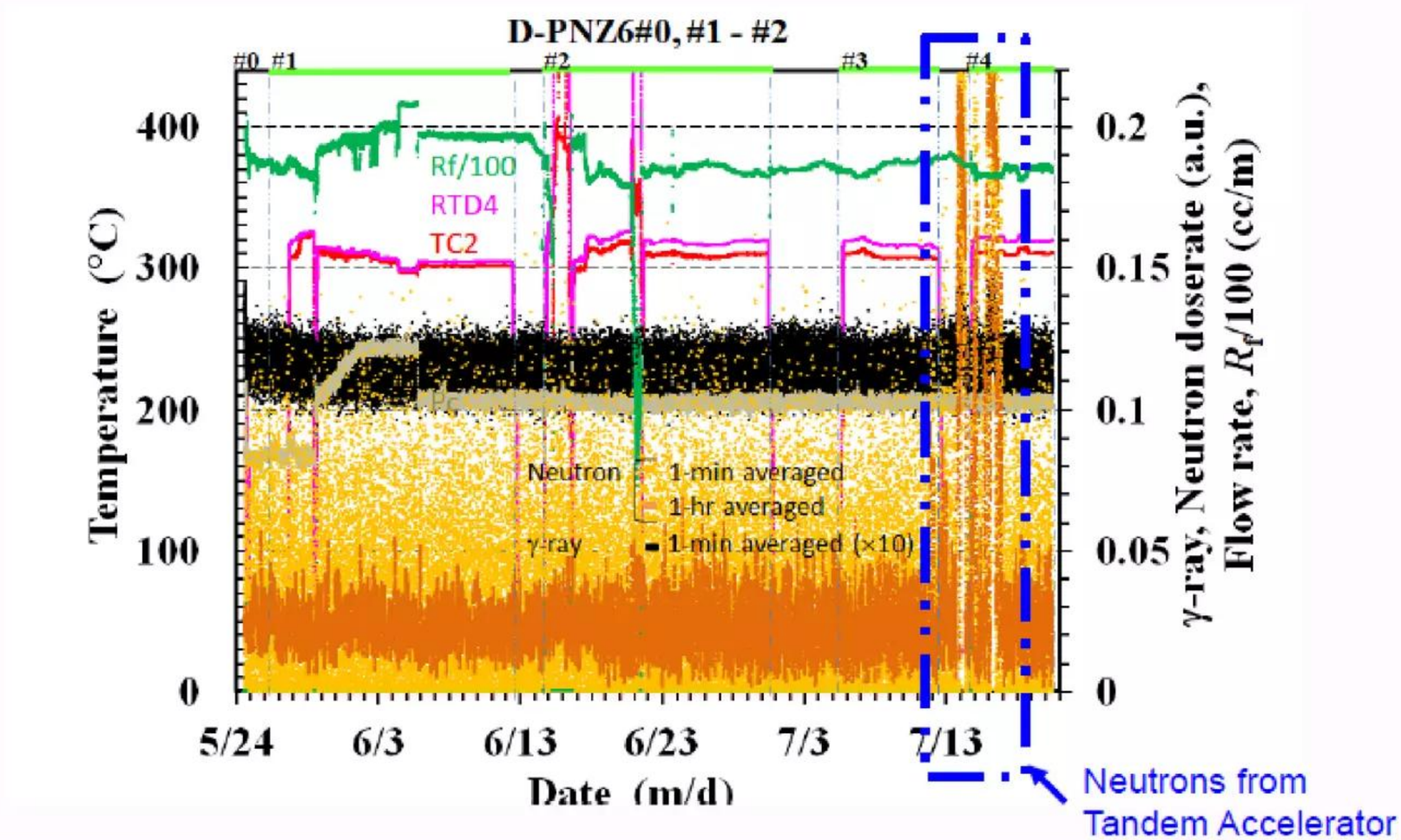
(cf.: 1 eV/atom-M = 0.96E+05 J/mol-M) Technova Inc. 19

https://www.researchgate.net/publication/321295906_Comparison_of_excess_heat_evolution_from_zirconia-supported_Pd-Ni_nanocomposite_samples_with_different_PdNi_ratio_under_exposure_to_hydrogen_isotope_gases

Radiation-free heat producing reactions in PNZ-type devices

No energetic neutron or gamma radiation emitted during heat production

Radiations and flow rate of coolant BT400



▪ Radiation dose rates during large-excess-power phases are almost the same as those during inactive phases, *e.g.*, Jn. 30 – Jy. 5.

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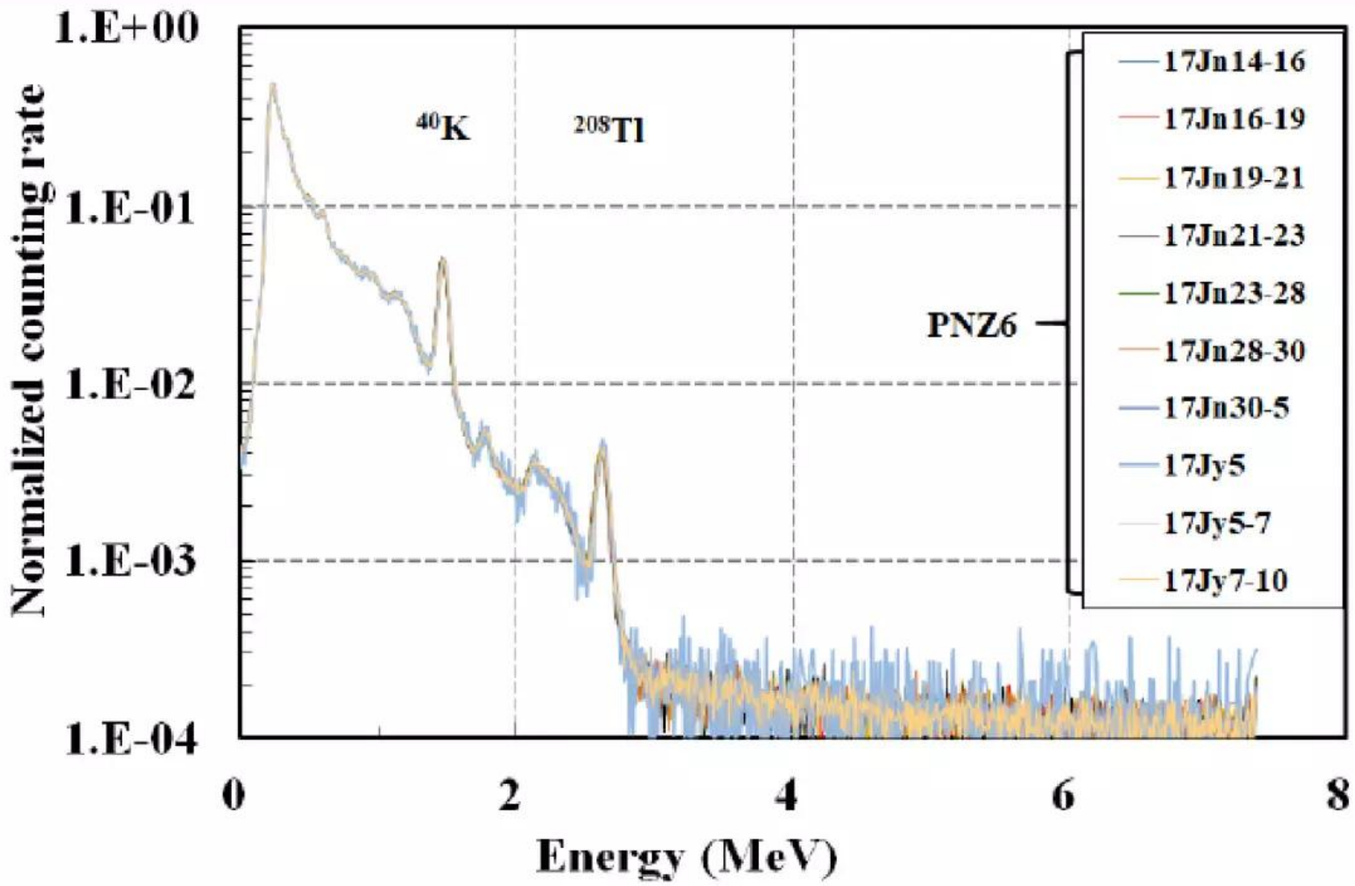
Radiation-free heat producing reactions in PNZ-type devices

No dangerous energetic gamma radiation emitted during heat production

γ-ray spectra



- Spectra during large excess phases are almost the same as those during inactive phases, *e.g.*, Jn. 30 – Jy. 5.

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Japanese have no explanation for absence of deadly gammas

Widom-Larsen theory explains anomaly; see Lattice's 2011 U.S. patent

US #7,893,414 B2: "Apparatus and Method for Absorption of Incident Gamma Radiation and its Conversion to Outgoing Radiation at Less Penetrating, Lower Energies and Frequencies"

Inventors: Lewis Larsen, Allan Widom Issued: February 22, 2011

https://www.slideshare.net/lewisglarsen/us-patent-7893414-b2

- Dynamic process whereby unreacted heavy-mass SP electrons in many-body LENR active sites can actively absorb and directly convert locally emitted or incident gamma radiation into many more less-energetic infrared (IR) photons at high efficiency while, of course, obeying law of conservation of energy (also has tiny, highly variable emission 'tail' in soft X-rays)
- When ULE neutron captures on atom located inside entangled 3-D Q-M domain of LENR active site, there are normally prompt gamma photon emissions by any atom that has absorbed a neutron. Since such capture-related gamma radiation occurs inside 3-D quantum mechanical structure of an ~2-D LENR-active sites, there are always heavier-mass electrons available nearby to absorb and convert such gamma emissions into IR. It does not matter where gamma emission occurs inside sites, it will always be locally converted; same for gammas from β-decays of local LENR transmutation products. **Large fluxes of MeV gammas will not be emitted externally from LENR active sites, no matter what x-y-z direction emission is measured from**

Lattice comments re aspects of NEDO LENR project reports

Transmutation product data wasn't reported; no discussion of active sites

Scientists working on NEDO project plausibly produced substantial amounts of excess heat (e.g. 85 megajoules) from small nanocomposite LENR devices for significant periods of time along with better experimental reproducibility

- **85 megajoules of excess heat per mole of absorbed H or D from ca. 130 gram LENR devices is non-trivial thermal power production.** By comparison, hydride formation (is exothermic) produces ~.0346 MJ/mol; complete combustion of Hydrogen produces .286 MJ/mol; an Iron-Aluminum thermite reaction releases ~.838 MJ/mol. IOW, crude LENR devices produce (85/0.286) = 297x more heat vs. completely combusting the same molar quantity of Hydrogen with Oxygen. Ergo, process producing excess heat in LENR devices cannot be chemical
- What is striking and peculiar about January 2018 summary report and other project reports is absence of any data about detected transmutation products; although, they say mass-spectroscopy (ICP-MS) is routine analytical technique. It is possible such data was deemed technologically sensitive and confidential, and therefore provided only to NEDO in 169-page Japanese language version?
- Another significant absence in NEDO project reports is any discussion about LENR active sites in context of device fabrication and maximization of excess heat output. It is possible they have not focused on active site concepts; or, are actively researching the subject but keeping such information very confidential

Lattice comments re aspects of NEDO LENR project reports

NEDO experimental gas-loading approach foreshadowed by 1990s work

In mid-1990s, report of Italian LENR experimenters using bulk Nickel and Hydrogen gas in heated stainless steel reactor vessel was published in what was then a peer-reviewed publication of the Italian Physical Society:

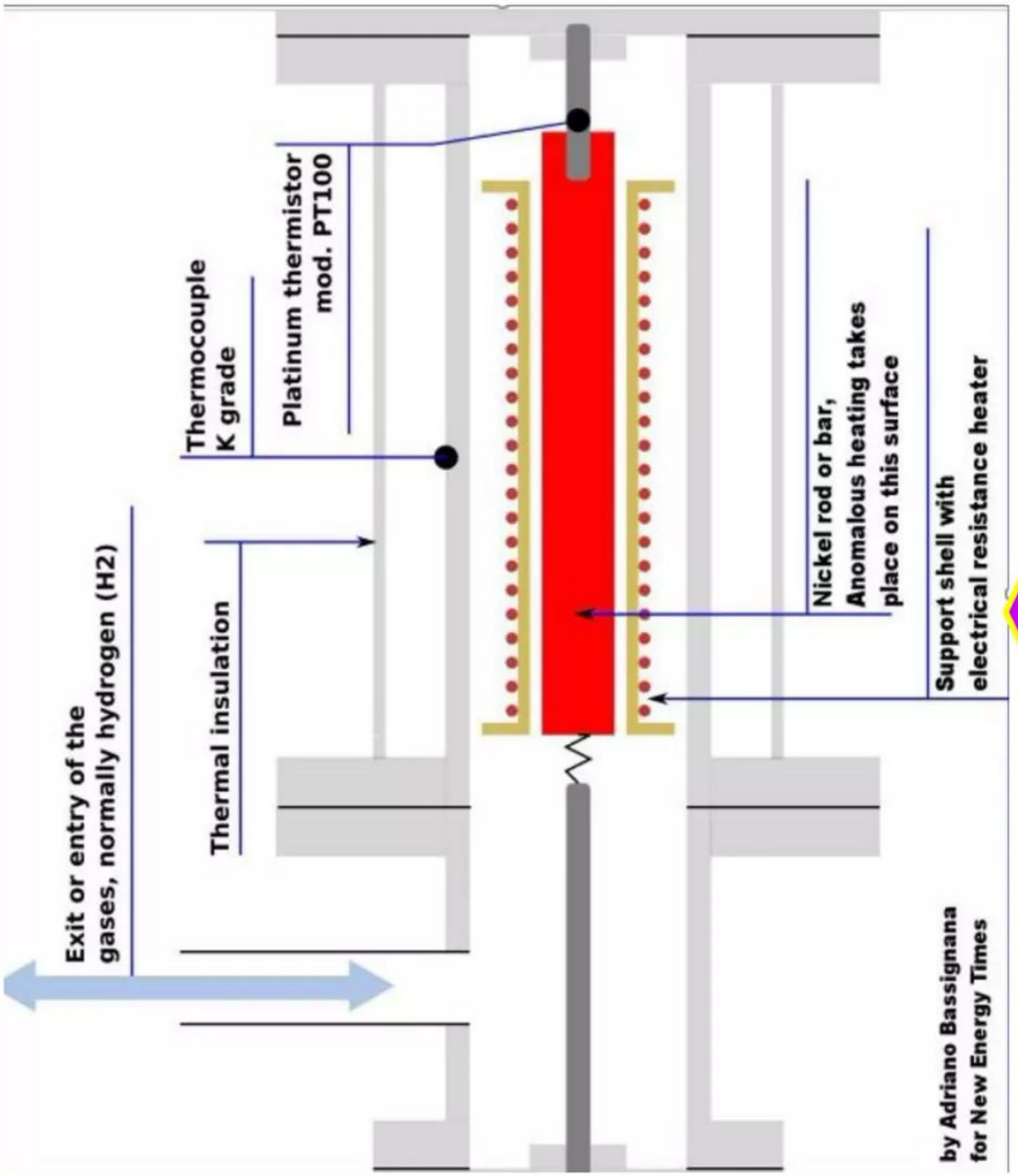
"Anomalous heat production in Ni-H systems"
S. Focardi et al., *Il Nuovo Cimento* 107A pp. 163-167 (1994)
https://link.springer.com/article/10.1007/BF02813080

- **While reproducibility was poor, during certain experiments large amounts of excess heat (up to ~900 megajoules) were plausibly measured with somewhat crude calorimetry over impressively long periods of time (months). NEDO project's calorimetric heat measurements are undoubtedly more accurate**
- **System-startup energy inputs were modest H_2 pressures (mbar up to ~1 bar) with initial heating provided by an electrical resistance heater (Pt heating wire coiled around long axis of ferromagnetic Ni cylinder, or planar Ni bars, attached to three equidistant ceramic support rods)**
- **Experiments exhibiting very large amounts of excess heat production did not produce any large, readily detectible emissions of 'hard' (defined as photon energies of ~1 MeV and higher) gamma radiation. Similarly, energetic MeV neutron fluxes were not detected, nor were significant amounts of long-lived radioactive isotopes --- anomalous absence of dangerous radiation emissions**

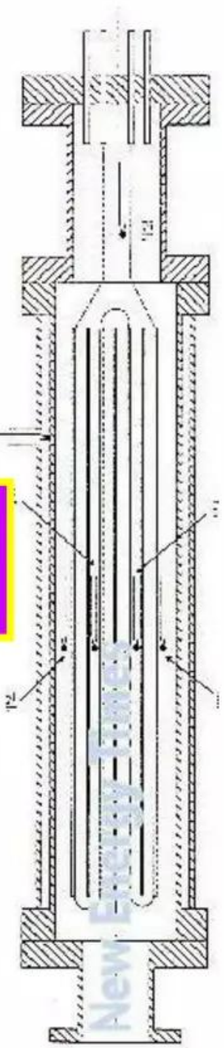
Lattice comments re aspects of NEDO LENR project reports

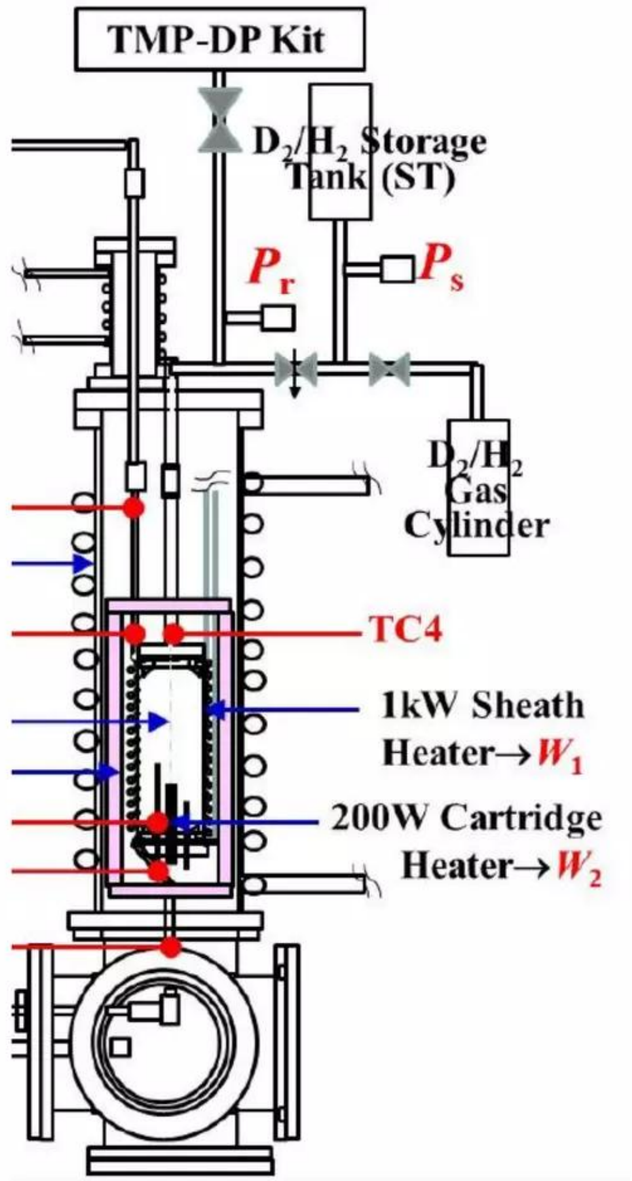
Italians used bulk Nickel rods; NEDO used Ni-Pd-Zr-Cu nanocomposites

1990s Italian bulk Nickel/H_2 gas experiments



NEDO Ni-Pd-Zr/H_2/D_2 gas experiments





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Lattice comments re Focardi et al. experiments in 1990s

Positive thermal feedback effect was observed in certain experiments

- Excess heat production also showed good evidence of positive thermal feedback from 420 - 720° K during some experiments. If these observations were correct, it strongly suggests that walls of stainless steel (SS) reaction vessels behaved as resonant E-M radiation cavities. Thus, LENRs may have turned 'on-and-off' as Nickel surface nanostructures moved in and out of resonance with spectral peaks of temperature-dependent infrared (IR) cavity radiation
- Unlike significant transparency to extremely penetrating hard gamma radiation, SS reaction vessel walls relatively opaque to lower-energy infrared (IR) radiation. Moreover, with thermal conductivity of 12 - 45 W/(m·K) SS vessel walls will retain heat much better than would Copper with a conductivity of 401 W/(m·K)
- When gamma conversion to IR occurs, released nuclear binding energy (in form of IR) can be retained inside reaction vessel cavity and thus be available to heat it further. Specifically, IR can be absorbed by surface plasmons (found on cavity walls and on LENR devices located inside vessel) that can concentrate incident IR energy and then transport it to many-body LENR active sites which can in turn produce more ULE neutrons, and so on. Such a 'virtuous circle' can potentially be realized in properly configured and well-functioning experimental apparatus. Importantly, such a virtuous circle would manifest itself and be experimentally observed as positive thermal feedback, as was reported by Focardi et al. (1994)

Gamma conversion to IR enables + energetic gain with cavity

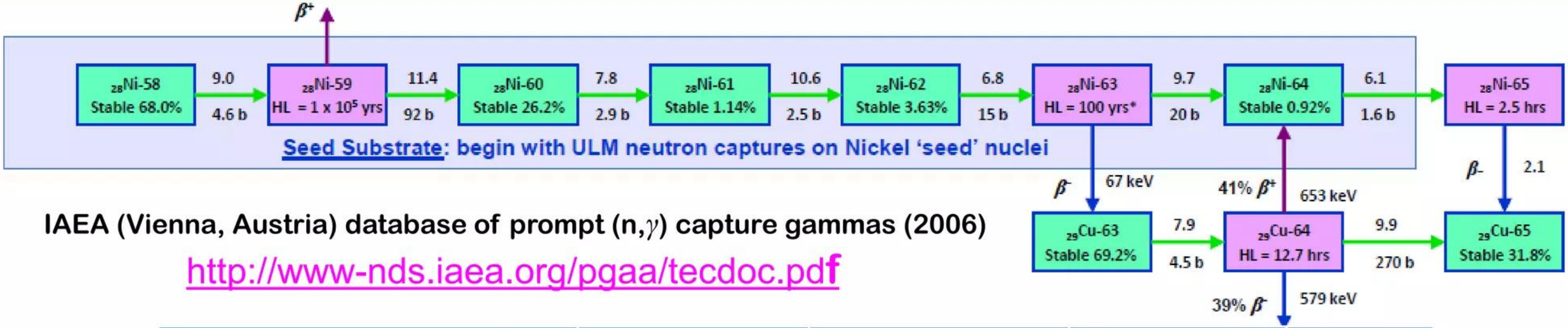
Widom-Larsen theory of LENRs explains results of Focardi et al. (1994)

- What enables virtuous circles of positive thermal feedback is internal gamma to IR conversion --- without it, reactor cavities would be able to readily 'cool' via emission of MeV gamma radiation through vessel walls
- If such a cavity were able to trigger exothermic LENR nuclear reactions that traverse transmutation pathways which provide net cumulative energy gain along the entire path, it would be said to possess positive energetic gain
- In theory, one could design an LENR reactor with accompanying 'fuel' to take advantage of positive gain. External input energy could be used to heat a reactor to its required operating temperature. Once it got going, heaters could be turned-off; reactor could then potentially continue to produce excess heat until usable, available hydrogenous reactants were exhausted
- Example of such a possibility is shown on next PowerPoint slide. Note that prompt gamma ray emission can comprise a substantial percentage of positive Q-values for ULE neutron capture process. Energy associated with gamma emission can comprise vast majority of pathway's total net Q-value of 57.04 MeV as well as for positive total gain across entire pathway of 8.83
- Focardi et al. (1994) results were extremely controversial and theoretically inexplicable until development of Widom-Larsen theory of LENRs. Results can now be explained; see Slides #38 - 44 in April 20, 2011 PowerPoint:

https://www.slideshare.net/lewisglarsen/lattice-energy-llcnickelseed-lenr-networksapril-20-2011

Gamma conversion to IR enables + energetic gain with cavity

Energetics of Nickel seed neutron-catalyzed LENR transmutation network



IAEA (Vienna, Austria) database of prompt (n,γ) capture gammas (2006)

http://www-nds.iaea.org/pgaa/tecdoc.pdf

Isotope capturing ULE neutron or beta decaying	Neutron capture Q-value in ~MeV (all +)	Some of its hard Gamma lines* (MeV)	Energy cost to produce ULE neutrons	Net Q-value per capture
Ni-58	9.0	8.1, 8.5, 8.9	0.78 MeV	8.22
Ni-59	11.4	Not in IAEA	0.78 MeV	10.62
Ni-60	7.8	7.5, 7.8	0.78 MeV	7.02
Ni-61	10.6	Not in IAEA	0.78 MeV	9.82
Ni-62	6.8	6.3, 6.8	0.78 MeV	6.02
Ni-63	9.7	Not in IAEA	0.78 MeV	8.92
Ni-64	6.1	6.0	0.78 MeV	5.32
Ni-65 (decay)	2.1	1.5	~1 (*neutrino)	~1.1*
Totals (MeV)	63.5	NA	6.46	57.04
Gain = (net total Q-value for entire pathway) divided by (total cost) = 8.83				

https://www.slideshare.net/lewisglarsen/lattice-energy-llcnickelseed-lenr-networksapril-20-2011

LENRs are not as exotic a technology as some might assume

Deep causal connections to ordinary chemical and enzymatic catalysis

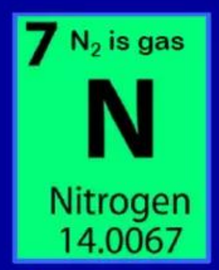
See June 27, 2017 Lattice PowerPoint: "Very high local electric fields ≥ 10^{10} V/m are key to vast increases in reaction rates for chemical catalysis, enzymatic catalysis, and electroweak nuclear catalysis ($e + p$ reaction) in condensed matter."

Lattice Energy LLC

Survival of 40% of world's population crucially depends on higher food production enabled by Ammonia fertilizer produced in large plants via same Haber-Bosch process first commercialized by German company back in 1909

Progress being made with new catalyst technology that could potentially reduce capital and operating costs of future Ammonia plants which would be cost-effective in much smaller sizes that enable distributed production

Very high local electric fields ≥ 10^{10} V/m are key to vast increases in reaction rates for chemical catalysis, enzymatic catalysis, and electroweak nuclear catalysis ($e + p$ reaction) in condensed matter



N_2 very inert

Lewis G. Larsen
President and CEO
Lattice Energy LLC
June 27, 2017
Contact: 1-312-861-0115
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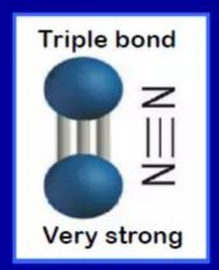


N_2 molecule

https://www.slideshare.net/lewisglarsen/lattice-energy-llc-japanese-confirm-lattice-hypotheses-re-importance-of-adsorbed-protons-and-high-local-electric-fields-in-chemical-catalysis-june-27-2017

Paradigm shifts are " … a new way of seeing things"

"There is a … reason the old [dominant conceptual paradigm] … persists beyond its time, an economic one. Even if a novel principle *is* developed and does perform better than the old, adopting it may mean changing surrounding [economic, academic, and governmental] structures and organizations. This is expensive and for that reason may not happen … another reason is psychological. The old principle lives on because practitioners are not comfortable with the vision – and promise – of the new. Origination is not just a new way of doing things, but a new way of *seeing* things … And the new threatens … to make the old expertise obsolete. Often in fact, some version of the new principle [paradigm] has been already touted or already exists and has been dismissed by standard practitioners, not necessarily because of a lack of imagination. But because it creates a cognitive dissonance, an emotional mismatch, between the potential of the new and the security [and serenity] of the old."

W. Brian Arthur
"The Nature of Technology
What it is and how it evolves"
pp. 139 Free Press (2009)

SPASER (surface plasmon amplification by stimulated emission of radiation) device's local electric fields (2009)

http://opfocus.org/content/v7/s5/opfocus_v7_s5.pdf

Widom-Larsen theory enables commercialization of LENRs

Nanotechnology must be utilized to develop commercial power sources

Large length scales

What was formerly thought impossible becomes possible by utilizing Widom-Larsen and applying nanotechnology

Nuclear-strength electric fields in μ-sized LENR active sites enable $e + p$ reaction

Enormous array of new technological possibilities and opportunities open-up at micron to nanometer length-scales

Widom-Larsen theory enables commercialization of LENRs

Applied nanotechnology and LENRs are mutually joined at the hip

Development risks are reasonable thanks to Widom-Larsen and nanotech

Guided by physics of the Widom-Larsen theory, an opportunity to commercialize LENRs as truly green CO_2-free nuclear energy source has been enabled by a unique juxtaposition of very recent parallel advances in certain very vibrant areas of nanotechnology (esp. plasmonics), quantum entanglement, new innovations in nanoparticle fabrication techniques, as well as an array of new discoveries in advanced materials science.

Simulation of high local electric fields associated with surface plasmon electrons on substrate

Many-body patches of p^+ d^+ form spontaneously on surfaces

Physical size of LENR active sites ranges from 2 nm to 100+ microns

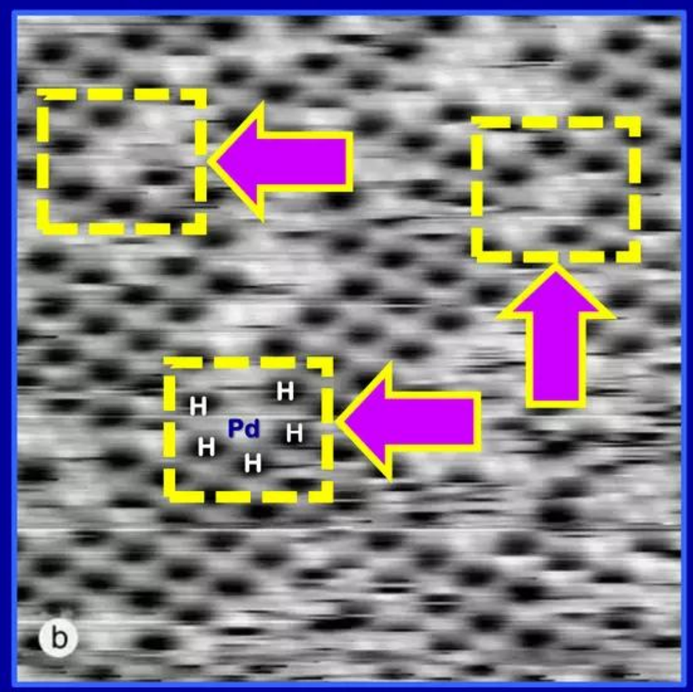
In metal hydrides lattice loading H(D)/metal must be > 0.80 for sites to form

Example shows formation of hydrogenous patches on metallic hydride surface

- **Lattice comment:** image shows small many-body patches of protons on Pd surface. Visual inspection of STM image in adapted version of Fig. 1 reveals that under Mitsui *et al.'s* experimental conditions, PdHx ratios at many surface sites would appear to be comfortably above the minimal critical value of H/Pd > 0.80 known to be necessary for LENR triggering; PdHx H/Pd ratios seen at some sites can apparently range as high as x = 5.0 (see Figure 1)

- **Therefore:** similarly high PdHx ratios would seem to be plausible in the case of high % surface coverage of hydrogen atoms (protons) on fully loaded Pd(111) surfaces at room temperature of 273 K and beyond. **Thus, high PdHx ratios could reasonably be expected to occur within nm to micron-sized, many-body, entangled hydrogenous active sites conjectured in the Widom-Larsen theory of LENRs**

STM image of H on Pd(111) adapted from Fig. 1 in Mitsui *et al.* (2003)



"Hydrogen absorption and diffusion on Pd (111)" T. Mitsui *et al.* *Surface Science* 540 pp. 5 - 11 (2003)

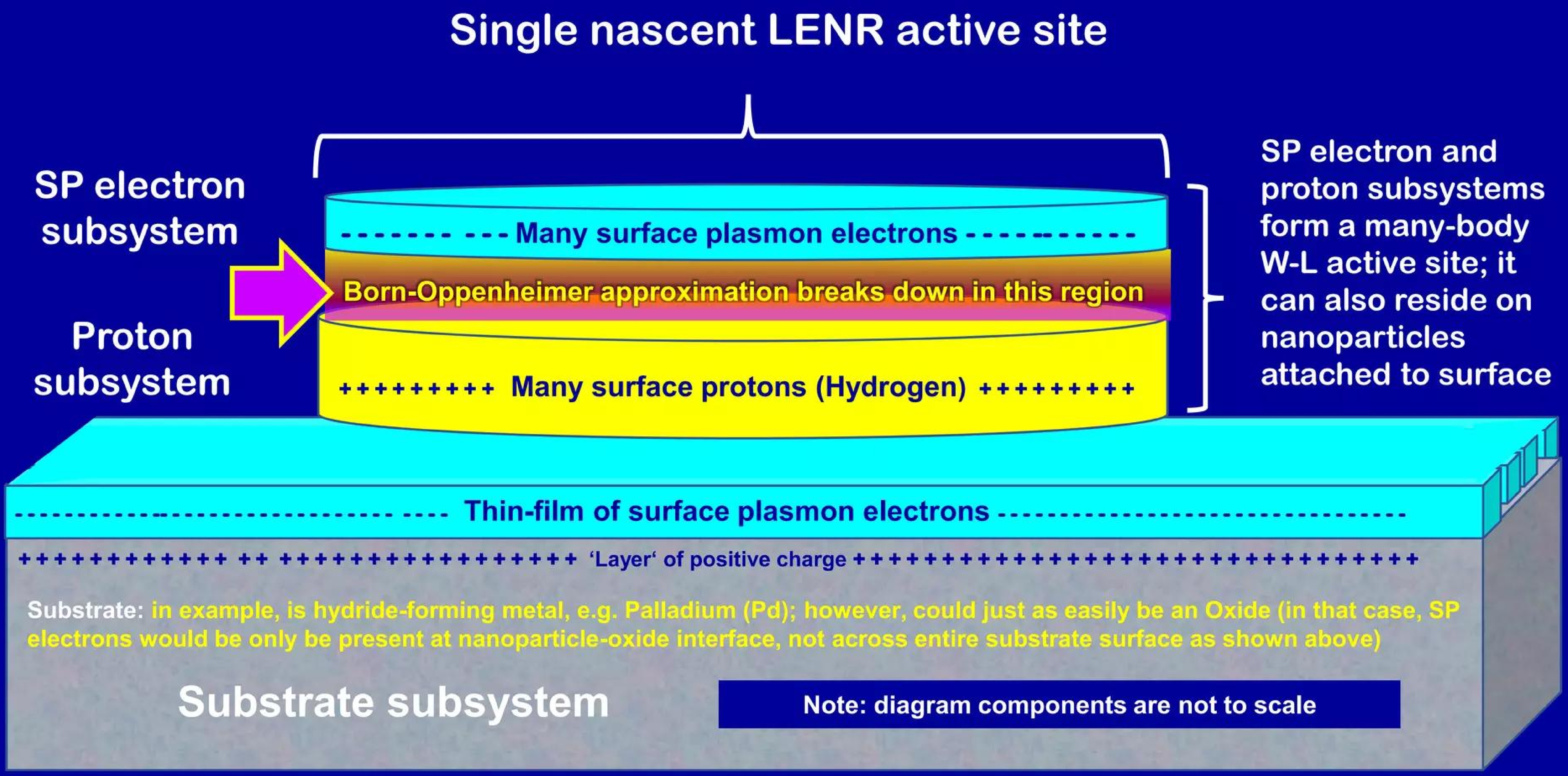
http://www.researchgate.net/publication/229342506_Hydrogen_adsorption_and_diffusion_on_Pd(111)

Lattice concept: LENR active site on surfaces or at interfaces

Comprised of many-body patches of protons and electrons on surface

Mutually quantum-entangled SP electrons and protons oscillate collectively

Sizes of many-body active sites can range from several *nm* up to ~ 100$^+$ microns

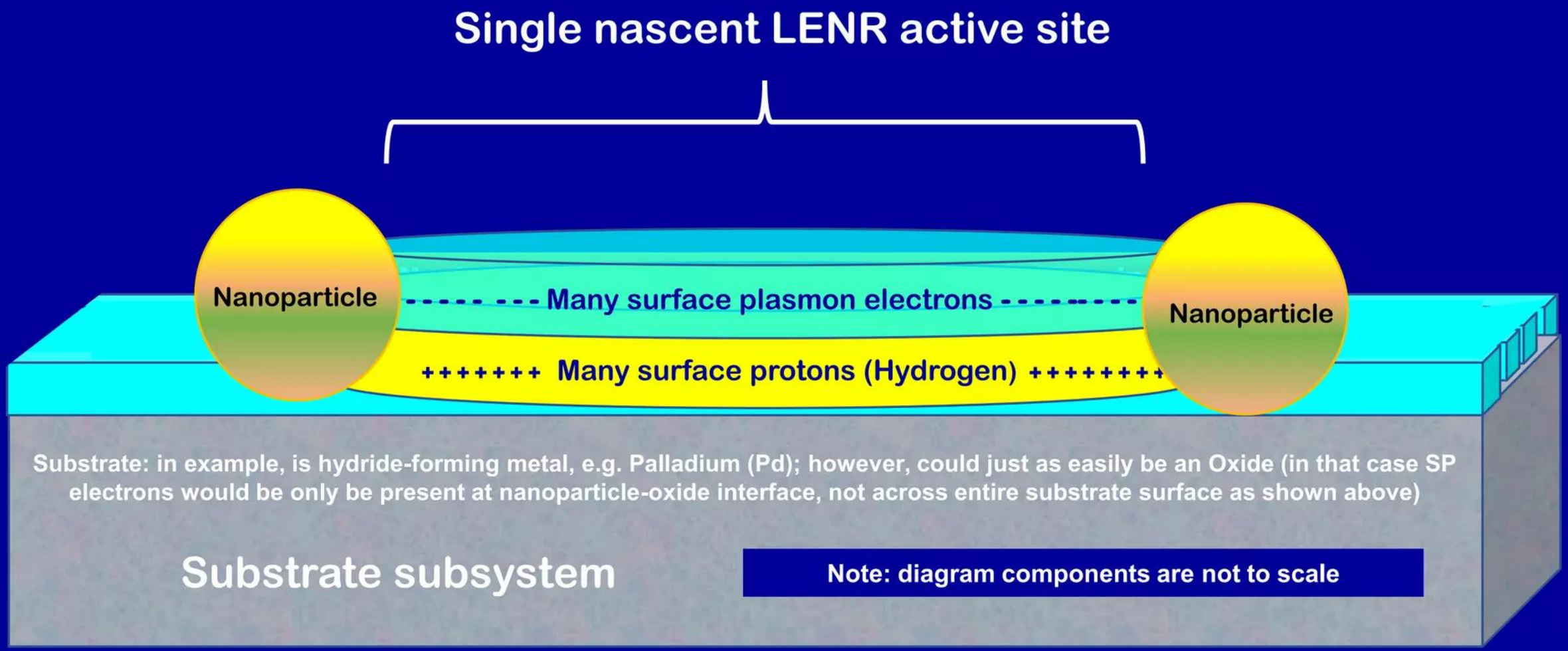


Input energy creates huge electric fields in LENR active sites

Born-Oppenheimer breakdown enables nuclear-strength local E-fields

Huge electric field increases effective masses e^* of some patch SP electrons

Input energy boosts local E-fields to > 2.5 x 10^{11} V/m between adjacent nanoparticles



$$\text{Input energy}_{\text{E-field}} + e_{\text{n}}{}^{-}{}_{sp} \rightarrow e_{\text{n}}{}^{-*}{}_{sp} + p_{\text{n}}{}^{+} \rightarrow n + \nu_e \text{ [condensed matter surfaces]}$$

Heating in LENR active sites can create distinctive 'craters'

Locally produced gammas converted to IR photons by heavy electrons

Ultralow energy neutrons produced & captured close to LENR active sites

After being produced neutrons capture on targets in and around active sites

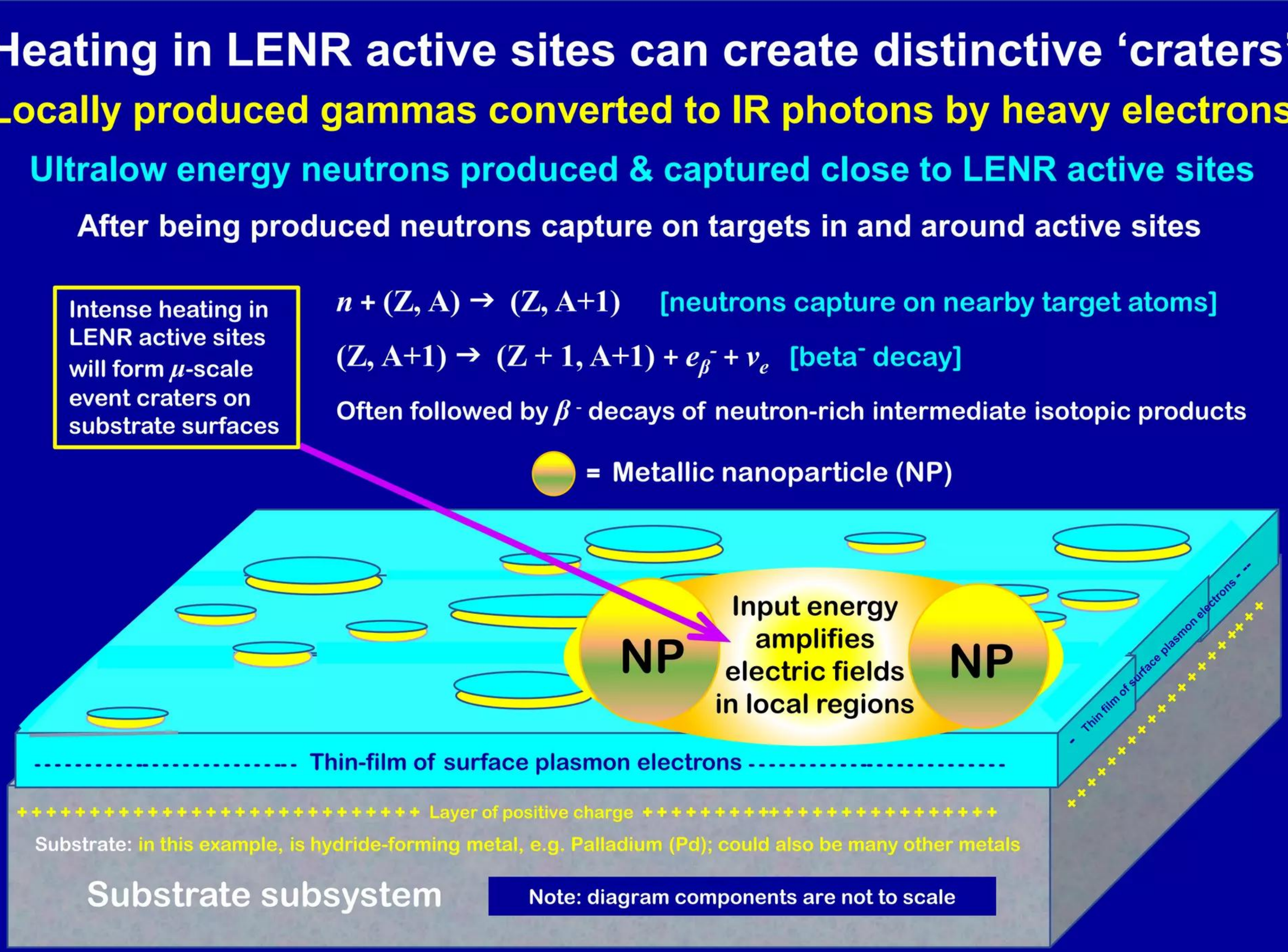
Intense heating in LENR active sites will form μ-scale event craters on substrate surfaces

$n + (Z, A) \rightarrow (Z, A+1)$ [neutrons capture on nearby target atoms]

$(Z, A+1) \rightarrow (Z + 1, A+1) + e_{\beta}^{-} + \nu_e$ [beta$^-$ decay]

Often followed by β^- decays of neutron-rich intermediate isotopic products

= Metallic nanoparticle (NP)

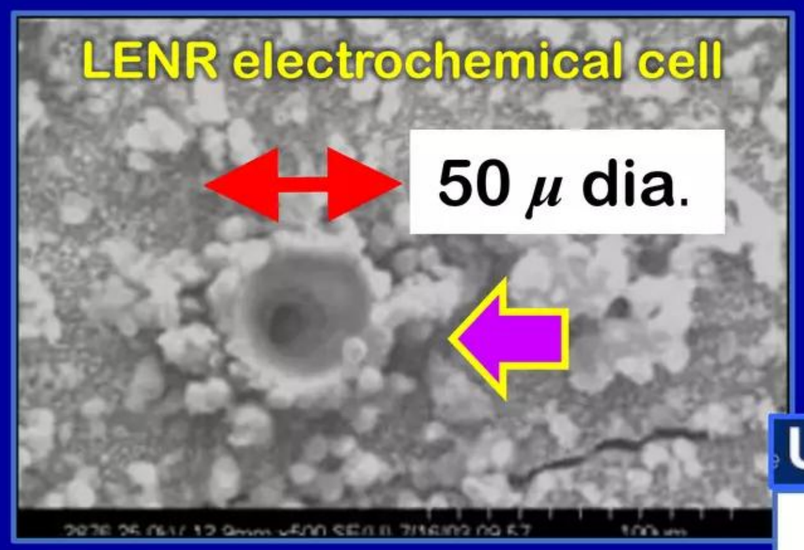


LENRs active site craters can be observed post-experiment

Size of LENR active sites ranges from 2 nanometers to ~100+ microns

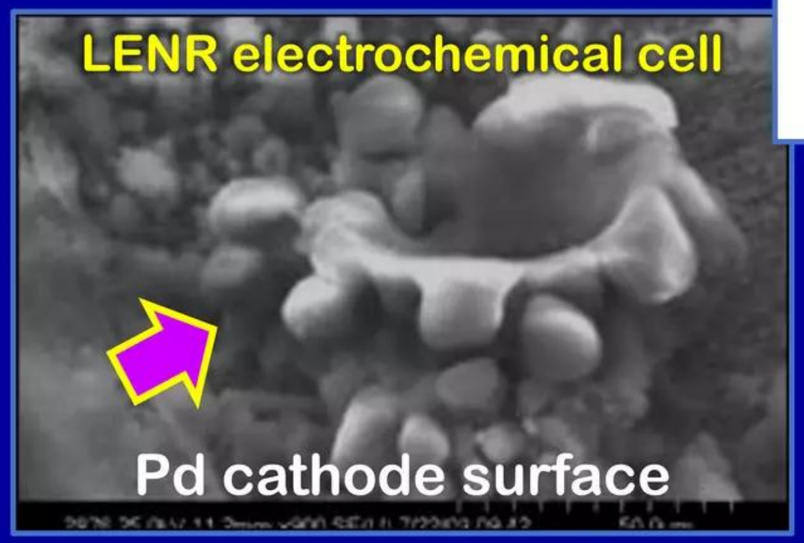
U.S. Navy SEM images of Pd surface; infrared video of working Pd cathode

50 μ LENR active site crater in Pd cathode



Credit: P. Boss, U.S. Navy SPAWAR

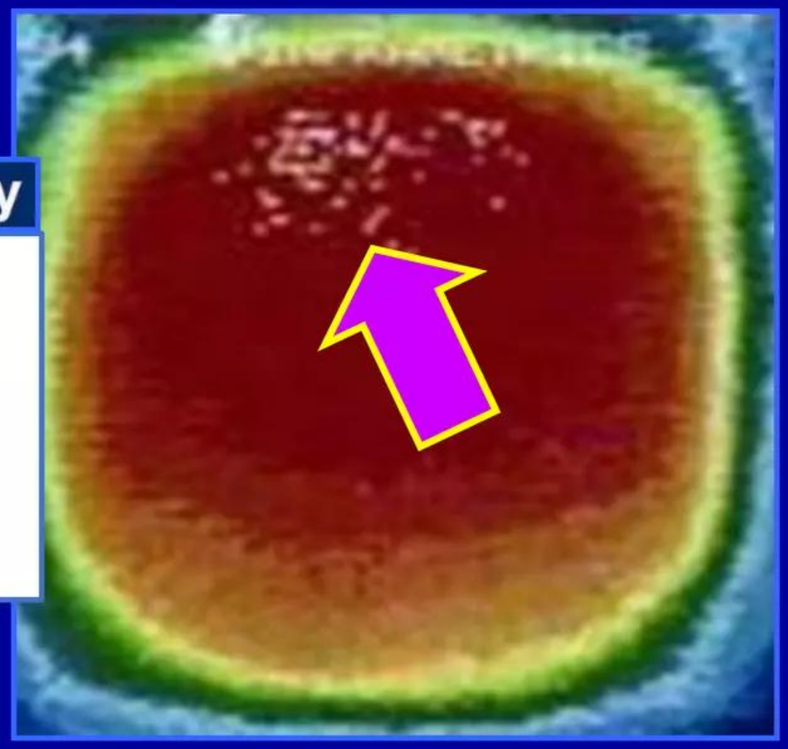
LENR active site crater



Credit: P. Boss, U.S. Navy SPAWAR

United States Navy
SPAWAR
Systems Center
PACIFIC

Infrared video of tiny LENR hotspots
that form spontaneously on Pd cathode
surfaces in aqueous electrochemical cells



http://www.youtube.com/watch?v=OUVmOQXBS68

Credit: P. Boss, U.S. Navy SPAWAR (1994)

Widom-Larsen theory enables commercialization of LENRs

Microscopic reproducibility of active sites is the key to commercialization

Stage of LENR technology is presently TRL-3; existing nanotech can be leveraged

- In present-day's successfully fabricated primitive laboratory devices, LENRs routinely reach temperatures of 4,000 - 6,000^{o} K in relatively small numbers of microscopic LENR active sites located on working surfaces. Evidence for existence of such tiny, very hot localized sites is provided in post-experiment SEM images of working surfaces wherein distinctive crater-like structures are visible. Such features are produced by nuclear heating in μ-scale LENR active sites that create local flash-boiling of metals such as Palladium and Tungsten
- Present stage of LENR technology is TRL-3: trying to now fabricate cm-scale and larger devices that can reliably and controllably produce macroscopically large fluxes of excess heat, "boiling a cup of tea," is suboptimal development pathway
- Main goal should be to first get key LENR effects --- especially excess heat and transmutations --- working reliably on nanoscopic length scales. One must be able to reproducibly create rationally designed nanoparticulate structures with dimensions ranging from nm to microns that are fabricated using selected, off-the-shelf nanotechnology techniques and methods. Such nanostructures are then emplaced, along with suitable fuel nuclei (e.g., Lithium, Carbon, transition metals) close to what will become LENR active sites on device working surfaces

Lattice's LENR engineering program has three key stages

(1) Reproducible fabrication of well-performing LENR active sites

(2) Scale-up heat output by increasing # of active sites per unit area/volume

(3) Select and integrate energy conversion subsystems suitable for specific applications

- **Once microscopic reproducibility of active sites is achieved, output of LENR heat sources could be readily scaled-up,** either by (1) fabricating larger area-densities of affixed nanostructures that facilitate formation of LENR active hot spot sites on device surfaces, or by (2) injecting larger quantities of specially designed target fuel host nanoparticles into volumetrically larger reaction chambers that may contain only gas rich in Hydrogen --- or turbulent dusty plasmas, with or without spatially organized magnetic fields being present
- **Variety of existing off-the-shelf energy conversion subsystems could potentially be integrated with commercial versions of LENR-based heat sources.** These include: thermophotovoltaic; thermoelectric; steam engines; Rankine cycle steam turbines; Brayton cycle gas turbines, simple boilers, etc. **Other more speculative possibilities involve some entirely new types of radical direct energy conversion technologies that are still in early stages of commercial development**

Key conclusions of theoretical paper published in Pramana

Journal is peer-reviewed publication of Indian Academy of Sciences

"A primer for electro-weak induced low energy nuclear reactions"
Y. Srivastava, A. Widom, and L. Larsen in *Pramana* (2010)

"The analysis presented in this paper leads us to conclude that realistic possibilities exist for designing LENR devices capable of producing 'green energy', that is, production of excess heat at low cost without lethal nuclear waste, dangerous γ-rays or unwanted neutrons. The necessary tools and the essential theoretical know-how to manufacture such devices appear to be well within the reach of the technology available now. Vigorous efforts must now be made to develop such devices whose functionality requires all three interactions of the Standard Model acting in concert."

Key publications about Widom-Larsen theory of LENRs

"Ultra low momentum neutron catalyzed nuclear reactions on metallic hydride surfaces"
A. Widom and L. Larsen (author's copy)
European Physical Journal C - Particles and Fields 46 pp. 107 - 112 (2006)
http://www.slideshare.net/lewisglarsen/widom-and-larsen-ulm-neutron-catalyzed-lenrs-on-metallic-hydride-surfacesepjc-march-2006

"A primer for electro-weak induced low energy nuclear reactions"
Y. Srivastava, A. Widom, and L. Larsen (author's copy)
Pramana - Journal of Physics 75 pp. 617 - 637 (March 2010)
http://www.slideshare.net/lewisglarsen/srivastava-widom-and-larsenprimer-for-electroweak-induced-low-energy-nuclear-reactionspramana-oct-2010

"Theoretical Standard Model rates of proton to neutron conversions near metallic hydride surfaces"
A. Widom and L. Larsen
Cornell physics preprint arXiv:nucl-th/0608059v2 12 pages (2007)
http://arxiv.org/pdf/nucl-th/0608059v2.pdf

"Index to key concepts and documents"
v. #20 updated and revised through Jan. 8, 2015
L. Larsen, Lattice Energy LLC, May 28, 2013
http://www.slideshare.net/lewisglarsen/lattice-energy-llc-hyperlinked-index-to-documents-re-widomlarsen-theory-and-lenrs-september-7-2015

Documents about LENRs and Widom-Larsen theory

"Scalability of LENR power generation systems"
http://www.slideshare.net/lewisglarsen/lattice-energy-llc-scalability-of-lenr-power-generation-systems-nov-29-2015

"LENR transmutation of Carbon is superior energy strategy - slashes CO_2 emissions for vehicles as well as electric power generation"
http://www.slideshare.net/lewisglarsen/lattice-energy-llc-lenr-transmutation-of-carbon-better-energy-strategy-than-obama-clean-power-plan-aug-3-2015

"Fossil fuels and nuclear vs. renewables for powering grids with climate change"
https://www.slideshare.net/lewisglarsen/lattice-energy-llc-fossil-fuels-and-nuclear-vs-renewables-for-powering-electricity-grids-during-process-of-ongoing-climate-change-nov-16-2017

"LENR technology's compelling value proposition for oil & gas companies"
Aromatics in oil convert to CO_2-free LENR fuels w. 5,000x > heat vs. gasoline
L. Larsen, Lattice Energy LLC, April 12, 2017 [48 slides - download enabled]
https://www.slideshare.net/lewisglarsen/lattice-energy-llc-lenr-technologys-compelling-value-proposition-for-oil-and-gas-companies-april-12-2017

"Hacking the Atom" (Volume 1 - 484 pages) popular science book
Steven B. Krivit, Pacific Oaks Press, San Rafael, CA, September 11, 2016
Paperback US$16.00; hardcover US$48.00; Kindle US$3.99
https://www.amazon.com/dp/0996886451

Working with Lattice Energy LLC, Chicago, Illinois USA

Partnering on LENR commercialization and consulting on other subjects

1-312-861-0115 lewisglarsen@gmail.com

L. Larsen c.v.: http://www.slideshare.net/lewisglarsen/lewis-g-larsen-cv-june-2013

- We believe Lattice is the world-leader in proprietary knowledge about LENR device engineering required to develop high-performance, long lived, scalable power sources. Our published peer-reviewed theoretical papers rigorously explain the breakthrough device physics of LENR processes, including the absence of dangerous energetic neutron or gamma radiation and lack of long-lived radioactive waste production
- Lattice welcomes inquiries from large, established organizations that have an interest in discussing the possibility of becoming Lattice's strategic capital and/or technology development partner
- Lewis Larsen also independently engages in consulting on variety of subject areas that include: Lithium-ion battery safety issues; long-term electricity grid reliability and resilience; and evaluating potential future impact of LENRs from a long-term investment risk management perspective for large CAPEX projects in the oil & gas, petrochemicals, transportation, utility, and aerospace industries