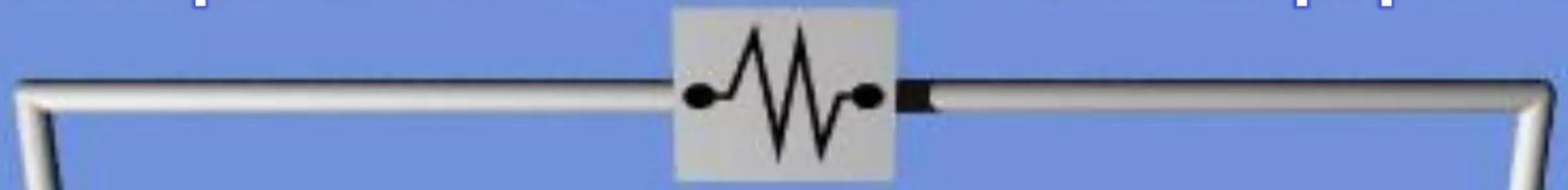
Lattice Energy LLC

Dash et al. published excellent conference paper in 1993



Dash LENR transmutation results effectively confirmed by Mitsubishi in 2012 but predated by Nagaoka in 1925

Mitsubishi changed from gas permeation method used since 2002 to electrochemical permeation more akin to Dash et al.'s experiments. Enabled MHI to aggressively increase their transmutation device product yields by 3 orders of magnitude in 3 years by increasing surface concentrations of e^+d^+ reactants & boosting input energy

Slides #37-43 discuss notable parallels between today's primitive LENR devices and development of transistors in the semiconductor industry

Lewis Larsen
President and CEO
June 24, 2016

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

Image credit:
Alksub at English Wikipedia

Supernovas are not required to produce Gold and Silver

For 60 years, Gold and Silver were elements that most astrophysicists believed could only be created in stars and manmade fission reactors.

Today, the Widom-Larsen theory (WLT) of ultralow energy neutron reactions (LENRs) explains how such precious metals can be produced --- albeit in minute quantities --- by modest DC electric currents running through battery-like, aqueous electrochemical cells operated at ambient temperatures and pressures, not at millions of degrees like a dying star.

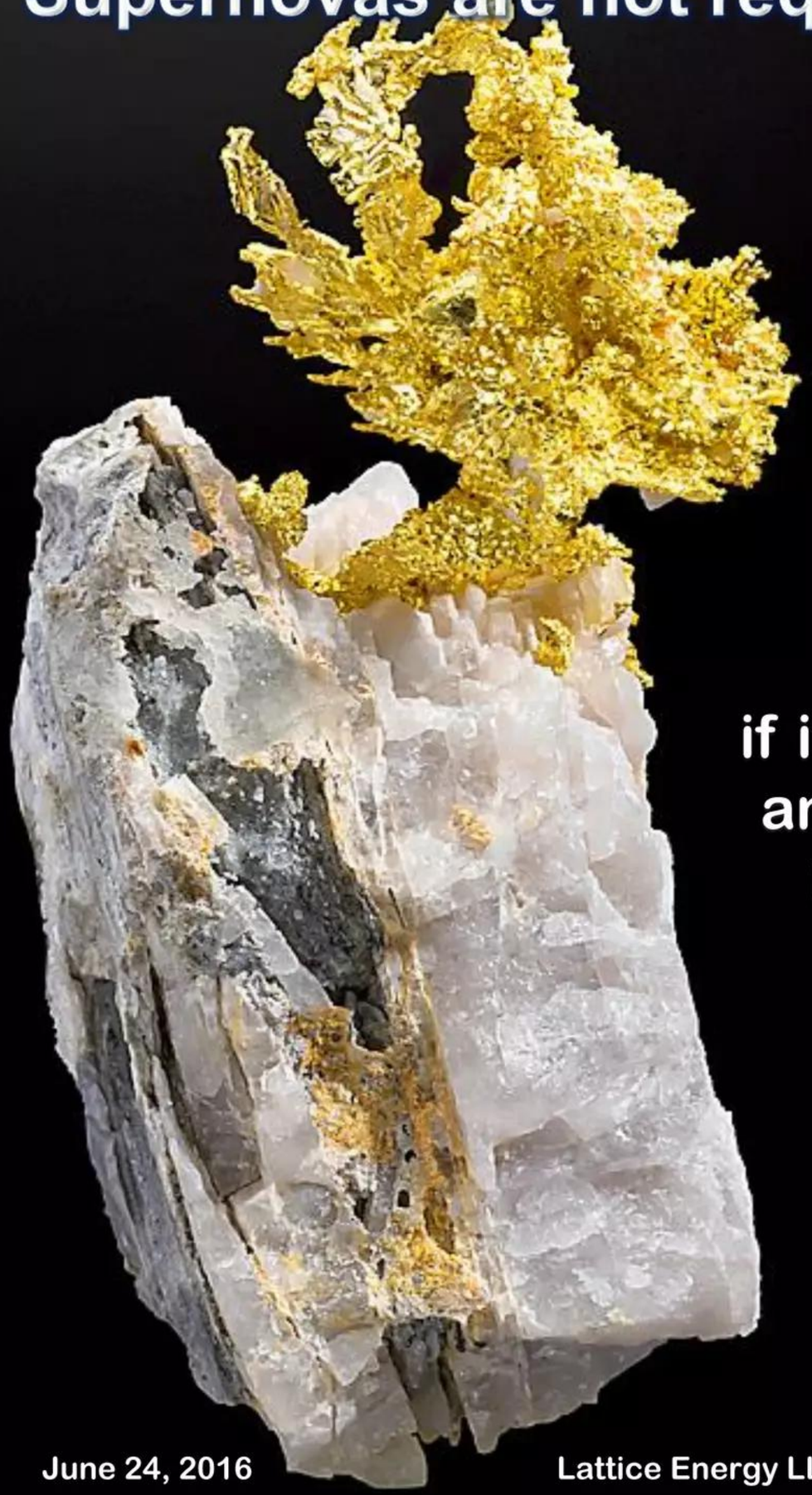
WLT's integration of condensed matter quantum effects with many-body collective physics can explain a large collection of varied anomalous experimental results that has accumulated for 100 years, including experimental data reported by Dash et al. (1993). Viewed through this new breakthrough theoretical lens, long-inexplicable observations as well as Mitsubishi's results are fully understandable on a scientific basis.

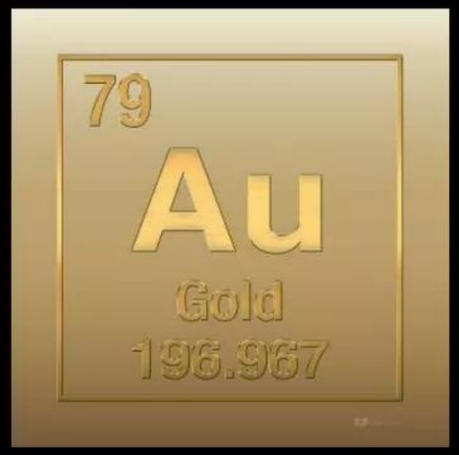
Practical extensions of basic published WLT provide a new conceptual framework that can guide thermal device engineering programs aimed at commercializing LENRs for green, radiation-free power generation.

Credit: NASA - supernova remnant GK Persei from star that exploded back in 1901

Contents

Supernovas are not required to produce Gold and Silver





“Nothing is too wonderful to be true, if it be consistent with the laws of Nature; and in such things as these experiments is the best test of such consistency.”

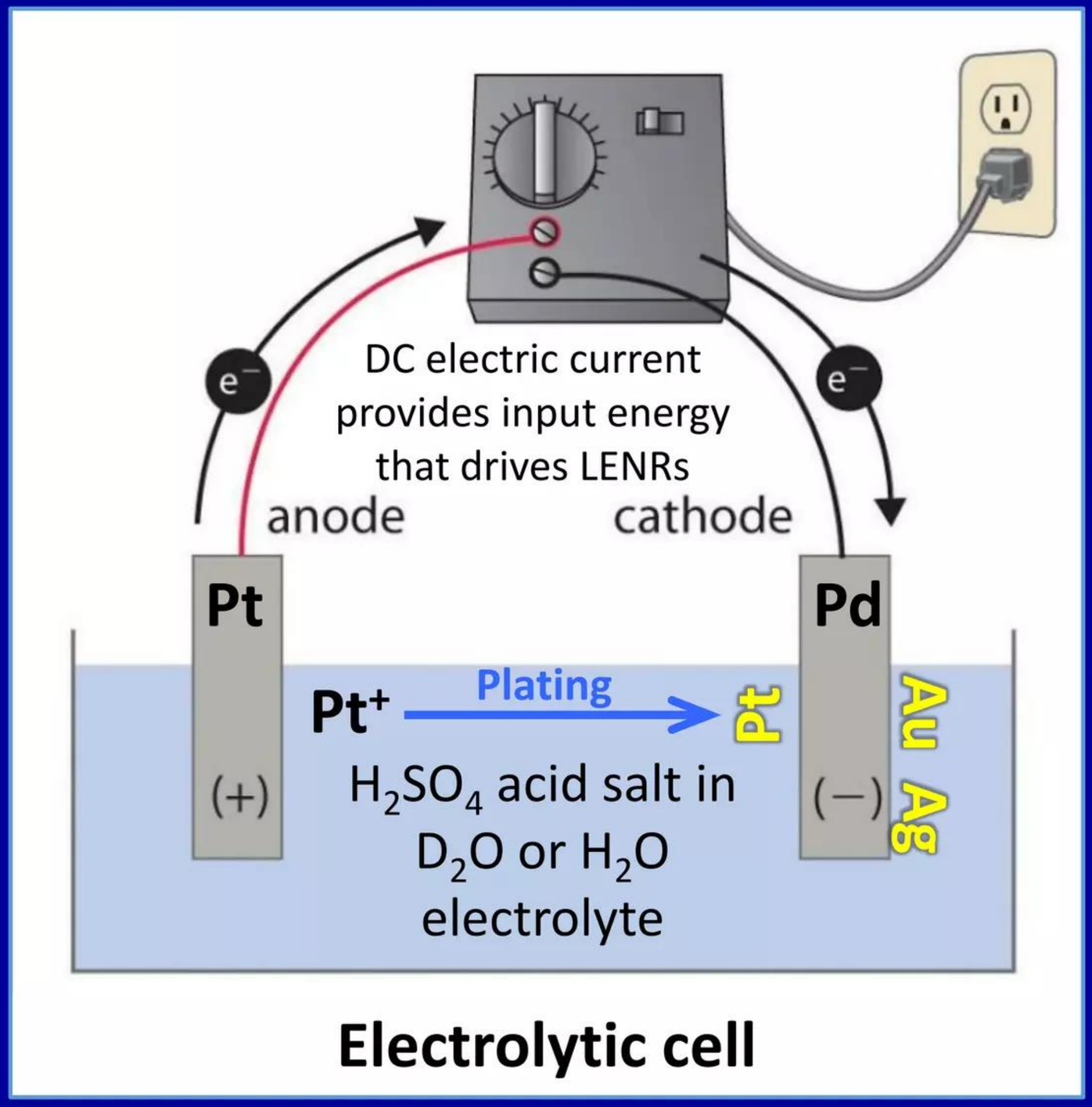
Michael Faraday
Laboratory journal entry #10,040
March 19, 1849

Native Gold on white Quartz
Eagle's Nest Mine, Placer County, California, USA

Widom-Larsen explain transmutation in electrochemical cells

Neutrons drive production of Gold from Platinum & Silver from Palladium

Stars and fission reactors are not required



Electrolytic cell

Transmutation of elements

Electricity provides input energy needed to produce neutrons

78	46
Pt	**Pd**
Platinum	Palladium
195.08	106.42

Neutron capture and beta decay

79	47
Au	**Ag**
Gold	Silver
196.967	107.868

Dash et al.'s results consistent with Widom-Larsen theory

Gold and Silver transmutation products created by LENR neutron capture

Widom-Larsen theory of LENRs in condensed matter systems	
Neutron production reactions	Transmutation of chemical elements/isotopes
Many-body collective electroweak	Neutron captures followed by beta$^-$ decays
H_2O cell: $e^- + p^+ \rightarrow 1\ n^0 + \nu_e$ D_2O cell: $e^- + d^+ \rightarrow 2\ n^0 + \nu_e$	n^0 + isotope of element $(Z, A) \rightarrow (Z, A+1)$ $(Z, A+1) \rightarrow (Z+1, A+1) + e_\beta^- + \nu_e$

Theory vs. Dash et al.'s results with Pt anode; Pd cathode; H_2SO_4 in D_2O or H_2O	
Predictions of Widom-Larsen theory	Experimental results reported in ICCF-4 paper
Per W-L, D_2O cell should produce ~ 2x total number of neutrons made in an H_2O cell; implies:	
D_2O cell should produce more heat vs. H_2O	Yes - more excess heat observed in D_2O vs. H_2O
D_2O should show > transmutations than H_2O	Yes - roughly 2x more Gold made in D_2O vs. H_2O
LENRs occur in areas of high current density	Yes - this observation was noted in their paper
Neutron captures on Pt can produce Gold	Yes - Gold transmutation product was observed
Neutron captures on Pd can produce Silver	Yes - Silver transmutation product was observed
LENR-active sites occupy tiny % of surface	Yes - heat made by estimated 0.4% of cathode

Paper's results consistent with Widom-Larsen LENR theory

Effectively lost since mid-1990s; Larsen recently saw a reference to it

Steven Krivit (New Energy Times) provided copy from document collection

http://newenergytimes.com/v2/library/1993/1993Dash-Surface-ICCF-4.pdf

- ✓ Prof. John Dash, who died on April 13, 2016, taught physics at Portland State University. He was a longtime LENR researcher who published many papers concerning experimental observations of nuclear transmutations in condensed matter systems. This paper was noted in a recent eulogy about John by Dr. Hideo Kozima; it had been effectively lost and simply unavailable since the mid-1990s
- ✓ Experimental data reported by Dash *et al.* in this conference paper presented some 23 years ago is fascinating. While reproducibility of otherwise plausible experimental results (especially with regard to production of excess heat on-demand) was then - and even still remains - a key commercialization issue, the quality and theoretical consistency of this data is excellent and worth examining
- ✓ 1993 was 12 years prior to 2005 arXiv publication of the Widom-Larsen theory of ultralow energy neutron reactions (LENRs) in condensed matter; we explain how neutrons can be created in a collective many-body electroweak reaction that occurs between electrons and protons or deuterons. Twenty-three years ago, Dash *et al.* correctly concluded that "slow neutrons" were key and responsible for creating Gold (Au) and Silver (Ag) transmutation products that were observed in electrochemical cells electrolyzed for 400 hours. However, they mistakenly hypothesized that the neutrons were being produced by a nuclear fusion process

"Surface morphology and microcomposition of Palladium cathodes after electrolysis in acidified light and heavy water: correlation with excess heat"

J. Dash, G. Noble, and D. Dinan

11-page ICCF-4 conference paper: held in Maui, Hawaii (Dec. 6 - 9, 1993)

To view and download a copy of this fascinating paper go to URL:

http://newenergytimes.com/v2/library/1993/1993Dash-Surface-ICCF-4.pdf

Abstract: "Experiments were performed using Pt [Platinum] anodes and Pd [Palladium] cathodes. The electrolyte contained H_2O [light water] and H_2SO_4 in one cell and D_2O [heavy water] and H_2SO_4 in a similar cell connected in series. Excess heat, localized melting, and localized concentrations of Au [Gold] or Ag [Silver] were observed. It is concluded that nuclear fusion is the most probable explanation for the excess heat, localized melting, and localized concentrations of unexpected elements."

Selected excerpts: "After about 400 hours of electrolysis … localized differences in chemical composition also were observed by using an energy dispersive spectrometer (EDS) attached to the SEM [scanning electron microscope]. EDS gives surface analysis to a depth of about 1 μm [one micron] … The spectrum [of the cathode] shows an appreciable amount of Pt and Au in addition to Pd. Similar spectra were obtained from regions C and D. It is likely that Pt is plated from the electrolyte where it occurs due to a slow dissolution of the Pt anode. Au, however, is not expected to come from a Pt anode. Nor is it expected to occur inhomogeneously as an impurity in Pd because Au and Pd are completely miscible [at all ratios] in the solid state."

J. Dash *et al.* - further excerpts from 1993 conference paper

Everything reported in paper is fully explained by Widom-Larsen theory

Selected excerpts continued:

"Similar analysis of the bottom of the heavy water Pd cathode on the concave side also revealed Au in localized regions. The concentration of Au on the heavy water cathode appears to be greater than the light water cathode. For example, analysis of an active area 10^{-3} mm^2 on the heavy water cathode gave 6% Au compared with 3% Au for an active area of the same size on the light water cathode." [~2x as much Au]

"Both cells used the same materials, except that the heavy water cells contained D_2O (Baker Analyzed G210-05) and the light water cell used deionized H_2O. Both cells were electrolyzed for exactly the same time with exactly the same current. Therefore, it is difficult to explain how a greater concentration of Au could be deposited on the D_2O cathode either by plating from there electrolyte or by diffusion from within the cathode." [Answer: Widom-Larsen theory posits D_2O produces ~2x number of neutrons as H_2O; neutron captures transmute atoms and release heat]

"A possible mechanism for the occurrence of Au on these Pd cathodes is transmutation caused by neutrons. The heavy water cell produced more excess heat than the light water cell, and the concentration of Au on the heavy water Pd is greater than that on the light water Pd. If the excess heat was caused by nuclear fusion, then neutrons may have been released. In the presence of hydrogen, transmutation may be greatly enhanced. If a neutron is captured by Pt^{196}, an abundant isotope, it becomes Pt^{197}, which quickly decays to Au^{197}, a stable isotope."

J. Dash *et al.* - further excerpts from 1993 conference paper

Everything reported in paper is fully explained by Widom-Larsen theory

Selected excerpts continued:

"… If 2.5 MeV is released along with each neutron from the assumed fusion reaction, then the energy produced by 6.4×10^{10} events is 2.6×10^{-2} J [Joules]. This means that about 0.6% of the cathode volume would produce about 6.4×10^{5} J excess heat. Transmutation byproducts would be concentrated in minute areas, requiring microscopic analytical techniques such as we have used."

"A possible mechanism for the occurrence of Ag in such areas is transmutation caused by neutrons. For example, if the excess heat observed for the heavy water cell was caused by nuclear fusion, then neutrons may have been released. If a neutron is captured by Pd^{108}, it becomes Pd^{109}, which rapidly decays to Ag^{109}, a stable isotope."

"Gold was found on palladium cathodes from both light water and heavy water cells which had been electrolyzed in series for about 400 hours. More gold was found on the heavy water cathode than on the light water cathode. This seems to correlate roughly with excess heat measurements; i.e., more excess heat was observed for the heavy water cell than for the light water cell. Gold was observed only on the highest current density portions of each cathode, and on a highly convoluted surface."

"The occurrence of gold and silver in these experiments seems unlikely to have been caused by impurities being deposited in the localized, high concentrations which were observed. On the other hand, these elements could have been produced by transmutation if slow neutrons were present."

Condensed matter ultralow energy neutron reactions

LENRs

Image credit: co-author Domenico Pacifici
From: "Nanoscale plasmonic interferometers for multispectral, high-throughput biochemical sensing"
J. Feng *et al.*, *Nano Letters* pp. 602 - 609 (2012)

Laura 13

No deadly MeV-energy gamma radiation

No dangerous energetic neutron radiation

Insignificant production of radioactive waste

Vastly higher energies vs. chemical processes

Revolutionary, no CO_2 , and environmentally green

Fully explained by physics of Widom-Larsen theory

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:

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 will 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**

Electroweak reaction in Widom-Larsen theory is simple

Protons or deuterons react directly with electrons to make neutrons

Need input energy source such as electricity to drive LENR neutron production

electrons + protons (Hydrogen) → neutrons + neutrinos (benign photons, fly into space)

Require source(s) of input energy

Input energy creates electric fields > 2.5 x10^{11} V/m

Collective many-body quantum effects: many electrons each transfer little bits of energy to a much smaller number of electrons also bathed in the very same extremely high local electric field

Many-body collective electroweak neutron production

Heavy-mass e^{-}* electrons react directly with protons

Quantum electrodynamics (QED): smaller number of electrons that absorb energy directly from local electric field will increase their effective masses ($m = E/c^2$) above key thresholds β_0 where they can react directly with a proton (or deuteron) → neutron and neutrino

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

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

Radiation-free LENR transmutation

Neutrons + capture targets → heavier elements + decay products

Neutrons induce nuclear transmutations that release enormous amounts of clean, CO_2-free heat

Many-body collective and quantum effects crucial to LENRs

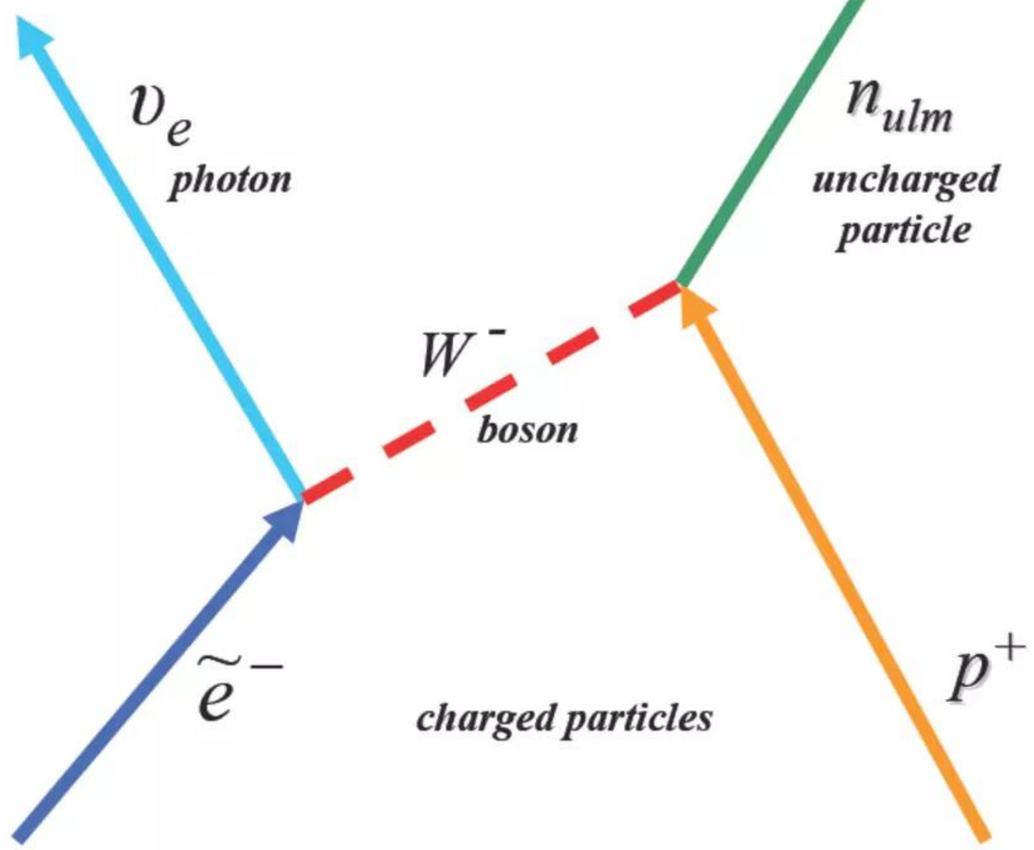
While written as two-body e^- + p^+ reaction, what happens is many-body

Many-body collective effects involve mutual quantum entanglement

What really happens is a many-body reaction amongst entangled particles

This collective electroweak reaction can thus be written as: $e_n + p_n \rightarrow n_{ulm} + \nu_e$

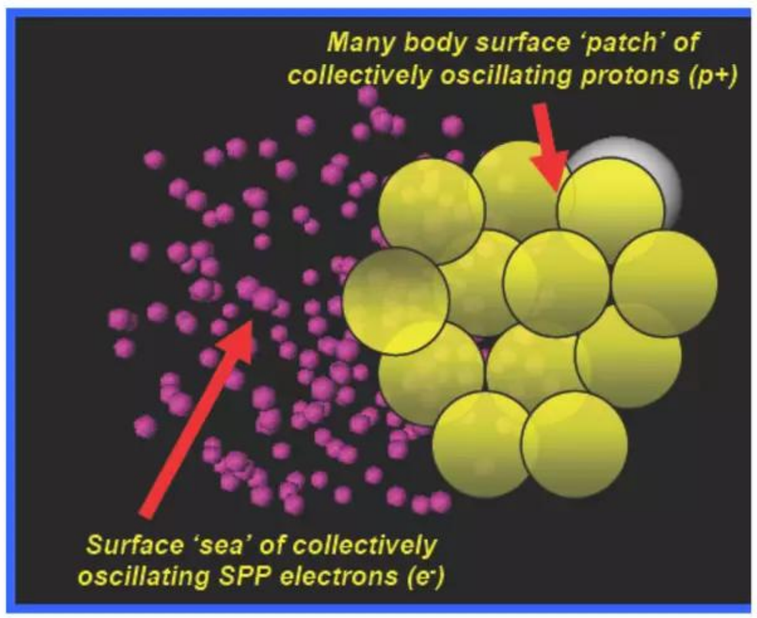
Simple two-body collision shown in Feynman diagram below:



What really happens is many-body process

$$\tilde{e}^- + p^+ \longrightarrow n_{ulm} + \nu_e$$

Now add collective rearrangements from condensed matter effects. It is not just a two body collision !!!



Many-body collective and quantum effects crucial to LENRs

Stars, fission reactors, tokamaks and nuclear explosions not required

Collective many-body transport and concentration of incident E-M energy

- ✓ Under proper conditions, the $e + p \rightarrow n + \nu_e$ (endothermic by 0.78 MeV) electroweak "neutronization" reaction (surface plasmon SP electrons react directly with surface protons to make a neutron and an electron neutrino) can occur at surprisingly high rates. Reaction occurs in micron-scale, monolayer, many-body patches of entangled, collectively oscillating protons or deuterons that form spontaneously on fully-loaded metallic hydride surfaces (this happens when the bulk hydride interstitial sites for Hydrogen as H^+ are all occupied)
- ✓ These surface patch sites range in size from ~2 nm to ~100 microns; they can become LENR-active when sufficient amounts of E-M input energy in proper form is transported to, and concentrated in, them by wide-area film of entangled SP electrons that cover entire surface of a metallic hydride device. Delocalized, entangled π electrons on surfaces of hydrogenated Carbon-based aromatic rings serve same function as SP electrons found on metallic hydride surfaces

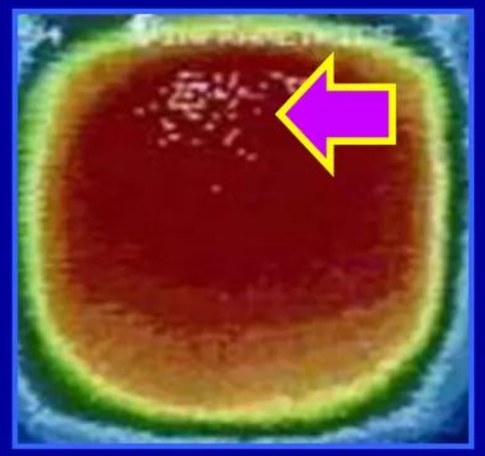
Widom-Larsen provides description for LENR-active sites

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

Active sites have limited lifetimes before being destroyed by fast nuclear heating

- ✓ Per Widom-Larsen theory LENRs occur in localized micron-scale LENR-active sites on ~planar surfaces: at certain types of interfaces\; or curved surfaces of various shaped nanoparticles
- ✓ Tiny LENR-active sites live for less than ~300 - 400 nanoseconds before being destroyed by intense heat; local peak temps range from 4,000 - 6,000° C; LENR-active sites spontaneously reform under right conditions in well-engineered LENR thermal devices
- ✓ Microscopic 100-micron LENR hotspot can release as much as several Watts of heat in < 400 nanoseconds; create crater-like features on surfaces that are visible in SEM images and show evidence for flash-boiling of both precious & refractory metals
- ✓ Extensions to W-L theory's physics have been integrated with unpublished details of Lattice's conceptual model for LENR-active sites. This company proprietary knowledge allows vastly better selection of nanostructural materials, channeling of very complex LENR transmutation networks, and choice of best fuel target elements. Also enables computer-aided design and very realistic simulation of fabricated nanostructures optimized for rapid formation and predictable operation of LENR-active sites

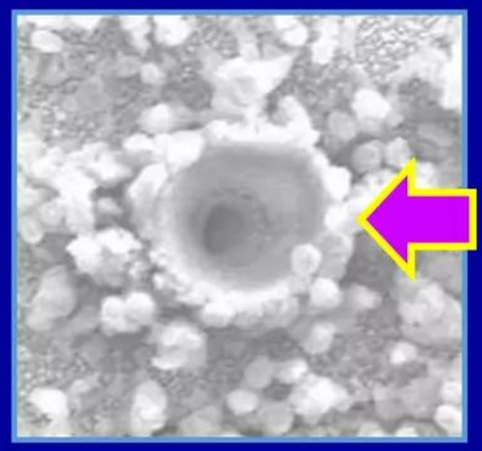
LENR hotspots on Pd cathode
Infrared video of LENR hotspots



Credit: P. Boss, U.S. Navy

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

100 μ LENR crater in Pd cathode
LENR electrochemical cell



Credit: P. Boss, U.S. Navy

Condensed matter LENR-active sites size from 2 nm to ~100μ

LENRs create heterogeneous elemental compositions on μ length-scales

Mitsubishi Heavy Industries has observed this effect while transmuting Cs → Pr

$$^{133}_{55}Cs \rightarrow {}^{141}_{59}\mathrm{Pr}$$

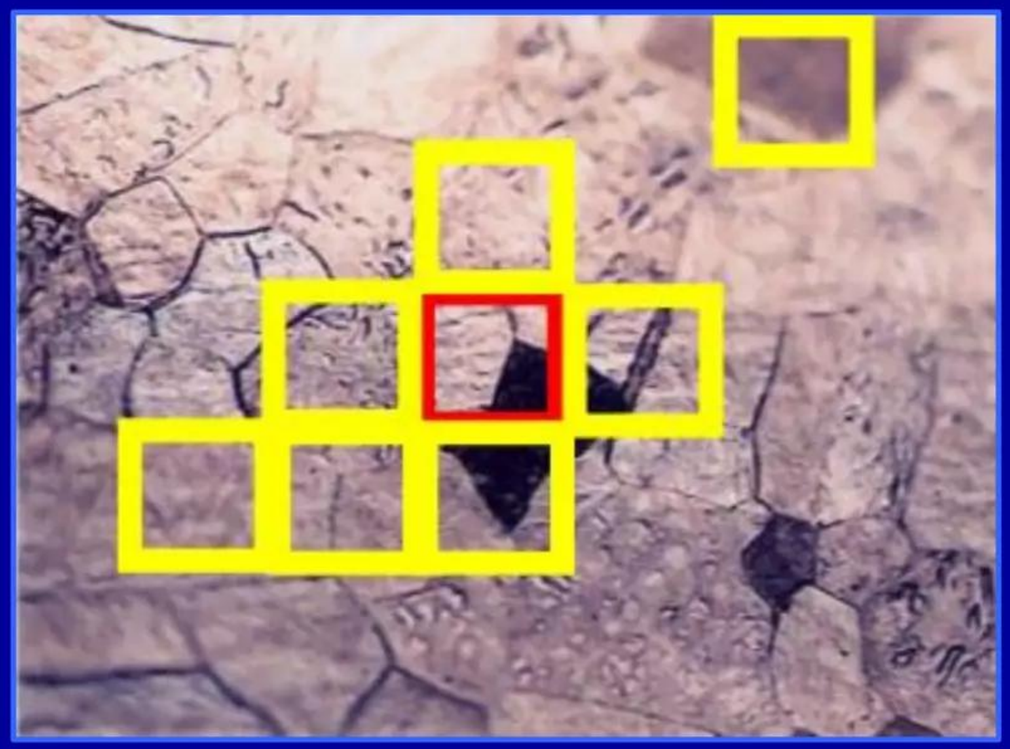
MITSUBISHI HEAVY INDUSTRIES, LTD.
Our Technologies, Your Tomorrow

Implanted Cesium

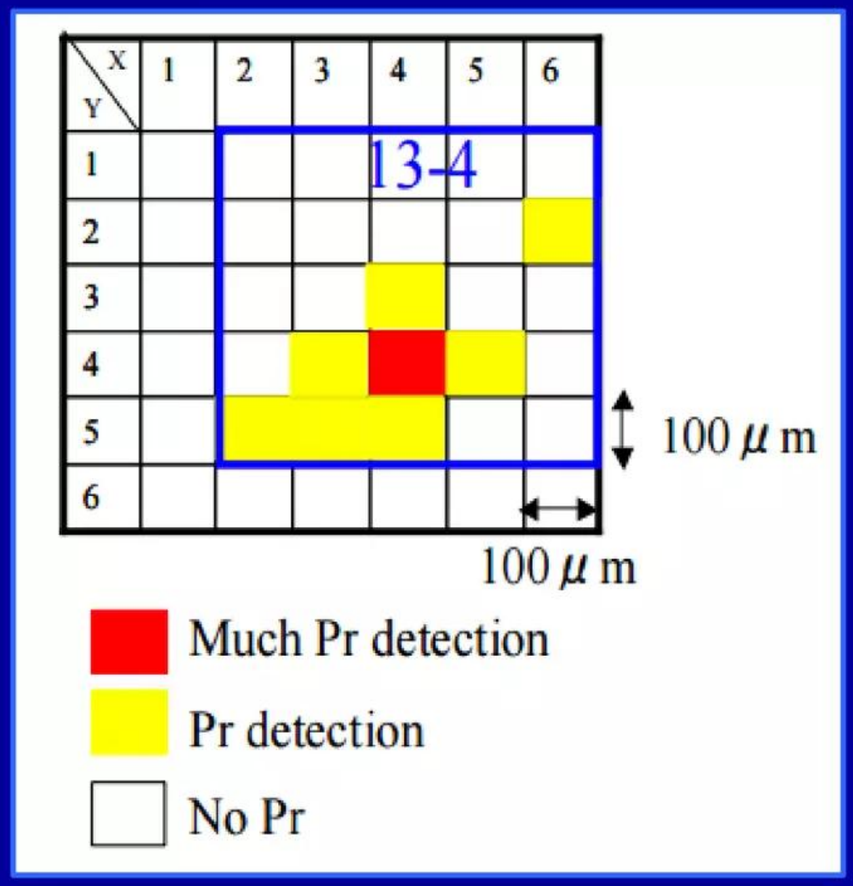
↓

Praseodymium

Surface of thin-film Pd/oxide heterostructure after experiment



Credit: Mitsubishi Heavy Industries



See Slide #44 in the following Mitsubishi PowerPoint conference presentation (2013):

http://tinyurl.com/zcr3azt

Neutrons are charge-neutral; atoms readily absorb them

Capture of neutrons by atoms will transmute them into other isotopes

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

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

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

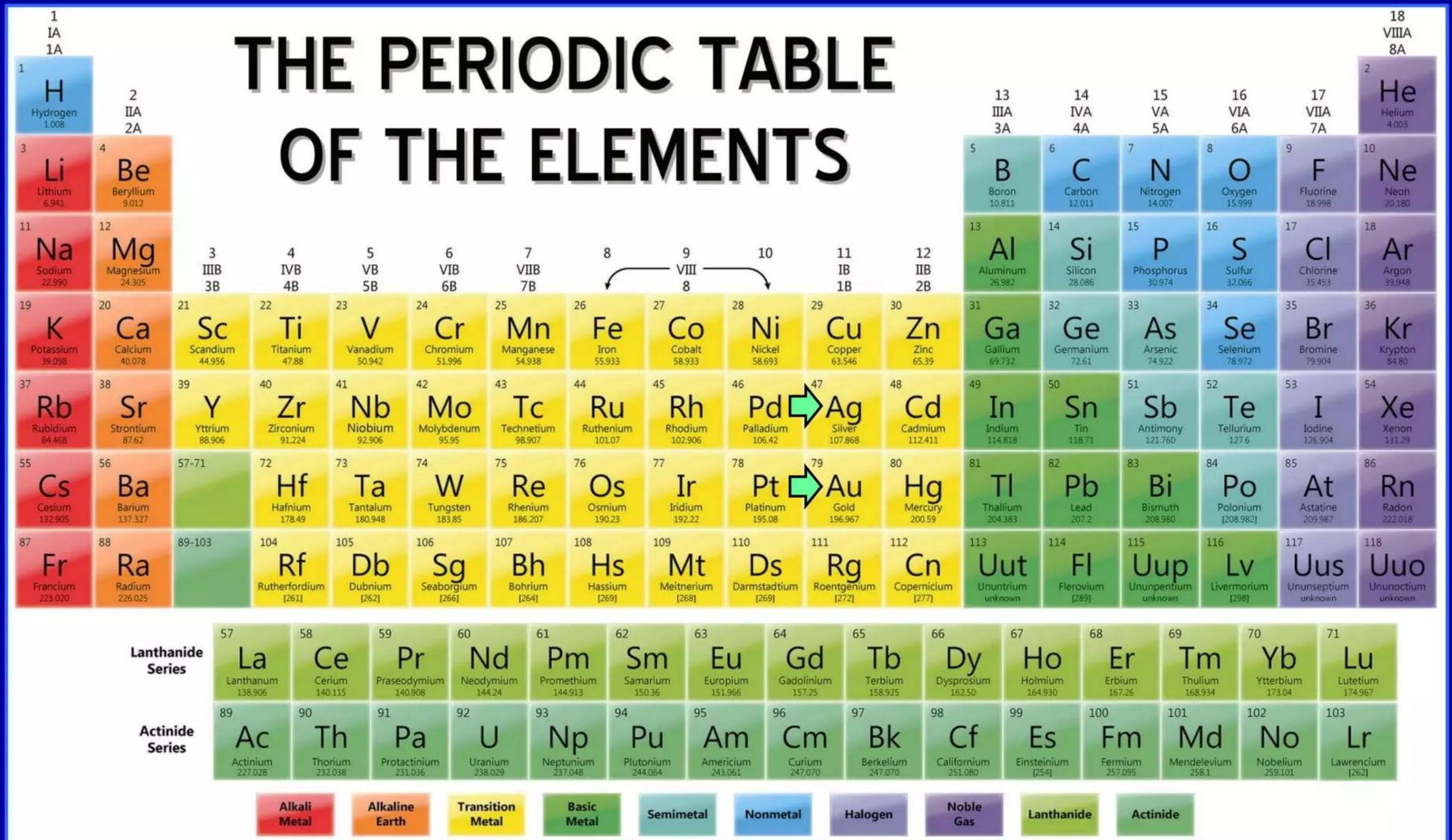
1 H Hydrogen 1.00794																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012182											5 [illegible] 10.811	6 [illegible] 12.0107	7 [illegible] 14.00674	8 [illegible] 15.9994	9 F Fluorine 18.9984032	10 Ne Neon 20.1797
11 Na Sodium 22.989770	12 Mg Magnesium 24.30											13 Al [illegible]	14 Si Silicon 28.[illegible]	15 P Phosphorus 30.97[illegible]	16 S Sulfur [illegible]	17 Cl Chlorine [illegible]527	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 Manganese 54.938049	26 Fe Iron 55.845	27 Co Cobalt 58.933200	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.39	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 [illegible]	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.90550	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	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 Re [illegible] 186.2	76 Os [illegible] 190.23	77 Ir [illegible]	78 Pt Platinum [illegible]078	79 Au [illegible]	80 Hg [illegible]	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 Bohrium (262)	108 Hs Hassium (265)	109 Mt Meitnerium (266)	110 (281)	111 (272)	112 (277)	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)

LENR transmutations traverse rows from left-to-right

Neutron capture by elements transmutes them into different elements

Dash et al.'s (1993) electrochemical cells have transmuted Pd → Ag and Pt → Au



Characteristic features of LENRs in electrochemical cells

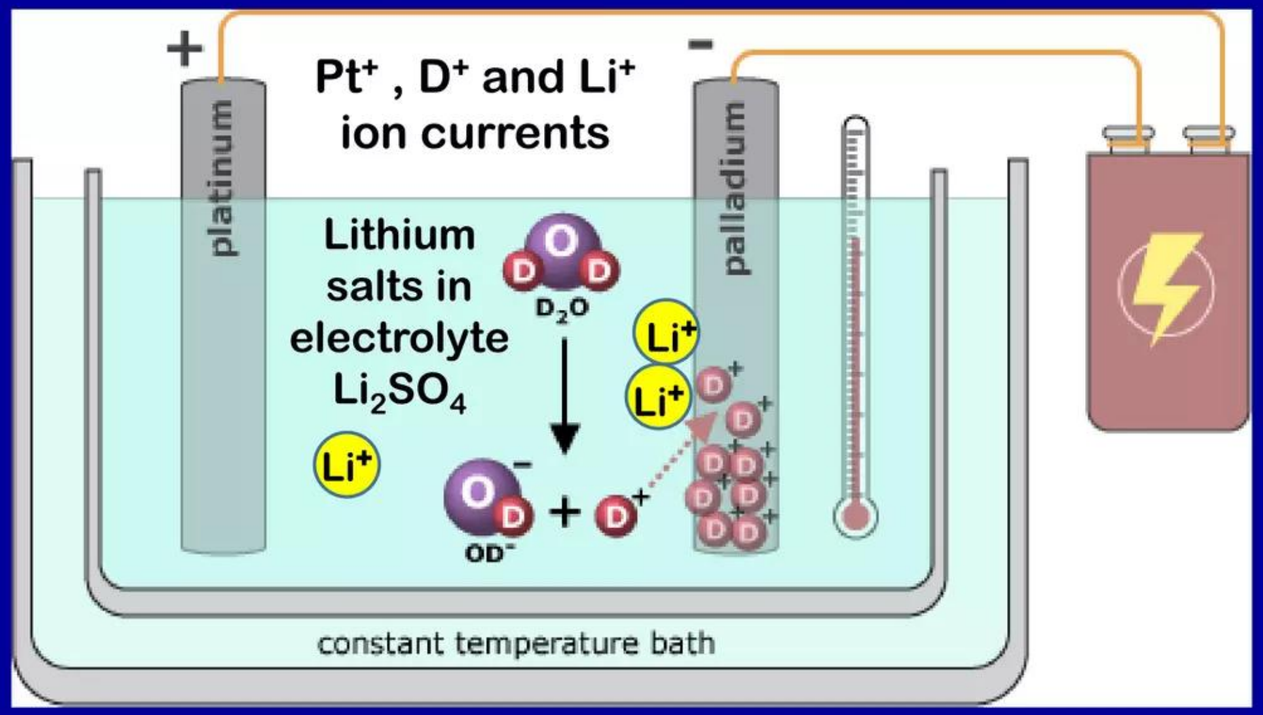
Feature	Electrochemical LENRs	Experiments: Dash et al. 1993
Reversibility	Irreversible; transmutes elements	Observed Au and Ag products
Basic reactions that produce neutrons	$e^- + p^+ \rightarrow 1\ n^0 + \nu_e$ $e^- + d^+ \rightarrow 2\ n^0 + \nu_e$	Per W-L neutrons produced via these reactions in D_2O and H_2O cells
Proton sources	Aqueous: H_2O, D_2O	Both light and heavy water used
Electrons	Surface plasmons (metal surfaces) or at certain interfaces	Surface plasmons exist on Pd metallic cathode surfaces
Anode materials	Platinum Pt, Tungsten W, Carbon C	Pt (Platinum)
Cathode materials	Pd, Ni, Ti, W, other metal hydrides, C	Pd (Palladium)
Electrolytes	H_2O, D_2O (Hydrogen bubbles will form on cathode surfaces)	Both light and heavy water electrolytes were used
Electrolyte salts	LiOD, LiOH, Li_2SO_4, H_2SO_4, K_2CO_3	H_2SO_4
Operating voltages	Vast range of experimental values: 2 V all the way to > 350 V per cell	Not explicitly disclosed but was probably on order of several Volts
Local electric field strengths	Briefly > 2.5 x 10^{11} V/m to produce LENR ultralow energy neutrons	Fields at these strengths on micron length-scales are required per W-L
Cell operating temperature range	Laboratory experiments ≤ 100° C Note: tiny LENR active-site hotspots briefly hit 4,000 - 6,000° C Generates excess heat	Cells were operated well below the boiling point of water; excess heat was measured and roughly correlated with observed transmutations

Conceptual overview of an LENR electrolytic chemical cell

Platinum anode, Palladium cathode, Lithium salts, aqueous electrolyte

Pt anode Pd cathode DC electrical power source

Analogous to when charging Lithium-ion batteries; LENR electrolytic cells typically have DC input current that provides the energy required to create neutrons via Widom-Larsen theory's 'green' electroweak $e + p$ reaction



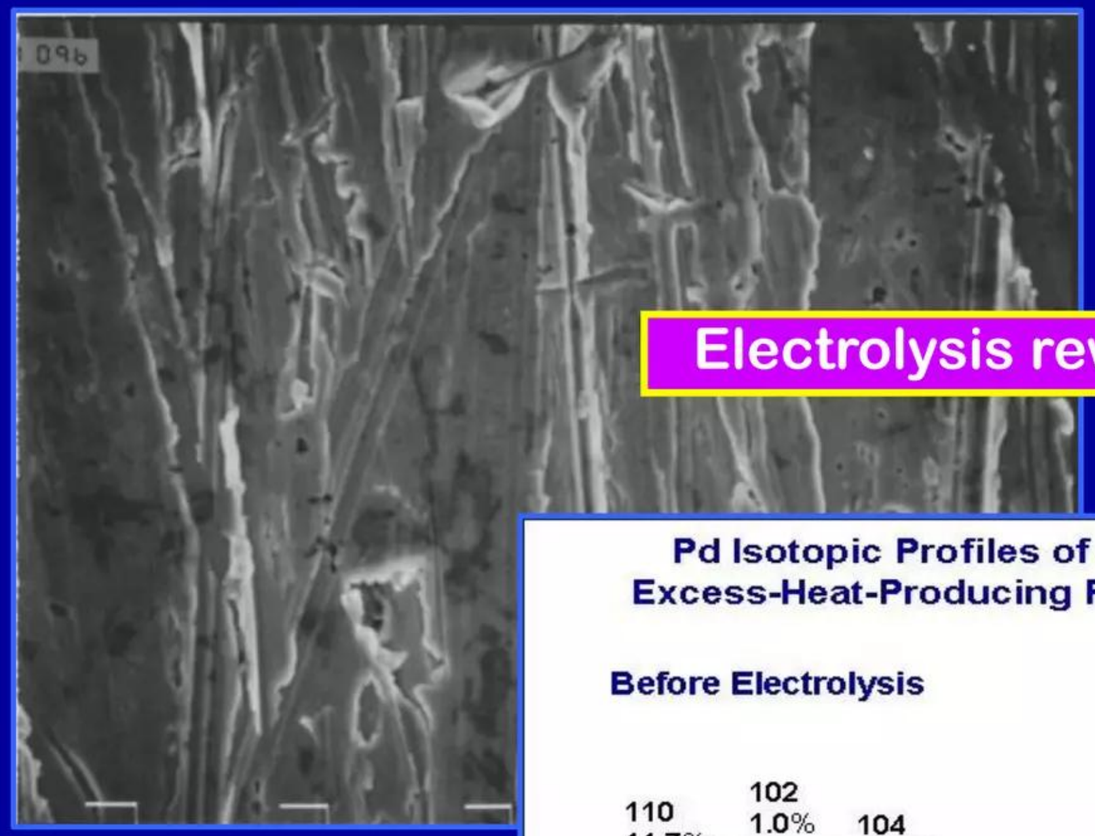
Credit: website "Understanding Science" by the Univ. of California Museum of Paleontology (UCMP)

Above is a conceptual schematic for an aqueous D_2O heavy-water electrolytic chemical cell used in many LENR experiments; typically use DC power supply as a source of electrical input energy. Using modern mass spectroscopy for post-experiment analyses of cathode materials, LENR researchers have carefully documented and reported the production (via LENR transmutation) of minute amounts of many different elements and isotopically shifted stable isotopes on cathode surfaces in such cells. In some cases, ultralow energy neutron fluxes were $>10^{12}$ cm^2/sec which then created a broad array of stable LENR transmutation products over the course of several weeks of electrolysis

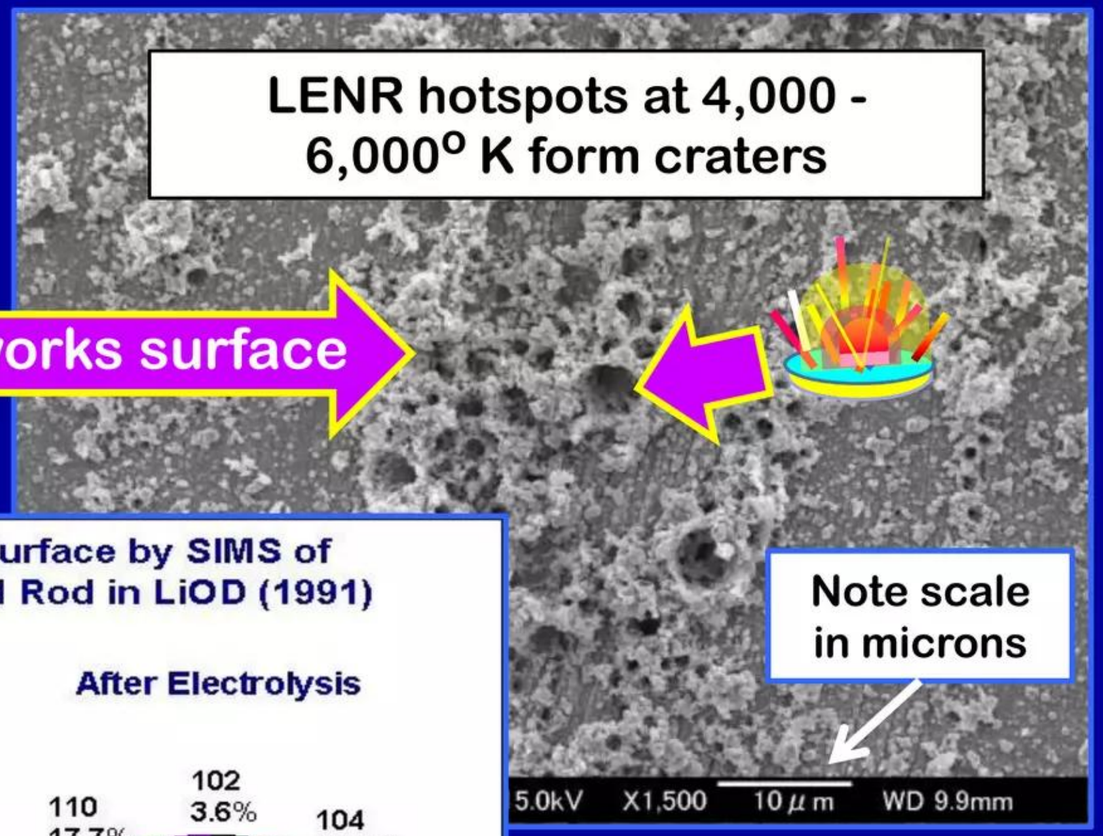
Palladium isotopic ratios are shifted in electrochemical cells

Mizuno et al. (2012) reported major changes in Palladium (Pd) isotopes

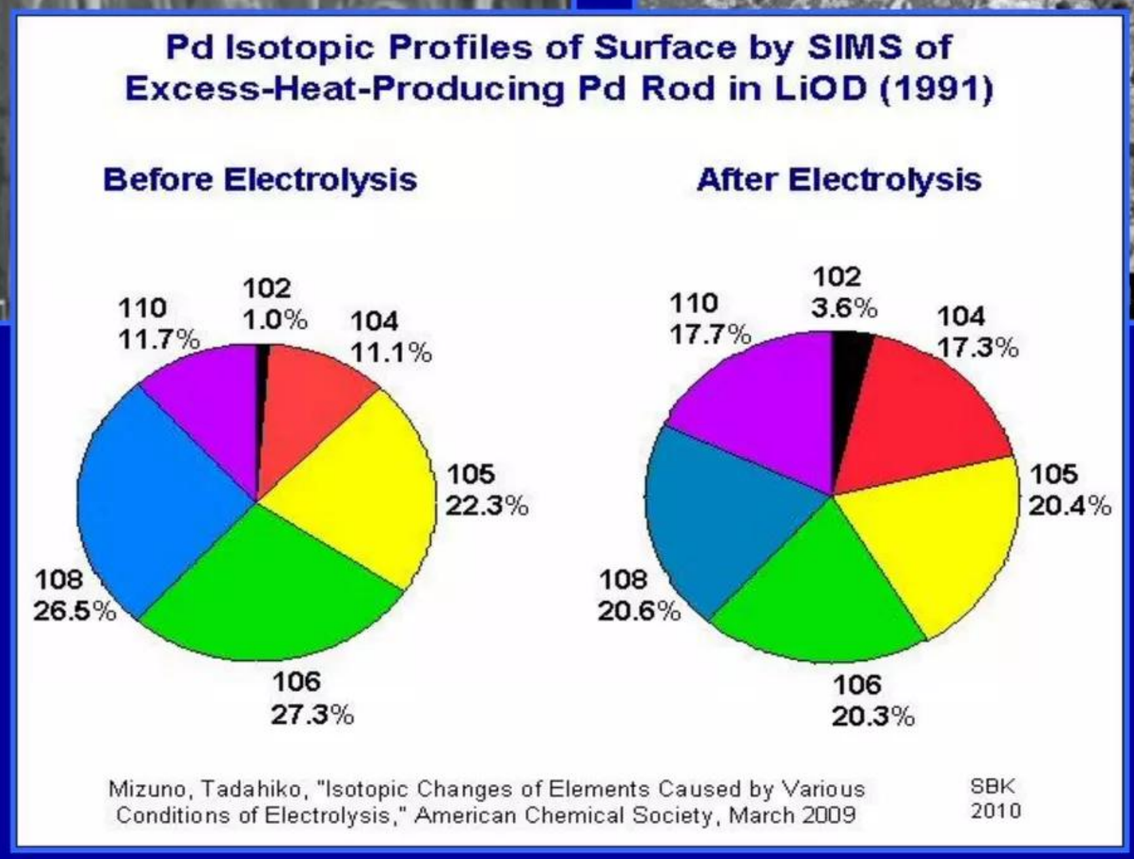
Before: smooth Palladium cathode surface



After: rugged surface with μm-scale craters



Electrolysis reworks surface



Source: ICCF-17 conference (2012) T. Mizuno *et al.*

Quoting: "These photo are the Pd electrode before and after the electrolysis. **Electrolysis was conducted for a long time, several day or several week.** Typical current density was 20mA/cm^2. Here, you see the metal particle (100 nm or less) on the surface after electrolysis. Some of them are less than 10 nano-meter …"

Graphic: New Energy Times

LENRs create changes in mixture of elements on Pd surfaces

Zhang & Dash (2007) electrochemically transmuted Palladium into Silver

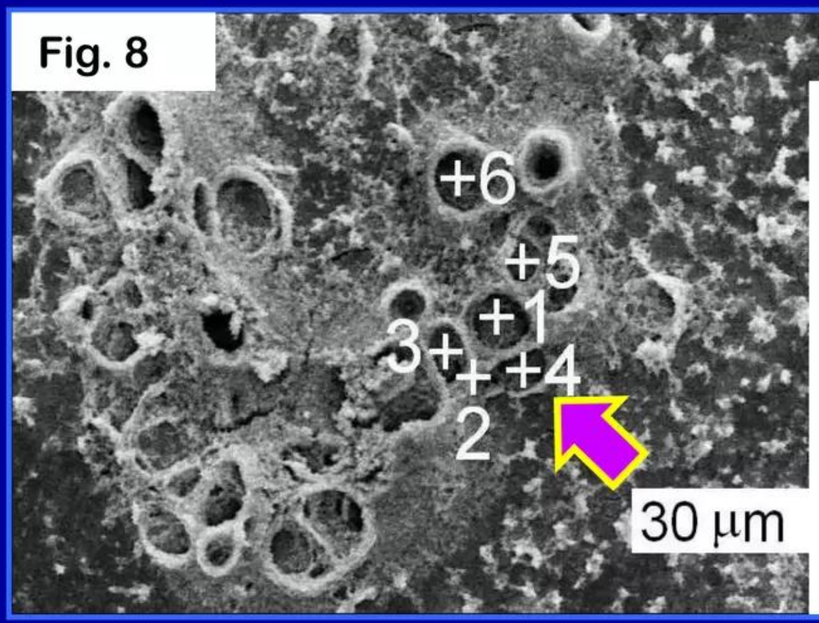
Widom-Larsen theory explains neutron-capture driven production of Ag from Pd

Pd + *n* → [unstable neutron-rich Pd isotopes] → Ag [two stable Silver isotopes]

http://www.lenr-canr.org/acrobat/ZhangWSexcessheat.pdf

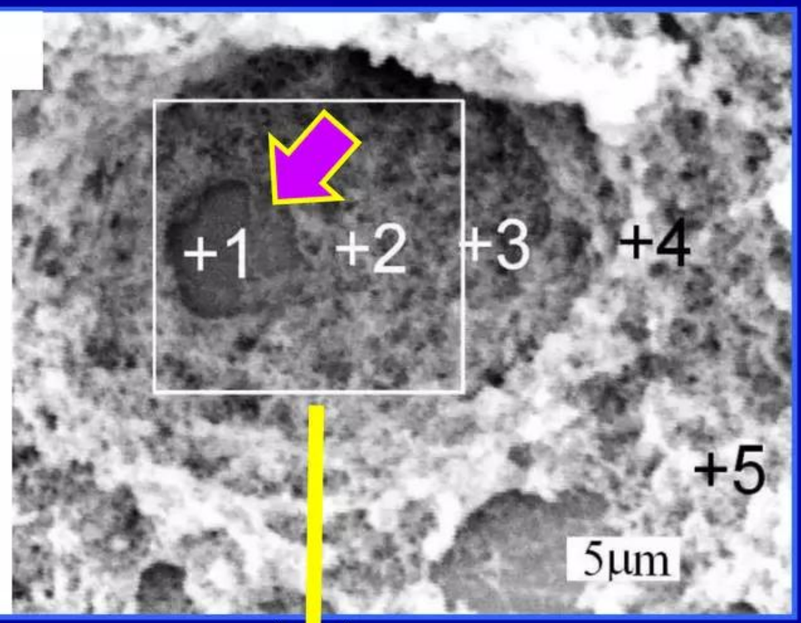
Pd cathode surface after lengthy electrolysis - Zhang & Dash (2007) - Figs. 8 and 9

Fig. 8



"The most common finding is that Silver occurs in craters, such as those shown in Fig. 8. These craters with rims almost certainly formed during electrolysis. Pt deposition was concentrated on these protruding rims."

Fig. 9



Zhang & Dash: Table IX. Relative atomic percent concentrations of Silver (Ag) in area and spots shown in Fig. 9

Spot #	wa*	area**	+1	+2	+3	+4	+5
Ag/(Pd+Ag)	1.2 +/- 0.5	5.6 +/- 0.4	6.8 +/- 0.4	5.6 +/- 0.3	6.3 +/- 0.4	3.6 +/- 0.6	1.2 +/- 0.5

*wa = whole entire area comprising image in Fig. 9

** area = delimited by the white square outlined in Fig. 9

Pd boiling point = 2,970° C

In 1924 - 25 Nagaoka produced Gold with electric discharges

Then considered the "Einstein of Japan" and competitor of Rutherford

Hantaro Nagaoka (1865 - 1950): "Nagaoka was … educated at Tokyo University. After graduating with a degree in physics in 1887 … In 1893, Nagaoka traveled to Europe, where he continued his education at the Universities of Berlin, Munich, and Vienna, including courses with James Clerk Maxwell on Saturn's rings and Ludwig Boltzmann and his Kinetic Theory of Gases … Nagaoka also attended, in 1900, the First International Congress of Physicists in Paris, where he heard Marie Curie lecture on radioactivity, an event that aroused Nagaoka's interest in atomic physics. Nagaoka returned to Japan in 1901 and served as Professor of physics at Tokyo University until 1925. After his retirement from Tokyo University, Nagaoka was appointed a Head Scientist at RIKEN, and also served as the first President of Osaka University, from 1931 to 1934." Wikipedia

"In late 1903, … Nagaoka … developed the earliest published quasi-planetary model of the atom … from 1887 spent his postdoctoral period in [Europe] before obtaining a professorship in Tokyo to become Japan's foremost modern physicist." *Compendium of Quantum Physics*, D. Greenberger, K. Hentschel, F. Weinert eds., book chapter pp. 22 - 23 Springer Berlin Heidelberg (2009)

Hideki Yukawa (Nobel Prize in Physics, 1949): "I think Professor Nagaoka was all powerful then among scientists … he had some very deep insight, although he did not work himself [at that point in his career] … Nagaoka was President of Osaka University when I moved from Kyoto to Osaka. But he was at the same time President of the Academy; he was the greatest boss among all the scientists in Japan. Although he was perhaps over sixty, he was mentally very young. And he was interested in new physics … " Recorded interview with Prof. John Wheeler (1962)

Electric discharge in transformer oil by Nagaoka et al. (1925)

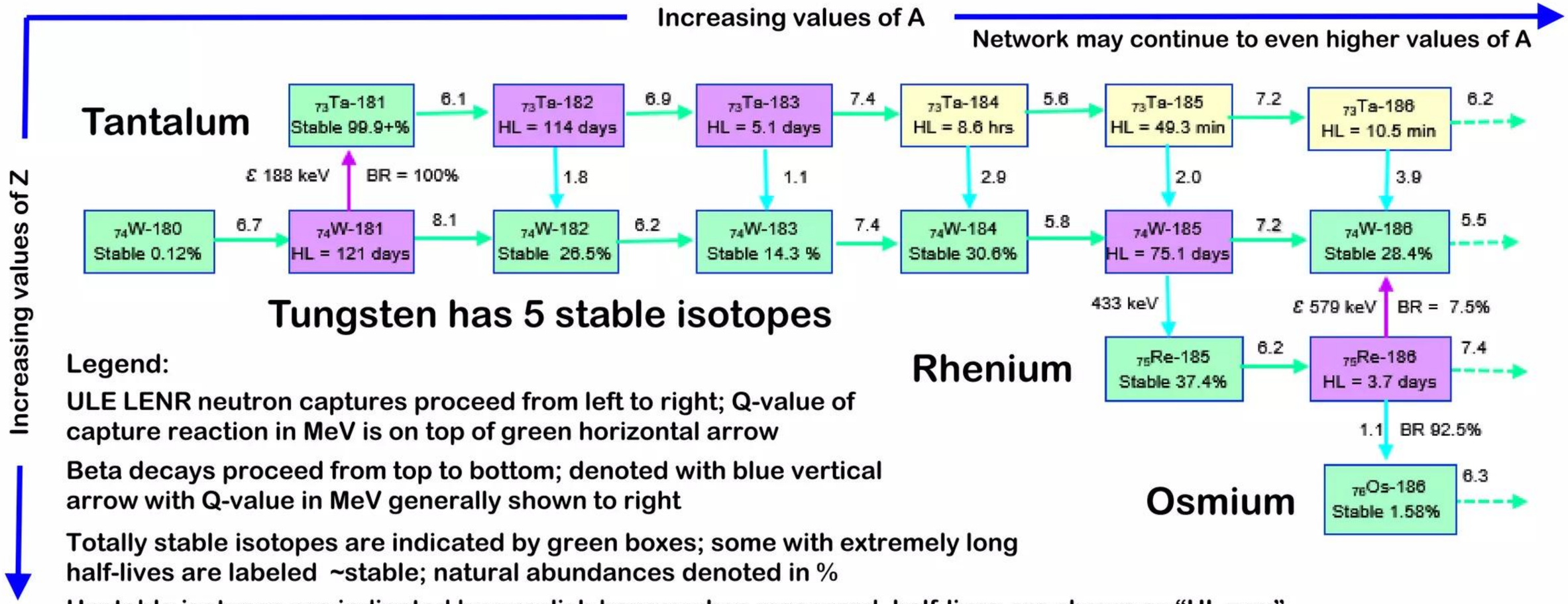
Currents between two Thorium-free Tungsten electrodes produced Gold

Results published in *Nature*: > 200 successful experiments - still not believed

"Mystery of Prof. Hantaro Nagaoka's 1920s Gold experiments in Japan"
L. Larsen on SlideShare - December 27, 2013

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-mystery-of-nagaokas-1920s-gold-experiments-why-did-work-stop-by-1930-dec-27-2013

Start LENR transmutation network with stable isotopes of pure Tungsten (W) metal



Legend:

ULE LENR neutron captures proceed from left to right; Q-value of capture reaction in MeV is on top of green horizontal arrow

Beta decays proceed from top to bottom; denoted with blue vertical arrow with Q-value in MeV generally shown to right

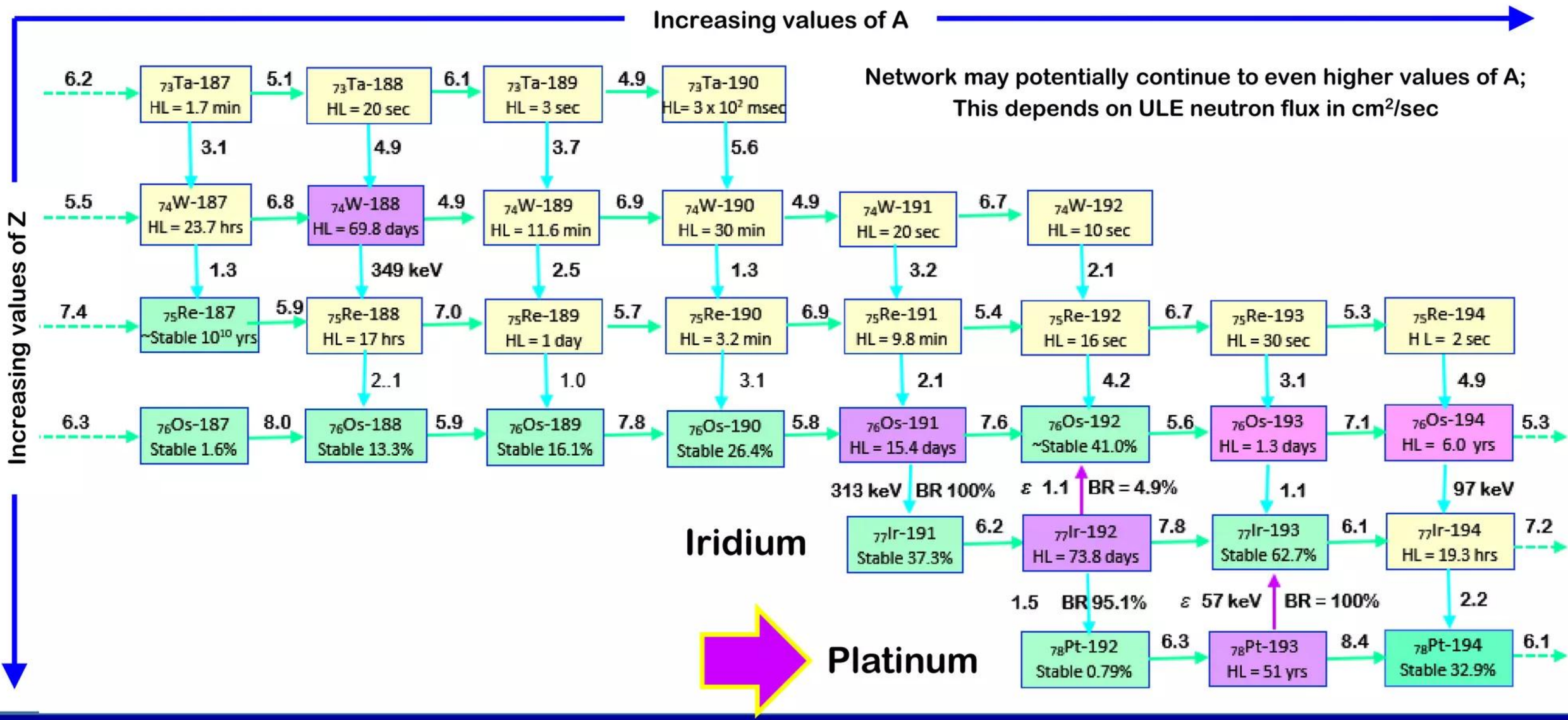
Totally stable isotopes are indicated by green boxes; some with extremely long half-lives are labeled ~stable; natural abundances denoted in %

Unstable isotopes are indicated by purplish boxes; when measured, half-lives are shown as "HL = xx"

Nagaoka's results are explained by Widom-Larsen theory

LENR transmutation network begins with neutron captures on Tungsten

From Sept. 1924 to June 1925, Nagaoka *et al.* at RIKEN in Japan conducted ~200 experiments with high-current electric arc discharges between Tungsten electrodes immersed in liquid hydrocarbon transformer oil in which they detected successful transmutation of Tungsten into macroscopic, visible flecks of Gold and Platinum. In July 1925, *Nature* published a Letter to the Editors where he reported these results



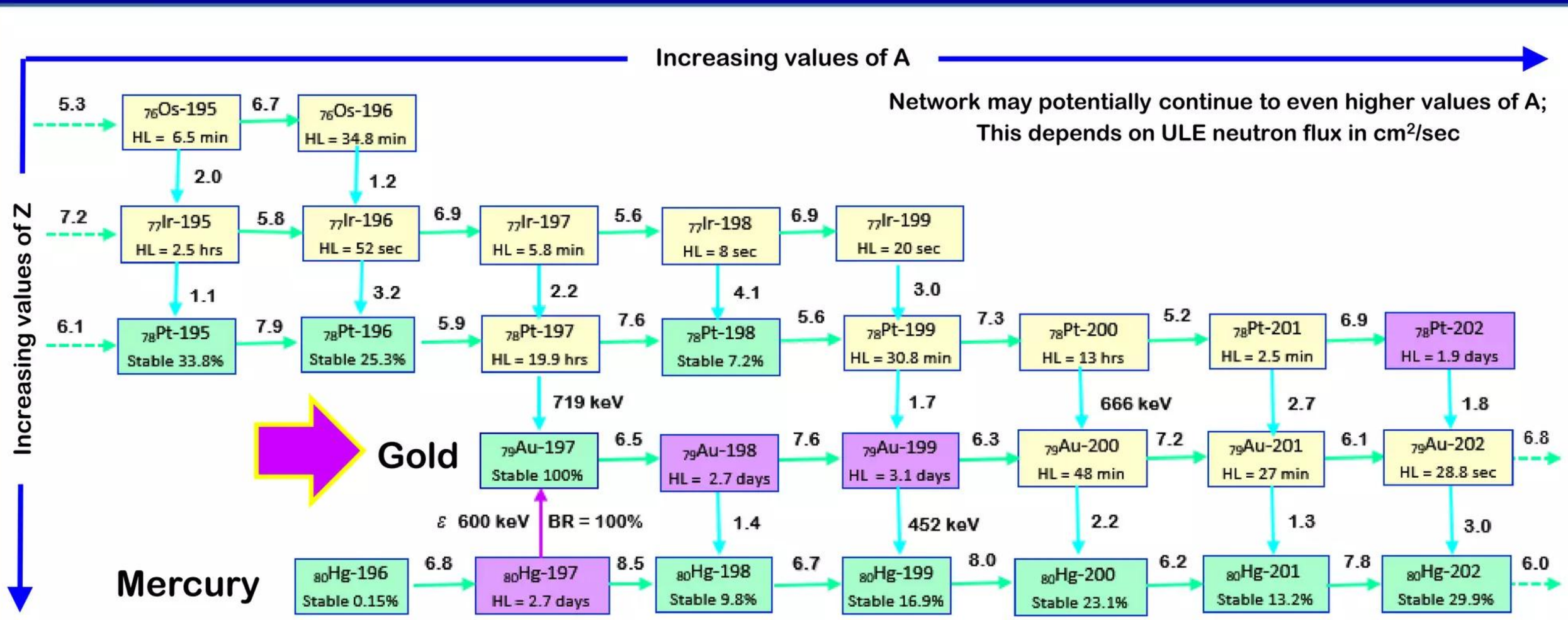
W → Au LENR pathway was confirmed by Mitsubishi (2012)

MHI used different experimental technique than Nagaoka or Dash et al.

Deuterium gas permeation has smaller neutron fluxes vs. electrochemical cells

"LENR transmutation networks can produce Gold"
L. Larsen on SlideShare - December 7, 2012

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-lenr-transmutation-networks-can-produce-golddec-7-2012

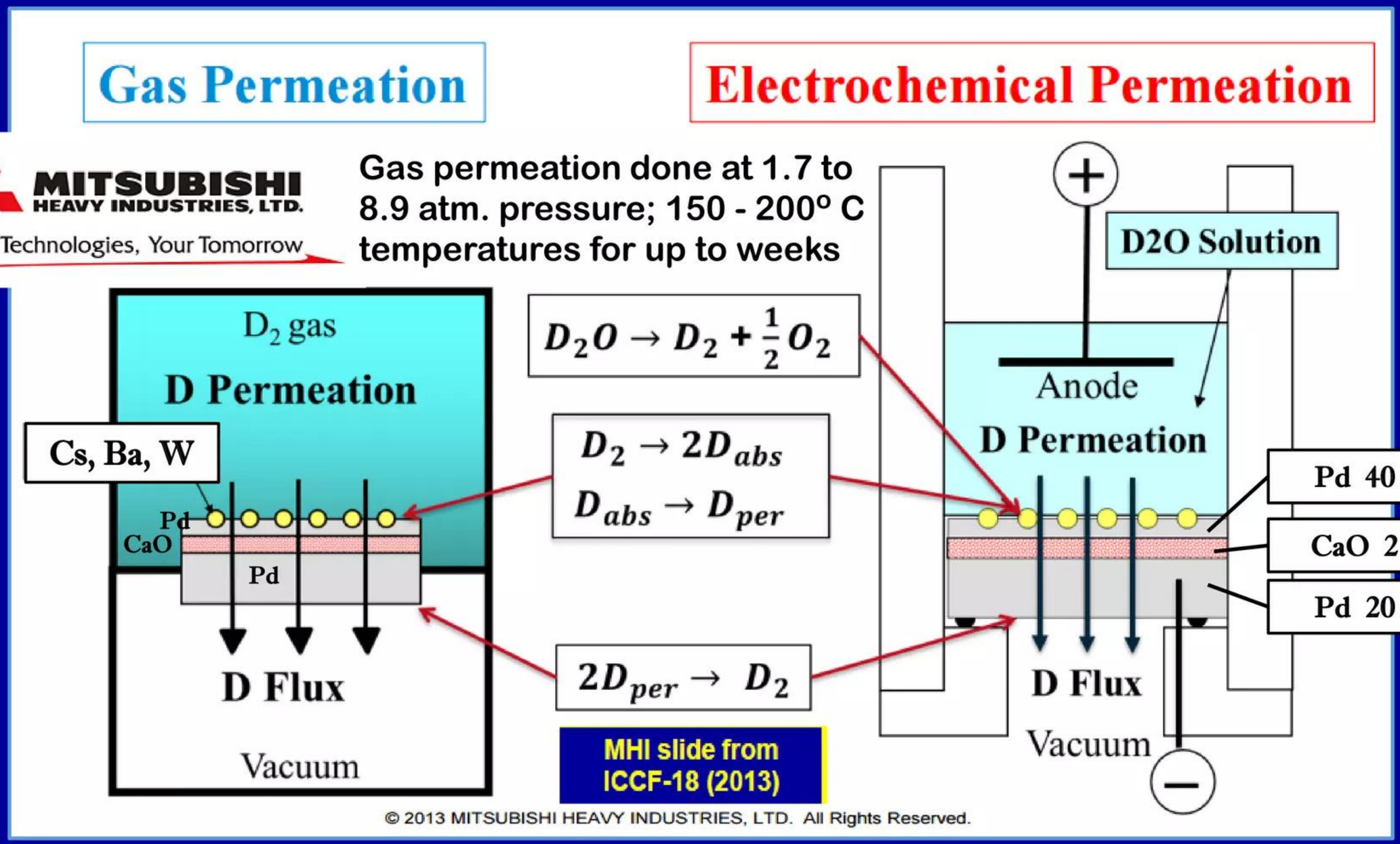


MHI transmutation: gas vs. new electrochemical method

D_2 gas permeation produces lower neutron fluxes vs. electrochemical

Gas method shows LENRs are triggered with very modest external energy inputs

Electrochemical current density of ~0.15 mA/cm² increased product yield to ~1 μg/cm²/week



Mitsubishi Heavy Industries (MHI) graphic has been adapted by Lattice

Widom-Larsen theory: Mitsubishi gas permeation method

Input energy is provided by D_2 pressure gradient and moderate heating

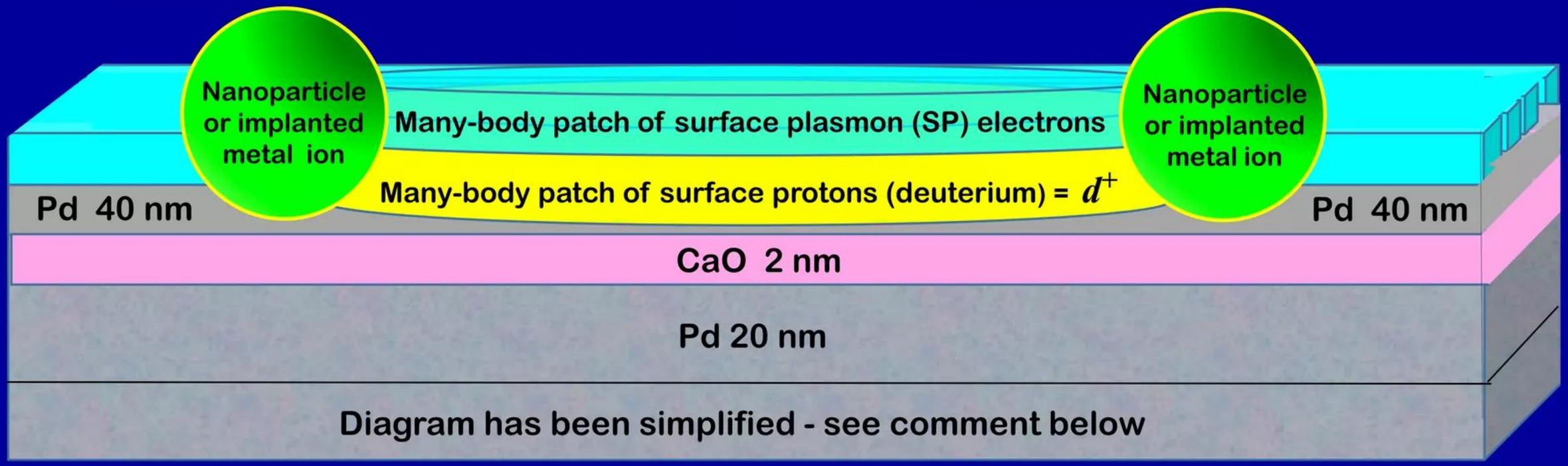
Many-body patches of deuterons and SP electrons form on surface of Palladium

Active sites: modest amounts of external input energy create huge micron-scale local E-fields > 2.5 x 10^{11} V/m on Pd surfaces or in between adjacent nanoparticles or near implanted W^+ ions

Electroweak reaction between deuterons and SP electrons produces ultralow energy neutrons

Input energy$_{\text{E-field}}$ + $e^-_{sp} \rightarrow e^{-*}_{sp} + d^+ \rightarrow 2\,n + \nu_e$ occurs on Pd substrate surface

LENR-active sites can also form on and around nanoparticles or near implanted ions



Note: SP electrons, nanoparticles, implanted ions, and thin film heterostructure component dimensions are not to scale; surface layer is of Pd (thickness = 40 nm); MHI's entire structure is not shown --- repeated structural units consists of 5 layers of CaO (thickness = 2 nm) interleaved with 4 layers of Pd (thickness = 20 nm); lowermost layer of Pd that is in direct contact with vacuum (thickness = 0.1 mm)

Nanoparticles can intensify E-fields at MHI's active sites

Implanted Tungsten (W) transmuted to Osmium (Os) and Platinum (Pt)

LENR sites begin as many-body patches of electrons (blue) & deuterons (yellow)

After being created, LENR neutrons captured by Tungsten atoms located near active sites

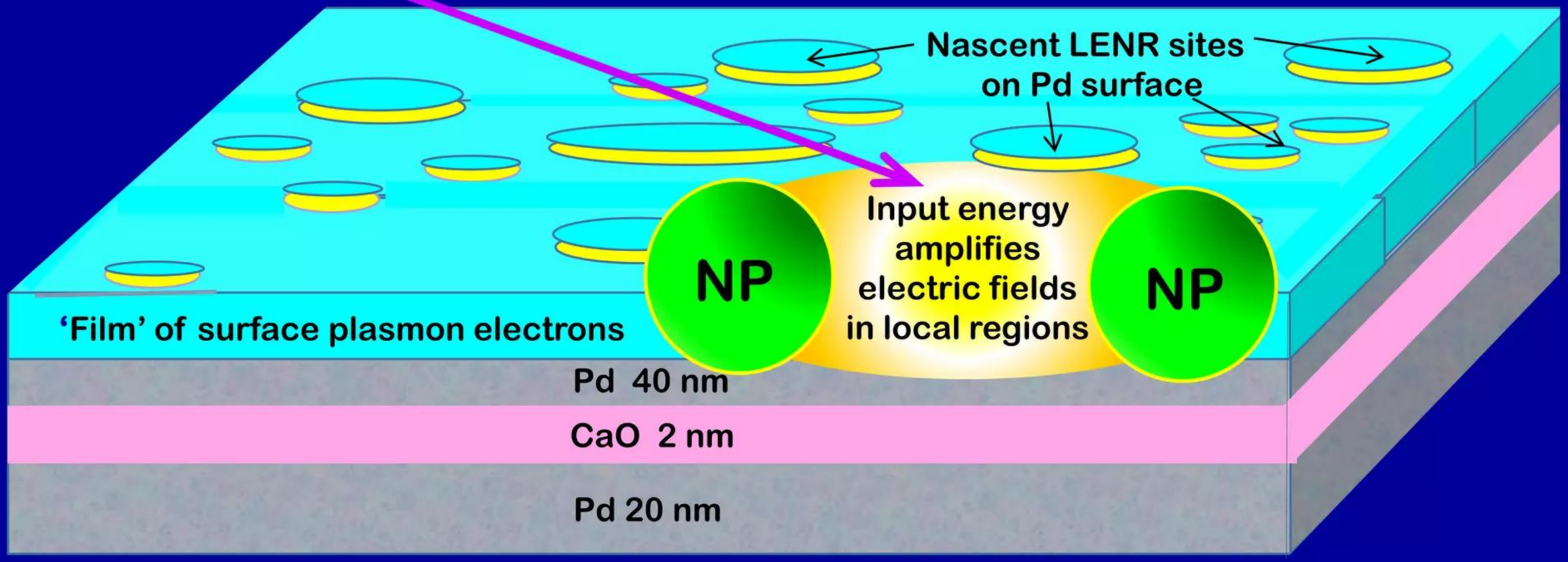
Intense heating in LENR-active sites often forms μ-scale event craters on substrate surfaces

MHI gas method: Tungsten (W) → Osmium (Os) → Platinum (Pt)

$n + (Z, A) \rightarrow (Z, A+1)$ neutrons are captured by implanted target W atoms

$(Z, A+1) \rightarrow (Z+1, A+1) + e_{\beta}^{-} + \nu_e$ beta$^-$ decay transmutes Pd to Os then Pt

NP = nanoparticle (NP) or implanted W^+ (Tungsten) ion



Note: dimensions are not to scale; simplified diagram - see comments about thin-film heterostructure on previous slide

Widom-Larsen enables commercialization of LENRs

Applied nanotechnology and LENRs are mutually joined at the hip

Development risks can be 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.

Visualization of surface plasmon electric field strength (Volts/meter) - highest fields are dark red

Release of nuclear binding energy produces usable heat

Several different mechanisms produce clean heat in LENR-active sites

Widom-Larsen explains what generates calorimetrically measured excess heat

- ✓ Conceptually, LENR neutrons act like catalytic 'matches' that are used to 'light the logs' of target fuel nuclei. A neutron-catalyzed LENR transmutation network operates to release nuclear binding energy that has been stored and locked away in nuclei 'fuel logs' since they were originally produced billions of years ago at many-millions of degrees in fiery nucleosynthetic processes of long-dead stars
- ✓ LENR transmutation devices can produce copious heat that comes mainly from:
  - Direct conversion of MeV-energy gamma photons (γ) into infrared photons (IR) by heavy electrons; e.g., γ from neutron captures or β and other decays. IR is then scattered and absorbed by local matter, increasing its temperature (heating)
  - Nuclear decays of unstable neutron-rich isotopes that emit energetic particles (e.g., betas, alphas, protons, etc.); these particles then transfer their kinetic energy by scattering on local matter, which increases its temperature (heating)
- ✓ Neutrino photons from weak interactions do not contribute to any production of excess heat; they will essentially bleed-off a small portion of released nuclear binding energy outward into space; unavoidable neutrino emissions are part of the energetic cost of obtaining energy releases in LENR devices from β^- decays

Widom-Larsen theory explains importance of input energy

Devices can be simultaneously driven by multiple types of energy inputs

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^+ → 1 n or e^-* + d^+ → 2 n, e^-* + t^+ → 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 an 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 moderate pressure gradient (Iwamura *et al.* 2002)
- ✓ **Incoherent and coherent electromagnetic (E-M) photon fluxes** - can be incoherent E-M radiation emitted within resonant electromagnetic cavities; with proper momentum coupling, SP electrons can also be directly 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 many organized and so-called dusty plasmas; scales-up to stellar flux tubes on stars with dimensions measured in kilometers

Widom-Larsen theory shows how to increase reaction rates

Maximize density of $e^{-}*p^{+}$ or $e^{-}*d^{+}$ reactants and amounts of input energy

"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

- ✓ Term $(\beta - \beta_0)^2$ in our published rate equation reflects the degree to which heavy-mass (renormalized) $e^{-}*$ electrons in LENR-active surface sites exceed minimum W-L threshold ratio for electroweak neutron production, β_0
- ✓ We predict that, all other things being equal, the higher the surface area-density of $e^{-}*p^{+}$ or $e^{-}*d^{+}$ reactants and greater the rate and quantity of appropriate forms of nonequilibrium energy inputs, the higher the rate of ULE neutron production in nm- to μm-scale LENR-active sites in properly engineered, nanotech-based, LENR thermal power generation devices
- ✓ LENR transmutation network pathways comprising series of picosecond-duration neutron captures interspersed with serial beta-decay cascades can release substantial amounts of nuclear binding energy, much of it in form of usable process heat, over periods ranging from hours to weeks --- depends on target fuels, pathways used, and availability of input energy

Mitsubishi pushing to increase device transmutation rates

Unknowingly followed guidelines detailed in W-L rate theory paper (2007)

"Transmutation reaction induced by Deuterium permeation through nanostructured multi-layer thin film" S. Tsuruga *et al.*, pp. 106 - 110
Mitsubishi Heavy Industries Technical Review 52 No. 4 (December 2015)

https://www.mhi.co.jp/technology/review/pdf/e524/e524106.pdf

Quoting: "4. Transmutation by electrochemical method As described above, we have conducted research with the emphasis placed on obtaining experimental data to explicate the transmutation phenomenon by the gas permeation method. In recent years, we have been conducting research for the purpose of increasing the reaction yield with an eye toward commercialization. From the research results so far, it is assumed that the deuterium density near the reactional film surface is one of the key parameters in the increase of the reaction yield. Based on this assumption, we used the method for increasing the deuterium density near the reactional film surface by electrolysis (electrochemical method) to increase the reaction yield …"

"In the electrochemical method, the increase of the current density during electrolysis enables the increase of the amount of D generated on the reactional film surface. Figure 8 shows the results of the reaction yield (yield per 1 cm^2 of reactional film and 1 week of reaction time) obtained by ICP-MS plotted relative to the current density during electrolysis. As the current density increases, the reaction yield tends to increase. In the conventional gas permeation method, the reaction yield was approximately 0.01 $\mu g/cm^2$ /week. In this electrochemical method, the reaction yield increased by two digits at most."

Mitsubishi pushing to increase device transmutation rates

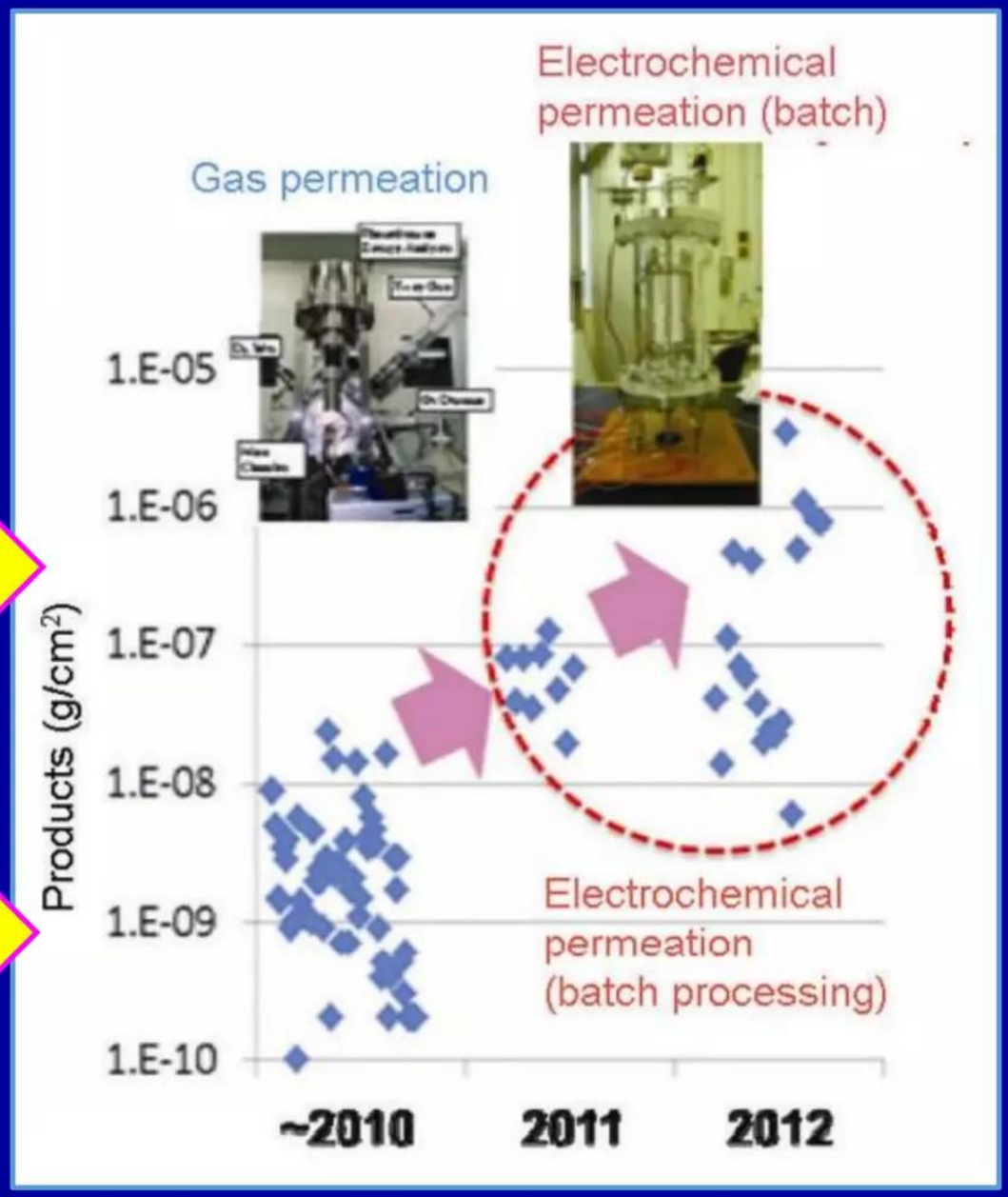
Unknowingly followed guidelines detailed in W-L rate theory paper (2007)

"Transmutation reaction induced by Deuterium permeation through nanostructured multi-layer thin film" reproduced Fig.6

Y. Iwamura *et al.*, *Current Science* 108 No. 4 pp. 628 - 643 (February 2015)

http://www.currentscience.ac.in/Volumes/108/04/0628.pdf

Changing MHI's older permeation method from 2002 that always used gaseous D_2 and a pressure gradient to current-driven electrochemical D_2O cells clearly increased LENR transmutation product yields by nearly 3 orders of magnitude in just about three years



Switching to a very different permeation method increased LENR transmutation product yields in MHI reactors because there are much higher densities of $e^{-}*d^{+}$ pairs on device's LENR-active working Palladium surface and the fact that a much larger quantity of input energy (in form of a several Volt DC electrical current) is being injected into experimental system

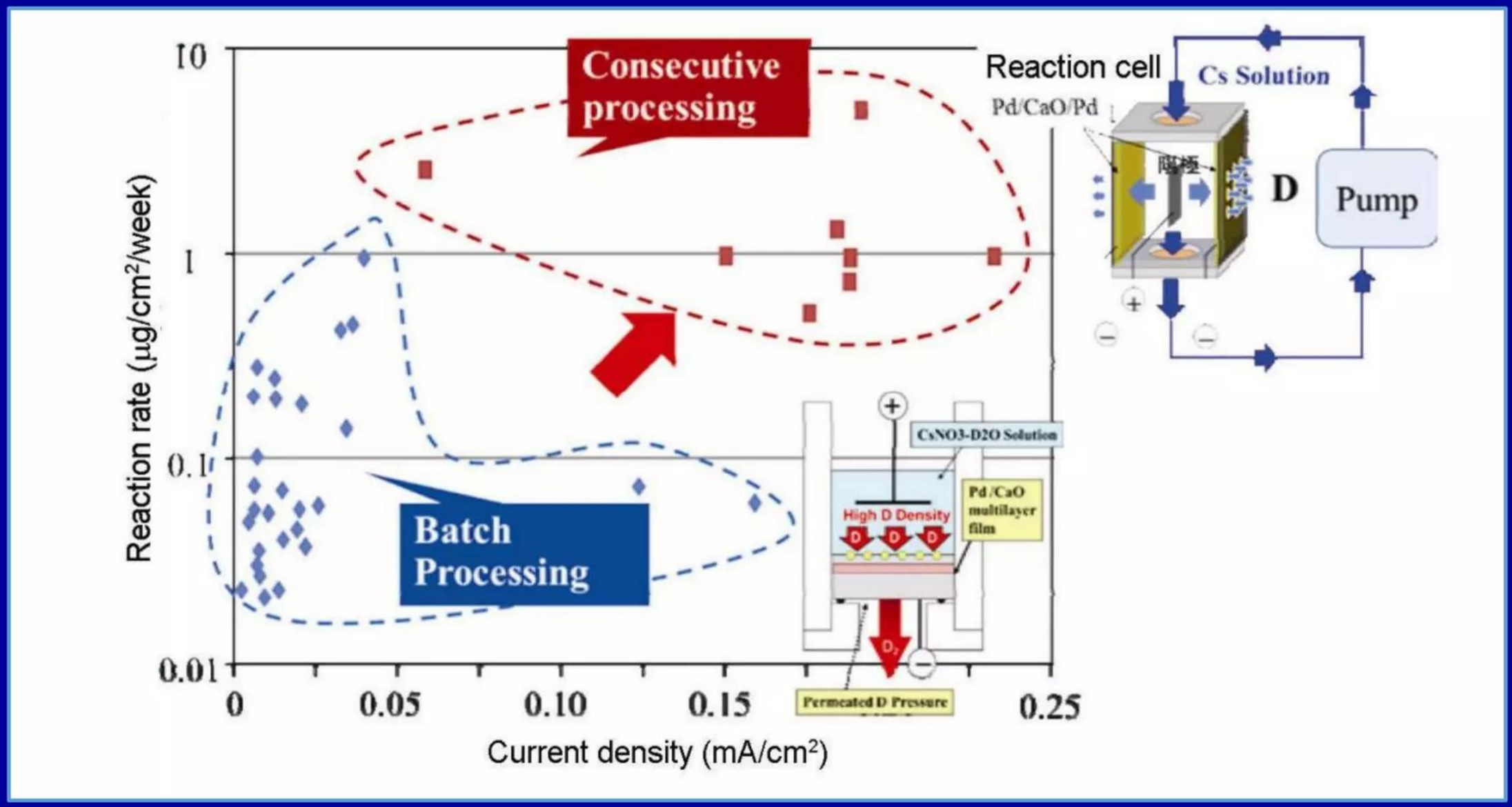
Mitsubishi pushing to increase device transmutation rates

Unknowingly followed guidelines detailed in W-L rate theory paper (2007)

"Transmutation reaction induced by Deuterium permeation through nanostructured multi-layer thin film" reproduced Fig.7

Y. Iwamura *et al.*, *Current Science* 108 No. 4 pp. 628 - 632 (February 2015)

http://www.currentscience.ac.in/Volumes/108/04/0628.pdf



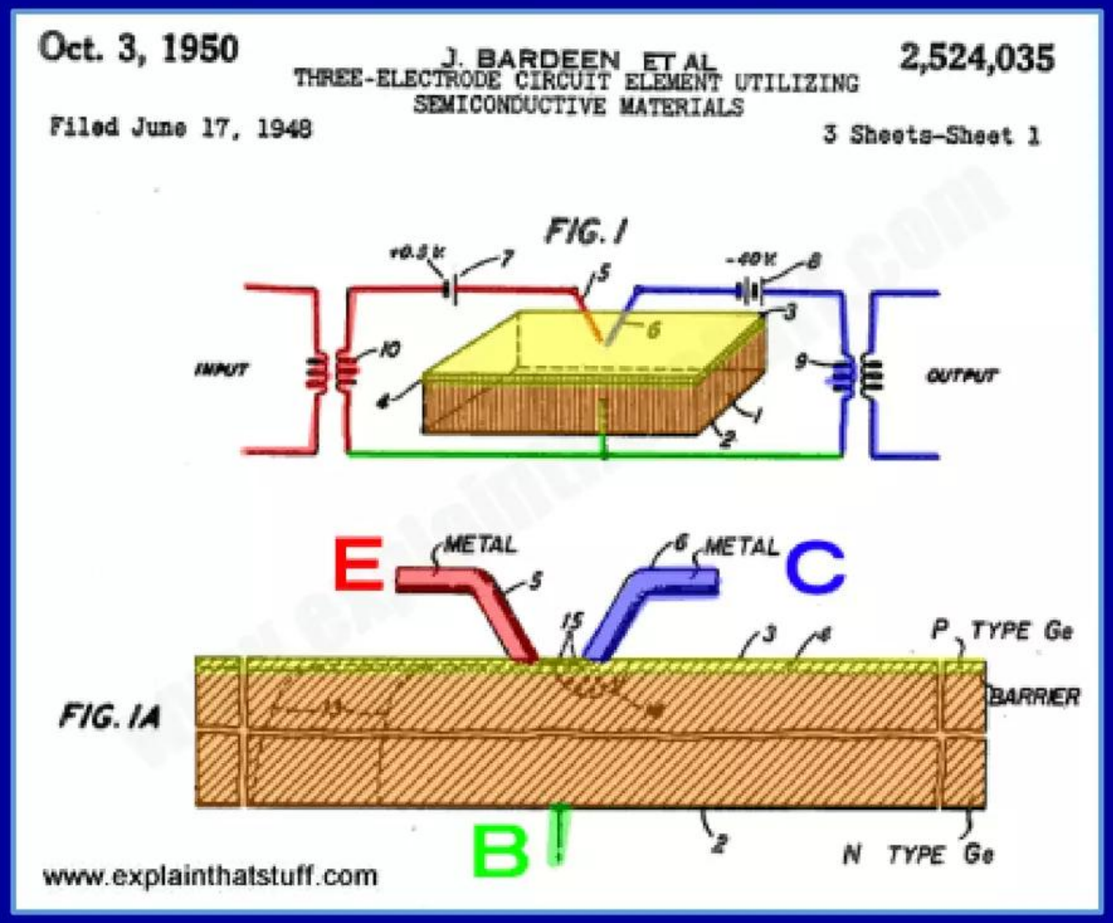
LENR active sites are analogous to transistors in some ways

"If you take a bale of hay and tie it to the tail of a mule and then strike a match and set the bale of hay on fire, and if you then compare the energy expended shortly thereafter by the mule with the energy expended by yourself in the striking of the match, you will understand the concept of amplification."

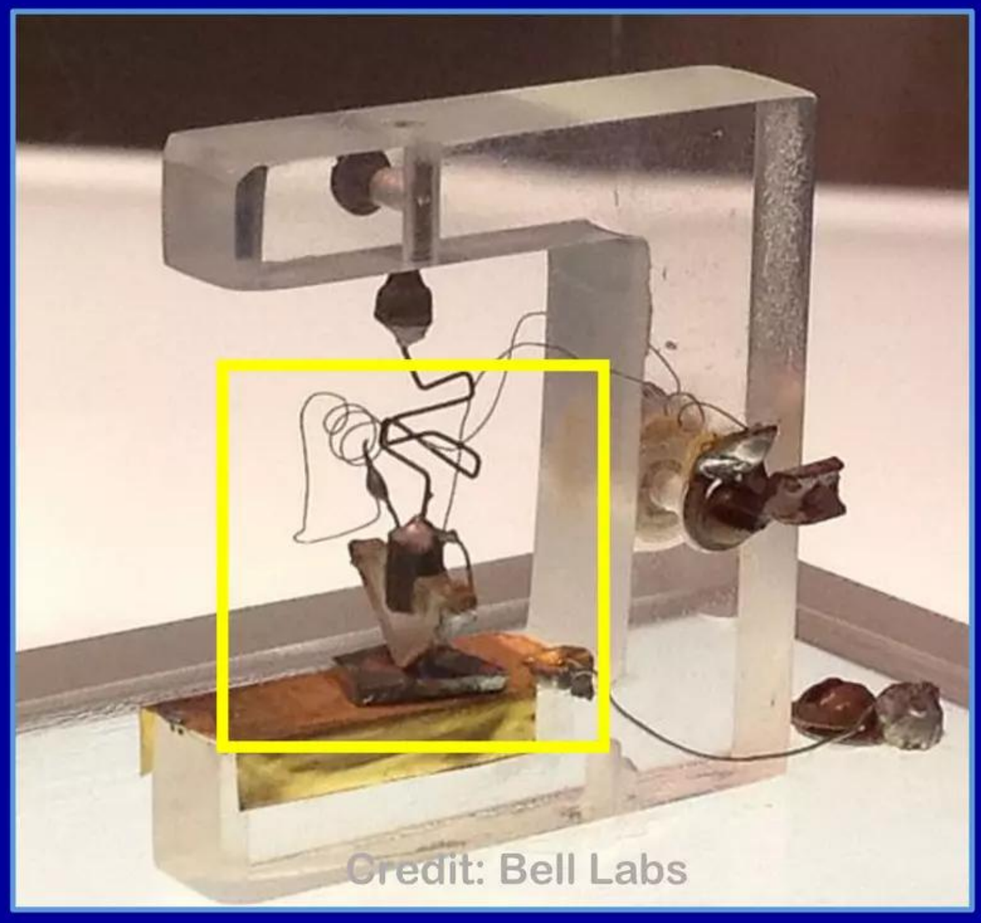
William Shockley's explanation of transistor amplification for his students

Along with John Bardeen and Walter Brattain, shared 1956 Nobel prize in physics for first invention of the semiconductor transistor in 1947

Patent drawings



First 0.5" transistor in lab photo (1947)



LENR active sites analogous to transistors in some ways

Key functional feature of transistors: ability to amplify Voltage: $V_{out} > V_{in}$

In LENR active sites target fuel atoms are Shockley's mule; neutrons are matches

- ✓ Transistor is key active, fundamental component of modern electronics; replaced vacuum tube technology invented in 1904 that was physically larger, much more power hungry, and more expensive to manufacture
- ✓ First experimental Germanium semiconductor transistor was invented at Bell Labs in 1947; crude handmade device was approximately 0.5" in size and was capable of signal amplification, i.e. small changes in input voltage created large changes in output voltage ($V_{out} > V_{in}$). Ratio of V_{out} divided by V_{in} is called amplifying gain; other major use of semiconductor transistors is to function as electrically controlled switches
- ✓ Like transistors, LENR devices will function as a type of amplifier --- only instead of amplifying modest voltage of an electrical signal, LENRs amplify input energy. Electronic or chemical energy on scales of electron Volts (eVs) is directed and concentrated to create neutrons in a radiation-free electroweak $e + p$ or $e + d$ reaction. Those neutrons are captured by target fuel atoms in an LENR device which releases nuclear binding energy on a scale of Mega-electron Volts (MeVs - 10^6 eVs). With all LENRs, maximum theoretical device gain of $Energy_{output} / Energy_{input}$ depends on target fuel that captures neutrons. Energetic gain with Deuterium and Lithium is 34x but Hydrogen with Nickel averages ~10x, depending upon Ni isotopic mix

Comparison: attributes of LENR active sites vs. transistors

Attribute	LENR active sites	Transistors
Key functional use	Input energy amplification	Signal amplification and switching
Operant forces in applicable physics	Electromagnetic, electroweak, and strong nuclear force are all important	Strictly the electromagnetic force; solid-state condensed matter
Importance	Triggers release of 'green' nuclear energy under moderate conditions	Key active component in modern electronic devices like microchips
Proton sources	Hydrogen or Deuterium	Not applicable
Electrons	Surface plasmons (metallic surfaces) and at certain metal-oxide interfaces; ***π:*** aromatic rings, graphene, fullerene	Conduction electrons - new future types of transistors may use surface plasmons instead of bulk electrons
Target fuel elements	Lithium, Carbon, Nickel, etc. - almost any isotope that will capture neutrons	Not applicable
Operating voltages	Vast range of experimental values: 2 V up to many thousands of Volts	Generally under several Volts except for high-power switching devices
Size	Ranges from 2 nm up to perhaps ~100 microns at the most	Current commercially available CMOS devices are at roughly 65 nm
Reusability	Individual sites will only be used once	In theory: enormous number of cycles
Manufacturing technologies, cost, and older preceding technologies that are or were threatened	By borrowing from existing nanotech fabrication techniques, they should be manufacturable in very high volumes at low cost; could compete directly against chemical power technologies	Experience curve effect and high unit volumes have enabled enormous decreases in size and device cost since 1950s. Almost totally replaced preceding vacuum tube technology

Over 50 years density increased by ~10^7; size shrank by ~10^4

Experience curve effect dramatically reduced size and cost of transistors

Figure 3: "The evolution of transistor gate length (minimum feature size) and the density of transistors in microprocessors over time"

Quoting: "Between 1970 and 2011, the gate length of MOSFETs shrank from 10 μm to 28 nm (yellow circles; *y* axis, right), and the number of transistors per square millimetre increased from 200 to over 1 million …"

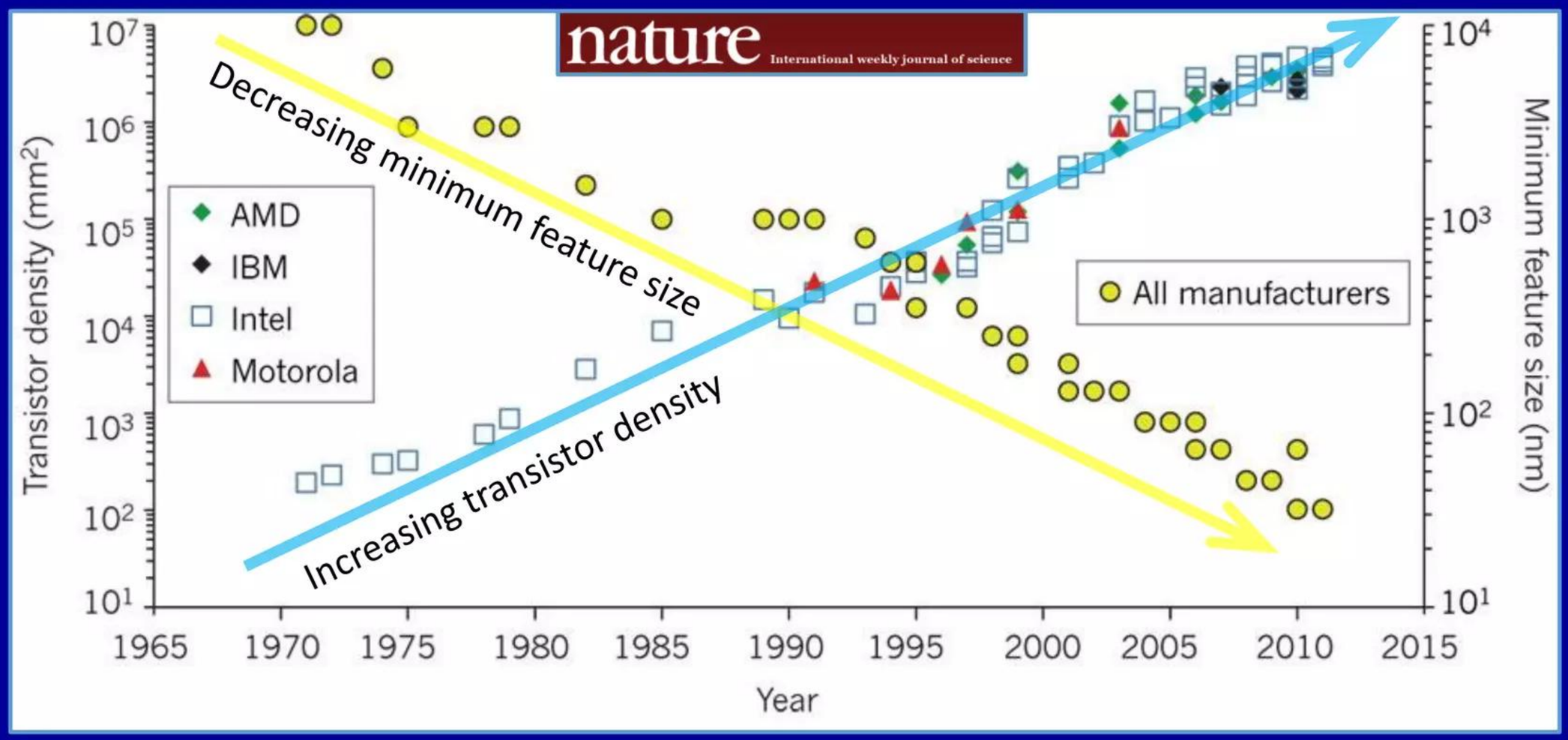


Fig. 3 in source: "Multigate transistors as the future of classical metal-oxide-semiconductor field-effect transistors" I. Ferain *et al*. *Nature* 479 pp. 310 - 336 (2011)

LENR active site physics deeply connected to plasmonics

Transistors using surface plasmons being developed; U.S. Navy patent

LENR active sites have huge local electric fields; also resemble SERS hot spots

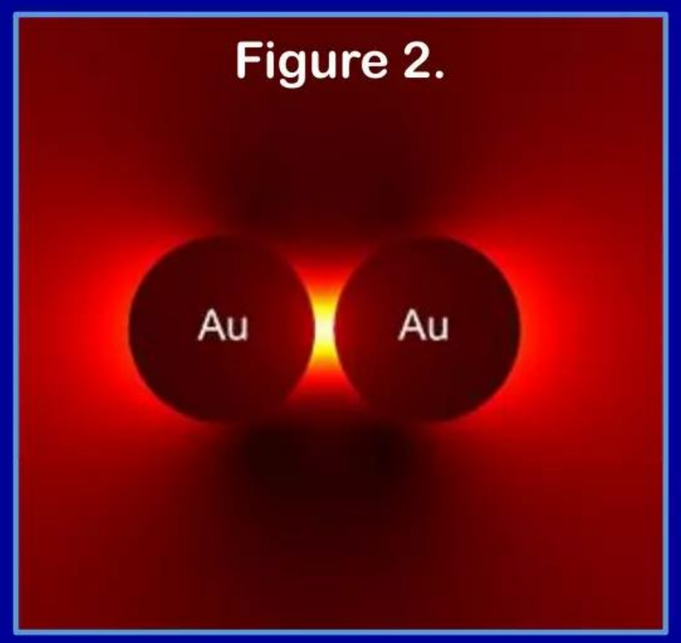
US #8,111,443 B1 "PLASMONIC TRANSISTOR"
Inventors: Stephen D. Russell and Joanna N. Ptasinski
Issued Feb. 7, 2012 Assignee: U.S. Navy

https://docs.google.com/viewer?url=patentimages.storage.googleapis.com/pdfs/US8111443.pdf

SILMECO *Simply put.* Better technology.

See article: "Hot spots"
http://www.silmeco.com/knowledge-base/hot-spots/

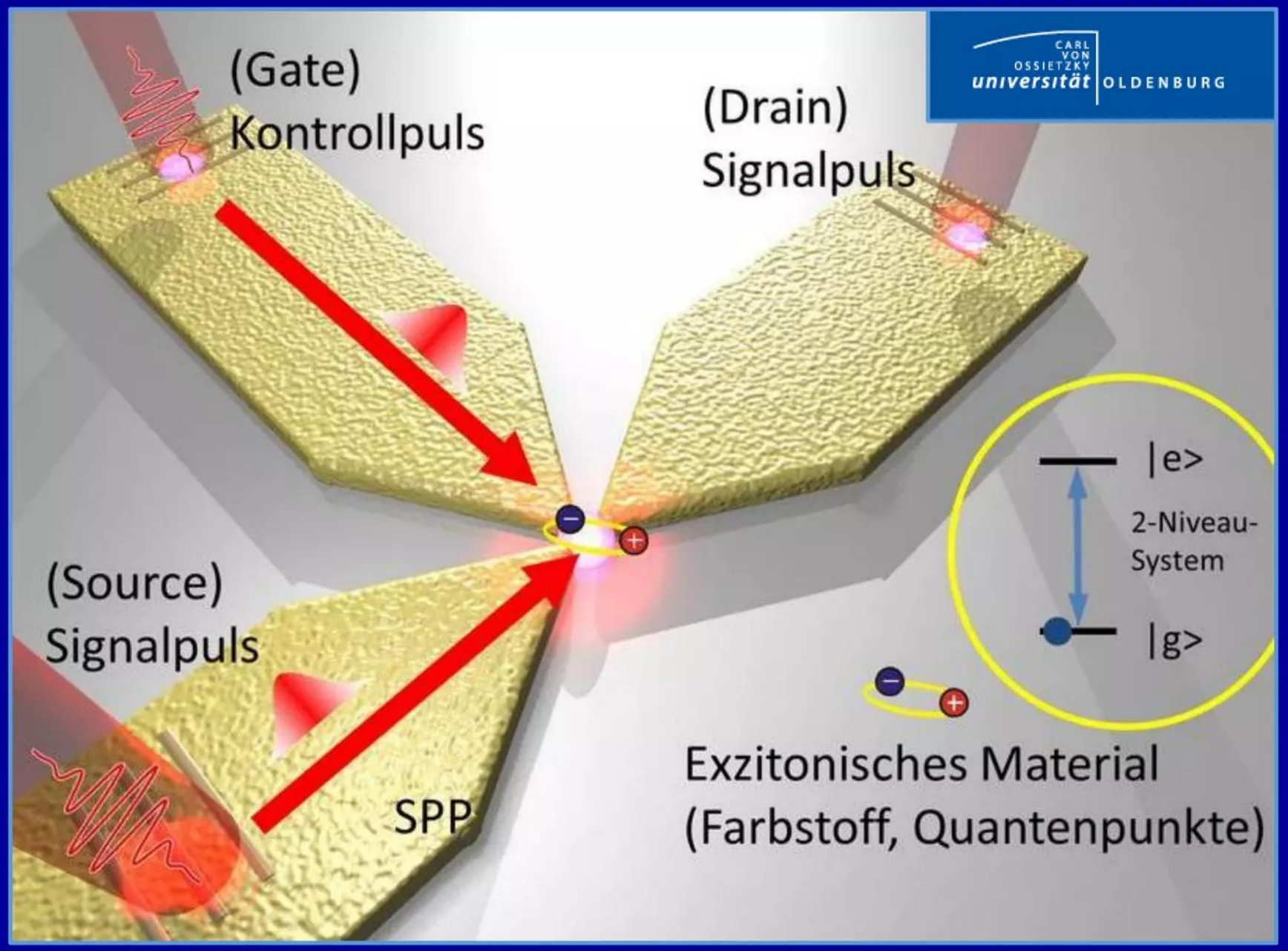
Figure 2. "The theoretical map is showing the electric field distribution around gold nanoparticle dimer. Particle diameter is 20 nm, interparticle separation is 2 nm, and the incident field is polarized in the x-direction. The wavelength of the incoming light is 534 nm."



LENR active site physics deeply connected to plasmonics

Surface plasmons on metal transport laser energy to LENR active sites

Univ. of Oldenburg: ultrafast nano-optics group developing all-photonic transistor



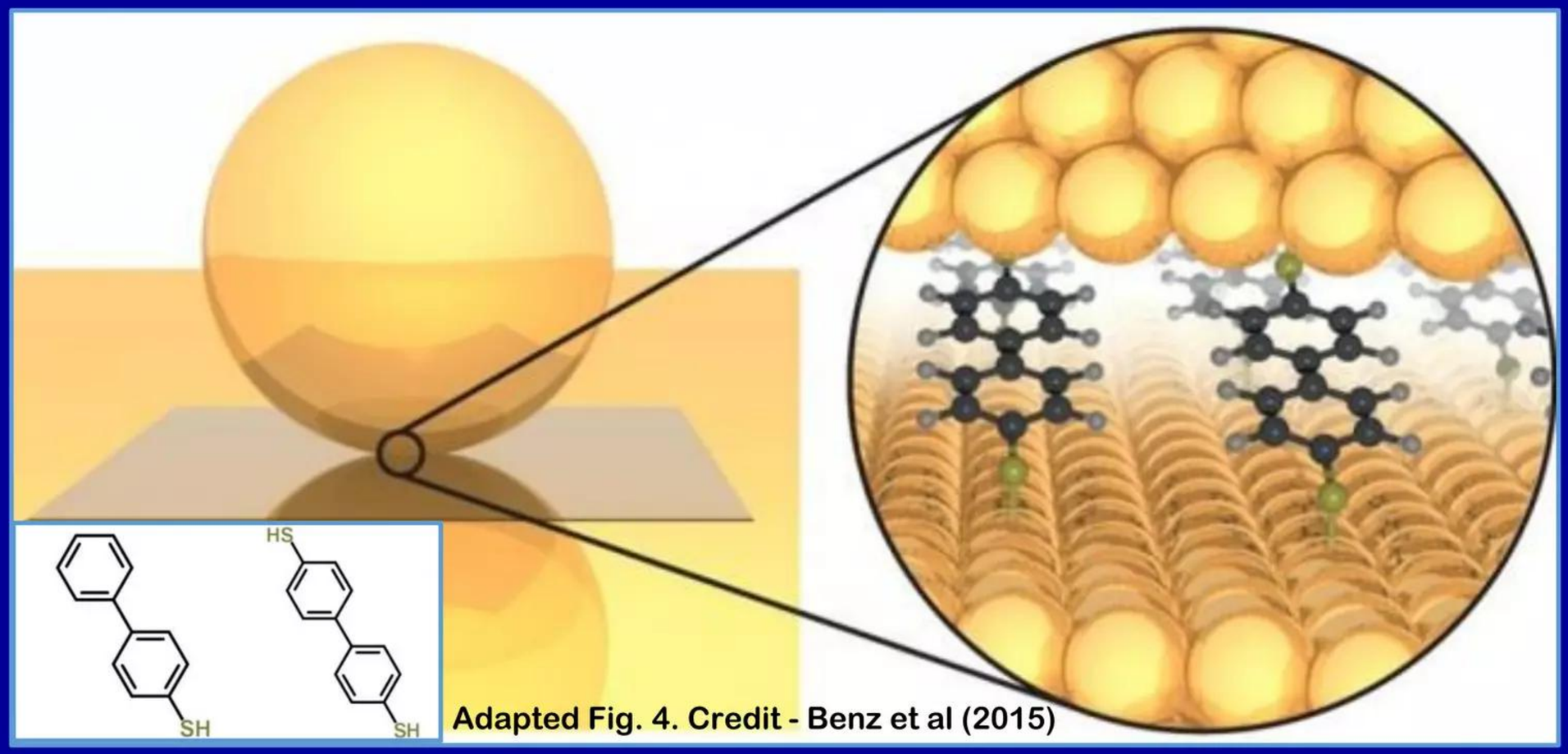
https://www.uni-oldenburg.de/en/physics/research/pictures-and-videos/

Future transistor type: hybrid organo-plasmonic devices?

HOPD goal: duplicate functionality of today's semiconductor transistors

LENRs can be triggered on Carbon aromatic rings; like HOPD but higher E-fields

Figure 4. "Conductive and nonconductive self-assembled monolayers in plasmonic junctions. (a) Schematic of nanoparticle on mirror geometry: a gold nanoparticle is placed on a gold film, separated by a thin molecular spacer layer."



Adapted Fig. 4. Credit - Benz et al (2015)

"Nanooptics of molecular-shunted plasmonic nanojunctions"
F. Benz et al. *Nano Letters* 15 pp. 669 - 674 (2015)

http://pubs.acs.org/doi/ipdf/10.1021/nl5041786

Mimic semiconductor industry to achieve market dominance

Maximize total unit volumes and ride cost curve to attack target markets

Some aspects of future transistor and LENR technology will converge & overlap

- ✓ LENR systems could exploit experience curve effect to reduce manufacturing costs; same as successful market penetration strategies used by electronics manufacturers; e.g., microprocessors, memory chips, PCs, and smartphones
- ✓ As product manufacturing experience accumulates and internal build costs are progressively reduced, leverage longer operating life and huge energy density advantages of LENRs (thousands of times larger than any chemical technology)
- ✓ Price LENR-based systems to drastically undercut price/performance features provided by competing electrochemical battery energy storage products and combustion-based power generation systems. Strategy can be used to attack portable, stationary, mobile, and central station power generation markets
- ✓ Small-scale LENR systems might seem to be light years away from being able to compete with huge 500 - 1,500 MW coal-fired and Uranium-fission power plant behemoths. However, please recall history of personal computers versus large mainframes. When PCs were first introduced 41 years ago, mainframe computer manufacturers regarded them as just toys, information processing jokes of no consequence. Less than 10 years later, mainframe companies weren't laughing any more. Today, except for just a handful of hardy survivors like IBM, mainframe and minicomputer dinosaurs have disappeared, replaced by microprocessor arrays

Widom-Larsen theory enables LENR device engineering

Microscopic reproducibility of active sites is key to commercialization

- ✓ In successfully fabricated primitive laboratory devices typical of today, LENRs can presently reach temperatures of 4,000 - 6,000^{o} K in relatively small numbers of microscopic LENR-active sites located on device surfaces. Evidence for the existence of such extremely hot localized sites is provided in post-experiment SEM images of working surfaces wherein distinctive crater-like structures are visible; these features are produced by rapid heat releases in LENR-active sites that briefly create local high temperature flash-boiling of metals like Palladium
- ✓ At present stage of LENR technology (TRL-2), trying to fabricate cm-scale and larger devices that can reliably and controllably produce macroscopically large fluxes of excess heat - “boiling a cup of tea” - is putting the cart before the horse
- ✓ Unlike its competitors, Lattice plans to use its unique proprietary knowledge of LENR devices and key operating parameters (e.g., achieving and maintaining very high local surface electric fields) to first get key LENR effects --- such as excess heat, transmutations --- working well microscopically. That is, to be able to reproducibly create purpose-designed nanoparticulate structures with their dimensions ranging from nanometers to microns that are fabricated using certain existing, off-the-shelf nanotechnology techniques/methods and then emplaced, along with suitable target fuel nuclei (e.g., Lithium) in close proximity, at what will become LENR-active sites situated on the surfaces of appropriate substrates

Lattice's engineering plan has three key phases:

(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 containing turbulent dusty plasmas, with or without spatially organized magnetic fields present
- ✓ Variety of 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 new types of direct energy conversion technologies that are still in very early stages of development
- ✓ Lattice's nanocentric approach to R&D is unique by being interdisciplinary and directly guided by various proprietary insights enabled by Widom-Larsen theory of LENRs and related relevant knowledge borrowed from advanced materials science, plasmonics, nanotechnology, and chemistry

Widom-Larsen theory of ultralow energy neutron reactions

Three key publications that begin in March of 2006 referenced below

Many-body collective effects enable radiation-free green nuclear power

"Ultra low momentum neutron catalyzed nuclear reactions on metallic hydride surfaces"
A. Widom and L. Larsen
***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

"Nuclear abundances in metallic hydride electrodes of electrolytic chemical cells"
A. Widom and L. Larsen
***Cornell physics preprint* arXiv:cond-mat/0602472v1 (2006)**

http://arxiv.org/PS_cache/cond-mat/pdf/0602/0602472v1.pdf

"A primer for electro-weak induced low energy nuclear reactions"
Y. Srivastava, A. Widom, and L. Larsen
***Pramana - Journal of Physics* 75 pp. 617 - 637 (2010)**

http://www.slideshare.net/lewisglarsen/srivastava-widom-and-larsenprimer-for-electroweak-induced-low-energy-nuclear-reactionspramana-oct-2010

Working with Lattice

Partnering on commercialization and consulting on certain subjects

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

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

- ✓ 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 fee-based consulting. This separate work covers subjects such as: micron-scale, many-body collective quantum effects in condensed matter; Lithium-ion battery safety engineering issues including minimizing risks for occurrence of thermal runaways; and development of ultra-high-temperature superconductors. Additional areas of expertise include: long-term strategic implications of LENRs for high cap-ex long term investments in power generation technology; energy storage technologies; and LENR impact on petroleum-related assets. Will consult on these subjects as long as it does not involve disclosing Lattice proprietary engineering details relating to developing LENR power generation systems

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