Chemistry and Materials Research
ISSN 2224- 3224 (Print) ISSN 2225- 0956 (Online)
Vol.3 No.12, 2013

Improved understanding of self-sustained, sub-micrometric multi-composition surface Constantan wires interacting with H_2 at high temperatures: experimental evidence of Anomalous Heat Effects

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Abstract

This article is an extension of what presented by our team at 17th International Conference on Cold Fusion, ICCF-17, in Daejon, Korea, in 2012 [1]. It documents the improvements on Constantan-related experiments, started in 2011, in order to study the feasibility of new Nickel based alloys that are able to absorb proper amounts of Hydrogen (H_2) and/or Deuterium (D_2) and that have, in principle, some possibility to generate anomalous thermal effects at temperatures >100°C. The interest in Ni comes in part because there is the possibility to use also H_2 instead of expensive D_2. Moreover, cross-comparison of results using H_2 instead of D_2 can be made and could help the understanding of the phenomena involved (atomic, nuclear, super-chemical origin?) due to the use of such isotopes.

Keywords: calorimeter, LENR, Nickel based alloys, sub-micrometric surfaces

1. An old alloy used for new purposes

Due to theoretical considerations, and thank also to some sentences reported in a paper (on catalysis) not related to LENR studies [2], we decided to explore the possibility to use the "large family" of CONSTANTANS alloys as starting material that could fit our purposes. One of the merit factors was, according to use, the ability to dissociate H_2. One of the Constantans ($Ni_{37}Cu_{63}$), among the materials studied in the already cited document, has the highest value (i.e. 3.2eV; in comparison, pure Ni and Pd have respectively values of 1.74 and 0.42eV) of such dissociation. Moreover, even with large changes (factor of about 2) in the relative atomic amounts of Ni in respect to Cu (i.e. from 0.37 to 0.62), the dissociation values remain almost constant (from 3.16 to 2.86eV).

We focused on a commercial (low cost) material, called ISOTAN44, nominal atomic composition $Cu_{55}Ni_{44}Mn_1$, developed several years ago by Isabellenhutte Heusler, GmbH, KG-Germany. The ISOTAN 44 was selected according to the following, overall, considerations, as pointed out by us [3, 4] since April 2012:

A. Measurable diffusion coefficient of Hydrogen, even in pure (not alloyed) elements, i.e. Cu and Ni, at high temperatures: Cu=10^{-6}cm^2/s at 200°C, 10^{-4}cm^2/s at 700°C; Ni=10^{-7}cm^2/s at 200°C, 10^{-6}cm^2/s at 350°C. In comparison, the (good) values for Pd are: 10^{-5}cm^2/s at 200°C, 10^{-4}cm^2/s at 420°C; at 600°C were reported values as large as $8*10^{-3}$cm^2/s, but not reproducible. We think that the "flux" of H_2/ D_2, inside lattices could be one of the key factors to generate anomalous effects.

B. Lower cost, overall, even considering the procedure to "build" nano-structure at the surface, in respect to Pd, very expensive precious metal.

C. Very good mechanical properties in respect to aging effects due to cycles of both low->high->low temperatures and H_2 absorption-desorption: the sample of our ("generation one") long time lasting experiment was working for over 7 months; only after such long time of operations, we observed serious damages rising-up. Our results are, in some aspects, different from that obtained by A.W. Szafranski et al.[5]: they observed extreme brittleness in, as received, Cu-Ni alloy that was only cold rolled from 200μm to 20μm (the penetration depth of H into Ni is about 30μm) and then cycled between 77K and 300K under 1GPa pressure of H_2. We could guess, only, that high temperatures and/or Mn (at

1%) addition have beneficial effects on reducing brittleness problems. Moreover, we never made experiments at 77K.

D. Extremely large values of (computed) [5] catalytic power (ΔE) in respect to the dissociation of H_2 as following:

$Ni_{0.3750}$-$Cu_{0.6250}$	==>	+3.16eV
$Ni_{0.6250}$-$Cu_{0.3750}$	==>	+2.86eV
$Ni_{0.8125}$-$Cu_{0.1875}$	==>	+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

E. The possibility, at least in principle, to produce nano-micro structures (and obviously voids) both at the surface and deeper into the bulk, because selective oxidation of Cu in such alloy at high temperatures (650-1050°C). Both the segregation of pure Ni among CuO_x and the cooling rate are key aspects of the preparation that still need to be studied in deeper details, although we already spent a lot of time (and money) to investigate such key aspects.

F. Our studies, very exploratory, were devoted to finding simple and reliable/reproducible procedures to get these kinds of structures. Experiments with the selected material were operated for times as long as possible: in order to have “strength” and aging tests.

2. Samples preparation (Procedure used for the experiment up to May 2012, “Generation One”). Similar composition materials, true nanometric, developed independently in Japan.

In our exploratory preparations/tests we used “standardized” wires: (“nuked”) Φ=200μm, l=105cm. Initial values of weight (e.g. 307.4mg), diameter (+-1μm) and resistance (e.g. 17.16 Ohm) were carefully measured.

We point out that, although very promising (expected) results with pure Constantan, in our explorative test (2-3 days of operations each, time span from February to June 2011) under H_2 atmosphere, we NEVER got any type of anomalies (like changing of resistance) on wires with applied temperatures as large as 900°C under the following status:

1. as obtained from the Company (we call them ultra-virgin);
2. with the surface cleaned-up from the enamel protection (enamel completely removed by burning up to 600°C in air) and stress released;
3. Acid etching of wire after burning at 600°C.

The wires at point 2, at the beginning, were just “cleaned-up” of the original “solderable” (type V) enamel insulating layer (as provided by Isabellenhutte) by Joule heating, in air, using a current as large as 2000mA (time 5m).

In Figure 1 we can observe the wire surface after enhanced heat treatments (generation one experiments).

In such conditions the power dissipated was about 70W and the resistance ratio, in respect to the reference value (at 100mA of current injected) increased of only 1%, as expected for such kind of material (commercial name is Constantan, i.e. constant resistance). After first thermal treatment, the weight decreased of about 13mg, the resistance decreased from 17.16 to 17.02 Ohm.

We found that increasing both the current (up to 2500-3000mA) and the time at high power (5-1000s), decreasing the cooling speed (from 100s down to <1s) had dramatic effects on the growing of nano-microstructures and their dimensions (see Fig. 1, as example). The role of O_2, due to the free air treatment, is quite important. The wire temperature, in some tests, was even larger than 1000°C (rough evaluation by colour temperature; the melting points of pure Cu is 1083°C, of Constantan about 1200°C in inert gas). The quality of wire produced by this method was evaluated by SEM observations. According to us, as smaller were the particles at the surface and larger the total fraction in respect to the whole wire (i.e. the core), as better was the procedure of preparation. The "best material" that we were able to produce, at the end of July 2011, using thermal treatments were put in our (high resolution) flow calorimeter.

As previously noted, such material was extensively studied, both in H_2 and D_2 atmospheres using a very accurate flow calorimeter (uncertainty <2%). The total times of experiments were really long (over 10 months) and only at the end the damages were so heavy to prevent further reliable interpretation of the experimental results. They were discussed, deeply, during the "X International Workshop on Anomalies…" on April 2012 [3, 4]. We were very happy to know that also Akito Takahashi and Akira Kitamura (and Colleagues), respectively from Osaka and Kobe University (Japan), studied in secret (like us), an alloy of Ni-Cu (at the lowest range of nanometric size, i.e. 5-20nm) dispersed in an inert matrix of ZrO_2. Such work was performed among collaboration with the Research Group of a Toyota Company (Technova). We got some information, by A. Takahashi and A. Kitamura, since January 2012, about promising results by a specific $(Ni_{85}$-$Cu_{15})$35%-(ZrO_2)65% alloy [6]. We recall that such material is a further development of the nanomaterial Pd_35%-ZrO_2_65% developed by Yoshiaki Arata (Osaka Univ., Japan) since 2005 [7].

The "short information" about Ni-Cu-ZrO_2 came because one of us (Francesco Celani, FC) was invited to give a Review talk, on Anomalous Effects in LENR Studies, at the WSEC 2012 Conference (World Sustainable Energy Conference 2012) organized by the ISEO (International Sustainable Energy Organization). The ISEO is an ONG linked to several not-politic Organizations (UNESCO, WHO, ILO…) connected to United Nations at Geneva. Obviously, FC requested that everybody involved in LENR studies, worldwide, communicate the most recent and interesting results to include in the Review. A similar talk, with more technical/scientific details, was given by FC even at CERN (Geneva) on March 22, 2012 in the framework of the (prestigious) CERN Colloquium [8]. Under FC specific request, it was added also a talk (by Y. Srivastava, Univ. Perugia, Italy) related to overview of theories in LENR [9].

The overall behaviours of Ni-Cu alloys although at different ratios of two main elements, in respect to H_2 and D_2 absorption, and the amount of anomalous heat detected, were, in several aspects, similar to the experiments performed both in Japan and Italy. Such kind of evidence reinforced our intention to develop a better material (from the point of view of nano-dimensionality), keeping the starting Ni-Cu composition "constant". In other words, our efforts were devoted to improve the amount of active material at low dimensions (<100nm) and, at the same time, avoid the adverse effect of "leakage" of the smallest particle from the surface, e.g. under dynamic vacuum conditions, thermal cycling and loading/de-loading cycles.

3. New transparent, dissipation-type, "calorimeter"

By the end of May 2012 we were able to produce sub-micrometric materials, with nominal overall performances several times better than the best material produced at the end of July 2011, with enough good reproducibility about preparation procedures.

The new method, although started from the old one in some key aspects, was really revolutionary about the practical parameters of: mechanical stability (reduced leakage of the "best" material from the surface), fraction of material at small dimensions. Such last parameter increased from previous 1-2% (generation one) up to about 30% of the whole material (generation two).

Such big improvements were obtained because large economical (and man-power) help of an Italian NE Metallurgical Company that "believed" in our previous results. We were able to design, and build, specific electronics and mechanical set-up to produce such kind of sub-micrometric wires. Systematic (but very boring and expensive) experimental work was the key factor for the success.

Moreover, since one of our goals was to see, naked eye, if the wire was really stable about the leakage of "good" materials even after several cycles of low-high-low temperatures and H_2 loading (and/or even de-loading), we built a new transparent reactor with borosilicate glass (Schott DURAN) of large (3mm) wall thickness to withstand large pressure drops (up to 8 bar), at internal wall temperatures up to 280°C. As a further advantage,

the glass tube will prevent the adverse effects of Sulphur (S) leakage from Stainless Steel (SS) surfaces at high temperatures. The S is a well-known poisoner to several catalyst.

For the calorimetric measurements, we adopted the simplified approach to measure the external glass wall temperature. Taking into consideration the temperature of interest, i.e. T_wall>140°C, the main channel of heat exchange to the environment is radiation of heat. In other words, it can be used the simple formula of Stefan-Boltzmann law:

$$P_{out} = \varepsilon * 5.67 * 10^{-8} * \left(T_{wall}^4 - T_{room}^4\right) \qquad \left[\frac{W}{m^2}\right] \quad (1)$$

In such formula the temperatures T are in K; ε, the reflectivity is kept for simplicity equal to 1, usual values are 0.85-0.95 in experimental conditions similar to ours. Calibrations were made using our usual procedure to add an inert wire, very close to the "active" one, and make several measurements with inert gases. In the specific new set up, the wires were parallel, alternatively and helicoidally shaped, 22 turns. They were changed the input power, used different gases (He, Ar, Vacuum), and fed the electric power alternatively to the inert and "active" wires.

Because in our real experimental set-up the geometrical dimension of the cell is constant (glass tube, external diameter 40mm, internal diameter 34mm, overall length of 280mm, central active length of 100mm), we can make a sort of simplified calibration curve just dividing the cited formula (1) by the input power. Obviously, we neglected the contribution to heat dissipations of free convection in air (usual values are 5-25 [W/m^2 K], in "normal environments" values are 12-15) [10]. Finally, we just recall that in the temperature range of our interest (internal cell 250-350°C), the thick borosilicate glass behaves like a black-body for the wavelengths of interest (>2.5μm). Moreover, the effects of pressure variations inside the reactor chamber, with related temperatures variation due to different convection values (i.e. the internal temperature increases versus pressure decreasing), have values of temperature changing that can be neglected at the external wall, for the purposes of our experimentations. Anyway, some tests were performed, in He, varying the pressure between 6.5 and 2.5bar. Such tests were made at the beginning of the experiment (wire new, reactor glass wall "clean") and after some months (wire used, glass wall lightly "dirty").

4. Results with the new wires ("Generation Two")

At the end of May, 2012 two wires were produced, both with the same new procedures (generation two).

The first one was used few days later to the experiment, the second one was just put inside a HDPE envelop and kept closed at Room Temperature (RT). We called the experiments:

[a] wire#1 (started 06 Jun, 2012);

[b] wire#2 (started 10 July, 2012).

The main improvements in respect to previous procedure of fabrication, according to SEM observations, were the multi-layered structures and total number of such layers, extremely large: of the order of 700. The thicknesses, of each multi-layers, were in the range of 20-100nm. The mechanical stability, against leakage of sub-micrometric materials, was largely improved.

The primary experimental procedures and results are listed as following:

1) In order to use simple parameters easy to be managed by calculations, we adopted the usual term of R/Ro. Ro is the initial value of resistance at RT, i.e. 23.5°C (in that calibration), in free air atmosphere, inside the reactor. With our wires we measured, in situ (I-V methods), a value of resistance of 16.9684 Ohm and 57.4394 Ohm, respectively for sub-micro_Costantan and Ni-Cr (supposed inert) wires. The measuring currents were just 4mA, to avoid self-heating of the wires.
2) First of all, calibrations by inert gases were made, with power of 5, 15, 30 and 48W applied to the inert wire. The maximum internal temperature of the chamber was of the order of 180-250°C, depending on the gas composition and its pressure. Some tests, as cross reference, were made also on active wire (AW). Using the values of temperatures measured outside the glass cell (and RT) it was possible to evaluate the "power exchange constant" of the small reactor by (1).

3) After adding a H_2/Ar mixture (75/25 ratio) at 7 bar of total pressure, and using as monitor parameter the resistance of both the active and inert wires, it was given power (48W, our reference value) to the inert wire. It was found (Fig. 2) that when the temperature inside the reactor was larger than 125°C, the resistance ratio of active wire, after a very limited increase (to 1.02), dropped to 0.92 in 2500s. Later on, in about 100000 sec, the R/Ro decreased to 0.88. We observed a correlated increase of the "anomalous excess heat" (although quite unstable) with the R/Ro decreasing. The temperature inside cell was about 180°C. In Figure 2 it is possible to observe details of first loading by H_2-Ar mixture. We recall that, because the cell wasn't fully gas tight, and because H_2 is easier to leakage, over time the partial pressure of H_2 decreased.

4) After 103000 sec from the beginning (Fig. 3), we stopped the power to the inert wire and allowed the reactor, and the wires, to cool to RT. The R/Ro value of AW decreased from 0.89 to 0.80.

5) Just after that, we give the same previous power to inert wire and after others 150000s from the interruption we measured an R/Ro value of 0.867. The anomalous excess power increased further (Fig. 3), in a way that, at a first observation, depends mainly on the time lasted and not to the R/Ro value (low decrease). The instability of excess power, if there weren't other uncontrolled parameters to fake it, had values quite large and was correlated to the small oscillations (<1%) of R/Ro values.

6) We observed that even the instabilities of room temperatures (usually 23-27°C) "helped", in some aspects, the anomalous heat production, because, speculatively, introduced some non-equilibrium conditions. In other words, in order to avoid misinterpretations of the results, after appropriate long times, the values of room temperature were the same at the starting while the anomalous heat increased over time.

7) Among others, the positive effect, of long time lasting under H_2 gas, was observed also by the A. Takahashi and A. Kitamura group (reported both at the X Pontignano Workshop and ICCF17). According to them, under their experimental conditions, constrains and materials, in 2 weeks of experiments the anomalous excess power slowly increased from 0 up to 3W.

8) We observed that the minimum cell temperature to stop the anomalous heat is around 120°C, i.e. similar to the first "loading" temperature (i.e. 125°C).

9) After 330000 sec from the first H_2/Ar intake, the power was given to active wire (Fig. 4).

10) We observed a further increasing of anomalous power that, if there are no mistakes around, was about twice (i.e. absolute value of over 10W) of that detected when the power was applied to inert wire. The R/Ro value, after initial increasing, stabilized to 0.808.

11) A possible explanation was that the local temperature of active wire, because Joule heating, was larger than that when the power was indirect. A very rough valuation of temperature is the range of 350-400°C, in respect to about 200°C with indirect heating.

12) If the consideration at point 11) is correct, we can think that the reaction, apart some temperature threshold, has a positive feedback with increasing temperature. Similar effects were found by: our self (with the old wire, and experiment, up to May 2012); A. Takahashi and A. Kitamura group with Ni-Cu-ZrO_2 powders.

    In Figure 4 it is possible to observe further details about the experiment with power (48W) applied to AW. Up to time 518ks the nominal gas mixture was H_2/Ar at 75/25 ratio. Later on, the power was reduced to zero and made vacuum: R/Ro was as low as 0.71. From time 522ks was added pure H_2: the excess power resumed the value before vacuum and, after controlled reduction of pressure, increased up to 16W.

13) After 360000s from the H_2/Ar gas intake (Fig. 4), i.e. time 515ks, the power was switched off: the R/Ro, at RT, dropped to 0.71. In other words, the direct heating (electro-migration phenomena and/or large temperatures) improved largely the loading, and then the anomalous power.

14) After 410000s from first H_2/Ar intake, we made vacuum and added H_2 at 100% concentration.

15) The results were similar to H_2/Ar gas and even better about anomalous heat production.

16) We can't discriminate if the further improvements of performances were due to effects of pure H_2 or just time lasted under active gas (increased embrittlement, i.e. reduced dimensionality of particles).

17) After another week of miscellaneous test, we decided to de-load the wire from H_2 absorbed, to be sure

that the resistance reduction observed was due to a real absorption and not to a variation of resistance due to the reduction of oxides (by H_2 or even H) at the nano-particles surfaces.

18) To get de-loading we put the cell under dynamic vacuum and increased the temperatures.

19) After several hours, we get the original starting value of R/Ro at 1: the test was fully successful.

20) We reloaded again the wire and get behaviour of R/Ro decreasing and anomalous heat not too different from the first cycle.

21) Again we de-loaded the wire from H_2 to make experiments with D_2 gas (Fig. 5). This time the final value of R/Ro was 0.93, not 1 as expected. We supposed that some H_2 was stored some-where in the lattice. In Figure 5 is represented the experiments under D_2 gas. At the beginning, up to 1 day long, the reaction was ENDOTHERMIC; later crossed the zero line and began to be exothermic, as usual with H_2, but at values of excess power lower and overall more unstable.

22) After D_2 intake, we increased, as usual, the temperature by power to the inert wire. The absorption was really of small amount.

23) We observed, for the first time in our experimentation with such kind of materials, some X (and/or gamma) emissions, coming-out from the reactor during the first increasing of the temperature from about 100°C to 160°C. We used a NaI(Tl) detector, energy range 25-2000keV used as counter (safety purposes), not as spectrometer. Total time of such emission was about 600s and clearly detectable, burst like.

24) About thermal anomalies, we observed, very surprising, that the response was endothermic, not exothermic. The second day the system crossed the zero line and later become clearly exothermic. Similar effects were reported also by A. Takahashi and A. Kitamura.

25) After about 350000s from the beginning of D_2 intake the temperature abruptly increased and the wire was broken. We observed that the pressure decreased, because some problems to the reactor gas tight, but at times of 80000s before. The SEM observations showed fusion of a large piece of wire. The shape was like a ball. Further analyses are in progress.

26) Starting from July 10, 2012, we used the second wire (#2), stored in the plastic bag.

27) In the meanwhile, we improved the overall detection of external temperatures and added 3 other thermometers. The main thermometer was moved from the original position, little bit close to one end of the wire, to exactly at the centre of the area of glass tube were are located (in the inner) the wires.

28) The results were qualitatively similar to the first wire, although at lower intensity. The starting temperature of loading, from the value of 125°C of the wire #1, increased to about 160°C. In particular, the wire was not able to withstand direct heating conditions. We think that the surface was partially obstructed from something (HDPE plastic?). In Figure 6 it is shown an example of anomalous heat on wire#2.

29) On July 23 we made de-loading and on July 24 we made loading again. The sequences were:

    a. dynamic vacuum conditions, 220°C internal reactor temperature, power at Ni-Cr, 50000s duration;

    b. H_2 filling.

    In Figure 7 it is shown the behaviour of first re-loading of wire#2.

30) The results (Fig.7) seemed largely improved about: speed of loading (time of the drop of R/Ro from 1 to 0.85 of only 2000s) and time necessary to get measurable anomalous heat (less than 6 hours).

31) The experiment had been stopped on July 28 to package and “shipping” the reactor to USA (National Instruments Meeting at Austin-Texas) and later-on to Korea (ICCF17 Conference at Daejeon).

32) The wire #2 “overcomes” the severe conditions of shipping (by air-plain) and long times (8 days) without H_2, under free air conditions. When we resumed all the electrical connections, at Austin (USA), we realized that the R/Ro value of Active wire remained almost unchanged (about 0.81). At Austin, ALL the control and measuring electronics (NI-PXIe), and new specific software, were provided by National Instruments modules and Researchers.

    In Figure 8 it is possible to see Dr. Celani, standing in front of the glass reactor, at Austin (USA).

33) The maximum excess power reached, after 3 days of operations (in public) at Convention Center of Austin (Fig.8), NIWeek 2012, was about 21W with indirect heating and about 25W with direct heating of sub-micrometric Constantan wire. The input power, as usual, was 48W. They were the best values that we observed up to now. We remark that, because we used the "old" value of calibration obtained in Italy with different experimental geometric set-up, the absolute value of excess power has to be fully controlled. Anyway, the peculiar trend to increase the excess power versus elapsed time was reconfirmed. After coming back to Italy in August we realised that the *new, fully automatized data acquisition system* used since August 3 in USA and later Korea, had input electric power calculations not fully correct in Constant Voltage operations. It worked properly only in the Constant Current operations. The worst case error was <14% at input power of 48W. Anyway, even considering fully such unexpected bad condition, the overall excess power was larger than 15W, i.e. better than the best values found in Italy at input power of 48W.

34) The reasons because, often, the aging effects are so important on improving the Anomalous Heat Effect are still now under discussions.

At the end of ICCF17 Conference (Daejeon-South Korea, August 2012) [1], several Researchers joined in the so-called "Martin Fleischmann Memorial Project" (MFMP). After in-deep discussions with one of us (FC), they asked to build a replica of the system (i.e. glass reactor and specially treated Constant wires) and some support specific to the know-how related. Such request was accepted and generated an international project (mainly in Europe and USA) which aim was to reproduce the experimental set-up and scientific results shown by us. The first positive results were obtained at the beginning of December 2012 and shown during a meeting on LENR held at the "Casa dell'Aviatore", Rome-Italy [11]. The scientific approach and methodology of the MFMP, i.e. Live Open Science (LOS), was very well accepted and appreciated at international level since it gave real-time and open access to experimental results to the scientific community.

5. Conclusions

It appears that the commercial Constantan alloy, with the surface deeply modified about geometry (i.e. skeleton type) and dimensionality of 20-100nm, multi-layers, is a good candidate for anomalous heat production due to:

a. intrinsic low cost of raw materials;

b. simple procedures (i.e. low-cost) of nano-structures growing, as recently developed by our group at INFN-LNF, Italy;

c. use of Hydrogen.

We observed that such materials have behaviour of "positive feedback" of anomalous power in respect to temperature increasing.

The experiment showed to be reproducible as experienced both during the Austin (USA) NI Week and ICCF17 Conference (Korea). Several of the results found were similar to what detected by the Japan group (A. Takahashi, A. Kitamura) in collaboration with Technova (side of Toyota Company), using Ni-Cu alloy dispersed in Zirconia matrix. Anyway more and systematic work is necessary to elucidate the several open questions, first of all the stability over time of the anomalous heat generation, safety and a confirmation about reproducibility, not mentioning the "strange" behaviour using Deuterium gas.

Collaboration of the Community involved in LENR studies is welcomed and a series of attempts to replicate the experiment is currently performed by different organizations and laboratories worldwide.

The next step will be the use of quartz tube instead of borosilicate, at the moment in use. The quartz will allows studies at temperatures over 300°C; at the moment it isn't allowed by borosilicate (1st softening temperature of typical borosilicate glass is around 300°C).

If positive results will be reconfirmed with the wire made by new procedures (i.e. "second generation" of preparation), it could be possible to reach "regions" of operation were even the self-sustaining regime could be observed, if enough large amounts of active materials will be used.

Acknowledgements

Work made in scientific collaboration (with usual suggestions/critics), and/or partially supported, by:
- Metallurgical Company of NE, Italy.
- Kresenn Ltd, 5a Frascati Way, SL6 4UY Maidenhead (Berkshire), United Kingdom
- Dennis Letts Laboratory, 12015 Ladrido Ln, Austin, TX 78727, USA.
- National Instruments, 11500 North Mopac Expressway, Austin, TX 78759, USA.
- Francesco Santandrea, ISCMNS, Latium1 Group, Via Cavour 26, 03013 Ferentino (FR), Italy
- Antonio Spallone, INFN-LNF, Via E. Fermi 40, 00044 Frascati (RM), Italy
- We are indebted with Dr. James J. Truchard (CEO and President of National Instruments) and Dr. Stefano Concezzi, (Director of Big Physics department): they convinced us to make a public demo both in USA and Korea and obviously, the invaluable work for developing a completely new SW, in few days (among others, by Brian Glass and his Colleagues), has to be deeply recognized.

References

[1] F.Celani et al. (2012), "Cu-Ni-Mn alloy wires, with improved sub-micrometric surfaces, used as LENR device by new transparent, dissipation-type, calorimeter". Presented at the "International Conference on Cold Fusion 17", (ICCF17), Daejon - Korea, August 12-17, 2012.

[2] S. Romanowski, S. Bartczak, W. M. Wesolkowski (1999), "Density functional calculations of the hydrogen adsorption on transition metals and their alloys. An application to catalysis", *Langmuir 1999*, issue 18, volume 15, 5773 – 5780.

[3] Celani et al. (2012), "Experimental Results on Sub-Micro Structured Cu-Ni Alloys under High Temperature Hydrogen/Deuterium Interaction", presented at X International Workshop on Anomalies in Hydrogen-Metal Systems", Pontignano - Italy, April 10-14, 2012.

[4] Celani et al. (2013), "Experimental Results on Sub-Micro Structured Cu-Ni Alloys under High Temperature Hydrogen/Deuterium Interaction" , *Chemistry and Materials Research*, 3(3), 27-56.

[5] A.W. Szafranski et al. (2005), *J. of Alloys and Compounds*, 404-406, 195-199.

[6] A. Kitamura, A. Takahashi, et al (2012), "Recent progress in Gas Phase Hydrogen Isotope Absorption/Adsorption Experiments", *ICCF17 Daejeon*, TUA2-1. In press by JCMNS.

[7] Y. Arata and Y-C Zhang (2005), "Development of 'DS-Reactor' as the practical reactor of 'cold fusion' based on the 'DS-Cell' with 'DS-Cathode'", *Condensed Matter Nuclear Science*, ICCF-12 (ISBN 981-256-901-4), Yokohama - Japan, World Scientific, 44-54.

[8] Francesco Celani (2012), "Overview of Theoretical and Experimental Progress in Low Energy Nuclear Reactions (LENR)", presented at *CERN Colloquium*, CERN, Geneva - Switzerland, March 22nd, 2012, http://indico.cern.ch/conferenceDisplay.py?confId=177379.

[9] Yogendra Srivastava (2012), "Overview of LENT Theory: Low Energy Nuclear Transmutations", presented at *CERN Colloquium*, CERN, Geneva - Switzerland, March 22nd, 2012, http://indico.cern.ch/conferenceDisplay.py?confId=177379.

[10] F.P. Incropera, D.P. DeWitt (2001), "Fundamentals of Heat and Mass Transfer", 5th ed., John Wiley & Sons, New York.

[11] Centro Studi di Biometerologia (2012), "Coherence 1999-2012, 13 anni di Coherent Quantum Electrodynamics", Casa dell'Aviatore, Sala F. Baracca, Roma - Italy, December 14, 2012.

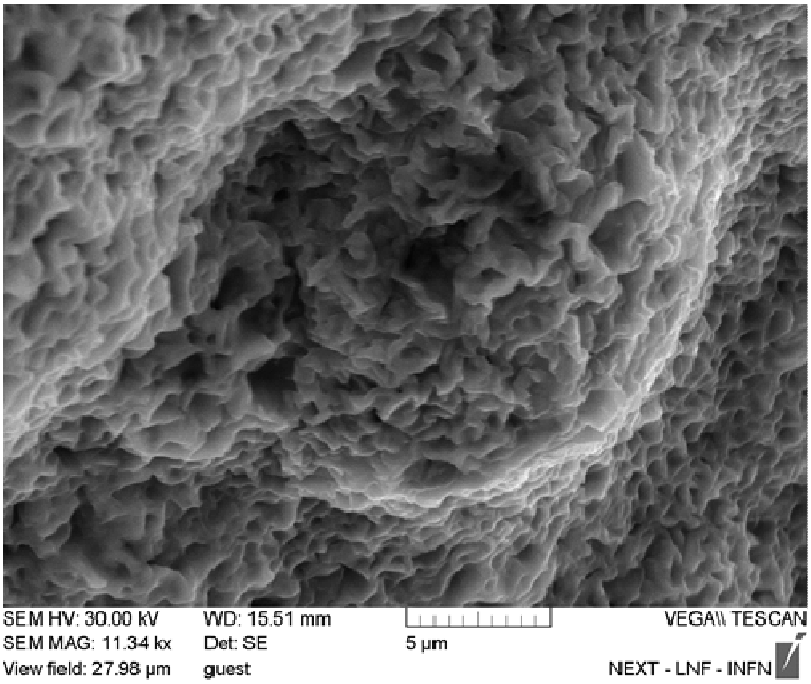

Figure 1. SEM. Wire surface after enhanced heat treatments, at I=2500m, 5minutes: typical *generation one* wire and experiments.

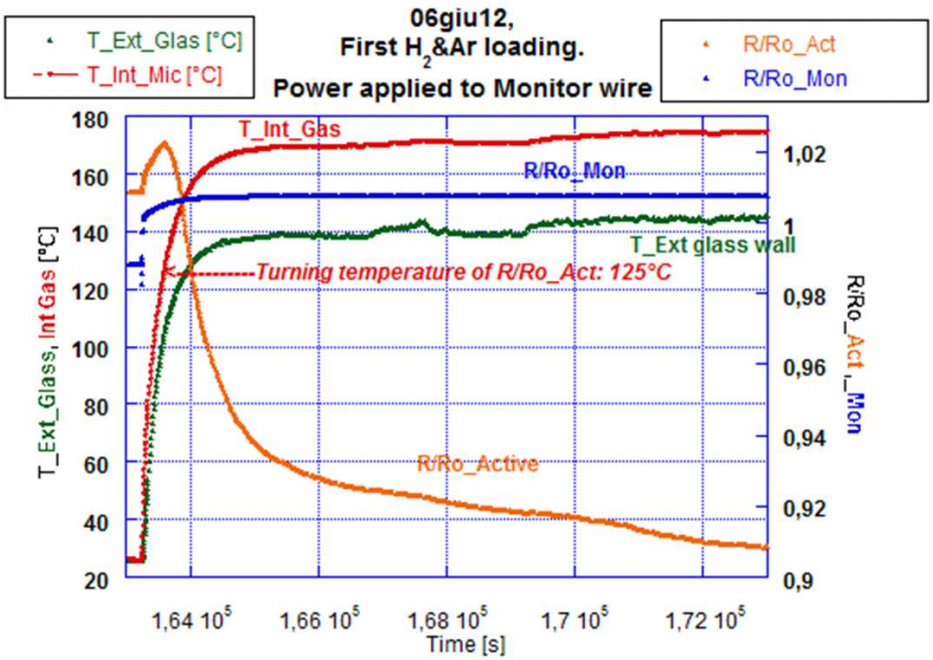

Figure 2. Details of first loading by H_2-Ar mixture. Over time the partial pressure of H_2 decreased.

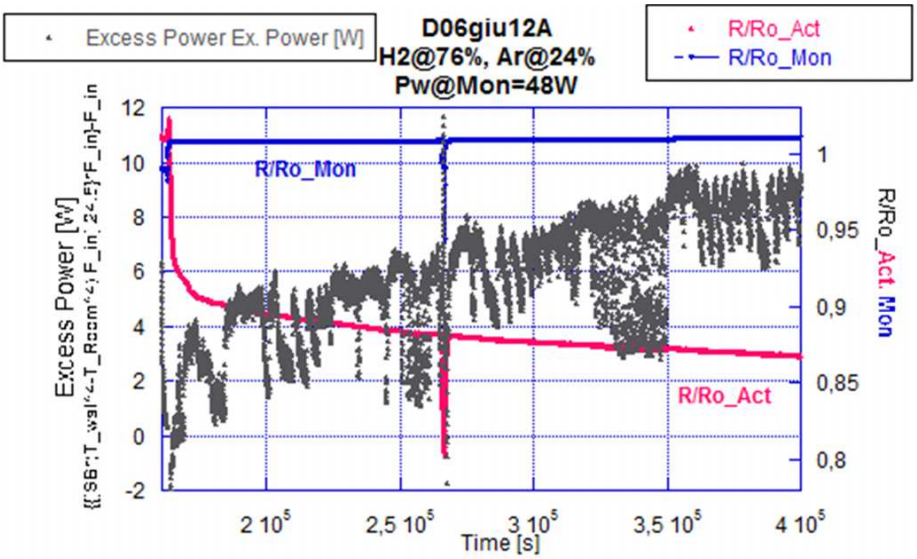

Figure 3. Behaviour of anomalous power generation, using indirect heating, i.e. power (48W) applied to Monitor wire. Over time the partial pressure of H_2 decreased.

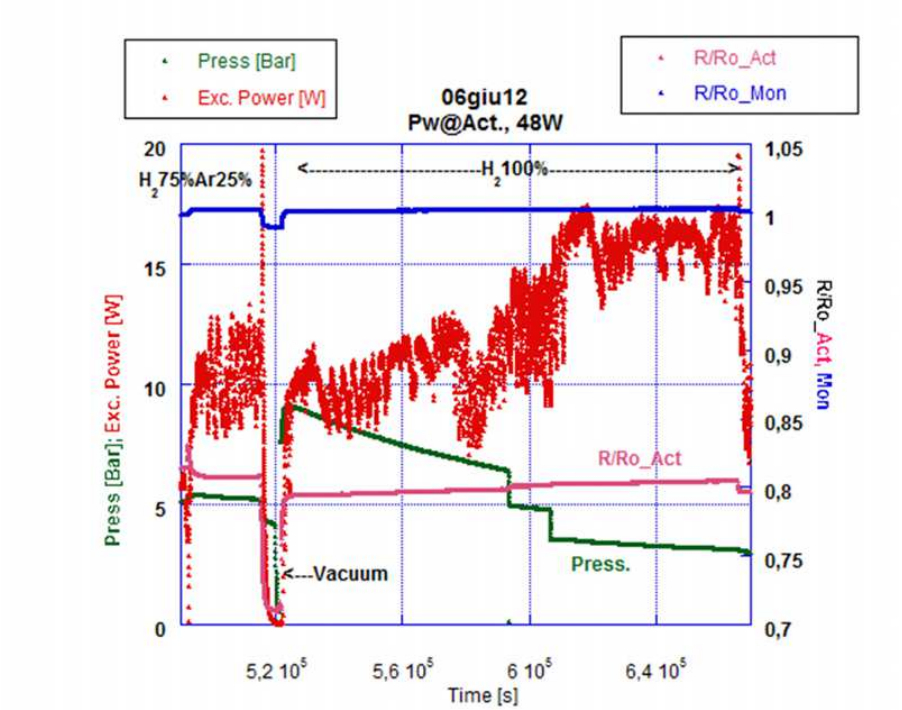

Figure 4. Experiment with power (48W) applied to Active wire. It is notable that the Anomalous Heat Effect (AHE) increased because H_2 pressure reduction. Such phenomenon is peculiar of Hydrogen.

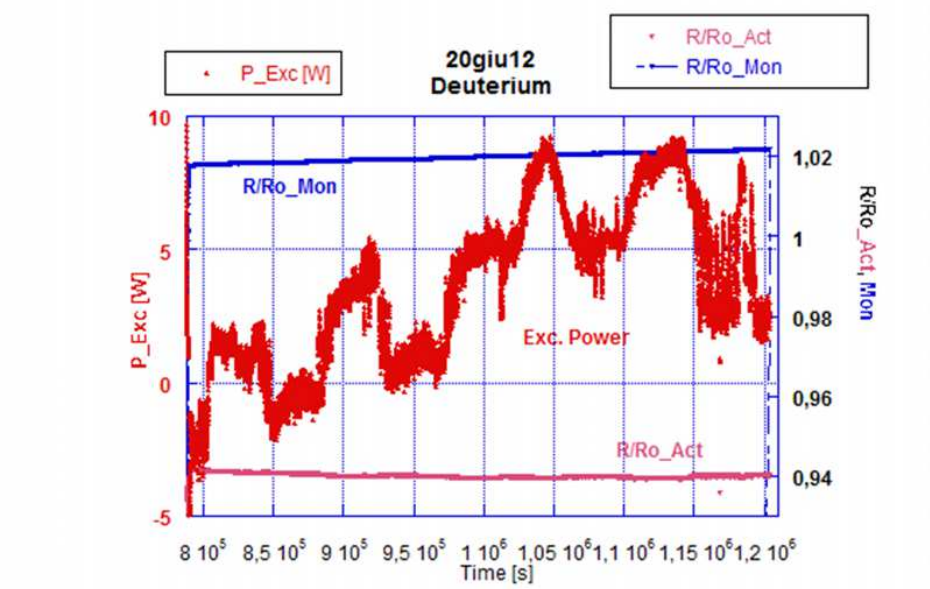

Figure 5. Experiments under D_2 gas. Since D_2 gas filling, the AHE was negative for several hours, behaviour quite different from H_2 during experiments in Italy.

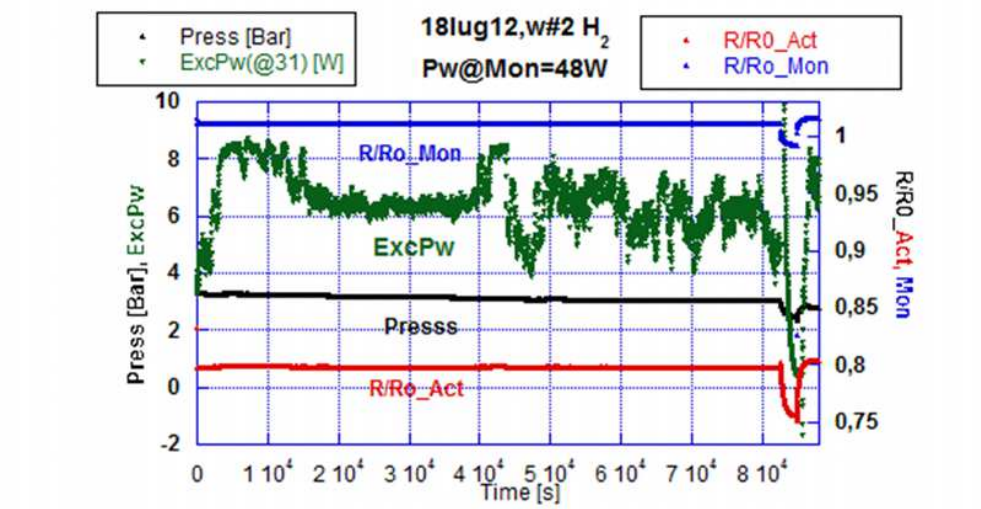

Figure 6. An example of anomalous heat on wire#2 in Italy, before the new experiments in USA and Korea.

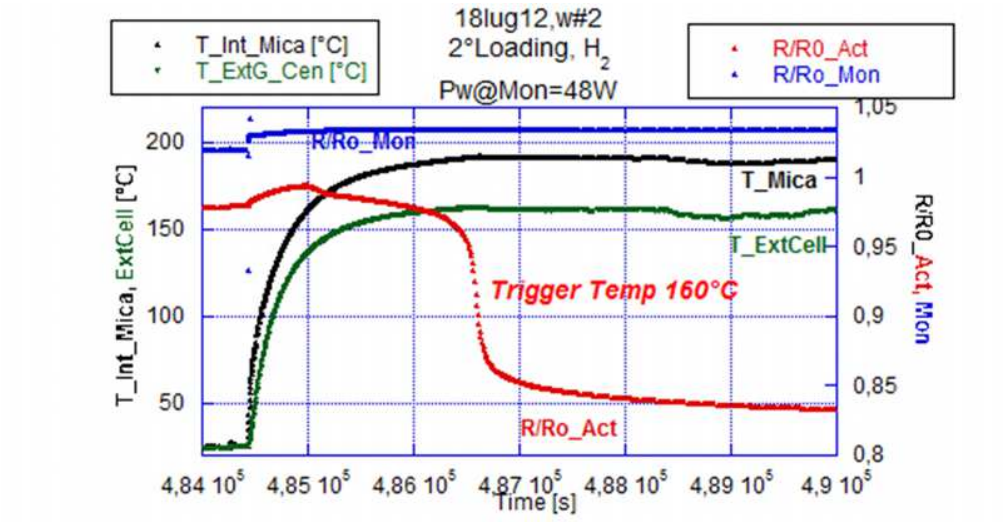

Figure 7. Behaviour of first re-loading of wire#2

Figure 8. Dr. Celani standing in front of the glass reactor at Austin (USA) during NIWeek 2012.

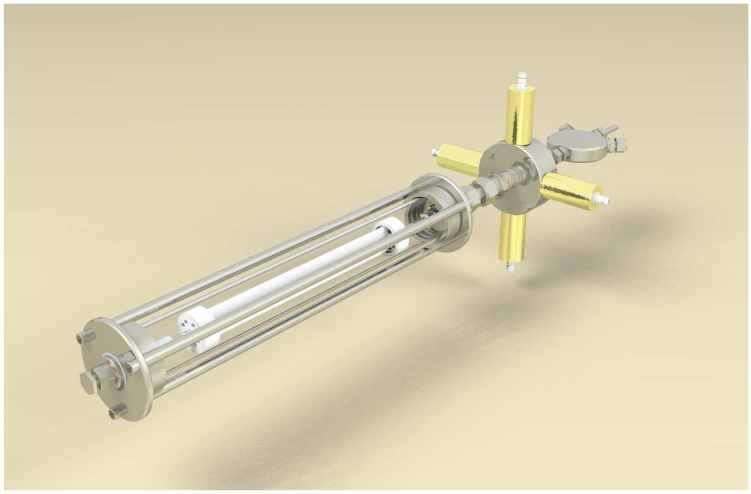

Figure 9. Glass reactor 3D model.