Observation of macroscopic current and thermal anomalies, at HT, by hetero-structures on thin and long Constantan wires under H_2 gas

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Introduction

Since the end of 2011 we introduced, in the LENR research field, a *new (low cost) material*, Copper-Nickel alloy, named "*Costantan*" (ISOTAN 44, Isabellenhutte-Germany, composition: $Cu_{55}Ni_{44}Mn_1$), wire shaped (l=100cm; Φ=0.1-0.2mm).
We *demonstrated experimentally* that such alloy, at nano/micrometric dimension and at high enough temperatures (>120°C), catalyzes the dissociation of H_2 to 2H and absorb/adsorb protons in the lattice.
[S. Romanowski et al., *Langmuir 1999,15, 5773-5780*].

The results, by computer simulations, of capability of H_2 dissociation, according to Romanowsky, were:

$Ni_{0.3750}$-$Cu_{0.6250}$	+3.16eV
$Ni_{0.6250}$-$Cu_{0.3750}$	+2.86eV
$Ni_{0.8125}$-$Cu_{0.1876}$	+2.10eV
Ni	+1.74eV
$Ni_{0.1825}$-$Cu_{0.8175}$	+1.57eV
$Ag_{0.8125}$-$Pd_{0.1875}$	+0.57eV
$Ag_{0.625}$-$Pd_{0.375}$	+0.51eV
$Ag_{0.1875}$-$Pd_{0.8125}$	+0.51eV
Pd	+0.42eV
Cu	-1.11eV
Ag	-1.42eV

In order to increase the overall catalytic proprieties, i.e. *the surface area*, the wires were subjected to specific thermal/electric treatments: made sub-micrometric and multilayered nanostructures, vaguely similar to hetero-structures. *The threshold temperature, in free air, to produce sub-micrometric structures, just by oxidation, is 600°C.*

Our specific thermal treatments were aimed to produce sub-micrometric geometries (chaotic like mixtures of Ni, NiO, Cu, CuO, $Ni_xCu_yO_z$), avoiding, at same time, self-sintering processes due to the high temperatures: irregularly shaped/mixed "materials".

The electric high peak power pulses (20kVA/g of material; t_r<1μs; J>50kA/cm²) even neglecting skin effect) induce extremely fast thermal treatments and shock waves. Obtained glassy materials at surface.

We were inspired by the "*Melt Spinning and Quenching*" metallurgical process, largely used by Yoshiaki Arata and Collaborators (Osaka, Tohoku Universities), to produce nanomaterials (Pd, or Pd_xNi_y, both dispersed into a matrix of ZrO_2 at 65% concentration) for his "SSF" (Solid State Fusion) devices under interaction with pressurized (up to 60 Atm.) D_2, H_2 at 150-300°C.

The key principles/procedures of Y. Arata, *specific nano materials*, were reproduced/modified, among others, by A. Takahashi-A. Kitamura (Osaka-Kobe Universities, also at Technova-Japan), B. Ahern (DARPA-USA), our group in Italy (by wires).

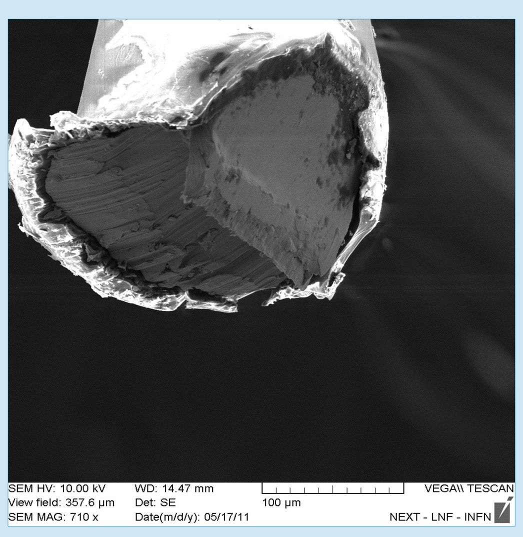


Fig. 1 – SEM - Cross section of virgin wire, as provided by Isabellenhutte, with "plastic" cover at the surface (lighter area at the micro-photography).

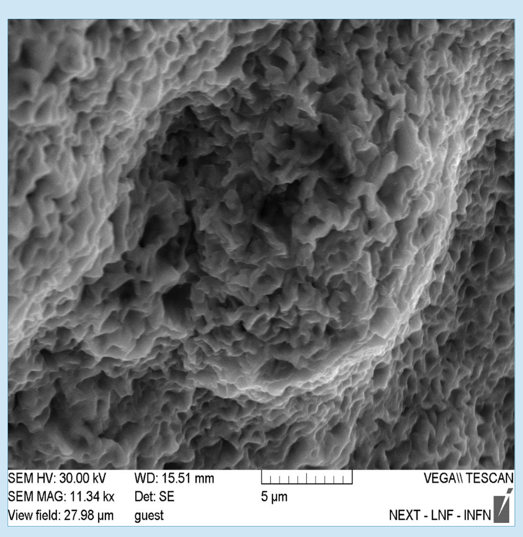


Fig. 2 – SEM - Wire's surface after heat treatments: DC current I=2500 mA, time 5 minutes.

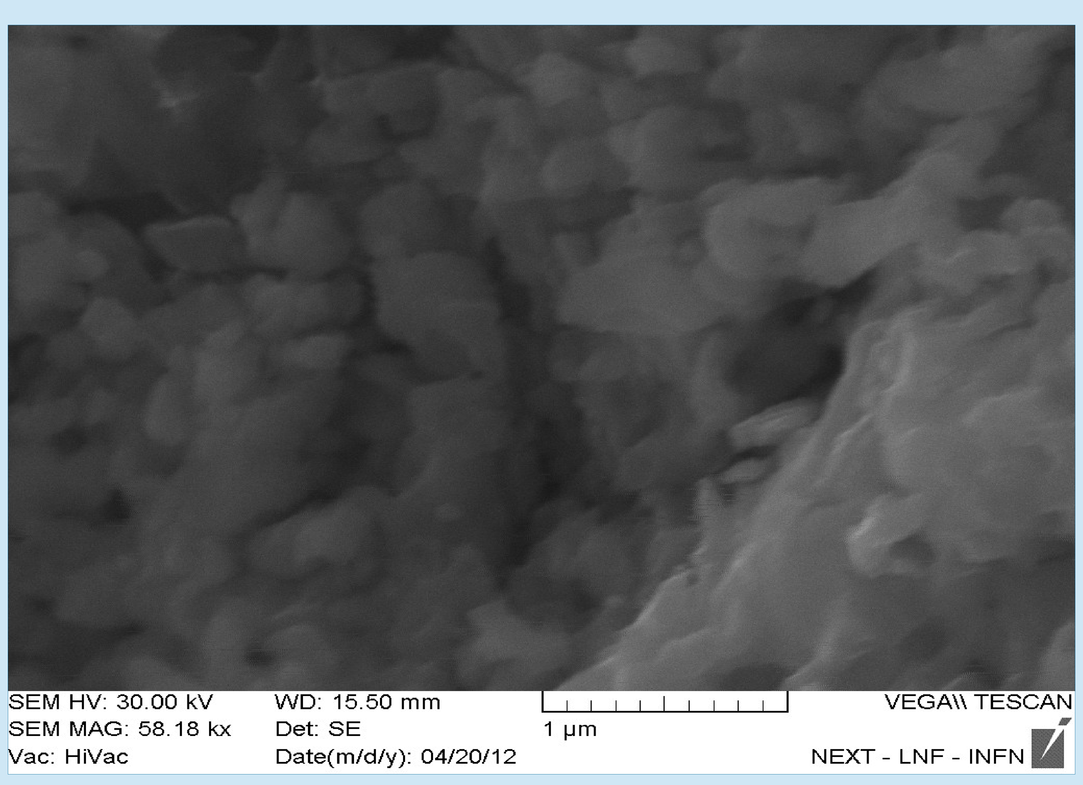
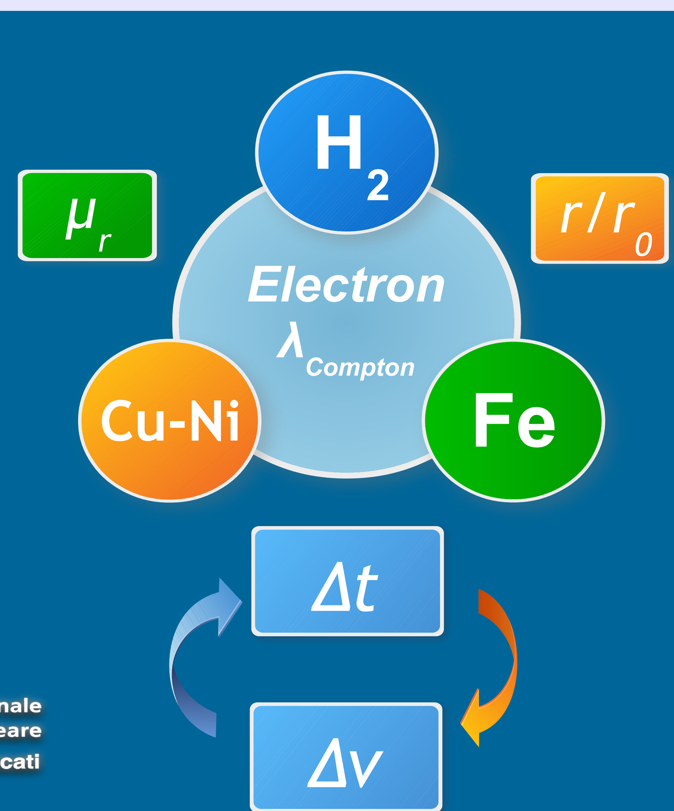


Fig. 3 – Typical SEM of wire surface after repeated pulse treatments by high power pulse.



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First Generation Experiment

Some of the results obtained, using a simple dissipation reactor made of a thick-wall Boro-Silicate Glass (BSG) tube, were quite reproducible and the Anomalous Heat Effect (AHE) detected (at Constantan wire surface temperatures of 160-400°C) was about 5-10W with 50W of electric input power [ICCF17, August 2012, Daejeon-South Korea].

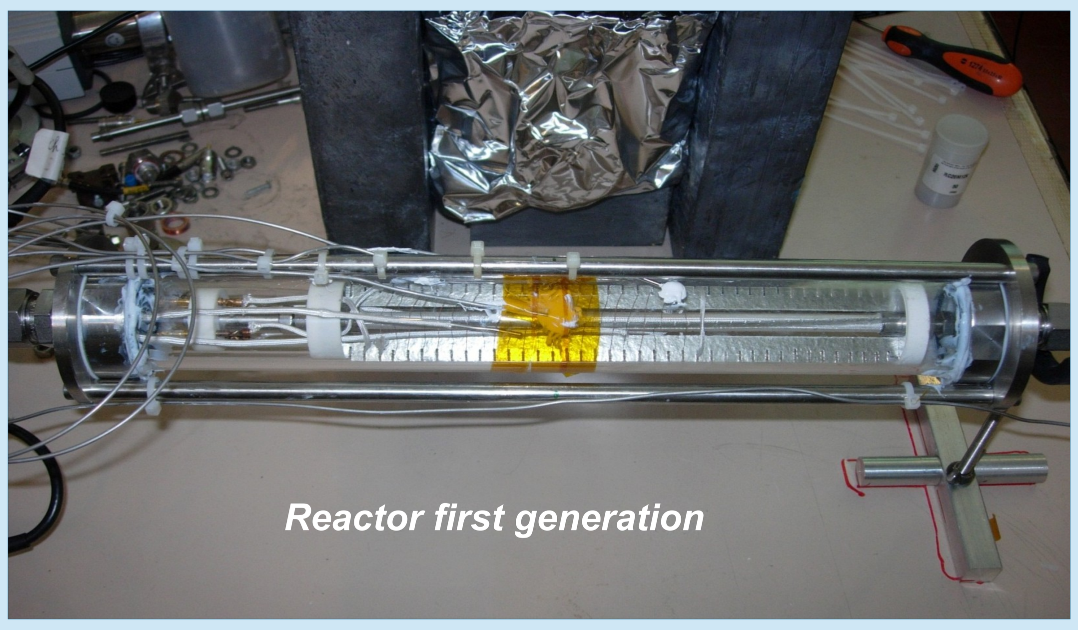

Fig. 4 - Photo of the small, dissipation type, transparent reactor operating at INFN-LNF. The volume is about 250cc. The 2 wires, reference and active, are rounded on a mica support. The thermocouples are Type K, SS screened (diameter 1.5 millimeter).

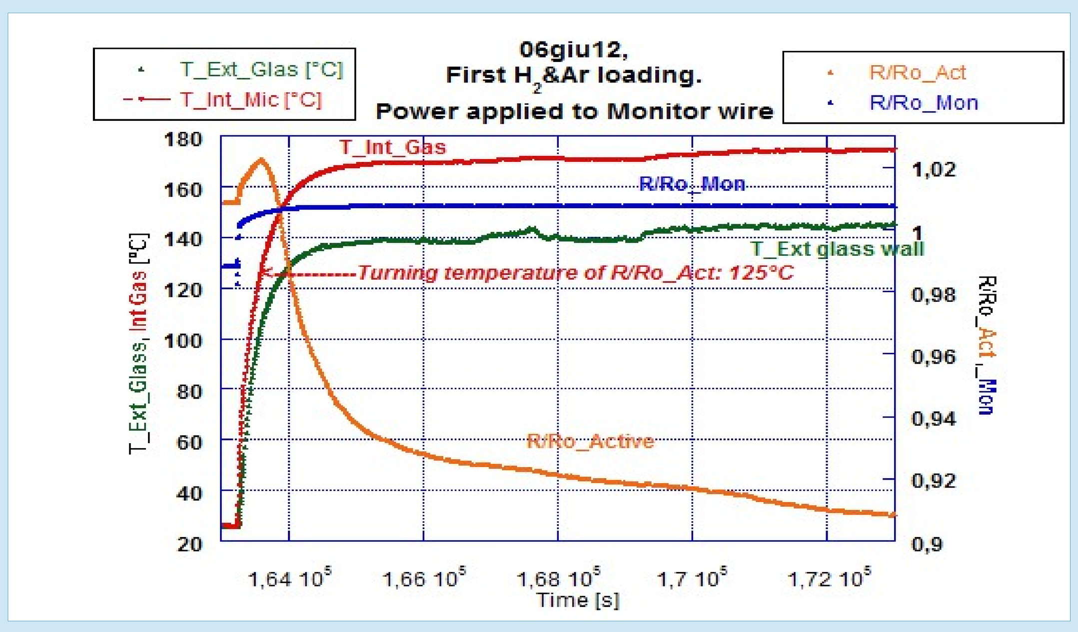

Fig. 5 - Details of first loading by H2-Ar mixture. The "trigger" temperature, to get the large resistance decrease of sub-micrometric Constantan wire, was about 125°C. Temperature measured by a type K thermocouple (SS sealed) inside the gas cell.

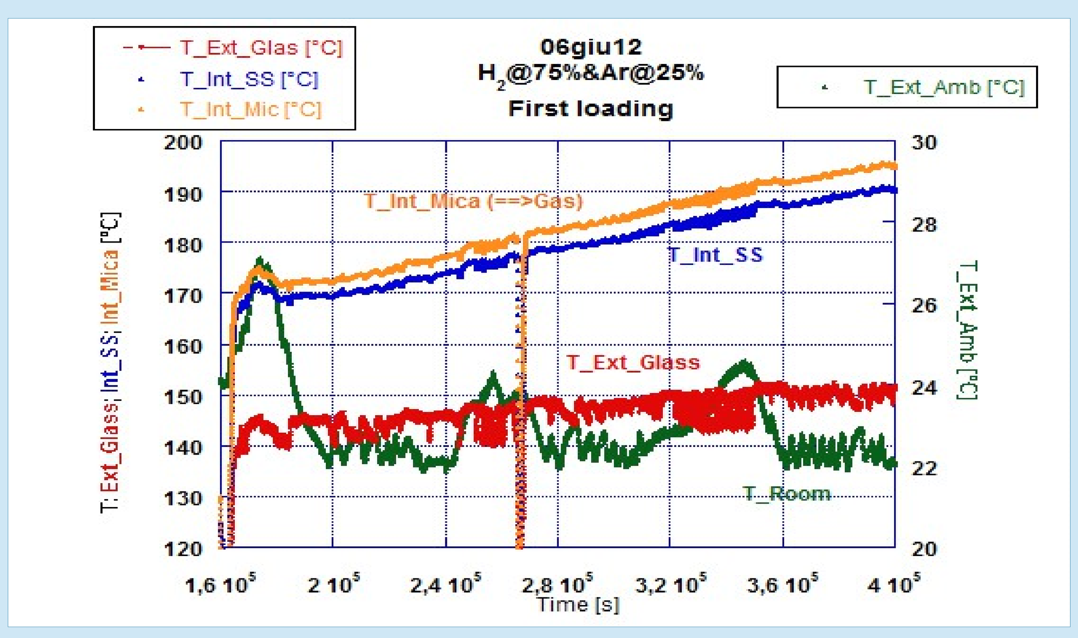

Fig. 6 - Behaviour of the temperatures of the reactor, at CONSTANT input power (48W at Mon. wire). Flowing the time, BOTH the external glass temperature (140-150°C) and the 2 internal (Gas, 170-195 °C; "Stainless Steel", 168-190°C), increased. The effect was not directly related to room temperature variations, altough such temperature variation helped to get not-stationary conditions.

Later on, we realized that the overall reproducibility was not satisfactory as observed in the first series of experiments.
Using SEM/EDS (and ICPMS) analysis we found, among others, that the first batches of raw material used (produced before 1970) had a composition different from more recent ones. The main difference was *Fe contamination*, in the order of 1000-5000 (and up to 10000 locally) PPM.

Effect of fiber Glass on H storage

We found that even the BSG fiber sheaths (BSGFS, SIGI-Italy), largely used in our experiments as electric insulator, could have some role in AHE generation. In short, hydrogen eventually dissociated by the Constantan wire, is largely adsorbed into the surface of the micrometric (Φ=5μm) braided fibers. Such BSG property was observed by Nobel Laureate Irving Langmuir since 1920. The amount of adsorbed H, at low temperatures, was in the order of 10^15 atoms/cm^2. In our experiment the effective surface of each sheath is >1m^2. The total amount of fiber used may have a total surface > 50m^2. We realized that such BSG property may enhance the absorption of Hydrogen in Constantan lattice and related AHE. [F. Celani et al: "MIT-2014 Colloquium on Cold Fusion Effects", March 21-23, 2014; Cambridge-USA].

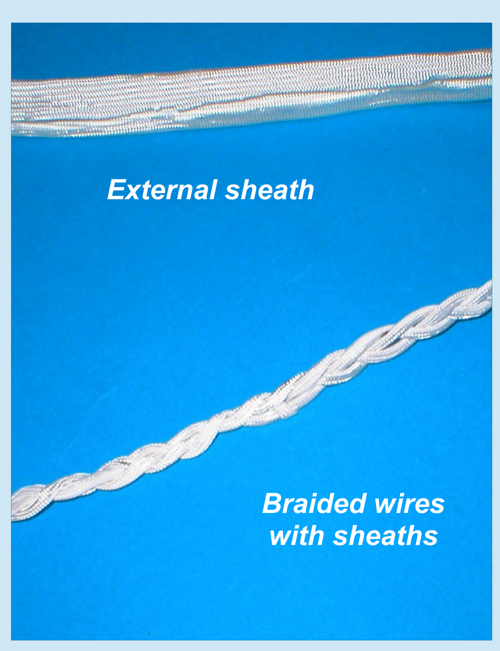

Fig. 7 – Photo of braided wires.

Single Wire Spontaneous Voltage Generation

In a typical setup we have a Platinum wire (Φ=100μm) used mainly for calibration purposes ("reference") and two Constantan wires (the "active") with different diameters (100, 200μm) and/or surface treatments. Each wire is inserted inside a BSGFS. The 3 sheaths are closely braided each other and put inside twin BSGFS for thermal homogeneity. We can control only two wires at same time. For this reason one of Constantan wires is not acquired by the DAQ (PIXIe, NI) and is left unconnected (floating), but periodically his resistance value is measured by a general-purpose multimeter to evaluate the presence of absorbed Hydrogen. We observed that the wire resistance decreases (up to values as low as 70% of initial one, the so-called R/Ro ratio), when the Constantan wire is heated in presence of Hydrogen. On June 25, 2014, we noted, almost by chance, that Constantan wire generates by itself a macroscopic voltage (>>100μV), that is function of many parameters (temperature, gas type, pressure, value of R/Ro). Maximum values (not stable over time, only few hours) were of the order of 1400μV and current of 120μA. Stable values were about half.
The effect is not the usual Seebeck effect because we use only one wire, NOT a junction of 2 different materials, like in thermocouples.

Iron Addition

Finally, taking into considerations our old results (2012) we developed a new procedure to add Iron, at nanometric dimensions, over the surface (and even into the bulk, some microns) of Constantan wires during the several preparation steps. The Fe is one of the few elements characterized by a solubility of H inside lattice that *increases*, largely, *increasing* the temperatures (from 0.37cc/100g at 400°C to over 7cc at about 1000°C). Because such reason, we added another sheath, over the usual BSGFS, based on Al2O3 material (T_max=1200°C). In order to increase the local wire temperature keeping costant the input power we we used also a mixture of Hydrogen with gas of low thermal conductivity (Ar,Xe). Comparing results, about AHE, we observed that low thermal conductivity gas mixture is more efficient to increase it. We remember that all the sheaths, since February 2013, were embedded by SrO, material at low working function for electrons emission, similar to CaO used by Yashuiro Iwamura at Mitsubishi Japan.

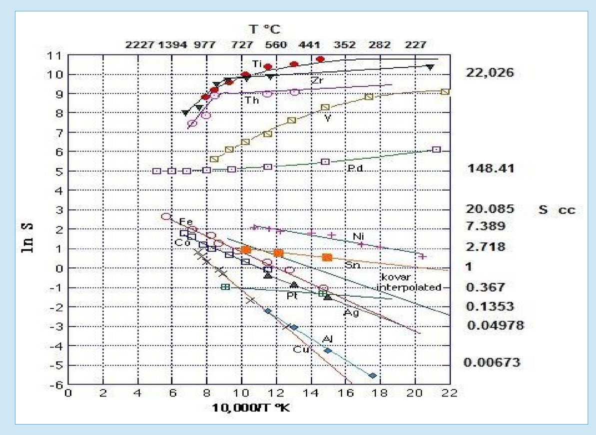

Fig. 8 -Solubility of H in various metal (100 g) vs. temperature at 1 Atm.

Thanks to a new procedure developed at INFN, 20-40 Fe thin layers can be made at wire surface, like multiple heterostructures.
Moreover, we introduced, local, geometric variation of the current paths injected inside the wire by making several (up to 20), low diameter hole (0.3-2mm) knots: even magnetic effects are expected. Obviously the knots are places of large *thermal not homogeneity* when the large current is flowing. Recent experiments with/without Fe and knots, and their combinations, show that such new setup could have measurable advantages from the point of view of Hydrogen absorption and AHE values, especially at High Temperatures (>400°C). *The best value of AHE, very conservative (i.e. the wire without local Fe added is supposed to be the blank with 0W of AHE), gives values larger than 15W at a local wire temperature around 800°C (estimation using Pt wire) and input Power of 100W.*

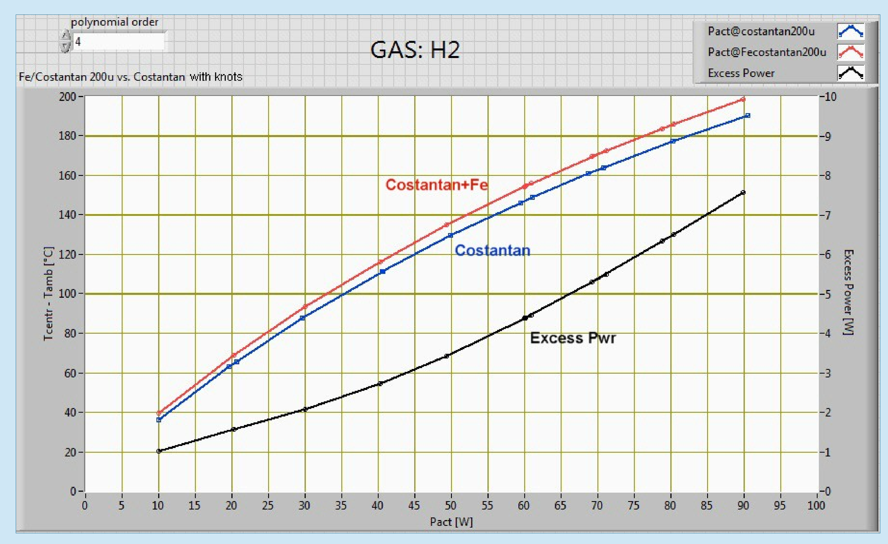

Fig. 9 – Gas H_2- Excess Pwr vs. applied Pwr for wires without and with Fe.

Very recently, with wires having several knots (hole diameter<1mm) filled with Fe at nanometric size (mostly inside knots), we observed that it generated currents up to 150μA and voltages up to 1900μV stable over long times.
Comparing the values of spontaneous voltages, both wires with the same number of knots, we measured values about 2.2 times larger using the Fe addition.

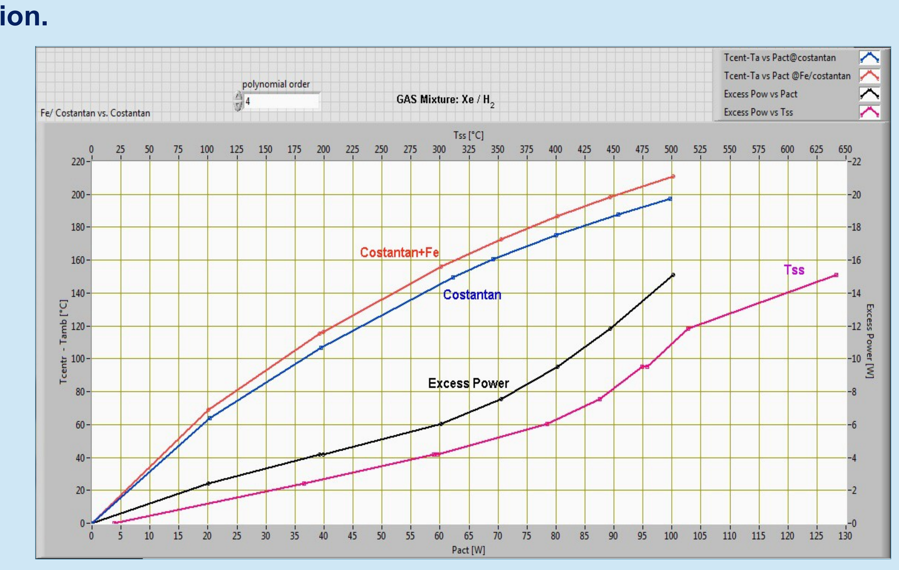

Fig. 10 – Gas mixture: Xe 1.4 bar, H_2 1.7 bar. Excess Pwr and temperature of stain steel Tss internal support.

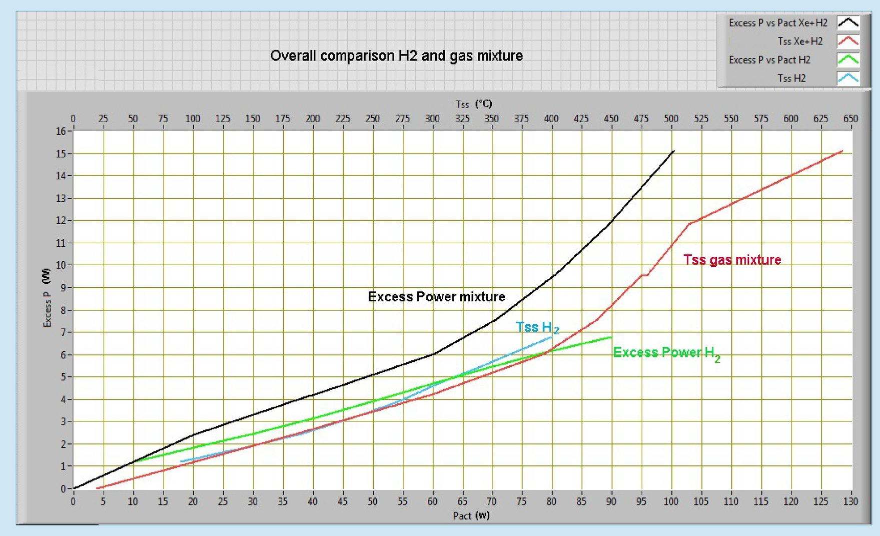

Fig. 11 – Overall comparison among H_2 and Gas mixture. Higher wire temperatures, correlated with higher values of Tss, give larger values of AHE.

Conclusions

According to our observations we can infer that the AHE, and *new spontaneous voltage*, are related to some of the following parameters and conditions:

- Absolute value of *temperature*, as large as possible, obviously avoiding material sintering;
- Enough amount Hydrogen absorbed/adsorbed by the catalytic material, i.e. *nanomaterial;*
- *Flux* (as large-fast as possible) of Hydrogen from region of high concentration to lower one;
- The addition of elements that have *Hydrogen concentration increasing with temperature* (like Fe);
- *The wires that have good performances from the point of view of AHE values show values of spontaneous voltages quite remarkable*;
- *The non-equilibrium conditions*, as large as possible, look the most important condition to get any type of thermal or electrical anomalies.
- More work is necessary to better understand the complex phenomenology and to increase further useful *"anomalies"*.