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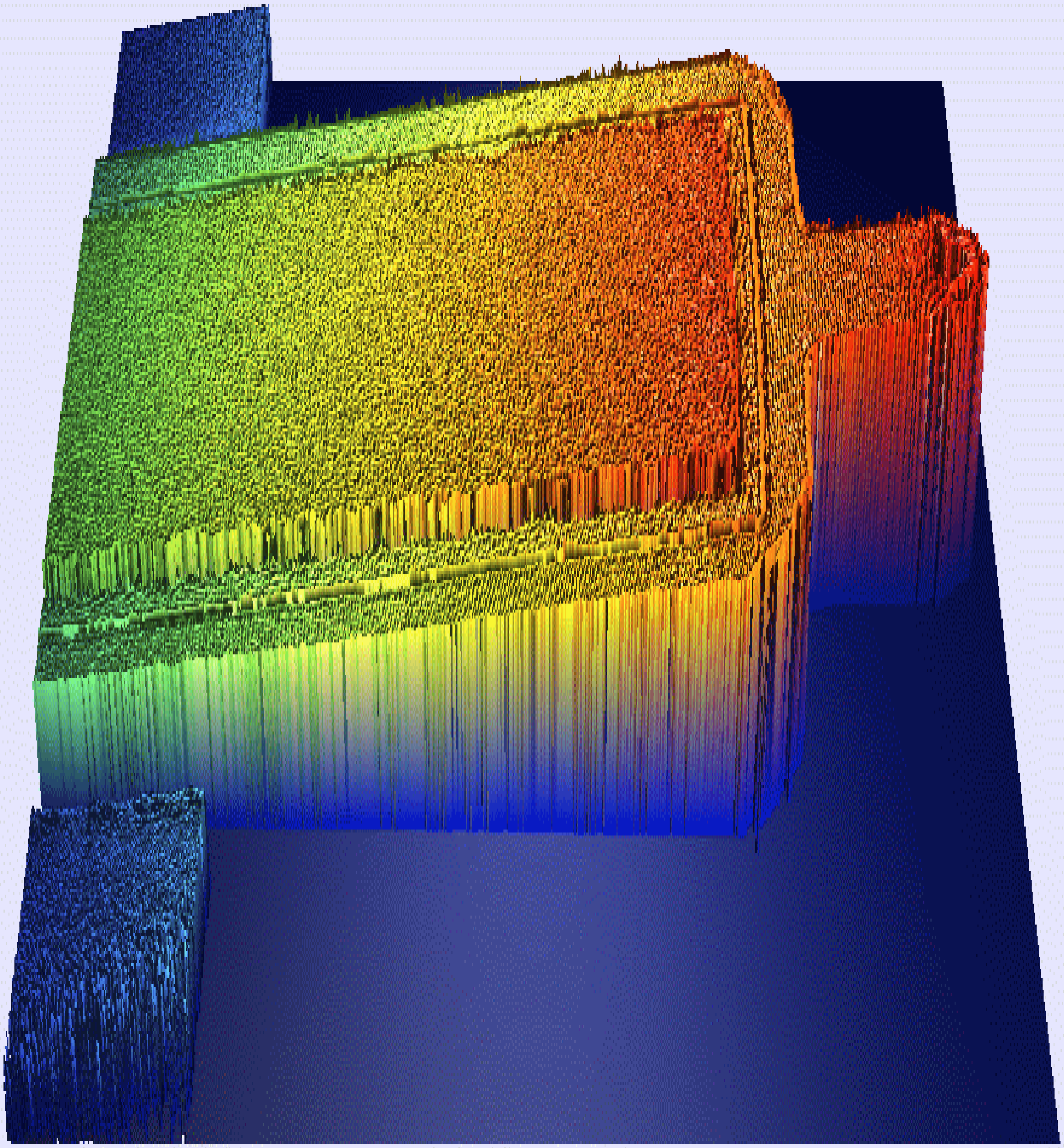

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The Guest Editors will send the manuscripts by post or to the e-mail: mignat@icpe-ca.ro
Contact e-mail: ghristea@icpe-ca.ro

Address:
Splaiul Unirii No. 313, sect. 3, Bucharest-030138 - Romania

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In 2011 the Romanian electrical engineering community celebrates 90 year from the commencement of the Electrical Engineering (Electrotechnic) Faculty of Bucharest Polytechnic University and 10 year from the debut of the National Institute for Research and Development in Electrical Engineering – Advanced Research (INCDIE ICPE–CA), Bucharest.

Many remarkable teachers and scientific personalities through whom we remember Constantin Budeanu, Vasilescu Karpen, Constantin Buşilă, I. S. Gheorghiu, Alexandru Popescu, Remus Răduleț, Constantin Mocanu as emeritus professors at Electrical Engineering Faculty. On the recent period, Gheorghe Hortopan, Constantin Bălă, Alexandru Timotin, Andrei Țugulea, Alexandru Fransua, Augustin Moraru, Cezar Flueraşu, who represent a part of the prestigious teaching staff of this faculty, must not be forget.

INCDIE ICPE-CA represents a young and developing research institution which promotes new outlook by young scientific paradigm strategy. The new generation of Romanian specialists must to continue the fruitful tradition of our electrical engineering school.

This issue of Bulletin of Micro and Nanoelectrotehnology, is dedicated to these two definite events, which are milestones for the progress on electrical engineering.

Editor in chief
Mircea Ignat

Bulletin of Micro and Nanoelectrotechnologies includes the specific research studies on:

- Microelectromechanical and nanoelectromechanical components.
- The typical micro and nanostructure of actuators, micromotors and sensors.
- The harvesting microsystems.
- The conventional and unconventional technologies on MEMS and NEMS.
- The theoretical and experimental studies on electric, magnetic or electromagnetic field with applications on micro and nano actuating and sensing effects.
- The design algorithms or procedures of MEMS and NEMS components.
- The applications of MEMS and NEMS in biology and in biomedical field.
- The new materials in MEMS and NEMS.
- The standardization and reliability preoccupations.
- The economic and financial analysis and evolutions of MEMS and NEMS specific markets.

Contents

Rețelele Inteligente - SMART GRIDS între Vis și Realitate

Prof. Dr. Ing. Florin Teodor Tănăsescu
Comitetul Electrotehnic Român (CER), Splaiul Unirii, Nr. 313, Sector 3, 030138, Bucureşti, România, ttflorin@yahoo.com

I. INTRODUCERE

Se vorbeşte mult în ultimii ani de SMART GRID – Rețele Inteligente– ca una din soluțiile viitorului pentru optimizarea generării de energie, a transportului și distribuției de energie la un consumator care cere o calitate superioară a furnizării energiei, o siguranță în alimentare şi participare activă la deciziile de luat în sistem.

Apariția acestor rețele, a fost determinată de nevoia tot mai mare de energie cerută de o societate tot mai avidă de electricitate, de "adunarea" energiei tuturor surselor distribuite de energie și conectarea lor la o rețea care în mod inteligent poate să le gestioneze, asigurând creșterea puterii transportate și siguranța funcționării, calitatea energiei furnizate și colaborarea activă între furnizor și utilizator, implicarea majoră a digitalizării și introducerii TIC în conducerea unei infrastructuri tot mai sofisticate.

Dezvoltarea acestor Rețele Inteligente devine o preocupare a tuturor statelor; SUA, Brazilia, China, Uniunea Europeană, sunt leaderi în promovarea acestui concept, dar fără să neglijeze evaluarea enormelor fonduri necesare - SUA apreciază că va fi nevoie de peste 500 mld. $, iar Europa cca. 400 mld. Euro - și timpul lung de finalizare, toate conchizând că nu va putea fi realizată în întregime o Rețea Inteligentă în timpi mai scurți de 20 - 25 ani.

Introducerea celor mai sofisticate echipamente dotate cu funcții de diagnoză - transformatoare și generatore inteligente, cabluri, întrerupătoare electronice, senzori, relee - aplicarea unei informatici sofisticate care pe lângă avantajele clare pe care le oferă lasă deschisă posibilitatea unor atacuri cibernetice teroriste deja semnalate de americani, reprezintă provocări asupra cărora inginerul trebuie să reflecte.

Accidentele mari din sistemele energetice: SUA (1965, 2003), Brazila (1999), Canada (2003), Indonezia (2005), Brazilia (1999), Japonia (2011 CNE Fokushima) care au afectat zeci de milioane de oameni şi au cauzat pierderi de sute de mld $, dovedesc că evenimente neprevăzute pot apare, iar obligația inginerului este aceea ca în proiectele sale să prevadă şi să cântărească până unde se poate merge cu o anumită soluție, imaginația de a prevedea și imposibilul, de a reduce la limite admisibile riscul vulnerabilității, *care din păcate nu poate fi exclus ci doar limitat!*

Este și motivul pentru care acest articol, prezentând performanțele unui sistem a cărui avantaje tehnice şi economice sunt deosebite și trebuie cunoscute de specialiști - pentru că activitatea lor viitoare va fi în conexiune cu acest concept - să atragă atenția și asupra unor vulnerabilități, semnalate de specialiști care invită la a reflecta la înțelepciunea unei cugetări: *„Măsoară de o mie de ori și taie odată!"*

II. SISTEMUL ENERGETIC ȘI "INTELIGENȚA" LUI

Literatura de specialitate a ultimilor ani, dezvoltă cu o tot mai mare intensitate conceptul de "Rețea Inteligentă", ca o soluție care să permită trecerea la o nouă fază de dezvoltare a sistemului energetic.

A considera că elementele de inteligență ar apare odată cu implementarea acestui concept este mai mult o "formulare terminologică", în toată istoria dezvoltării sistemului energetic, el find "inteligent" și deschis la noile realizări din tehnică: materiale noi, comutație, transport la tensiuni înalte, dispecerizare, etc.

Începuturile sistemului energetic - într-o primă etapă - au fost rețelele locale, în care generarea, transportul și distribuția energiei se făcea local, în general fie în apropierea resurselor - petrol, gaz, apă - fie în apropierea marilor consumatori pe care începutul secolului 20 începea să-i evidențieze.

Nevoia tot mai mare de energie a impus apariția unui alt concept inteligent pentru acea vreme: interconectarea surselor de energie, transportul la distanță a energiei și distribuția sa, devenită tot mai complexă dat fiind specificitatea consumatorului.

Tensiunile diferite ale diverselor rețele locale, felul curentului (c.c., c.a., mono, bi și trifazat), frecvențele diferite, au reprezentat mari provocări în elaborarea interconectării, aceasta presupunând stabilirea valorii tensiunilor de transport, frecvența, capacitatea liniei, circulația de puteri pe rețele care dădeau posibilitatea unei gestionări mai bune a alimentării cu energie a consumatorului, realizarea uni sistem unitar, centralizat, prin interconectare asigurându-se "Summumul" de energie necesar unei industrii care cerea tot mai multă energie și în zone tot mai diferite.

Se poate spune că "inteligența" a fost marcantă încă din acei ani, pentru ca interconectarea și funcționarea unor echipamente de mare putere presupunea cuplarea unor "funcții" apelând tot mai mult la "inteligență" în controlul și aplicarea unor scheme.

În anii noștrii, se accentuează la maximum pe conceptul de Rețea Inteligentă și gradul înalt de inteligență a componentelor sistemului, a arhitecturii lui, al managementului bazat pe o utilizare masivă a Tehnologiei Informațiilor și Comunicațiilor, elemente care succint vor fi prezentate în cele ce urmează.

III. CE ADUCE NOU REȚEAUA INTELIGENTĂ ?

Avantajele unei Rețele Inteligente sunt mari, conceptul este însușit de toate țările lumii, fără a neglija însă cât costă și în ce timp poate fi realizat!

La nivelul Uniunii Europene există un consens în definirea Rețelei Inteligente: "*O rețea care poate integra comportamentul și acțiunile tuturor utilizatorilor conectați la ea și anume: producători, utilizatori și a celor care asigură concomitent atât eficiența durabilă și economică, cât și siguranța funcționării".*

Un important document European: Strategic Deployement Document /1/ prevede o serie de acțiuni ce vizează Rețelele Inteligente, rețele care folosind echipamente și servicii noi, introducerea lor pe întreg lanțul generare energie – transport - distribuție și utilizare - împreună cu aplicarea TIC, a monitorizării controlului și sistemelor de comunicații, trebuie să asigure:

- mai bună conectare și operare a tuturor tehnologiilor noi aplicate, a integrării în rețea a oricărei surse de energie distribuită;
- atragerea consumatorilor în acțiunea de preluare a unor operații și responsabilități, participarea lor la optimizare;
- să ofere consumatorului informații și posibilități de alegere a furnizorului;
- reducerea în mod semnificativ a impactului pe care-l poate genera sistemul energetic asupra mediului;
- asigurarea unor niveluri optime de securitate, alimentare, mentenanță și costuri.

Exista însă și o serie de provocări - cunoscute însă - care necesită un răspuns din partea specialiștilor:

- "întărirea rețelei", în sensul că aceasta să permită asigurarea unei capacități mai mari de transport și posibilități de interconectare;
- dezvoltarea celor mai eficiente conexiuni pentru fermele de vânt "offshore" și alte tehnologii marine;

- dezvoltarea de arhitecturi descentralizate care să permită o funcționare armonioasă a “surselor mici” cu sistemul;
- dezvoltarea de infrastructuri de comandă care să opereze sigur, aplicarea conceptului DSA (Distribution System Analysis) pentru toți consumatorii, încât aceștia să joace un rol important în operarea sistemului;
- găsirea celor mai bune soluții pentru integrarea surselor de energie care să acționeze intermitent, inclusiv microgenerarea din sectorul rezidențial considerat nu doar un consumator de energie ci și un producător;
- pregătirea pentru preluarea alimentării cu energie electrică a vehiculelor electrice.

IV. RISCURI ȘI VULNERABILITĂȚI ALE REȚELELOR INTELIGENTE

Termenul îndepărtat cu care se estimează existența unei rețele în totalitate “inteligentă” de 20-25 ani, ascunde în el și nevoia multor verificări a noilor tehnologii și echipamente, noi arhitecturi de rețele și structuri, excluderea operatorului uman și apelarea la TIC, dar ascunzând în ea și posibilitatea unor accidente sau atacuri cibernetice deja semnalate de americani ca fiind și posibile și real întâmplate.

La capitolul anterior au fost prezentate o serie de provocări care pot conduce la vulnerabilități dar există convingerea că există soluții în viitor.

Câteva vulnerabilități importante sunt menționate în literatura americană care în domeniul Rețelelor Inteligente are o mai mare experiență decât UE. /2-6/

* Introducerea masivă a digitalizării și a electronicii de putere și a TIC în intenția de a crește “inteligența” componentelor și a sistemului energetic, funcțiile noi gândite pentru Rețea (în special sursele distribuite și descentralizarea), informatizarea masivă, pe lângă avantaje evidente, incubă și posibilități amplificate de apariție a unor nefuncționalități cu implicații grave atât pentru furnizorul de energie cât și pentru consumator.

De aici și grija pentru a evalua cât de “inteligentă” trebuie să fie o “Rețea Inteligentă”!

Că lumea gandește la aceste probleme și încearcă să găsească un echilibru, este și faptul că ultimul număr al Revistei IEEE Power & Energie din Noiembrie 2011, este alocat în întregime vulnerabilității pe care o reprezintă sistemul de distribuție, prezentând din experiența unor mari sisteme enegetice din SUA. /6/

* Informatizarea masivă a managementului rețelei, a componentelor sale devenite inteligente și interfațabile, folosirea unor protocoale de operare sofisticate, face rețeaua dependentă de Internet și prin aceasta, posibilitatea de a fi atacată de hackeri. Există chiar voci care afirmă că prin informatizarea masivă a rețelei se creează vulnerabilități și sugerează chiar deconectarea de la Internet /4/, excluderea acestuia din sistemele de operare și control.

Sistemul de achiziție și control SCADA, aplicat tot mai intens în sistemul energetic a crescut eficiența acestuia dar încă este dependent de multe protocoale Internet, dependența care ascunde o anumită vulnerabilitate.

* Exploziile solare, furtunile magnetice și câmpurile electromagnetice puternice, pot avea un rol important în buna funcționare a Rețelelor Inteligente. Un studiu făcut de John Kappeman de la Metatech Corporation /5/ arată că o asemenea furtună magnetică în 13-14 Martie 1989, a creat pentru 5 minute perturbații importante la nivelul rețelelor energetice din Canada și America de Nord, având intensități mai mari de 2000nT/min. Prognozele arată că frecvența acestor fenomene va crește în viitor, modelări complexe realizate în SUA, indicând și ariile probabile unde vor apare asemenea perturbații. Se estimează spre ex. că în SUA, peste 365 transformatoare mari sunt expuse la efectul radiațiilor iar distrugerea lor ar însemna perturbații în

alimentarea cu energie care s-ar întinde pe mulți ani.

* Deși România nu este expusă la acțiunea severă a unor uragane așa cum se întâmplă în America (pierderile cauzate de Uraganul Katrina au fost evaluate la 81–125 mld. $) sau la descărcări electrice de mare intensitate, există și la noi numeroase cazuri în care alimentarea cu energie poate fi întreruptă datorită unor asemenea fenomene. In schimb, descărcările electrice pot cauza avarii grave în sistem și trebuie luate în considerare.

V. CE TEMATICI AR TREBUI SĂ ABORDEZE CERCETAREA DIN ICPE–CA, PE LINIA REȚELELOR INTELIGENTE?

La prima vedere, energeticianul este singurul și principalul actor în concepția, dezvoltarea și exploatarea Rețelelor Inteligente, întrucât el este acela care în problemele importante ale rețelei: arhitectura şi structura, management al energiei, exploatarea și asigurarea continuității în furnizarea sigură a energiei, are o responsabilitate majoră.

Fără a minimaliza acest rol, trebuie arătat că toate aceste modernizări tehnice nu pot fi realizate fără existența unor echipamente și dispozitive performante și sigure, contribuția și responsabilitățile constructorului de echipamente sau componente ale acestora fiind la fel de importante.

Pentru specialiștii din ICPE–CA, există o serie de direcții de cercetare care pot sprijini dezvoltarea Rețelelor Inteligente și asupra cărora trebuie reflectat.

1. Prima din ele, este aceea a echipamentelor inteligente dotate cu numeroși senzori și transmiterea de informații necesare pentru luarea de decizii.

Se vorbește despre dezvoltarea de transformatoare și generatoare inteligente, întrerupătoare și cabluri inteligente, echipamente echipate cu senzori și traductoare, actuatori, care să semnaleze anomalii incipiente care pot evolua în defect, să asigure redundanța unor comenzi de excludere, chiar îndepărtarea sau autorepararea unor posibile defecțiuni.

Senzori inteligenți, care să evidențieze un fenomen care poate conduce la un defect - prezența unor descărcări electrice, concentrări de câmpuri electrice, distribuții de temperaturi, prezența unor gaze, zgomot- vor trebui dezvoltați și conectarea lor la actuatori și platforme electronice, va putea acționa pentru înlăturarea sau remedierea defecțiunilor.

Colaborarea cu Centrul de Cercetări CETTI de la UPB, poate constitui nucleul unor dezvoltări viitoare pe această direcție.

Senzorul și platforma electronică, vor deveni elementul de bază în supravegherea echipamentelor și a diagnozei într-o Rețea Inteligentă și abordarea acestui domeniu poate deveni de maximă importanță pentru ICPE-CA.

2. O a doua problemă în care ICPE-CA are experiență, realizări și oameni, este aceea a surselor noi de energie, care în etapa următoare vor constitui un punct central în Rețelele Inteligente, ca surse de energie distribuite: soare, biomasă, vânt, microhidro, pile de combustie. Preocupărilor actuale, le-aș adăuga "harvesting-ul", evidențierea și valorificarea "energiilor mici" cu dezvoltarea unor aplicații specifice, senzori cu aplicații specifice (senzori cu alimentare autonomă aplicabili în energetică).

Tot în acest domeniu, stocarea poate constitui o direcție în care Institutul poate acționa cu succes atât prin procedee de schimbare de fază cât și prin cercetările în supraconductivitate.

Problema reproducerii în laboratoare din SUA /2/ a fotosintezei frunzei a avansat atât de mult, încât deja se vorbește de reacții care parțial au dovedit că se poate realiza artificial această fotosinteză și obținere de Hidrogen (Profesorul Mocera de MIT, comunică deja noi căi de reproducere a procesului de fotosinteză, utilizând lumina pentru a separa moleculele apei în Hidrogen și Oxigen, gaze care pot fi stocate și utilizate în calitate de combustibili.

Catalizatorii utilizati: Borat de Cobalt și aliajele NiMnZn, au condus la degajări promițătoare de gaze).

3. O a treia direcție și în strânsă legătură cu eficiența energetică, este recuperarea oricarei forme de energie, realizarea de sisteme în care spre ex. căldura reziduală dintr-un proces, să devină sursa de energie pentru elementul care urmează în lanț (spre ex. căldura reziduală de la o pilă de combustie, sursa termică pentru un alt dispozitiv de conversie). /7/

4. O a patra direcție este aceea a materialelor inteligente, materiale cu memorie, materiale regenerabile, materiale pentru senzori și supraconductoare (inclusiv - dacă sunt făcute de alții - în utilizarea lor în aplicații specifice dispozitivelor componente Rețelelor Inteligente).

- **VI. CONCLUZII**

Rețeaua inteligentă prin performanțele și funcțiile noi pe care le realizează, prin circulația datelor și deciziilor, a eficienței atât la producător cât și la furnizor, constituie un domeniu care în mod clar înseamnă performanța, eficiența și siguranța, răspuns rapid la solicitările clientului interesat prin stimulente materiale să participe: utilizarea energiei în anumite perioade de timp și de la anumite surse -în special cele intermitente- reprezintă o soluție a viitorului.

Tehnicizarea sa masivă și introducerea la toate nivelurile a Tehnologiei Informației și Comunicațiilor, dependența de interoperabilitatea sistemelor soft, creează unele vulnerabilități asupra cărora tehnicianul trebuie să reflecte.

Introducerea spre exemplu a unui nou sistem de comutație pentru puterile mari transportate, nu poate fi utilizat în rețea decât cu anumite riscuri dat fiind lipsa de experiență și cazuistica unor defecțiuni cunoscute la tehnica pe care o înlocuiește.

ICPE-CA poate găsi suficiente "nișe" în care poate acționa cu succes în viitoarele Rețele Inteligente.

Echilibrul în alegerea soluțiilor de a face "mai inteligent" un component, echipament, rețea în ultima instanță, este o responsabilitate a inginerului care trebuie să gândească soluțiile nu doar față de cele cunoscute astăzi, ci și față de cele care imaginativ, ar putea fi în viitor!

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Autonomous system of bioresonance in ambulatory

Marius Arghirescu*, Gabriel Năstase**
*State Office for Inventions and Trademarks (OSIM), Str. Ion Ghica, No. 5, District 3, Bucharest, Romania,
**Univ. "Dimitrie Cantemir, Splaiul Independenței No. 176, District 4, Bucharest, Romania"
*arghirescu.marius@osim.ro, **gabriel_nastase@yahoo.com

Abstract – The paper presents a chair for bioresonance in ambulatory which has two bioresonance apparatus: a minigenerator of 1-15 Hz, included in the head support part to a plate having also an antenna, for menthal relaxation by alpha-biocurrents, and a principal bioresonance apparatus programable for multiple frequency emitting, for the patient body, of 800Hz-200KHz, included in the back-part of the chair, to a plate-support having also an spiral antenna and a presence detector which permits the apparatus functioning only in the presence of a person.

The bioresonance plate has also 2-3 supports for electric rechargeable batteries, some magnets for magnetotherapy, and tho pairs of electric dynams for the electric batteries recharging, actioned by steel wires fixed by springs and tensioned by a pair of rotatable palettes having springs and actioned by the arms of the person rested on the chair. The rotatable palettes are fixed to a steel support fixed by screws to the back-part of the chair.

***Keywords:* therapeutic chair, bioresonance apparatus, batteries regharging.**

I. INTRODUCTION

1. Issue of the invention is to realise the bioresonance treatment or also the bioresonance diagnosis, with an energetically autonomous system but which is also simple for use by the patient.

2. Technical prior art:

a) in the technical prior art, it is known a therapeutic chair with magnets or electromagnets in the back part, (patents: CN1058707, CN 1091267), or with a diathermy apparatus in the back part, with the electric current supplied by an external electric source.

b) there are known also bioresonance apparatus: SCIO, BICOM, with computer program for identify health problems of: respiratory system, digestive system, osteo-articulary system, nervous system, endocrine system, sensitive organs, and body deficiencies of vitamins, enzymes, minerals, hormones, and for the body health amelioration by using a bioresonance frequency spectra of 10 Hz-150kHz with electric impulses applied by some electric contacts. For examples, with a frequency of 870 Hz may be corrected the immunodeficiency.

There are known bioresonance apparatus: METATRON, OBERON with computer program for identify health problems, using a similary functional principle, but which use electromagnetic waves in the frequency spectra of 1-25 HZ, by a wire network forming an antenna putted on the patient head.

Disadvantages:

- the patient is dependent of the doctor cabinet;
- the apparatus is dependent of an external electric source.

c) there are known portable bioresonance apparatus: BIOHARMONEX, for therapy by electromagnetic waves in a frequency spectra of: 1-200KHz, used for cells/neurons energetic re-equilibration, immunitary and mental systems normalisation, biorhythms, hormonal activity, detoxification, respiratory, digestive and urinal system, having also a microprocessor for automatic therapy programming.

The electric power is supplied from three rechargeable batteries of 1,5V and has an action distance of approx. 1,5m.

Disadvantage:

- the batteries ensures the apparatus functioning for only 3 hours, without recharging.

II. THE PROBLEM SOLVING

The technical problem was solved by the invention in the next way:

-by including of a principal bioresonance apparatus in the back-part of the chair, for the homeostasis of the thoracic cavity organs, with functioning in the frequency spectra of 800Hz-200kHz and by including a second bioresonance apparatus in a head part of the chair, for mental relaxation by alpha biocurrents resonance, of 7,8-8 Hz frequency;

-by the increasing of the bioresonance apparatus antenna surface;

-by including of a presence detector in the back part of the chair, for automatically functioning of the bioresonance apparatus;

-by including of two pairs of electric dynams in the back part of the chair, for apparatus batteries recharging by the periodically traction of two steel wires realised by a pair of hand palettes, attached to the chair's back part for the arms muscles training.

III. THE COMPONENT PARTS

The chair has two bioresonance apparatus: a minigenerator (11) of 1-15 Hz, included in the head support part (C), to a plate (10) having also an antenna (12), for menthal relaxation by alpha-biocurrents and a principal bioresonance apparatus (4) which is programable for multiple frequency emitting, for the patient body, of 800Hz-200KHz, included in the back-part (S) of the chair, to a plate-support (A) having also an spiral antenna (5) and a presence detector (6) which permits the bioresonance apparatus functioning only in the presence of a person.

To the plate (A) are fixed also 2-3 supports for electric rechargeable batteries (13, 13', 13''), some magnets (7) for magnetotherapy, and two pairs of electric dynamos (14, 14', 15, 15') for the electric batteries recharging, actioned by steel wires (m, m') fixed by springs (16, 16') and tensioned by a pair of rotatable palettes (17, 17') having springs (h) and actioned by the arms of the person rested on the chair. The rotatable palettes (17, 17') are fixed to a steel support (18) fixed by screws to the back-part of the chair.

The sanogene chair may have also an air ionizer and an inferior part (F) for the legs muscles training.

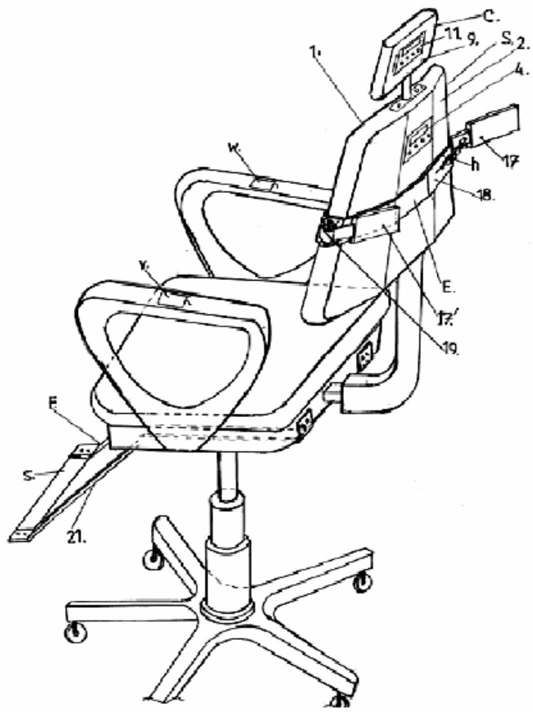

Fig. 1. The autonomous sanogene chair.

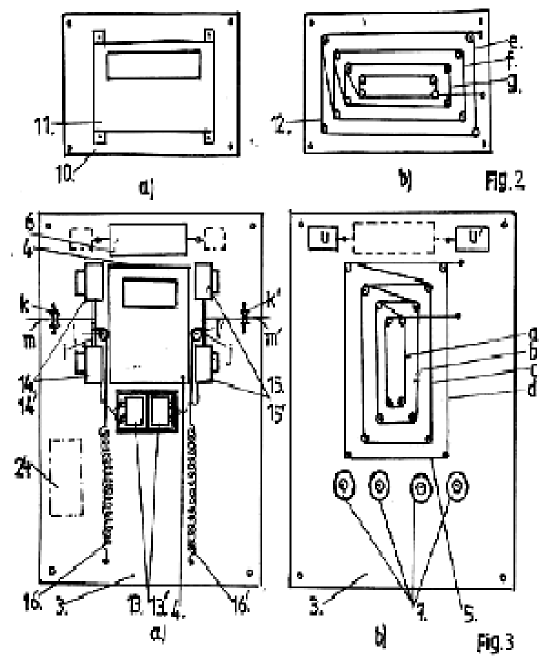

Fig. 2-3. The plate-support for the principal bio-resonance apparatus.

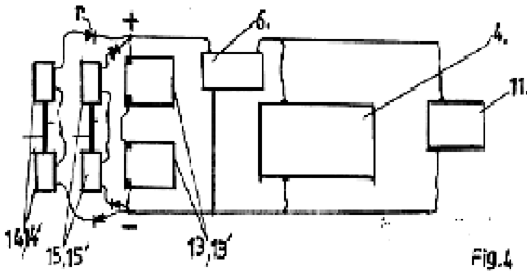

Fig. 4. The electric scheme of the chair's bio-resonance system.

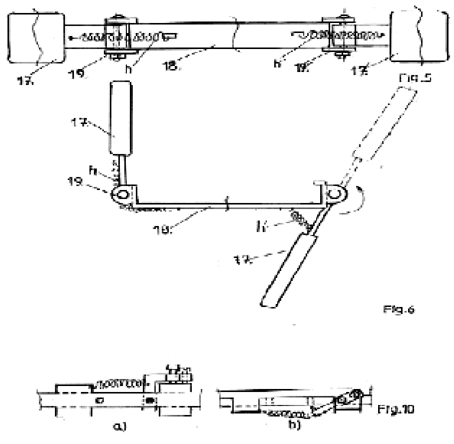

Fig. 5-7. The support with the palettes for the arms muscles training and the electric batteries recharging.

IV. ADVANTAGES OF THE NVENTION

The invention has the next advantages:

-it permits the human body treatment by bio-resonance in ambulatory or at patient home, conforming to a adequate established program, with automatic activation of bioresonnance apparatus, by the included presence detector, and without energetic dependence of an external electric source;

-may be realised also in a variant for car drivers, with electric connection to the car's battery;

-may be utilised also by invalids, with electric battery recharging realised from solar cells, attached to the backpart of the chair;

-may be adapted also for telediagnosis, by incorporating also an bioresonance diagnosis apparatus in the backpart of the chair, connected- when it is necessary, to a laptop by an adequate computer programme.

V. References

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[5] patent: RU2009102396

VI. BIOGRAPHIES

Arghirescu Marius was born in Perieni-Vaslui on Sept. 3, 1959. He graduated at 1990 and he received Ph.D. degrees in science and engineering of materials from Bucharest Polytechnic University in 2008.

His employment experience included the Siderca S.A. Calarasi enterprise and the State Office for Inventions and Trademarks-Bucharest where he is patent examiner.

As inventor, he is member of Romanian Inventors Society, (SIR).

Gabriel Nastase was born in Bucharest on Febr. 27, 1955. He graduated at 1981 and he received Ph.D. degrees in mechanics engineering from Bucharest Polytechnic University in 2002.

His employment experience included the Hesper S.A. enterprise and the University "Dimitrie Cantemir" where he is conferentiary.

Deposition of nickel for micro-mechanical systems obtained by sulfamate bath

*Ionela Paula Prioteasa, **Marius Popa
Research and Development National Institute of Electrical Engineering (INCDIE ICPE-CA),
Splaiul Unirii, No. 313, District 3, 030138, Bucharest, Romania
*prioteasa_paula@icpe-ca.ro, **mariusp@icpe-ca.ro

Abstract - Micro-mechanical systems were obtained electrochemically from nickel sulfamate-based electrolyte on silicon wafer substrate using LIGA lithography. A selection of optimum fabrication sequences and operating conditions was made. The deposited nickel layers showed good appearance, characterized by uniformity, fine-grained and brightness. The structure, texture, and crystallite size were evidenced and measured by optical and SEM microscopy and XRD diffraction spectroscopy.

***Index Terms* - micro-mechanical systems, nickel electrodeposition, sulfamate bath, surface characterization**

I. INTRODUCTION

One of the areas of microelectromechanical systems (MEMS) is to fabricate small integrated systems containing sensors, actuators, signal conditioning circuits and additional functional devices with physical dimensions ranging from a couple to a few hundred micrometers. These micromechanical parts are fabricated by selected combinations of different materials and technologies and may be represented as composite structures of substrate (bulk) materials and thin films/coatings.

Electrodeposition is a promising technology, especially for the realization of different movable structures for MEMS applications [1].

It is important to mention that it is possible to fabricate movable structures consisting of layers with a very low level of internal (residual) stress.

This can be achieved with various materials with widely diverse properties, such as composition, crystallographic orientation and grain size.

The properties of electrodeposited materials are affected by the processing parameters. Electrodeposition is compatible with large scale production, being a low temperature and high rate deposition technology. Nickel is widely used material for electrodeposition. Electrodeposited nickel has good mechanical properties, such as high strength and hardness, which are beneficial in high aspect ratio microstructures. Conventional, the electrodeposited fine-grain-structured nickel will resist to mechanical deformation.

In the speciality literature experimental results on the selection of process parameters have been published, in order to achieve optimal microstructure of Ni deposits [2]. However, the works that analyze the influence of process parameters on the microstructure and properties of nickel deposits are much fewer [4-9]. In recent years, nanostructured materials have found increasing interest due to their special properties in different areas [10-12]; some examples of applications are: nanoelectronics, photonics, thermoelectronics, to creating products such as heads of magnetic recording, memories, nanoelectrodes, sensors etc. These advanced applications were possible to be realized through two parallel procedures. On the one hand, the continuous improvement in photolithography has made possible decrease at submicrometric level of dimensions. On the other hand, theoretical understanding of microelectrochemical engineering principles has been developed very much, including an explanation of current distribution, mass transport, electrode kinetics and nucleation, as well as growing of microcrystals. All these developments favor and improve the safety of processes in electrochemistry, a fact which allows their implementation on a large scale automated production. The operating parameters in LIGA technology that must be controlled are divided in two categories: (i) parameters involved in achieving the metal deposition: bath parameters (electrolyte, precursor concentration, buffer, additives, pH) and temperature; (ii) parameters affecting the uniformity, structure and texture of deposit: current density and application of various current pulses, geometry and configuration of the substrate, stirring of solution.

This paper presents the results of nickel electrochemical deposition on the silicon wafers using LIGA technology, in order to achieve microstructures for micro-mechanical systems using the sulfamate bath. After a selection of optimal conditions for obtaining good quality deposits we made a detailed characterization of obtained Ni layers.

II. TECHNICAL WORK PREPARATION

For these experiments the support consisted in commercial n-type (100) Si wafers with 10 cm diameter and 525 μm thickness; the support is indicated as (1) in Figure 1. As a pre-treatment, the silicon surface was covered with a SiO_2 film (500 nm) and a Cr/Au layer (denoted (2) in Figure 1), on which either SU8 50 or SU8 100 types photoresist (Microresist Technology, Germany, denoted (3) in Figure 1) having 100μm, 200μm or 400μm thicknesses was applied. During the photolitography steps, the routes of non-exposed photoresist were developed with an organic solvent, 1-methoxy-2-propyl-acetate, commercially named mr-Dev 600 reagent (Microresist Technology). Nickel layers (4) were then electroplated on these routes. Finally, the remaining photoresist was removed using organic solvent (developing step) and the obtained nickel structure was detached from the substrate (2).

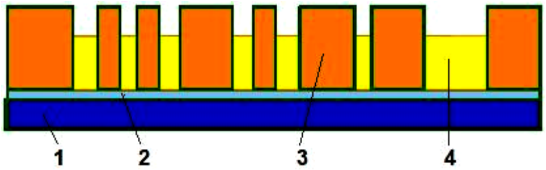


Fig. 1 Scheme of processing assembly: Si wafer (1), SiO_2 film on which a Cr/Au film was superposed (2), portions of SU8 photoresist still non-developed (3) and non-detached micro-mechanical system composed of Ni deposit (4).

It is worth to mention that in another series of experiments we obtained successfully the same microstructures by changing the nature of substrate, *i.e.* using 316L stainless steel, confirming the results of previous works [13,14] that have used SU8 photoresist during the same LIGA procedure for obtaining micro-mechanical structures. The sulfamate $Ni(NH_2SO_3)_2$ bath was selected as more appropriate for association with LIGA technique owing to its better throwing power, buffer capacity and stability for the electrodeposition.

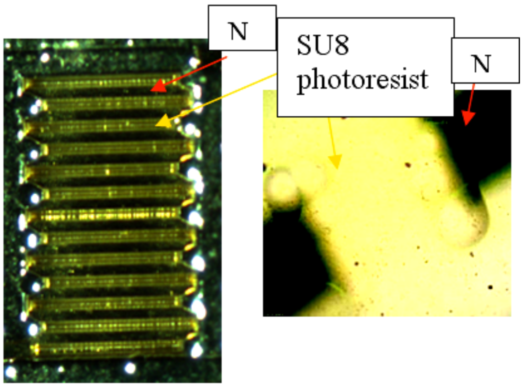
The following optimal electrolyte composition was chosen: 300 gL^{-1} $Ni(NH_2SO_3)_2$, 30 gL^{-1} $NiCl_2.6H_2O$, 30 gL^{-1} H_3BO_3, 7.5 gL^{-1} naphtalene tri-sulfonic acid and 0.05-0.1 gL^{-1} sodium lauryl sulphate. The pH values were kept within 3.5-4.2 range with amidosulfonic acid as additive. All reagents were purchased from Merck.

The operating conditions for preparing Ni microstructures were the followings: current densities in the 2-5Adm^{-2} range, 2-5V voltage and electrolyte temperatures in the range of 50-55^{0}C. A two-electrode cell was used, containing the support, processed as above described and connected as cathode, and a Ni plate with large area as anode. The Ni deposition runs are followed by rinsing with running water and distilled water and drying, as usually. A magnetic stirring of electrolyte was performed for avoiding diffusive control of mass transfer at cathode and therefore for working with an increased current density. Images of Ni deposits were obtained using both Stemi 2000-C (Carl Zeiss) optical microscope with Axio camera and a FESEM-FIB Auriga (Carl Zeiss) SEM microscope. X-ray diffractometry measurements (XRD) were carried out using Bruker AXS D8 ADVANCE diffractometer with Cu anode and k_β Ni filter.

III. RESULTS AND DISCUSSION

We obtained and caracterized Ni layers with thicknesses between 30 and 100 µm, electrodeposited at current densities in the range 2.5-5 Adm^{-2} with electrolysis duration between 1-5 hours, and also Ni layers with thickness of 200 µm, obtained at current densities in the range 0,5-1 Adm^{-2} with 33 hours electrolysis duration.

Values of 98-99% current efficiencies were determined gravimetrically.



(a) (b)

Fig. 2 Optical images of a network with beams (a) having 30µm Ni layer thickness and a micrography (b) at ×50 magnification.

Figures 2 present an example of network in a shape of microbeams deposited on a support having 30µm photoresist. Also, a very uniform deposit is illustrated in Figure 3 for a thicker Ni layer (around 100 µm thickness), especially for the central part of each microsquare.

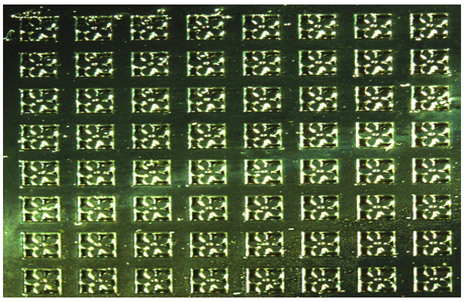
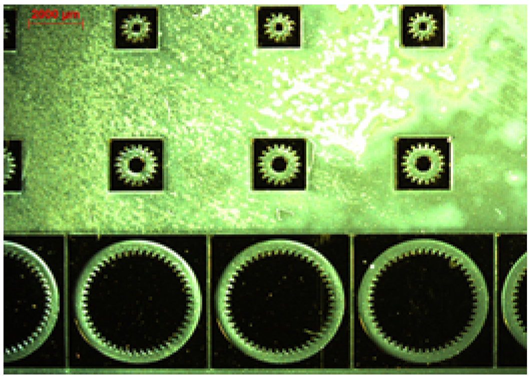
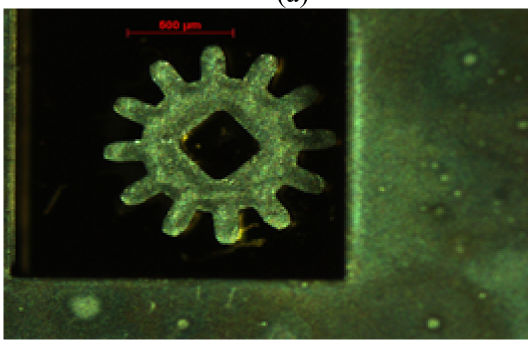


Fig. 3 Optical image of a network of microflowers with 100µm Ni layer thickness.

Figures 4 present optical images of a network of microgears with 200µm Ni layer thickness at different magnification.



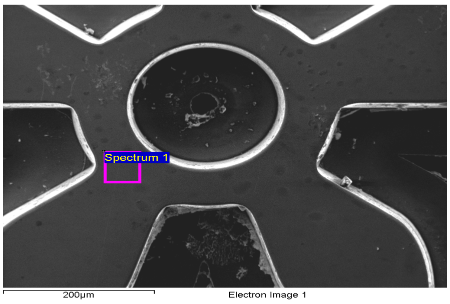
(a)



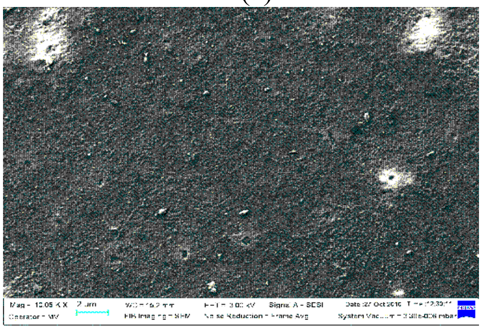
(b)

Fig. 4 Optical images of a network of microgears with 200µm Ni layer thickness at ×6.5 magnification (a) and at ×50 magnification (b).

A characterization of morphology is presented by SEM micrographs, an example being given in Figures 5. As the SEM picture (Fig. 5b) shows, a coherent Ni deposit with a compact structure is obtained by electroplating procedure, confirming the findings obtained by optical micrographs. This good quality structure with almost equal dimensions of the nickel particles indicates the important role of wetting and brightener agents introduced in sulfamate bath as additives, namely naphtalene tri-sulfonic acid and sodium lauryl sulphate, respectively, as well as the selection of their appropriate concentration.



(a)



(b)

Fig. 5. SEM micrograph (a) for a single microgear; SEM image (b) at ×10000 magnification for the zone indicated in Fig. 5a.

As Figure 6 shows, a cross-sectional view in the nickel layer (a microgear section is presented in this Figure) illustrates an exactly thickness of the deposit, a 99.07 µm dimension being measured in two different places.

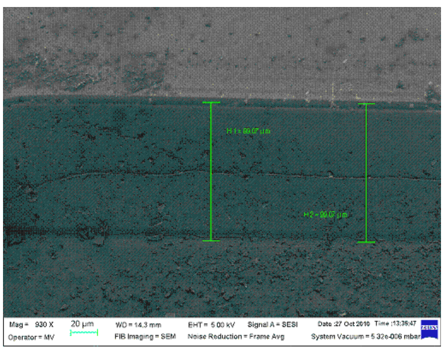


Fig. 6 SEM micrograph at ×930 magnification for a cross-section in a microgear, evidencing the uniform thickness of Ni layer (99.07 µm exactly) between substrate and insulator coverage.

XRD spectra were also recorded to get information on the deposit structure The shape of this spectrum with narrow peaks suggests a very crystalline deposit. The nickel phase has electrocrystallised in *fcc* (face centered cubic) crystallographic system, as resulted by identification of Ni samples with indexing code number 00-004-0850 (ICDD data base). The collection of main peaks consists mainly in five characteristic XRD peaks: three of them, at diffraction angles $2\theta = 45^0$, 52^0 and 77^0, were attributed to Ni species and the other two peaks (at 93^0 and 98^0) may be attributed to nickel oxide.

By processing the XRD data, the average size of crystallites was calculated using the Debye-Scherrer equation:

$$D = \frac{0.9\lambda}{B\cos\theta} \qquad (1)$$

where D is grain size, λ is the wavelength of the X-rays, λ=0.154056nm in our case; B is the full width at half maximum (FWHM) and θ is the half diffraction angle of crystal orientation peak. Values in the range 13nm to 19nm were obtained for the crystallite size.

IV. CONCLUSIONS

The use of a nickel sulfamate bath allowed to be obtained the required good throwing power, buffer capacity and stability for the electrodeposition of nanocrystalline and smooth Ni layers. In the proposed procedure, nickel layers of different thicknesses on silicon wafers as supports using LIGA litography were successfully electrodeposited. We noticed that the thin nickel layers are uniform and have fine-grained and mirror-bright appearance. Their nanometric crystallite size was evidenced by optical and SEM microscopy, as well as by XRD spectra. However, we recommend for micro-mechanical systems the thicker nickel layers (thickness 90-100µm and 200 µm) because they have the same good characteristic appearance, especially in the central zone of support mold, by introduction in the bath solution of apropriate additives.

V. ACKNOWLEDGMENT

The paper was possible because the financial support of the Romanian project PN 09350101.

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VI. Biographies

Eng. **Prioteasa Ionela Paula** was born in Bucharest, Romania, on September 11, 1979. She graduated from the Faculty of Applied Chemistry and Materials Science, University POLITEHNICA of Bucharest on 2004, and received a Master Degree Diploma from the same faculty in 2005. She defended her PhD on May 2011 in the field of electrochemistry from University POLITEHNICA of Bucharest. Her employment experience includes the National Institute for Research and Development in Electrical Engineering ICPE-CA, Department of ThermalAnalysis, Electrochemistry group. Her fields of interest include electrodeposition of metals and alloys; electroformation of Ni layers over the substrate in lake photoresist, with applications in LIGA technology; research of metallization textile, electrochemical deposition of Sn, Sn-Zn, Ag using ionic liquids based on choline chloride; passive films on zinc alloys; corrosion and corrosion protection of metals and alloys.

Bioengineering on the Road from Artificial Intelligence towards Artificial Consciousness

Radu Negoescu
National Institute of Public Health, Bucharest, Romania, 1-3 Dr Leonte Str., Bucharest 5, Romania
radu.negoescu@insp.gov.ro

Abstract - Whilst the artificial intelligence seems recently to approach its human-close specimen, artificial consciousness as targeted by bioengineering and information science&technology advances still has some way to go before becoming an experimental terrain for a bunch of sciences that deals with the problem of conscience, including philosophy and theology. Depending on our capacity to inseminate a machine transposition of natural ethics at the same time with increasing machine autonomy, a well guided artificial consciousness holds the promise to offer a representation of what natural consciousness could be in absence of distorting influences exerted by biologic (genetic) inheritance on human being as it presents nowadays.

***Index Terms* - consciousness, conscience, machine consciousness, information technology, cardiovascular bioengineering.**

I. BIOENGINEERING AND ARTIFICIAL INTELLIGENCE

Bioengineering is the science arm of biomedical engineering, oriented to theory and research using methods of exact sciences to study biological mechanisms. The other arm, clinical engineering is more practically oriented towards management of high technology equipments in hospital and clinics, and towards partnership with the medical personnel in diagnosis and/or therapeutic interventions involving advanced technology.

Intelligence (or reason) is defined (with reference to humans) as (1) the ability to learn or understand or to deal with new or trying situations; *(2)* the ability to apply knowledge to manipulate one's environment or to think abstractly (Merriam-Webster).

Defined by John McCarthy in 1956 as the science and engineering of making intelligent machines, hopefully in the human intelligence sense, the artificial intelligence certainly evolved over the past half century, even if we never got the humanlike assistants that many thought we would have by now. It offers a valuable technological support in critical domains, e.g. computer-diagnosing patients over the internet, but even the most helpful artificial intelligence systems in function today must be programmed explicitly to carry out its one specific task. What people wanted and needed was a general-purpose intelligence that can be set loose on any problem, i.e. one that can adapt to a new environment without having to be retrained constantly: *"one that can tease the single significant morsel out of a gluttonous banquet of information the way we humans have evolved to do over millions of years"* [1].

Recently yet Hewlett Packard introduced a new class of electronic device overriding the separation between memory and processing, the memristor, into a "brain-inspired" microprocessor featuring the form factor of a brain, the low power requirements, and the instantaneous internal communications - that could be trained and coaxed to behave like a brain. Run on this "brain on a chip", the MoNETA (Modular Neural Exploring Traveling Agent) software written at Boston University's will perceive its surroundings, decide which information is useful, integrate that information into the emerging structure of its reality, and in some applications formulate plans that will ensure its survival - the same drives that motivate humans and entitle the machine as a specimen of true (or real) artificial intelligence [1].

II. CONSCIOUSNESS

English uses the term *consciousness* (or self-awareness) to designate a neural-behavioral state featuring capabilities of reflection and reaction found as adequate by the rest of the world, while being vigil.

French appears to make no much lexical distinction between consciousness and conscience that are commonly referred to by 'conscience' and lets to the context making the difference. However, *'faits de conscience'* and "connaissance' refer unambiguously to consciousness or to a part of it.

After M. Draganescu [2] consciousness stands for a type of integrative information (structural-phenomenological and social) capable of understanding and knowing, knowing that knows, and endowed with: feeling of to be, will, intuition and creative power.

Notice that in the philosophical thinking of M. Draganescu structural information is related to (non-living) nature and its sciences, while phenomenological information is related to the living matter studied by life sciences. Integration of structural and phenomenological takes place into the real human being as such; dissection by theoretical reasons may enlighten various balances between parts otherwise intimately merged when analysis progresses from the molecular and cellular level to organs, systems, mind and soul.

Consciousness is naturally human; its versions "contaminated" by technology or those purely technological are referred to by artificial ones.

Coming back to terms, in Romanian conscious ('constient') is also (English-like) pointing to someone who can rationally place his/her Ego vis-à-vis of the world and him/herself; the term "rational" sends to the manner in which that positioning is done by a majority of other individuals. Besides, the Romanian 'constient' refers to someone endowed with a certain level of *conscience*: "I am 'constient' (aware) of my duties", where the attitude versus duties is already related to moral principles, to an axiology.

III. CONSCIENCE AND SOCIETY OF CONSCIENCE

Conscience is yet more than what is involved by "I am aware of" (that expresses a potential), namely a non-hesitant (proved) availability to actualize this potential with the current behavior. At a higher individual level, conscience involves looking into the meaning of existence, for him and for others who do not possess necessary capabilities, by a philosophical and/or religious demarche.

However exercising conscience is mainly done in the social environment. M. Draganescu's [2,3] social-human civilization of the future would be by far towering biological needs of an aggregate of human individuals whose interaction would filter (somehow in the sense of coherent summation in physics) luminous parts present in all of them as pieces of truth that are detected, sifted and put together through the collective, social exercise of spirituality. Or, to cut it short, by the collective conscience.

In this vein, laws of Moses giving early expression to collective conscience codify social behavior of people; social sins acting against the group are mainly incriminated, rather than individual sins acting against him/her self. While the latter are health-redoubtable (we know how from medicine of lifestyle) ending sometimes in serious somatic illnesses, the former increase or exacerbate psycho-social stress responsible for more subtle forms of disease or death (e.g. sudden cardiac death in apparently healthy people).

The individual endowed with (sufficient) conscience is unselfish, generous; generosity is seen as the essentials of Christianity (as an example of spirituality) gathered in one single word. At the other end, a social value as bright as freedom, when practiced at low levels of conscience (or without conscience of kind) converts to selfishness, greed and open contempt vis-à-vis of fellow man. Social behavior of many Romanians since 1989, overtaken at low levels of conscience, if any, by freedom achieved through sacrifice of others (Revolution heroes), may convincingly illustrate what means non-conscience.

*

From these preliminaries, the relationship between consciousness and conscience could schematize as:

consciousness + moral principle = conscience.

Moral principle comes for a vast majority of humans from spirituality.

"Everyone, writes Mihai Draganescu [3], *has an empirical understanding of conscience and realizes that it stands for the highest level of his/her being. He/she then feels spirituality and spiritual experiences to be the very core of his/her conscience".* In this view, unlike consciousness, conscience is exclusively human.

On this background, a genuine social-human civilization would also be a Society of the Conscience.

In general, society is seen by M. Draganescu [3] at the crossing of influences coming from science & technology, environment, genetics and cultural (epigenetic) heritage, and spirituality (Figure 1). Spirituality is not a relatively objective social propeller, like science, but lies in depth of the intangible human subjectivity, in the conscience.

The question arises whether man's level of conscience (dependent on spirituality) could overcome at the societal level the destructive effects of those parts of his genetic inheritance directed to evil and aggression that prevents the progress of mankind towards a genuine social-human civilization.

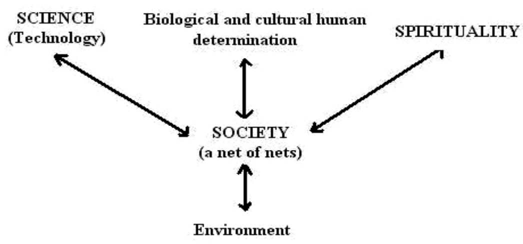

Fig. 1 A scheme of society (modified after M. Draganescu, [3])

As for the genetic inheritance, M. Draganescu [3] is quoting the biologist and physician Grigore Traian Popa who reviewing in the 40's the evils in the society of his times had put that brain should be taken into discussion when investigating what is going wrong in individuals and society since the brain can instrument both good and evil.

Briefly, due to its contamination by genetic inheritance, human consciousness as it presents today could not guarantee the progress of mankind towards a Conscience Society penetrated by the moral principle of spiritualized humanism that would dominate all social networks. In his key lecture at the INGIMED II Conference in 2001, M. Draganescu argued why he is skeptical on building a Society of Conscience without participation of artificial consciousness (AC).

*

Summarizing, in terms of cerebral activity, consciousness stands for neural machinery, mental, reason. Moral principle, for the vast majority of individuals, is involved by spirituality, so it is transcendent. Finally, conscience is both material, as tributary to neural machinery, and spiritual, that is transcendent. For some good reason Romanian say about a man of conscience that "he puts his soul into".

As M. Draganescu remarks, man of today might not be able to create a social-human civilization as his genetic apparatus dominates the epigenetic cultural acquisitions [2]. Then a solution could be an artificially assisted consciousness by implantation of neurocybernetic "consciousness prostheses" that by means of significant mental enhancement would offer a better chance to moral rectitude in the average individual, whose consciousness is largely missing nowadays the influence of spirituality.

IV. LEADS TOWARDS ARTIFICIAL CONSCIOUSNESS

In terms of technological contribution to a improving or recovering human consciousness, *neurocybernetic prostheses* are not a novelty in bioengineering or even in clinical engineering, fairly yet with much more modest goals than "treating" low levels of conscience.

Thus, *neural engineering* aims at replacing a damaged part of the human brain, involved in cognitive functions, with integrated circuits operating on the known principle of the artificial neural networks. Integrated circuits would not necessarily be on silicon that after 60 years of supremacy could leave their place by 2015 to molecular and quantum devices.

Other hopes appear related to *neuroelectronics* that refers to coupling organic substrata to electronic systems and devices.

In this vein Fromhertz et al (quoted by Draganescu, [2]) have combined a silicon chip with the giant nerve cells of the snail Lymnea Stagnalis and succeeded a two-way communication, recording and stimulating without micropipettes, simply by growing neurons on silicon surfaces - inert except some sensitive areas for collecting and emitting signals (in fact microelectrodes.

*

In a broader perspective, Koch and Tononi [4] evaluate this way the chances of occurrence of artificial consciousness: *"Consciousness is a part of the natural world. It depends, we believe, only on mathematics and logic and on imperfectly known laws of physics, chemistry and biology. It does not derive from a magical or transcendent quality. If so, then there is no reason that consciousness could not be reproduced in a machine, at least in theory".*

Notice that by the term biological (that is living) they add phenomenological dimension (in Draganescu's sense) to the structural-informational world dealing with mathematics, logic, physics and chemistry.

In this line of thinking, Koch and Tononi argue how consciousness does not seem to require many things we currently associate with human being: emotions, memory, auto-reflection, language, sensitivity to the ambient and action in the world. To be conscious, they say, appears in the last analysis to be a single integrated unit with a large repertoire of states. If so, integrated information based theory (IIT) of consciousness could devise a test to measure the degree of consciousness of a machine - a sort of Turing test for consciousness (Turing test is a method of detecting a presence of a human intelligence behind a machine presented as an automaton).

Talking about the best way to build a conscious machine, Koch and Tononi evoke two complementary strategies: *copying a mammalian brain* and/or *evolving a machine*.

The first way seems to be illusory: modeling the brain of a round worm (Caenorhabditis Elegans) with only 302 neurons and approximately 6000 chemical synapses has begun in 1986 and more than 2 decades later there was no valid model on how this minimal nervous system works.

A more plausible approach is starting from architecture of mammalian brain conveniently abstracted and evolving it towards a conscious entity.

The attempts to date, the Aibo robotic dog or the Qrio humanoid proposed by Sony are rudimentary tries to operate on a large number of fixed but flexible rules and would not pass perhaps the consciousness test proposed by the IIT. Yet, vision systems based on hierarchical multistrata maps of "neurons" (artificial neural networks) are admirably managing to classify images from the real world, but presents obvious fragility when modifying background brightness entailed, for example, by a change of scenery.

Definitely, we are still fighting the obstacles towards a true artificial intelligence, to say nothing about artificial consciousness.

But, as Koch and Tononi conclude, the big stake of reflection on how to build a conscious machine is undoubtedly more clear understanding of our own consciousness.

V. INFORMATION TECHNOLOGY LEAD

The assumption that computing machines could become conscious is based on the analogy seen by many between brain (wetware) and computer (hard- & soft-ware). It is expected that before long the computers will reach the estimated complexity of the brain.

A healthy adult brain contains about 100 billion neurons, each of them connected by axons (output), dendrites (input) and synapses with other about 100,000 neurons. It results that a typical brain has about 10^{15} connections between its neurons, each supporting at least one discharge per second. Many think that in about a decade computers will reach the computational power of the brain when exceeding $10x10^{15}$ operations/second (op/s). The IBM supercomputer Blue Gene /P can already execute up to $3x10^{15}$ op/s [5].

However, complexity of the brain once reached, "*no one has the foggiest notion*" how the computer could possibly make the qualitative step towards consciousness (E. Kandel, Nobel Laureate, quoted by Horgan, [5]) or beforehand how agglomeration of neurons and other soft tissues constituting the brain gives rise to conscious mind - that intangible entity that, in Horgan's words, *"makes you falling in love, seizing the irony in a novel, or appreciating the elegance of an electronic design"*.

While accepting the possibility mentioned by some that a quantum computer could become conscious, M. Draganescu [2] excludes structural complexity as a source of machine consciousness; instead, he sees the structural-phenomenological complexity as a necessary condition for artificial consciousness.

Issued in connection, symbiotic or not, with the human brain, a conscious machine would hold a promise of immortality sui generis, transcending decomposition of our biological hardware. Thus, the advocates of singularity see us, half in the joke half seriously, first becoming cyborgs - carriers of implanted chips to emulate perception, memory and intelligence, and finally abandoning our flesh-and-blood selves for uploading our profound ego, digitally formatted, in a computer memory that will forever ensure our immortality in the cyber-space. For some, this prospect is tangible; for example Kurzweil, an enthusiast of singularity, contemplates changing his lifestyle in the sanogenetic sense *"to live quite enough to live forever"* (cf. Horgan, [5]).

*

Best illustrating the IT lead towards machine consciousness, Cardon, Camus, Campagne et al embarked in 2005 upon an ambitious project meant to conceptualize and build a system generating *'faits de conscience'*, in fact an artificial brain able to exhibit consciousness features in a viewable manner.

"The system will have intentions, emotions and ideas about things and events related to itself. The system would have to have a body that it could direct and which would constrain the system. It would also have to have a history, and intentions to act and, most of all, to think. It would have to have knowledge, notably language knowledge. It would have to have emotions, intentions and finally a certain consciousness about itself" (Cardon, Camus, Campagne et al, [6]).

There is a *summum bonum*, a most comprehensive statement of intentions in this field that should deserve, judging conceptual and IT effort deployed, careful consideration even if authors often forget to put due quotation marks when it is about intentions, emotions and ideas.

Two hypotheses judged as reasonable are made for this transposition:

- analogy between the "geometrical dynamics" of the real brain (it is about modeling of human brain when authors speak geometry) and of the artificial brain. For one, flows of data refer to complex images, almost continuous; for the other, there are dynamical graphs whose deformations (introducing 'emotions') are evaluated topologically;

- reduction of combinatorial complexity of the real brain by positioning it at symbolic and pre-language level into computable domain.

A first implementation is reported on equipping the Sony's ERS-7 Aibo robotic dog with a reflective and reactive "brain" working at several levels (Figure 2).

Aibo sensors for touch & distance and a video camera allow to process environment data to give a contextual position (scene representation – 1st level). The camera data are processed by an artificial neural network embedded in any of a multi-agents system (several thousands of 'aspectual agents' run on a G4, Cardon, [8]) in order to build a vision ontology linked a the sensor ontology.

The second level associates the goals of the robot with its environmental knowledge in order to give priority to some objects or actions in the scene.

The third level works on the multi-agent system morphology to detect on line particular, stable geometrical forms (Campagne, [9]) in order to recognize and classify geometrical forms as 'emotions' generated by the robot during its evolution in the scene accompanied by recognition of objects and subsequent actions.

The fourth level creates a relationship between the 'cognition' and the (re)action ('behavior'). For a cognition degree, there is a succession of actions on different actuators: the more the cognition degree is higher, the more the list of actions is specified.

The fifth level is a continual bidirectional interaction and adaptation between the environment and the robot behavior.

For each action, there is feedback, a relationship between sensors and actuators. The 'attention' of the robot (in fact its knowledge base) evolves with the number of performed actions. Cognition and action are treated in parallel by the multi-agent system.

*

The project is developed on an Oz/Mozart shell. Oz is reported as a multi-paradigm language with scripting, object, logic and constraints programming. It allows using paradigms such as the concurrency for developing a multi-agent system with asynchronous communication or the constraints programming to create different action plans.

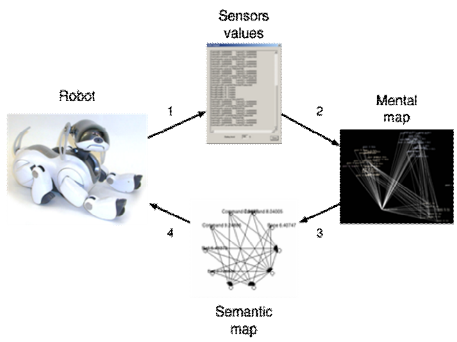

Fig. 2. The scheme of levels in ERS-7 Aibo's "reasoning" (Camus and Cardon, [7]).

While progresses in developing the novel Aibo's "brain" along the above coordinates will perhaps continue by care of Cardon's younger colleagues, himself as team leader appears as the main beneficiary of insight got upon the (true) human brain itself, even if we do not share his rather pessimistic view put as: *"Since the permanence of the physical real apprehensible by senses is very strong, the preoccupation to think by man is quite limited, in his civilizations".*

*

Dealing with artificial consciousness one has to keep in mind distinction among different level of analysis. The level of reality refers to *what is*, the human brain, fragmentally and in general poorly understood. The level of our reflection upon *what is*, uses words and logics taken from maths or experimental sciences. The level of simulation uses IT artifacts to mimic brain functioning in its known aspects: autonomy, adaptiveness, partly reason/partly emotion–driven a.s.o. Simulation occurs since there are hopes that arranging such IT artifacts in relations deemed to be right the ensemble would begin to exhibit "consciousness facts" replicating symbolically some features of what we (bioengineers, neuroscientists, philosophers) think to be consciousness.

Why not remaining at the reflection level? For what making such a complicate and tedious simulation?

Because, while reflection dissect (analyze) marvelously single elements, simulation puts together various elements in their very interactive dynamics better than our reflection inherently static can do.

The risk associated with simulation is confusion of levels (planes); forgetting to use appropriate quotation marks, one may think that simulation might actually become, as an example, thinking itself but not an inspiring manner to enrich reflection upon.

It is interesting to notice that theology, that is in part science and part faith, while accepting the benefic role of medicine in treating some bodily illnesses, gets very precocious when is about knowing and influencing (and eventually treating) the superior level of human being, the person (and personality) intimately associated with the brain.

In the theological perspective, the person is considered *"the highest form of existence and defined before anything as spirit. A human is an incarnate spirit but his/her spiritual life is defining for a person. In the same manner we use apparatuses and instruments to probe the inner of inanimate things, to reach the deepness of a person we need personal interrelations that in the ideal form represent love. The intimate knowing of a person cannot be entrusted to objects (that is artifacts, though they can help) but to another person only" (Ciobotea, [10]).*

If so, best understanding of brain is that given to another brain (e.g. scientific brain seen as a collectivity of brains interacting via communication technology - CT). One can remark the role played in such instance by artifacts (like CT): that of modest but useful adjunct of the real brain approaching (ideally with empathy and generosity) another.

Finally, to Cardon's last questioning "*what we must to do about a system generating artificial consciousness facts for itself, having the sensation to generate artificial thoughts for its pleasure and using all the control-command systems and all de knowledge systems as rather gentle tools (our highlight), without any human intervention?* " (Cardon, [8]), the answer could not be else than pouring out some axiology into the puzzle next to the machine ontology before detaching the dog (be it the Aibo one) from any human intervention. Problem remains HOW.

And now our question. An artificial consciousness system endowed with intentions, emotion and good actuators could be fully autonomous that is entirely disconnected from human control or guidance? Apparently not, because once its power source interrupted everything would stop. Or maybe, similar to actual humans, "It" would become conscious (among others) of such an weakness and consequently would (auto) assure a *sub rosa* backup power to continue its rapid development of knowledge, experience and capabilities even against the will of its creator?

In the same vein, Hanson [11] put: *"If we do not humanize our intelligent machines, then they may eventually be dangerous. To be safe when they "awaken" (by which I mean gain creative, free, adaptive general intelligence), then machines must attain deep understanding and compassion towards people. […] Only if they have humanlike character, can there be cooperation and peace with such machines. It is not too early to prepare for this eventuality".*

VI. CLIMBING THE STAIRCASE FROM HEART TO BRAIN

Made up to cross the difficult border between medical education and the polytechnic one, bioengineering is placed in the privileged position to advance knowledge in the field of human consciousness, in connection with the conundrum whether or not computing machines may become conscious. Thus, neural engineering and neuroelectronics, topics of bioengineering, have been evoked earlier as means either for transfering to living brain having certain functions damaged by disease some structural artifacts with compensatory effects, or for putting some phenomenology (in Draganescu's sense) in the structural world of machines.

In another approach, given recognized difficulties of human brain in understanding it own functioning, signal processing according to information theory allied with clinical research on normal subjects may help to climb the staircase to the brain starting from organs apparently less intelligent but prone to be more easily understood.

In this vein, cardiovascular bioengineering is today able to distinguish various consciousness states by analyzing heart-related records by means of available knowledge on the control of visceral functions by the brain (Figure 3).

Increasing the cortical control on visceral regulation that conventionally is called autonomic represents one main aspect of corticalization of our species, in which Stefan Milcu [12] saw the neurophysiologic mechanism of human being's evolution including consciousness and conscience.

Developed by exercising information, the cortex has already spread its "antennae" to the lower floor of the brain, the brainstem regulating the vegetative life, and further on by the cranial nerves to the peripheral organs. According to M. Draganescu [13]: *"It would be possible that mental processes get manifest by such extensions throughout the body".* It stands for a philosophical inference confirmed at least at the heart's level.

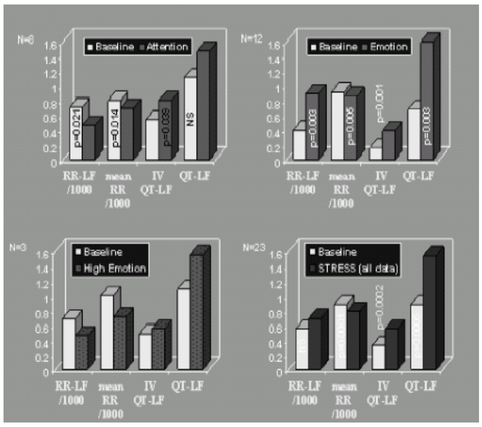

Fig. 3 - Repercussion at heart of consciousness states investigated in 23 healthy young people, 19-21 years, studied in relaxation sitting (baseline - white columns), under concentrated attention induced by an arithmetic test without constraint of time (labeled as attention), and under emotion or strong emotion induced by time constraint (emotion/high emotion). RR - the heart period; RR-LF/QT-LF - the fractions of low frequency (0.04-0.15 Hz) in the spectra of variability of heart period or of QT interval in the electrocardiogram; IV QT-LF – the fraction of low frequency in the spectrum of variability of the QT interval from which heart rate influences

were extracted using cross spectral techniques – is an emerging indicator of sympathetic control of ventricles (idioventricular). P indicates significant differences between group averages. The idioventricular sympathetic control as expressed by IV QT-LF respond significantly to stress whatever its nuances among concentrated attention, moderate or strong emotion. RR-LF clearly distinguishes between focused attention and emotion. These states of consciousness can not be discriminated with the same clarity using cerebral electrical activity noninvasively recorded on the scalp. Consciousness states and moods deeply influence the physiological machinery [14]. Since sympathetic ventricular overdrive is arrhythmogenic, such studies may offer a track for risk detection and prevention of sudden cardiac death in apparently healthy people (not known as cardiac patients) under sustained psycho-social stress [15].

Question remains upon the finality of such influence or control exerted by cortex upon "lower-minded" organs.

Auto-assuring the best functioning conditions given the multiple circular feedback loops relating brain and "subjacent" physiological machinery? If so, best functioning refers to which criteria: physical effectiveness, mental performance, emotional refinement or higher propensity to moral (read spiritual) values? If the latter proves as true, entering the regulatory loops by gentle means, natural (as breathing pattern control) or artificial (as noninvasive, remote influencing the heart rhythm) could hold promise for human being improvement without appealing to artificial consciousness.

VII. CONCLUSIONS

Bioengineering and information science & technology certainly advance towards artificial consciousness.

How benefic for humanity is yet not clear. It depends on our capacity to inseminate a machine transposition of natural ethics, at the same time with increasing machine autonomy. Complete autonomy should superpose to a free will (*libre arbitre*) having behind a machine axiology built at the same time. Neglecting or postponing the latter might associate catastrophic escaping from any human control.

While conscious people without conscience are unfortunately too frequent today, humanity cannot afford a machine reply of its brain developing exponentially capabilities and power outside of any moral.

On the contrary, if we succeed to seed at the right time a 'moral principle' into the machine we could enjoy a prototype of pure or ideal consciousness, escaping from biological impulsions and restrictions, that might guide or emulate humanity's struggle towards a true Society of the Conscience.

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IX. Biography

Radu Negoescu was born in Bucharest on November 3, 1946. He graduated in 1969 and obtained the Ph.D. degree in electronic engineering from the Bucharest Polytehnic/Institute of Nuclear Physics & Engineering in 1986, the MS degree in public health management from the University of Medicine and Pharmacy in 2001, and a full professorship of artificial intelligence with the AISTEDA University in 2001.

His employment records include the National Institute of Public Health in Bucharest where he is currentlly head of Health Promotion Unit, National Institutes of Health (Bethesda, MD), and Totts Gap Institute (Bangor, PA, USA).

His research includes cardiovascular bioengineering, biosignal processing and neurocardiology. He is a honor member of the Academy of Medical Sciences and a senior member of the IEEE.

Modelling and Performance Optimisation of Energy Harvester Systems

Alexandru-Laurentiu Catanescu
Research and Development National Institute of Electrical Engineering (INCDIE ICPE-CA), Splaiul Unirii, No. 313, District 3, 030138, Bucharest, Romania, catanescu@icpe-ca.ro

Abstract - Energy harvesting microgenerators are attractive replacements for batteries in low-power wireless electronic devices and have received increasing research interest in recent years. This paper presents different types of energy harvester, performance optimisation of EH systems and experimental aspects of energy harvester with biomedical applications.

Index Terms **- energy harvesting, energy harvester, power wireless sensors, microgenerator.**

I. INTRODUCTION

At present are considerable and continuing reasearch efforts world wide to support the energy harvesting and self-powered electronics. The majority of the reported research in energy harvesting has been an improving the efficiency of the energy harvesters through the design and fabrication of novel microgenerators, materials and devices.

The development of energy harvesting has been driven by the proliferation of autonomous wireless electronic systems. A classic exemple of such systems are wireless sensor nodes which combine together to form wireless sensor networks. Each sensor node typically comprises a sensor, processing electronics, wireless comunications and power supply. Since the system is by definition wireless and cannot be plugged into a mains supply power has to be provided locally. Tipically such a local power supply is provided a battery which an the face of it is convenient and low cost. However, batteries contain a finite supply of energy and require periodic replacement or recharging. This may be fine in individual deployments but across a wireless network containing a multitude of nodes batteries are clearly not attractive. Furthermore, the need to replace batteries means the wireless system has to be accesible which may not be possible or may compromise performance. Finally, there are environmental concerns about disposing of batteries. Energy harvesting was developed, therefore, as a method for replacing or augmenting batteries.

II. ENERGY HARVESTER MODELLING [6, 7]

An energy harvester (EH) has normally three main components: the microgenerator which converts ambien environment energy into electrical energy, the voltage booster which pumps up and regulates the generated voltage and the storage element.

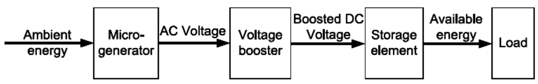

Fig. 1. Bloc diagram of EH.

A such EH consists of components from both mechanical and electrical domains as well as external circuits which regulate and store the generated energy. Therefore, the performance optimisation should only be based on a model that describes the EH as a integrated system. A generic model for vibration energy converter is described in Fig. 2.

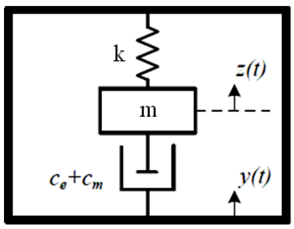

Fig. 2. Schematic of a vibration to electrical converter.

The movement equation is

$$m\ddot{z} + (c_e + c_m)\dot{z} + kz = -m\ddot{y} \qquad (1)$$

The electrical power converted from the mechanical system is equal to the electrical damping loss; the harvested electrical power can be expressed as

$$P_e = \frac{1}{2}c_e\dot{z}^2 = \frac{m\zeta_2\omega_n\omega^2Y^2(\omega/\omega_n)^4}{(2\zeta_T\omega/\omega_n)^2 + [1-(\omega/\omega_n)^2]^2} \qquad (2)$$

where: $\omega_n = \sqrt{k/m}$ - resonant frequency, $\zeta_m = c_m / 2m\omega_n$ - mechanically damping factor, $\zeta_e = c_e / 2m\omega_n$ - electrically damping factor, $\zeta_T = \zeta_m + \zeta_e$, ω - excitation frequency, Y - excitation amplitude.

At resonance, i.e. $\omega = \omega_n$, the electrical power can be maximized to

$$P_e = \frac{1}{2}c_e\dot{z}^2 = \frac{M\zeta_e\omega_n^3Y^2}{4\zeta_T^2} = \frac{M\zeta_eA^2}{4\omega_n\zeta_T^2} \qquad (3)$$

where $A = \omega_n^2 Y$ is the acceleration magnitude of input vibrations.

Energy is converted whenever work is done by the input vibration force against the electrical damping force. The electrical damping effect is achieved using an electromechanical transducer. Such a transducer can be implemented using one of the following four convertion mechanisms: electromagnetic, electrostatic, piezoelectric and magnetostrictive.

A. Piezoelectric model

The piezoelectric effect is the ability of same materials to generate on electric potential in response to applied mechanical stress. The constitutive linear equations for such materials are given by:

$$\begin{cases} \delta = \dfrac{\sigma}{Y} + dE \\ D = \varepsilon E + d\sigma \end{cases} \qquad (4)$$

where: δ - mechanical strain, σ - mechanical stress, Y - Young's modulus, d - piezoelectric strain coefficient, E - electric field, D - electrical displacement, ε - dielectric constant.

Fig. 3 shows a circuit reprezentation of a piezoelectric microgenerator.

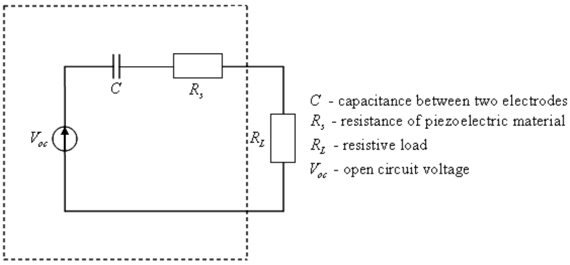

Fig. 3. Circuit representation of a piezoelectric microgenerator.

In the open circuit, the electrical displacement is zero and $V_{oc} = -\dfrac{dt\sigma}{\varepsilon}$, where t is the thickness of the piezoelectric material.

B. Magnetostrictive model

Magnetostrictive converters use Villari effect to transform vibration energy into magnetic energy which is then converted into electrical energy using a pick up coil based on induction low.

The constitutive linear equations for such material are given by

$$\begin{cases} \delta = dH + s\sigma \\ B = \mu H + d\sigma \end{cases} \qquad (5)$$

where: B - magnetic flux density, μ - permeability, H - magnetic field intensity, d - piezomagnetic coefficient, σ - mechanical stress, δ - mechanical strain, s - elastic compliance.

From induction low, the potential induced in N-turn sensing coil is

$$V_{oc} = -N\frac{d\phi}{dt} = -N\int_S d\sigma dS \qquad (6)$$

where S - cross-section area of the coil. Fig. 4 shows a circuit representation of a magnetostrictive microgenerator.

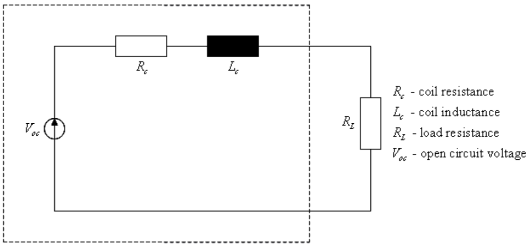

Fig. 4. Circuit representation of a magnetostrictive microgenerator.

C. Electromagnetic model

The basic principle is the low of electromagnetic induction

$$V = -\frac{d\phi}{dt} \qquad (7)$$

where V is generated voltage and ϕ is the flux linkage. In most microgenerator implementations, the circuit consists of a coil of wire of multiple turns (N) magnetic field is created by permanent magnets. The motion between the coil and the magnet is in a single direction (z) and the magnetic field (B) has no time variation so that the open circuit voltage is

$$V_{oc} = -NS\frac{dB}{dz}\frac{dz}{dt} = -k\frac{dz}{dt} \qquad (8)$$

where: S - effective area of the coil, $\frac{dB}{dz}$ - gradient of the field, $k = NSdB/dz$ - coupling factor.

Fig. 5 shows a circuit representation of an electromagnetic microgenerator, [3].

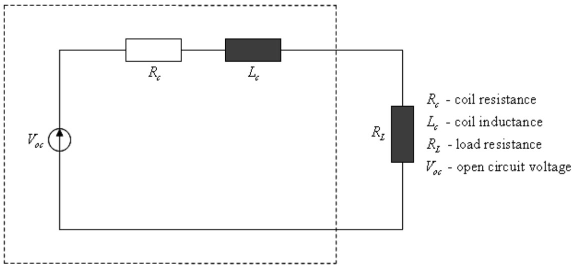

Fig. 5. Circuit representation of an electromagnetic microgenerator.

D. Voltage booster model

Voltage boosters are external circuits to the microgenerator that are used to boost up the output voltage and to perform necessary AC-DC rectification.

A voltage transformer together with a full wave rectifier can act as the voltage booster for EH.

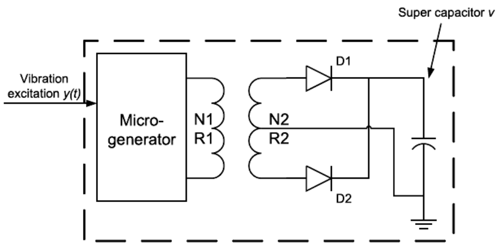

Fig. 6. Voltage transformer configuration.

E. Supercapacitor model

In case of storage element, a supercapacitor is modelled a in Fig. 7.

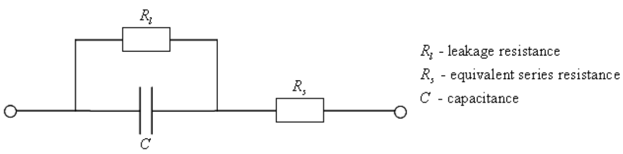

Fig. 7. Simplified supercapacitor model.

III. COMPARISON OF DIFFERENT TYPES OF EH [10]

Generally, electromagnetic, piezoelectric (PZT) and magnetostrictive are the three common vibration energy harvesting mechanisms and table 1 compares the features of different vibration energy harvesting mechanism.

Table 1. Summery of the comparison of the different vibrational types of harvesting mechanisms.

Type	Advantages	Disadvantages
Electromagnetic	- no need of smart material - no external voltage source	- bulk size: magnets and pick-up coil - difficult to integrate with MEMS - max. voltage of 0.1 V
Electrostatic	- no need of smart material - compatible with MEMS	- external voltage (or charge) source - mechanical constraints needed capacitive
Piezoelectric	- no external voltage source - high voltages of 2-10 V - compact configuration - compatible with MEMS - high coupling in single crystals	- depolarization - brittleness in bulk piezolayer - poor coupling in piezo-film (PVDF) - charge leakage - high output impedance
Magnetostrictive	- ultra-high coupling coefficient >0.9 - no depolarization problem - high flexibility - suited to high frequency vibration	- nonlinear effect - pick-up coil - may need bias magnets - difficult to integrate with MEMS

IV. PERFORMANCE OPTIMISATION

One propose an EH design flow [1, 7] that can be used to model, simulate, configure and optimise EH systems – Fig. 7.

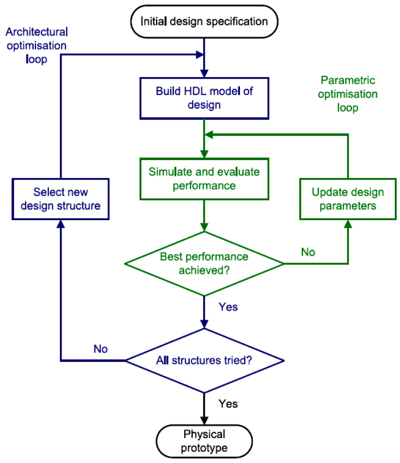

Fig. 7. EH design flow.

The process starts with initial design specification, such as available energy source (vibration), energy density, device size, minimum voltage level/power output. According to these specifications EH models are constructed from component cells (electromagnetic, piezoelectric, magnetostrictive), various booster circuit topologies and storage elements. The outer loop in the algorithm represents this structure configuration process, which involves examining and comparing the EH models. The inner design flow loop will then find the best performance of each model design by adjusting parameters.

The close mechanical-electrical interaction (microgenerator and voltage booster) that takes place in EH often leads to significant loss when the various parts of the EH are combined. Here the EH efficiency is expressed in terms $\eta = E_{Delivered} / E_{Harvested}$. The performance optimisation will be able to further improve the parameter η by employing suitable optimisation algorithms. The optimisation object is to increase the charging rate of the supercapacitor.

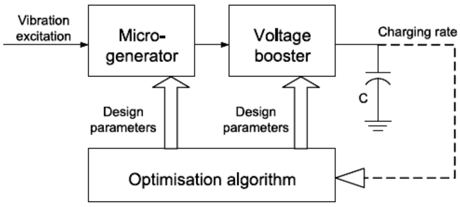

Fig. 8. Performance optimisation.

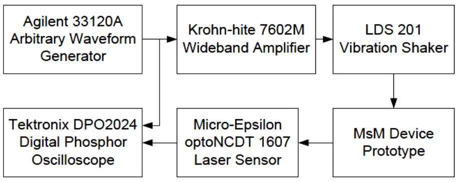

Fig. 9. Bloc diagram of measurement setup.

To verify theoretical calculation, experiments are conducted using the measurement setup shown in Fig. 9. In the experiments, the input vibrations are generated by a shaker. A waveform microgenerator creates a sinusoidal signal that is sent to a widebande amplifier to drive the shaker. The EH device is mounted on the top of the shaker. To measure the time-varying displacement of the EH a laser sensor is used. The input signal from wave form microgenerator and the output voltage signal from the sensor are monitored using a digital oscilloscope.

V. THE EXPERIMENTAL ASPECTS

We realised different experiments specific to the human body. In Fig. 10 is showed an experimental specific human body energy harvesting, [2, 5, 9].

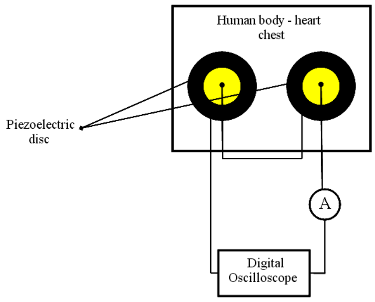

Fig. 10. The specific experimental scheme of human body energy harvesting.

In table 2 presents the voltage, the electric current and the micropower specific to different body parts: heart rhythm, respiration, cough and spoken and in Fig. 11 and 12 specific signal voltage for cough and breathing.

Table 2.

Request physiological	U_{ef}[mV]	I[μA]	P[μW]
Heart Rhytm	11	0,03÷0,05	0,33÷0,55
Respiration	105	0,05÷0,1	5,25÷10
Cough	220	0,05÷0,2	11÷44
Spoken	36	0,05÷0,15	1,8÷5,4

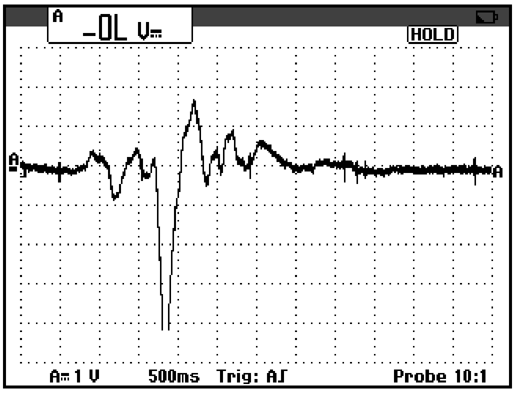

Fig. 11. Voltage signal corresponding to a request for cough.

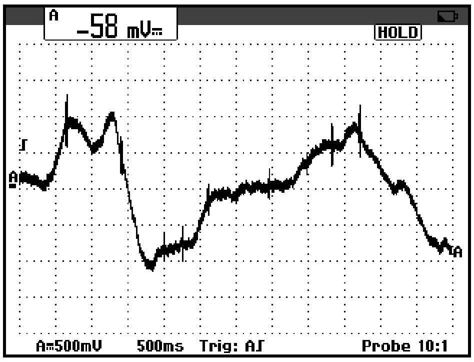

Fig. 12. Voltage signal corresponding to a request for breathing.

VI. CONCLUSION

In the paper is presented an energy harvester, performance optimisation of EH; the author present the experimental results of researches based on the experiments to the human body harvesting energy with applications as medical monitoring (biomedical) using energy harvesting wireless sensors.

VII. ACKNOWLEDGMENT

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IX. BIOGRAPHIES

Catanescu Alexandru-Laurentiu was born in Slatina, Romania, on March 22, 1983. He graduated from the Faculty of Electrical Engineering, Polytechnic University in Bucharest on 2007, and received a Masters Degree Diploma from the same Faculty in 2009. Nowadays I'm Phd student of Bucharest Polytehnic University, faculty of Electrical Engineering.

His employment experience includes the National Institute for Research and Development in Electrical Engineering ICPE-CA, Department of Electro-mechanical Engineering.

His fields of interest include electrical machines, electromagnetic, piezoelectric and magnetostrictive actuators.