Improved stability and performance of surface-modified Constantan wires, by chemical additions and unconventional geometrical structures.

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[Abstract]

Since 2011, at INFN-LNF, we investigated the behavior of Constantan (Cst) alloy ($Cu_{55}Ni_{44}Mn_1$; ISOTAN44) as concerns Hydrogen and/or Deuterium (H_2/D_2) absorption and generation of Anomalous Heat Excess (AHE) at High Temperatures (HT, i.e.>>200 °C). To further improve the intrinsic, excellent, catalytic proprieties of Cst toward $H_2 \rightarrow 2H$ dissociation, surface underwent repeated cycling of "flash" oxidation (pulsed power up to 20 kVA/g), obtaining sub-micrometric particles at *mixed composition* (Cst-NiO_x-CuO_y-$Cu_xNi_yO_z$) and reducing deleterious self-sintering problems of nano-materials at HT. Despite results on thin (Φ=200 μm)-long (l=100 cm) wires were generally positive and excess power (10-20%) was frequently recorded (5-10 W at 50 W input), reproducibility remained yet unsatisfactory.
Later on, we realized that Fe impurities (up-to 1% into old, pre-1970 batch of Cst) enhanced AHE generation, especially at T>500 °C. Since 2014, we added $Fe(NO_3)_3$ solutions both at the Cst sub-micrometric surfaces (during flash oxidations process), and at borosilicate glassy sheaths (SIGI-Fabier; micrometric fibers, previously wetted-dried with $Sr(NO_3)_2$ solution) where wires were inserted (electrical insulation reasons). Recently, we adopted the methodology to make several knots along wires (holes 150-200 μm), later coated multiple times with iron solution. Successively, we introduced Potassium in the solution (known as a promoter of iron catalytic performances) and, eventually, Manganese to prevent/decrease Potassium evaporation. H^+ electro-migration, due to large current (>2 A) flowing along the Cst wires as well as to high magnetic fields at the center of the knots and on Fe micro-particles (absorbing H at HT) deposited inside micro-holes of Cst, is supposed to play a role in AHE. The cylindrical thick-glass wall reactor had a volume of 250 cc; operating pressures were 0.1-3 bar; gas used were He (calibration), D_2, pure or mixed with Xe (ultra-low thermal-conducting gas). Differently from previous experiments, we employed *only* D_2 and not H_2. The 3 wires we used were: Pt for calibration purposes and "indirect heating" of Cst wires, Cst with 41 and 71 knots. Input power range was 10-90 W. Up to now we have observed that the AHE, measured at the external wall of the reactor, reached the largest values (over 85 W, by *comparison/extrapolation* with Pt under He, isoperibolic procedure) when the highest input power (90 W) was applied to the 71-knots Cst in *D_2 mixed with Xe*. Further work is necessary to evaluate effects of: I versus J, numbers of knots, gas mixtures, temperature (including electron emission from SrO: inspired by Iwamura's experiments**,** Richardson-law).

Keywords: Surface-modified Cu-Ni-Mn alloy; H_2 and/or D_2 absorption at high temperatures into Constantan; Anomalous Heat Excess (AHE); high-temperature H storage into Fe; Low Working Function materials; $H_2 \rightarrow 2H$ dissociation by Constantan; electro-migration phenomena; spontaneous voltage generation along hydrogen-absorbing wires.

1. Introduction

The main motivations for our new experimental work were:

a) Improving the reproducibility of results after realizing (since 2014) that some Fe impurities into the main material (Constantan, an alloy with composition $Cu_{55}Ni_{44}Mn_1$, brand name ISOTAN44 by Isabellenhutte-D) and K (at low concentration, about 10% atomic in respect to Fe), are crucial to get positive results.

b) Increasing the amount of Anomalous Heat Effect (AHE) previously (2011) detected by our group using the Constantan (Cst) with its surface modified (sub-micrometric shape) and exploring the role of wire knots.

c) Further studying the spontaneous anomalous voltage/current detected along wires once absorbed H or D.

Aside from other effects, AHE is mainly due to the interaction of Hydrogen (H_2) or Deuterium (D_2) gas absorbed and/or adsorbed by the Cst itself and/or on proper host sites, by enhancing effect of nanostructures (pioneered by Y. Arata-JP), under forced *non-equilibrium conditions*, even local, of any type. Up to now, the following phenomena leading to non-equilibrium conditions have been explored in the LENR field: electrical (everybody); thermal (everybody); H or D electro-migration (F. Celani-IT); D flux (Y. Iwamura-JP); magnetic; laser (Cravens&Letts-USA; L. Holmlid-SE and S. Olafsson-IS; others); radiation stimulation (several); ultrasound (R. Stringham-USA); fractures (A. Carpinteri-IT [1]); nano-magnetism and energy localization (Brian Ahern-USA); femto-chemistry (F. Celani-IT); etc.

We remark that, according to our experience, the AHE origin/process with Cst is similar to that with Pd. Nevertheless, Cst has the advantages of a significantly lower cost and higher robustness; in fact, AHE was still present after months of experiments and after repeatedly cycling the wires between several hundred °C and room temperature. Unfortunately, we also observed that the catalytically active surface tends to become less effective upon exposure to high temperatures (HT) under vacuum or in presence of an inert gas, probably due to sintering and loss of the key nanostructured surface produced by current pulses during wire preparation.

As described in our previous reports, we selected Cst because of its catalytic activity in Hydrogen dissociation [2], providing around 3 eV for the dissociation of H_2 (D_2=?) from molecular to atomic state ($H_2 \rightarrow 2H$). We typically used Cst in the shape of long (l=100 cm) and thin (Φ=0.2mm) wires, with weight 278 mg. Their surface was made sub-micrometric (some particles have dimension less than 200 nm, see SEM in Figure 10) by means of proper, high-peak power, electric-thermal treatments: the typical energy was as large as 600-1000 J/g of Cst and given several hundred times by pulses with a width of 50 ms [3]. Because of such type of powerful, fast rise/fall times (<1μs) and short duration pulses, the wires get red color (about 800-900 °C), oxidize in some ms of time and rapidly quench at the end of the pulse. In air, the oxidation conditions vanish at about 600 °C. The energy density (J/g) is evaluated supposing no *skin effects*, but the effective one is larger. For some aspects the flash oxidation we developed is similar to "explosive" preparation procedure adopted for production of nanomaterials, because of the formation of craters at the surfaces.

The procedure we developed resembles the highly-sophisticated, melt-spinning and quenching procedure adopted/optimized by Prof. Yoshiaki Arata and Coll. (Osaka and Tohoku University-JP) to produce, since 1995, nano-powders of Pd and Pd-Zr in the field of Solid State Fusion (the name given to LENR by Prof. Arata) [4]. We point out that we were deeply inspired by such procedure and properly modified it for the use with wires.

In previous, successful experiments, after prolonged cycling at high-low temperatures, under H_2 gas at HT, the SEM of the wires showed the presence of fracturing phenomena due to Hydrogen embrittlement: the typical dimensionality of the particles was *smaller* with respect to an untreated sample used as reference, then, an useful effect.

2. Description of Experimental Set-up: Some Key Details

The experimental set-up is basically similar to that developed and published since 2011 [3]. In addition, we performed *several modifications to the wire geometry with the introduction of knots and adopted a new procedure for the chemical impregnation of the borosilicate glassy sheaths*. In the following, we explain only the set-up of the latest experiment (started on 20/05/2016; so far operative). We used only D_2, not H_2. D_2O was also employed in the preparation of the solution for impregnating the sheaths and coating the knots. In fact, there is still a possibility of some residual Hydrogen coming both from HNO_3 used for preparing Iron Nitrate and from water adsorbed by the hygroscopic glassy sheaths (when assembling the reactor). From the isotopic point of view, H_2, HD, D_2 will be present, at different concentrations. The amount of radioactive Tritium, i.e. Tritiated water (T_2O) in the Heavy Water (D_2O) that we used is quite low: measurements by LSC (Liquid Scintillation Counting) gave values < 250 dpm/ml (disintegrations per minute/milliliter), i.e < 4 Bq/ml. The half-life of T, a β- emitter, is 12.3 y and its specific activity (in the gas phase at RT) is $3.6*10^{14}$ Bq/g. Shortly, local internal excitation by β- radiations (end point at 18.59 keV) appears unlikely. As radiation stimulation we used a weak (10 kBq), γ-source (decay of natural Th^{232}, sintered with W, i.e. usual TIG electrodes used for welding), well enclosed inside a thick SS cylinder, just positioned outside the wall of the glass reactor.

The overall system, quite complex and developed even using several unconventional procedures, is based on the following features/facts:

a) Thick wall (3mm) borosilicate glass tube (Schott-Duran, -D; further processed by "*Glass blowers Spaziani Rolando Srl"*-IT), l = 25 cm, Φ = 32-40 mm. Gas pressures: vacuum, pressurized. The maximum pressure depends on glass temperature for safety limits: e.g. < 3 bar ABS at 300 °C of glass-tube wall temperature.

b) Pt wire (usually l = 100 cm; Φ = 100 μm). In this specific experiment l=102.5 cm. Pt has multi-purpose uses: *1*) power calibration of the system using inert gas (He); *2*) indirect heating of the Cst wires; *3*) evaluation of mean wire temperature (i.e. Pt used also as thermometer).

c) 2 Cst wires, Φ = 200 μm. One with 41 knots, the other with 71 knots nominal. The initial length (without knots) were 113 and 127 cm. After making the knots, the apparent length reduced to 102.5 and 108.5 cm. During assembly, the length of all wires was equalized to 102.5 cm: the number of knots in the 71-knots wire was reduced to 65. Nevertheless, because of the previous convention in our log-book, we kept the identification name of Cst71.

d) Usually, one wire is polarized and the other is left unconnected and used to measure the so-called "spontaneous voltage" (by a high resolution Fluke 187 multimeter) or current (by a 2-ohm shunt resistance at mA range). The current is limited only by the internal resistance of the wire (about 17-21 ohm). The resistance decreases when D_2 is absorbed, similarly to previous (since 2011-2012) experiments with H_2.

e) Each wire is inserted inside a *borosilicate glass multi-filamentary flexible sheath* (made by SIGI&Favier-I&F) with Φ = 1mm. Each filament, porous, has a diameter of 5 μm. The weight of the 1-mm diameter sheath, after burning the oil used for texture of fibers by SIGI, is 1.9135 g/m. Each fiber is immersed into $Sr(NO_3)_2$ solution (home-made: starting from decomposition of $SrCO_3$ by 65% HNO_3 and diluted by D_2O). After drying/heating (to 400°C) and the partial dissociation of $SrNO_3$ to SrO (a Low Working Function material for electron emission, similar to CaO used by Yasuhiro Iwamura-JP since 2000, [5] and References therein), the weight increases of typically 44 mg/meter.

f) We guess that SrO, at nanometric size, could have a Working Function (W) even lower than the value usually reported (about 2.1 eV), similarly to what happens when using Cesium [6]. According to such hypothesis, large electron emissions may occur at significantly smaller temperatures (i.e., 500 °C instead of usual 800-900 °C) than those enabling emissions from Low Working Function metals (generally mixtures of Ba, Sr, Ca Oxides used in the so called "Vacuum Tubes"). The electron emission in vacuum follows the well-known "law" developed by Williams Richardson (Nobel Laureate in 1928):

$$J = A_C T^2 exp\left(-\frac{W}{k_B T}\right),$$

where J is the current density (A/m^2), $A_C = \lambda_r A_0$ is a constant with λ_r usually 0.5 and $A_0 = 4\pi m_e k_B^2 e/h^3$ = 1.2017*10^6 A m^{-2} K^{-2}, T is the absolute temperature (in Kelvin); m_e is the electron mass (9.109*10^{-31} kg), e is the electron charge (1.602*10^{-19} C), k_B is the Boltzmann constant (1.38*10^{-23} J K^{-1}), h is the Planck constant (6.626*10^{-34} J s).

g) We had indications (since 2013) that the glassy sheaths can play a key-role in the whole reaction [7] and Reference 4 therein), also following the very detailed works of Irving Langmuir (1915-1930; Nobel Laureate in 1932) on the H absorption on glassy bulb surfaces ($H_2 \rightarrow 2H$ dissociation by W filament at T>2000 K). Accordingly, the multi-filamentary borosilicate sheaths could absorb huge amounts of H/D just because of the extremely large values of surface (over 10^4 cm^2 for each sheath covering the wire) and its favorable geometry, being almost in contact with the Cst that dissociates the molecular H_2/D_2 to atomic H/D.

h) *NEW PROCEDURE*. After inserting the 3 wires inside the sheaths, they are immersed in a solution of $Fe(NO_3)_3$+$KMnO_4$ in D_2O. Atomic ratio of Fe:K-Mn is 10:1. K is used as "promoter" of activation for the ab/de-sorption reactions of H/D by Fe_xO_Y (mixed oxides, like FeO, Fe_2O_3, Fe_3O_4), similarly to the Cst dissociation proprieties. H is adsorbed inside the Fe lattice at high temperatures (> 500 °C). *Mn is mainly used to reduce K "evaporation", keeping the reactivity of Fe-K quite stable over time* [8].

i) In separated tests, we measured an increase of 10-20 mg/m of weight of sheaths due to $Fe_{10}K_1Mn_1O_x$ deposited at fiber surface, after drying and the partial decomposition of nitrate and the (partial) oxidation at 500°C. The glassy sheaths are mechanically stable up to about 600 °C.

j) After drying/heating at 500 °C, the glassy sheath is inserted into another sheath (Φ = 2 mm), consisting of Al_2O_3, able to withstand, without self-damaging, up to 1200 °C in continuous operations: avoided dispersion of glassy sheaths (at T > 650 °C), FeKMn, Cst mixed-composition surface, improved electrical insulation.

k) The 3 sheaths were closely braided around each other (Figure 5) and inserted inside another one of 12 mm of diameter, providing so mechanical stability and further thermal homogeneity.

l) At the end, they are rolled up around the SS (Φ = 4-2 mm) tube central support (covered by a glassy sheath). To reduce the problem of Sulfur content of AISI 304 (< 0.015%), all the SS materials were several times conditioned at 700 °C: cleaned with acid etching and ultrasounds. S is usually deleterious to catalysts.

m) A K-type (gas tight by SS sheath) thermocouple is inserted inside the SS tube to measure the inner temperature of the reactor (Tss nomenclature in the following).

n) The 3 wires are interconnected to external ambient using a MACOR® cylinder (Φ = 7-24 mm) inside the reactor: it is heavy (10 g). Aside from the central hole (4 mm) there are other 8 small holes (Φ = 1.6 mm, like

the cylinder of a revolver). The MACOR® cylinder is not in direct contact with the main glass-tube wall: 5 mm gap. An overview of the reactor, with MACOR location and the key thermometers, is shown in Figure 6.

o) We guess that such MACOR® cylinder, among others effects, could act also as location for the recombination of $D + D \rightarrow D_2$ gas. We remind that MACOR®, by Corning Inc.-USA, is a so-called ceramic glass that can withstand continuous operation up to 800 °C and for short time up to 1000 °C. Its composition, weight in percentage, is: 46% SiO_2, 17% MgO, 16% Al_2O_3, 10% K_2O, 7% B_2O_3, 4% F. At 25 °C: thermal conductivity = 1.46 W/(m*°C), specific heat =.79 kJ/(kg*°C). In-deep discussions on such specific aspects and related thermal effects are still now in progress.

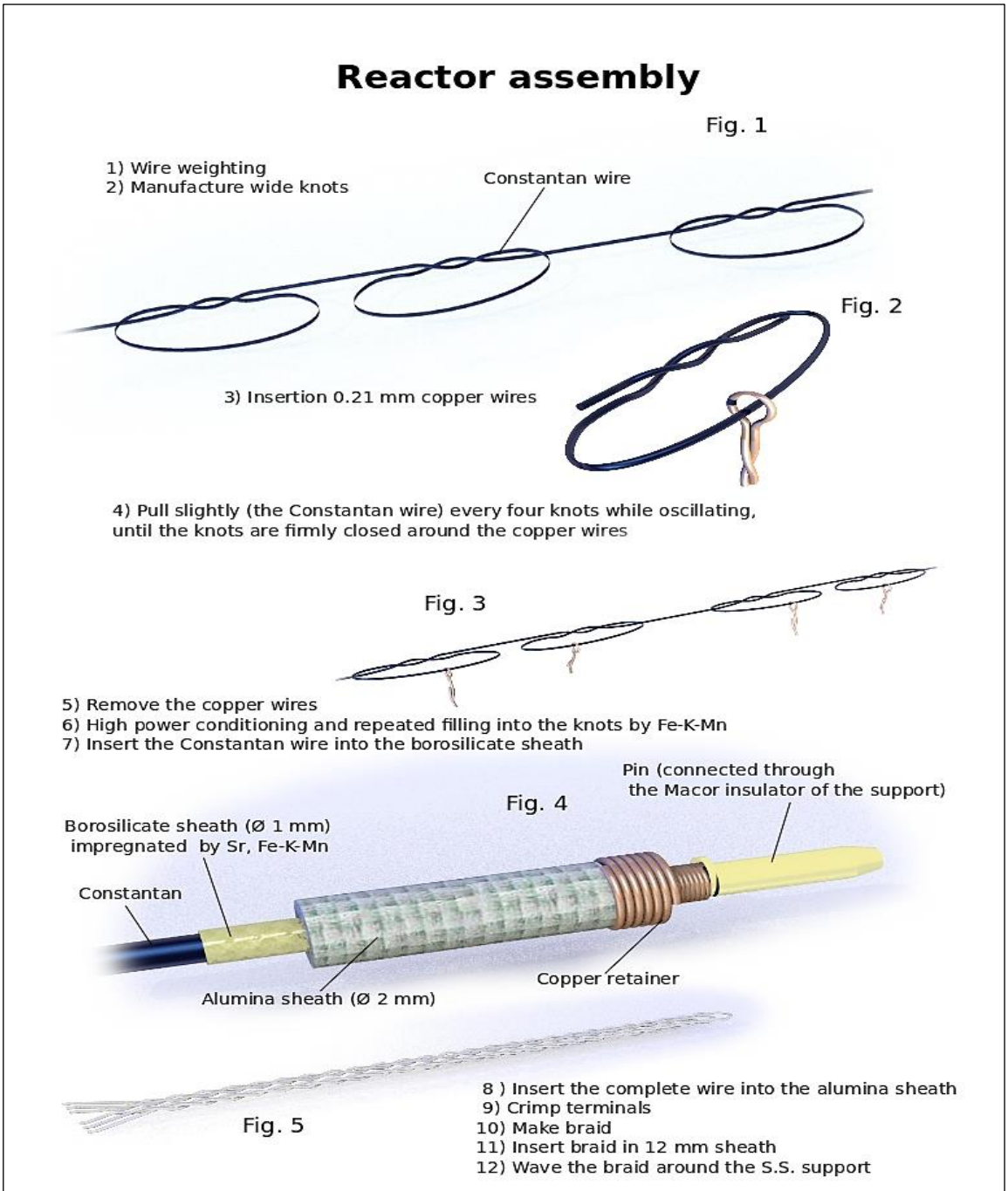

Figure 1: Preparation of the knots in the Constantan wire.

Figure 2: Insertion of the copper wires in order not to completely tighten the knot.

Figure 3: Critical point of tightening the node due to possible stress of the Constantan wire.

Figure 4: After conditioning, insertion of the wires inside the several glass sheaths.

Figure 5: Braid of the three wires to be waved around the SS support.

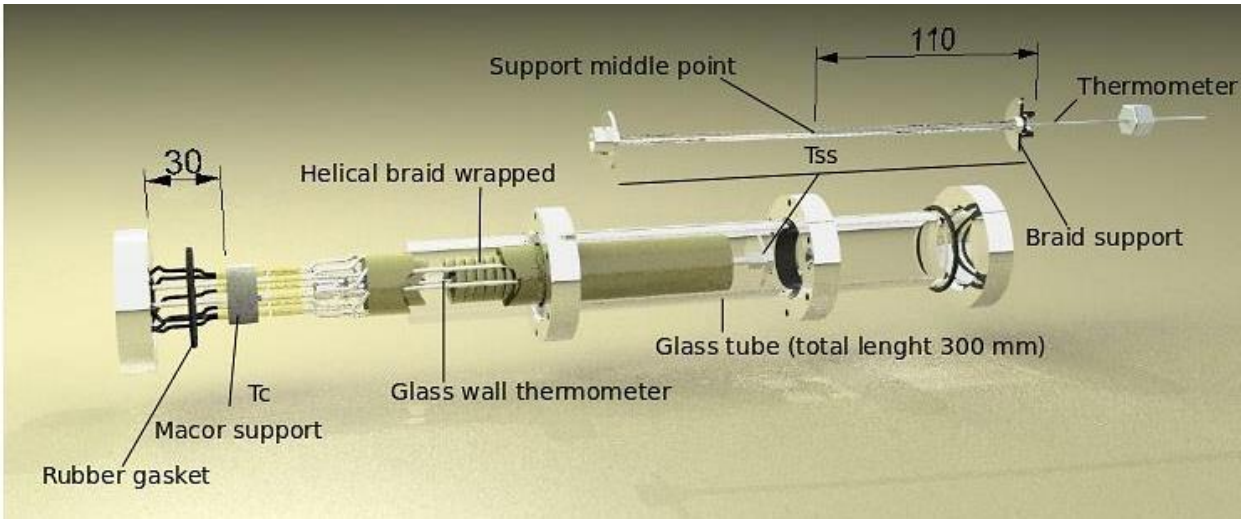

Figure 6: Overview of the reactor once assembled. Regarding temperatures, Tc is external, Tss is internal to the reactor core.

3. Procedure for Wire Preparation: Some Details

The steps of wire preparation procedure, quite elaborated, are detailed in Figure 1, Figure 2, Figure 3, Figure 4, Figure 5.

In Figure 1, steps 1, 2, we show the initial procedure, i.e. wire accurate weighting and manufacture of knots.

In Figure 2, step 3, we detail the insertion of Cu wire (Φ = 0.21 mm, gold color), reference for the "*main hole*"; see also steps 5 and 6 in Figure 3.

In Figure 3, we describe the steps 4 and 5 for "locking" the reference Cu wire up to the proper dimension, without causing the wire too large stress. Such steps are the most critical/delicate of the assembly.

In Figure 4, steps 6, 7, we report the *key* processes for "conditioning" the Cst in order to modify the surface from smooth to sub-micrometric (by "flash oxidation" electric pulses) with different chemical compositions (Cst, CuO_x, NiO_y, $Cu_xNi_yO_z$). The main hole and the micro-holes generated by explosive-like pulses on wire surface are filled with liquid Fe-K-Mn solution several times. Such steps are the more tedious, time consuming (several hours) and risky: the wire can get destroyed because of combined effects of aggressive chemicals (e.g. liquid nitrate, $KMnO_4$) and extreme thermal and mechanical stresses (e.g. pulsing to very high temperatures up to 900-1000°C and cooling in few ms). The Cst wires are inserted inside a borosilicate sheath (from SIGI-Favier; Φ = 1 mm), previously wetted and dried, sequentially, with a solution of $Sr(NO_3)_2$ and Fe-K-Mn both in D_2O. At step 8 the borosilicate sheath is inserted into another sheath of Al_2O_3, Φ = 2 mm able to withstand continuously up to 1200 °C. At step 9, the ends of wires are crimped with a gold plated mini-connector. At step 10, the 3 wires are braided around each other and put, at step 11, inside another borosilicate sheath (Φ = 12 mm) for mechanical stability and thermal homogeneity reasons (not shown).

In Figure 5, step 12 the (Φ = 12 mm) sheath is rounded at the SS support, previously covered by a (Φ = 4 mm) glassy sheath. The rounded sheath is, at the end, covered with a (Φ = 25 mm) final sheath (not shown) for mechanical stability reasons and overall thermal homogeneity toward the borosilicate thick-glass reactor with internal diameter of 34 mm.

4. SEM Pictures

Figure 7, Figure 8, Figure 9 and Figure 10 display the overview of a typical Cst wire after thermal treatments (for oxidation and structuring of the micrometric surfaces) and Fe-KMn depositions. The actual diameter of the main hole is 160 µm, less than the "stated" 200 µm by Cu reference wire in Figure 3.
After several cycling of Hydrogen/Deuterium loading-deloading at high temperatures, the diameter of the particles decreases in a remarkable way, supposing no sintering due to vacuum or inert gases happened. We guess that the "new" addition of Fe-KMn compound at the surface of the wires reduces the "weakness" of Cst toward sintering problems. We remind that H is adsorbed at HT (> 500 °C) inside Fe lattice. Perhaps, the addition of K to Fe is even able to reduce the starting temperature of absorption.

Figure 7: Detail of a typical knot after preparation.

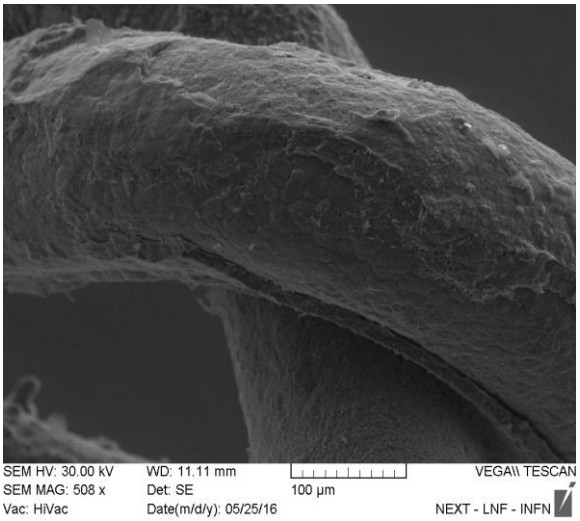

Figure 8: Detail of knot surface showing the irregular shape of material surface.

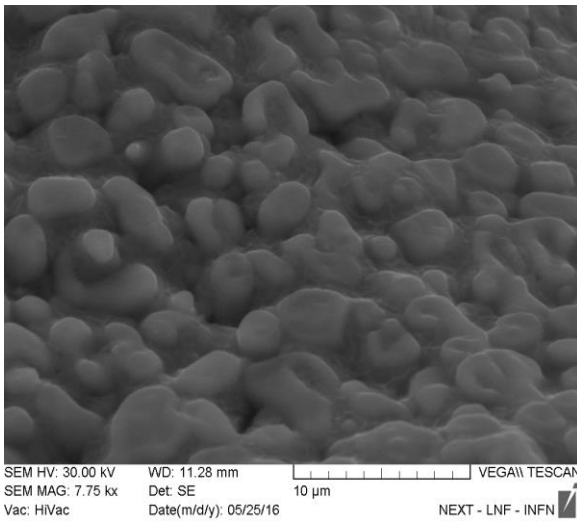

Figure 9: Knot surface view at 10 µm length scale.

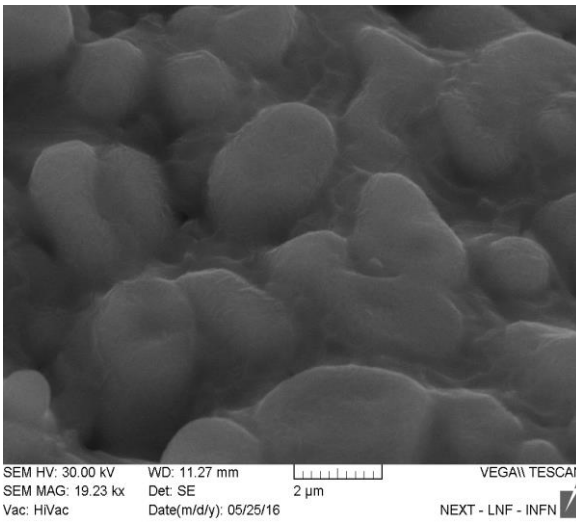

Figure 10: Knot surface view at 2 µm length scale.

5. Main Results

After calibration under vacuum and He gas with power applied *only* to Pt to avoid sintering of the nanoparticles at Cst surface (due to high temperatures in vacuum or inert/noble gas atmosphere), the experiments were performed using D_2 at high (2 bar) and low (0.2 bar) pressures. The combined effect of pure D_2 (a cracking agent to reduce dimensionality of surface nanomaterials) and several Low→High→Low temperature cycling further promotes Deuterium absorption into the bulk of Cst, obtaining *useful aging effects*.

In order to increase wire temperature, with beneficial effects for AHE, keeping as low as possible the external power applied, we added to pure D_2 Xe gas at 50% ratio. Among other useful/strange effects, to be fully explored/reconfirmed by us, this noble gas has an extremely low value of thermal conductivity. Most of the results we report are obtained with Xe-D_2 mixture, mainly at a total pressure of 0.2 bar. Since 2010 [9], we added high Z noble gas (e.g. Ar) to reduce thermal conductivity of the reactors. We observed that such addition even improved the AHE, but the results were of too-low absolute values to be completely sure about. For such reason we moved from Ar to Xe (although quite expensive). Since then, we made several speculations about the role of Noble gas but they were not enough conclusive.

The results are shown in Figure 11, Figure 12, Figure 13, Figure 14, Figure 15.

Figure 14 displays the behavior of the so-called spontaneous voltage, which increases with the loading of the wire, the concentration of atomic Deuterium and temperature.

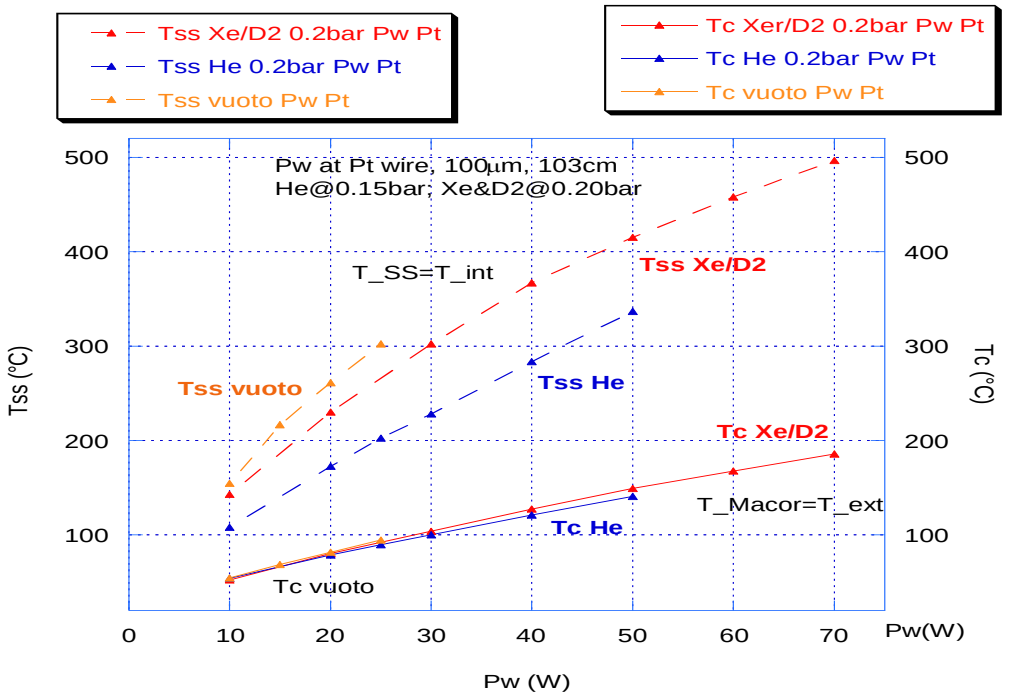

Figure 11: Calibrations by Vacuum and He with power applied at Pt wire. Both temperatures, internal (Tss) and external (Tc), increase in Xe+D2 (50%-50%) gas mixture atmosphere at 0.2 bar. The extra temperature at constant Pw, with active gas D2, could be originated by AHE on both Cst wires.

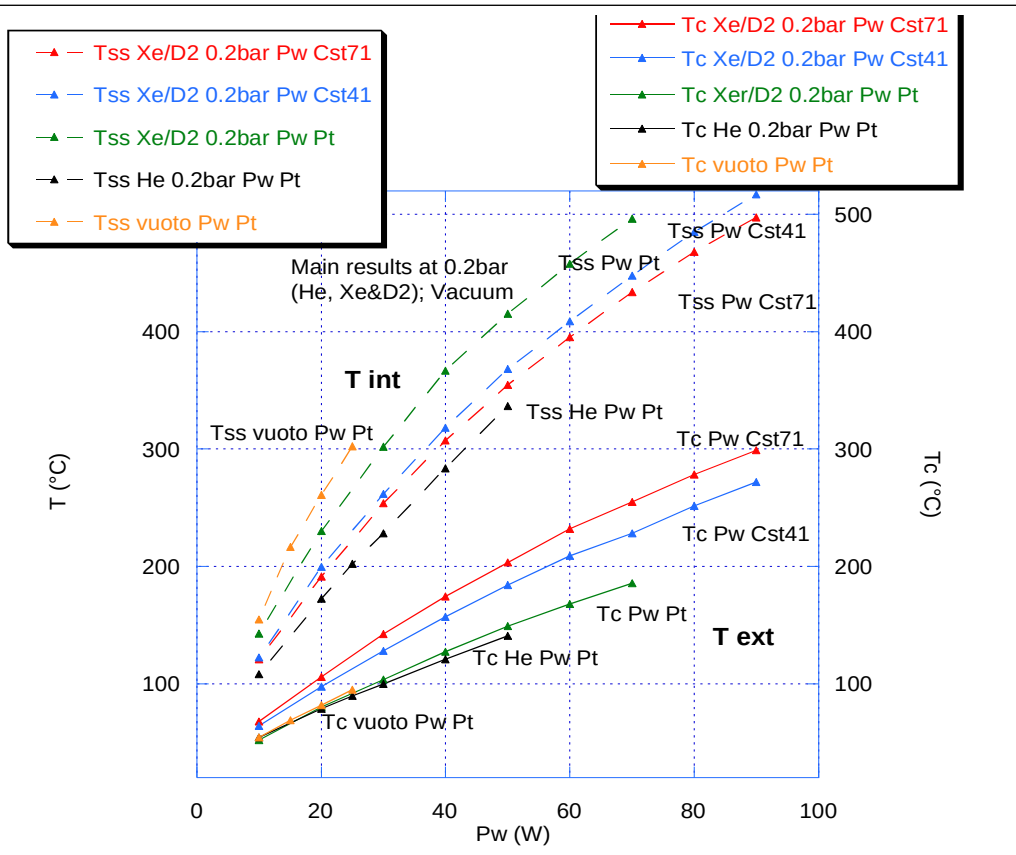

Figure 12: Overview of the *main experiments* performed using Vacuum (Pw at Pt), He (Pw at Pt), Xe+D_2 mixture (Pw at Pt, Cst41, Cst71). It is discernable a large increase of external temperature Tc with respect to Pt case, when Pw is applied at Cst41 and Cst71 (best result).

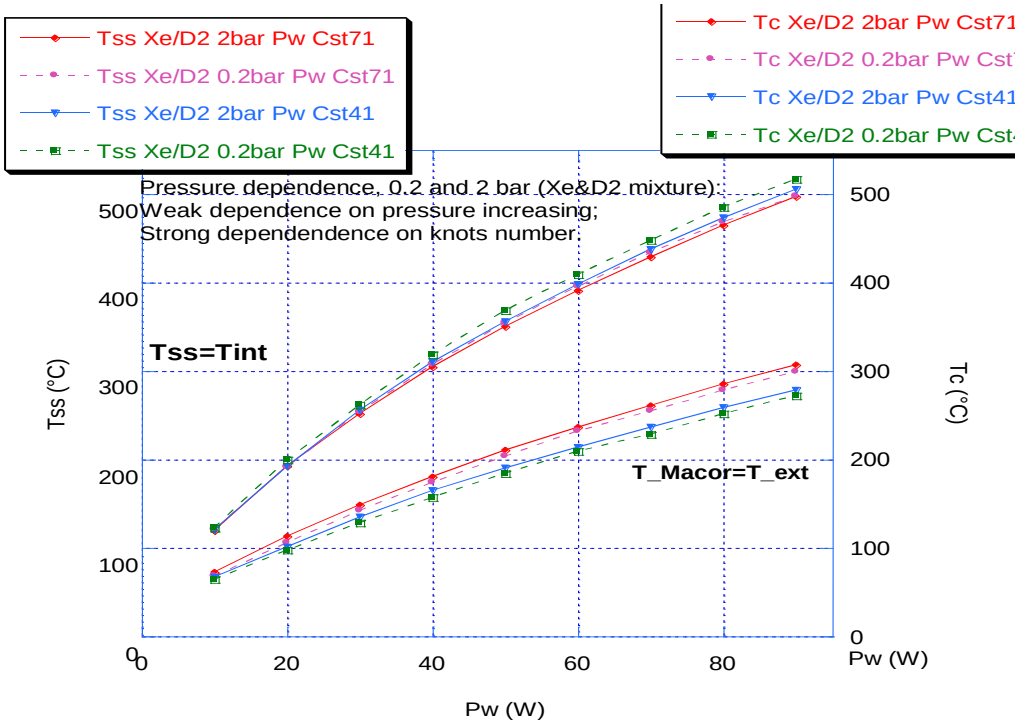

Figure 13: Dependence of internal and external temperatures on gas pressure of Xe+D_2 mixture: 0.2 and 2 bar. The effect is quite weak. At constant input power, temperature depends mainly on the number of knots.

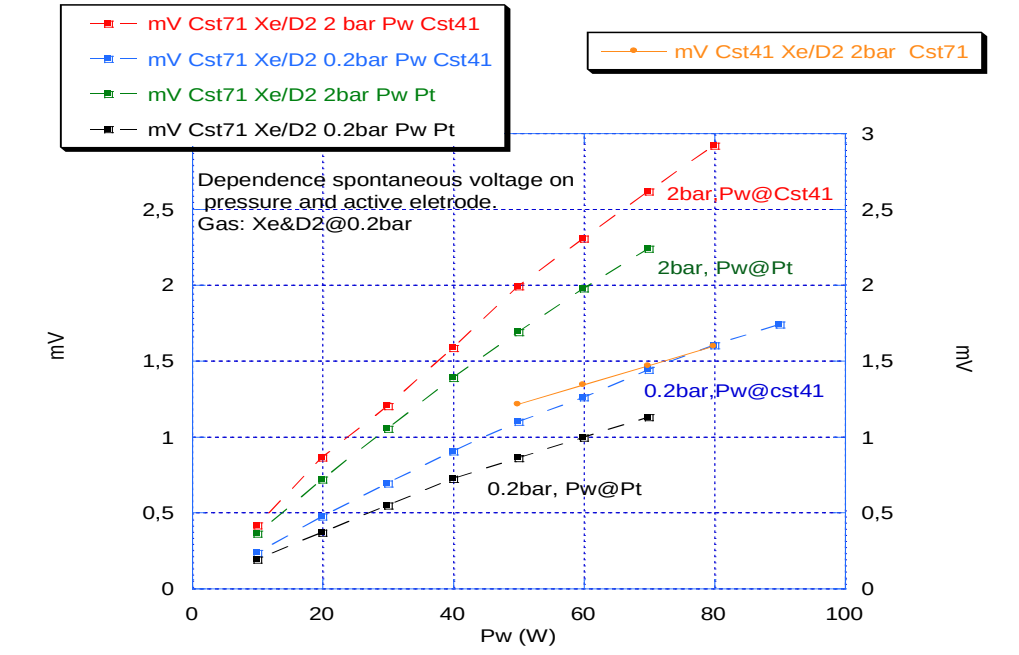

Figure 14: Spontaneous voltages (on 10 MΩ load) measured at the ends of Cst71 wire, *not* connected. The current produced (at 2 Ω load) depends only on the internal resistance of the wire (around 18 Ω). Aside from internal temperature, voltage increases with gas pressure and with the "amount" of atomic D allowable: when Pw is applied at Cst41 (a guessed good catalytic material) the results are larger than with Pt.

6. Highlights

The addition of Fe-Mn-K mixed oxides to our experimental set-up has caused a significant increase of the AHE with respect to our previous similar experiments. Data point toward a complex of phenomena mediated by atomic hydrogen/deuterium formation, transport and recombination despite pressure and temperature (unfavorable for atomic

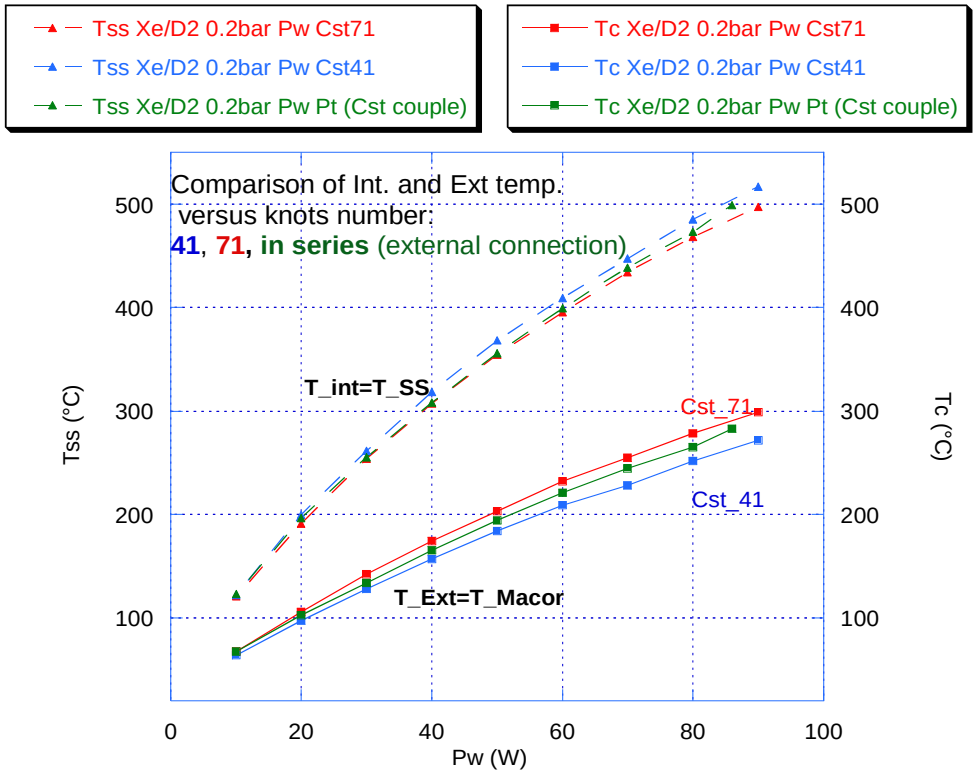

Figure 15: Case with the 2 Cst wires connected in series (green lines). It can be argued that the AHE, at constant Pw, is *not* strongly related to the internal temperatures (Tss) of wires (individually lower because of lower voltage drop) due to the current.

hydrogen). In fact, the energy gain seems to strongly correlate with the process of dissociation and recombination of atomic hydrogen/deuterium.

We also have early indication that the migration of the active species is enhanced by current and voltage in the Constantan.

On the basis of our observations we propose a simplified model of the experiment where atomic hydrogen/deuterium is firstly formed by exothermic adsorptive dissociation on the surface of Constantan (Ni/Cu), migrates toward the Fe-Mn-K impregnated fiberglass sheath and exothermically recombines (especially on MACOR ceramic) (Figure 16). The energy for sustaining this process comes in form of current on Constantan (via Joule heating and a possible electrochemical factor) and from a *yet unknown process, possibly at electron Compton wavelength scale, justifying the apparent excess heat.*

Future work will be dedicated to identify and better understand the active sites of energy generation.

At the same time, special care will be given to exclude any "electrochemical" Peltier-like effect capable of mimicking certain of the reported thermal anomalies.

In that respect we consider particularly valuable the work of Dr. Groszek that has been recently brought to our attention. In reference [10] and [11], he has recently described experiments where hydrogen absorbed on transition metal catalysts reacts with oxygen, releasing a heat pulse far beyond the enthalpy of combustion. Having said that, we may suppose that in our experiments we are continuosly regenerating the catalyst and the reagents of Groszek-type experiment, allowing a steady excess heat release. Future work will be dedicated to identify and better understand the active sites of energy generation and the role of the mixed oxides.

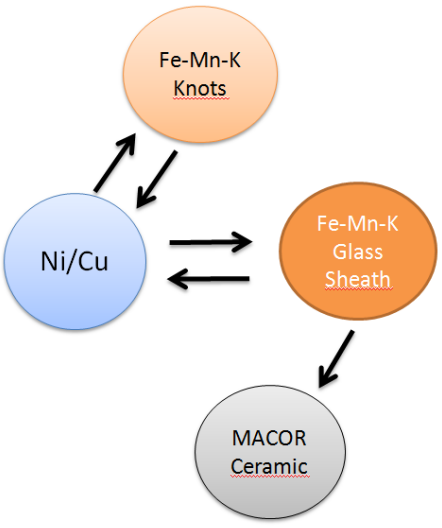

Figure 16: Possible exchange of atomic hydrogen in the current experiment.

7. Final Remarks

Transport of atomic hydrogen may possibly occur from dissociation to recombination sites. These transport phenomena appears to be enhanced by current in Constantan, hence calling for a possible intervention of charged hydrogen/deuterium species. Dissociation/transport/recombination makes it difficult to identify sites where excess heat occurs. A minor risk for some sort of Peltier-like effect mimicking certain observations cannot be excluded yet.

8. Addendum

Very recently, after the ending of ICCF20, by chance, it has come to our attention that a Researcher from Germany (Prof. Ing. Dr. Horst Preusker, 25469 Halstenbek) [12] claimed in an extremely short patent (3 pages, filed in 1994) that Xe acts as a catalyst for the nuclear reaction $D_2+D_2 \rightarrow {}^4He$ with emission of large amount of energy, once D_2 gas is properly ionized. We do not have, up to now, elements to judge if the claims of Prof. Preusker are correct. Anyway, we have experimental evidence of a performance increase *after* the introduction of Xe inside the reactor, even at low concentration, especially when the power is applied to Cst.

Because of the possible effect of Xe, and others high-Z noble gases as co-catalytic agents of the AHE reactions (at least in our specific environment), we repeated previous test (since 2013) to confirm the role of Ar and Xe. Additionally, after taking into account a possible role of water which we may always consider present in traces in our experiment (mostly coming from the glassy sheaths and the mixed oxides), we intentionally added again D_2O again in the reactor chamber. Table 1 summarizes some thermal data collected at a fixed input power (Pw) of 50 W on Cst. We can argue that the additions of Ar and, even better, of Xe gas to D2, *are really effective in increasing AHE, out of any possible doubt*. Water is also very effective and a synergistic effect with Xe can be observed. How all these compounds are interacting with the wire and mixed oxides is under investigation.

Table 1: Measurements performed at input power of 50 W on Cst71 wire in different gas-mixture atmosphere. The presence of the noble gas (Ar and, in particular, Xe) enhances AHE.

Cst71 Wire								
Gas type	D_2	Xe / D_2	Xe / D_2	Ar / D_2	He	H_2	D_2O (2 cc) Air (10 cc)	D_2O (2 cc) Air (10 cc) Xe (45 cc)
P at reactor off (bar)	1	1 / 0.8	1 / 0.8	1 / 1	1	1		
P at reactor on (bar)	1.41	2.63	2.64	2.71	1.346	1.32	0.20	0.51
Pw (W)	50.18	50.13	50.38	49.91	49.75	50.25	50.11	50.30
Tc (°C)	197.2	208.3	208.6	205.5	191.03	192.8	203.73	212.42
Tss (°C)	258	342	342.9	308.9	253.5	243.7	367.8	400.08
T_{Pt} (°C)	257	318	319.4	292.26	252.1	244.6	344.69	376.14
T_{amb} (°C)	20.7	20.4	19.98	18.35	17.04	17.8	20.53	20.57

9. Conclusions

1) One of the weakest points of LENR studies in general, i.e. the not at all satisfactory reproducibility, in our specific experimental situation seems to be overcome with the addition of some Fe-K-Mn to our Constantan wires and glassy sheats (saturated with SrO, whose role is the emission of electrons even at low tempertures, i.e. 600 °C).

2) The effect appears also related to the concentration (or hyper-concentration according to some authors such as Leif Holmlid and Svein Olafsson) of Hydrogen or Deuterium in specific sites, including Fe (absorbing H only at High temperatures, > 500 °C), once H_2 or D_2 are dissociated in situ.

3) The role of glassy sheaths, due to their specific composition and geometry/porosity, seems to be important, similar to that of alumina "support" in the field of car catalyser for exaust gas conditioning.

4) The observation of "strange" nuclear effects, even including a reduction of ambient radioactivity and/or the emission of some low energy photons (< 250 keV), has to be fully elucidated yet. Anyway, such phenomena arise only after *long*-time (several months) operations of the reactor and large/stable "loading".

5) The effect of the so-called “spontaneous voltage”, firstly observed by us, by chance, on June 2014, is real and, since the first observation, has been increased of over one order of magnitude for given power produced. It seems like a new type of TEG (Thermo Electric Generator) induced by Hydrogen or Deuterium in the bulk and (perhaps) at the surface of Cst wires: practical application???

6) Further *multidisciplinary* work is mandatory to exploit the full potentialities of (our) Cst and LENR in general. Several phenomena are really unexpected and are *not* experimental errors:

Some of the new phenomena observed have the potentialities for a practical application.

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Finally, we notify that several Italian Politicians (Lower and Higher House, independently from their own affiliation) made very notable “recommendation” and pressures to allow the survival of LENR Scientific studies in Italy.

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