

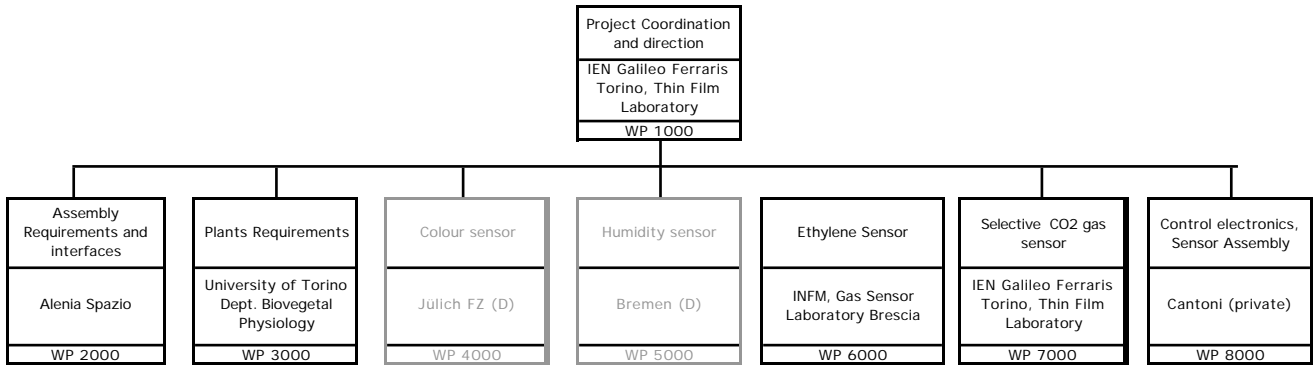
1. AREA: - Scienza dell'ingegneria 2. Line Strategica: Programmi ESA INDIRIZZO DI RICERCA: Materiali e tecnologie per applicazioni spaziali	Riservato ASI Numero:
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2. Title of project: CHECS (Closed Habitat Environmental Control Sensors)

3. Principal Investigator: Position: Institution: Office /Organization Division: Address: Telephone: Fax: e-mail:	<i>First name:</i> Luca <i>Last name:</i> Boarino <i>Degree:</i> Physics Researcher Istituto Elettrotecnico Nazionale Galileo Ferraris Laboratorio Film sottili per la metrologia e la sensoristica Strada delle Cacce 91 I-10135 Torino 0113919627 011346384 lboarino@ien.it
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4. If the project has passed/presented to an international announcement of opportunity (AO), specify name, date and origin of the AO. MAP AO-99-LSS-017, submitted december 1999, accepted april 2000, started june 2001

Work Breakdown Structure



5. Research group(s) (duplicare la tabella per ciascuna Unità Operativa)

<i>U.O.</i>	<i>First name Last name</i>	<i>Insitution</i>	<i>Position</i>	<i>Time (months)</i>	<i>Other ASI project</i>
<i>IENGF</i>	Luca Boarino	IENGF	Researcher	4	1
	Giampiero Amato	IENGF	Senior researcher	3	1
	Andrea Mario Rossi	IENGF	Researcher	4	0
	Stefano Borini	IENGF	Student (PhD)	4	0

<i>U.O.</i>	<i>First name Last name</i>	<i>Insitution</i>	<i>Position</i>	<i>Time (months)</i>	<i>Other ASI project</i>
<i>ALENIA</i>	Cesare Lobascio	Alenia Spazio	WP manager	1	1
	Riccardo Rampini	Alenia Spazio	Engineering Support	3	1

<i>U.O.</i>	<i>First name Last name</i>	<i>Insitution</i>	<i>Position</i>	<i>Time (months)</i>	<i>Other ASI project</i>
<i>BIOVEG</i>	Massimo Maffei	Dip. Fisiologia Vegetale U.d. Torino	Full professor	2	0
	Simone Bossi	Dip. Fisiologia Vegetale U.d. Torino	Student (PhD)	3	0
	Cinzia Berteza	Dip. Fisiologia Vegetale U.d. Torino	Student (PhD, fellowship)	3	0
	Wanda Camusso	Dip. Fisiologia Vegetale U.d. Torino	Student (PhD)	1	0

<i>U.O.</i>	<i>First name Last name</i>	<i>Insitution</i>	<i>Position</i>	<i>Time (months)</i>	<i>Other ASI project</i>
<i>INFM-GSL</i>	Giorgio Sberveglieri	INFM-GSL	Full professor	2	1
	Guido Faglia	INFM-GSL	Professor	1	1
	Camilla Baratto	INFM-GSL	Researcher	3	1
	Elisabetta Zampiceni	INFM-GSL	Student (PhD)	2	1

<i>U.O.</i>	<i>First name Last name</i>	<i>Insitution</i>	<i>Position</i>	<i>Time (months)</i>	<i>Other ASI project</i>
<i>Cantone Eng.</i>	Andrea Cantone	Cantone Eng.	Engineering Support	2	0

6. Personnel dedicated to the project in 2002

	Number	months
<i>Researchers:</i>	9	22
<i>Students (PhD, fellowship)</i>	5	13
<i>Collaborators</i>	1	3
<i>Technicians:</i>		

7. Estimate of the expenditure

(duplicare la tabella per ciascuna Unità Operativa)

UNITA' OPERATIVA N. 1 IENGF		ESTIMATE OF THE EXPENDITURE FOR 2002	
	DESCRIPTION	MLT	EURO
<i>Consultants/Fellowships</i>	<i>Fellowship</i>	30	15494
<i>Industrial activities</i>		0	0
<i>Equipments *</i>	<i>Set-up for electrical contacts deposition on porous silicon High and low vacuum Pirani</i>	60 10	30987 5165
<i>Supplies</i>	<i>Silicon compatible materials</i>	11,627	6005
<i>Travels</i>	<i>Italy Europe No Europe</i>	4 8 0	2066 4132 0
<i>Other expenses</i>		0	0
TOTAL		123,627	63848

UNITA' OPERATIVA N. 2 Alenia		ESTIMATE OF THE EXPENDITURE FOR 2002	
	DESCRIPTION	MLT	EURO
<i>Consultants/Fellowships</i>		0	0
<i>Industrial activities</i>		82,1762	42440,47
<i>Equipments *</i>		0	0
<i>Supplies</i>		0	0
<i>Travels</i>	<i>Italy Europe No Europe</i>	3	1549,37
<i>Other expenses</i>		1	516,46
TOTAL		86,1762	44506,29

UNITA' OPERATIVA N. 3 BIOVEG		ESTIMATE OF THE EXPENDITURE FOR 2002	
	DESCRIPTION	MLT	EURO
Consultants/Fellowships		0	0
Industrial activities		0	0
Equipments *	Set-up of plants	15	7746,85
Supplies	GC-MS supplies, head space SPME	6	3098,74
Travels	Italy Europe No Europe	2,5 2,5 0	1291 1291
Other expenses		5,539084	2860,70
TOTAL		31,539084	16288,58

UNITA' OPERATIVA N. 4 INFM GSL		ESTIMATE OF THE EXPENDITURE FOR 2002	
	DESCRIPTION	MLT	EURO
Consultants/Fellowships	Interface, electronics packaging Consultancy	6,357391	3283
Industrial activities		0	0
Equipments *	Electrometer	45	23241
Supplies	Gases, materials for deposition, cases	25	12911
Travels	Italy Europe No Europe	4 5 6	2066 2582 3099
Other expenses		0	0
TOTAL		91,357391	47182

UNITÀ OPERATIVA N. 5 Cantone Eng.		ESTIMATE OF THE EXPENDITURE FOR 2002	
	DESCRIPTION	MLT	EURO
Consultants/Fellowships	Fellowship	18	9296
Industrial activities		0	0
Equipments *		0	0
Supplies	PCB realisation and electronic devices	2,757265	1424
Travels	Italy	1	516
	Europe	1	516
	No Europe		
Other expenses		0	0
TOTAL		22,757265	11753

* specify each equipment with value is > 10 Mlt

8. Equipments and services available for the project (organizzato per Unità Operative)

IENGF Facilities

The Thin Film Technology Laboratory at IEN is composed by a clean room class 100 and a grey area class 10.000.

1. Photolithography is carried out by means of a Karl Süss profilometer, with resolution of 1 μm , and other complementary apparatuses, like spinner, hotplate, fume hood, etc.
2. Chemical and electrochemical treatments are carried out in three different fume hoods. In the case of electrochemical treatments (PS formation), several cells, up to 6" diameter wafers are available.
3. Si structuring is also obtained by plasma treatments in a Leybold Reactive Ion Etcher, with CF_4 gas source, or by a LFE barrel etcher with gas sources: CF_4 , O_2 , H_2 .
4. An ASM furnace, equipped with H_2/O_2 sources is used for Si oxidation or doping by diffusion.
5. Low Pressure Chemical Vapour Deposition of Si Nitride, PolySi, Low Temperature Oxide, and Amorphous silicon is carried out by means of a Tempres and an ASM LPCVD furnaces, equipped with the following gas sources: $\text{SiH}_4/\text{SiH}_2\text{Cl}_2/\text{NH}_3/\text{O}_2/\text{H}_2/\text{N}_2\text{O}$.
6. Two high vacuum evaporators, from Varian and Leybold allow for both thermal and e-beam evaporation of metallic and dielectric thin films.
7. Two sputtering systems, from Leybold and Balzers, allow for the deposition of metallic and superconducting films.
8. A freeze drying/preoxidation chamber allow for drying and passivation of freshly prepared PS layers.
9. An optical holography system for the definition of submicrometric periodic structures onto Si surfaces.

The characterization systems of the laboratory are briefly summarized hereafter:

1. A Tencor P10 profilometer to monitor the deposition/etching processes.
2. An optical microscope (1000 X) is used as a first characterization of the devices.
3. A Scanning Electron Microscope, equipped with a pattern generator for e-beam lithography has been recently purchased, and will be available in the near future.
4. A Raman spectrometer (Jobin Yvon) is used for the structural investigation of the sample.
5. A Beckman UV-Vis spectrophotometer allows for the characterization of optical devices.

BIOVEG Facilities

Facilities at the Department of Plant Biology include:

1. Electron Microscopy Center, equipped with Critical Point Driers and Gold Sputtering for SEM observations; Cryomicrotome for thin and ultrathin section preparations; two Transmission Electron Microscope able to perform X-ray analyses; Film developing and printing facilities; Image analysis computers and equipment.
2. Molecular Biology Laboratories equipped with PCR, GenePhor, PhastSystem for electrophoresis, Electrophoresis units, and all related equipments;
3. Biochemistry laboratories equipped with ultracentrifuges, high speed centrifuges, cold rooms with column chromatographies, Fast Protein Liquid Chromatography, UV-IR Spectrophotometers with dual beam and single beam technology, Rotaphor electrophoresis for preparative analyses.
4. Plant Physiology laboratories with portable photosynthesis units; flux detectors for xylem sap speed; membrane potential units for electrophysiological studies, Oxygen uptake detectors for polarographic studies, High Performance Liquid Chromatographs based on diode array detectors, Gas chromatographs and integrators.
5. *In vitro* laboratories with laminar horizontal and vertical flow cabinets, sterilizing systems, Batch-type 8-liter fermenter, Phytotrons and thermostatable cabinets, incubators and all related equipments, Micromanipulators.
6. Biosystematic and Palynology labs with optical microscopies, laser-confocal microscopy, UV-fluorescence microscopy, Static cytofluorimeter microscopy, Stereomicroscopes and optical fiber light emitters.
7. Internet web site through www.unito.it powered with infoseek (infoseek) search engine.
8. Classrooms, exercise classrooms and all kind of pedagogic facilities.

INFM - GSL Facilities

The *Gas Sensor Laboratory (GSL)*, directed by Prof. G. Sberveglieri, is one of the research units of the Department of Chemistry and Physics of University of Brescia. Besides it is a member of Italian National Institute for Matter Physics. Twelve people are on the staff at GSL. Since its establishment in 1988, the activity of GSL has been focused to the development of novel sensing layers, realised by physical vapour deposition techniques, and the development of prototypes for many sensing applications.

Resources available for thin film deposition and characterisation at the GSL are:

1. Two sputtering plant (one brand new) in a clean room (class 100) and a plant for a controlled thermal co-evaporation and co-sputtering equipped with cryogenic pump.
2. Three advanced system for the measurement of the DC and AC electrical response of up to five sensors to gas mixtures at variable humidity, a MS spectrometer monitors the outlet of the test chamber. One of the system has been especially designed for ozone characterisation.
3. SEM characterization is carried out using the facilities present in the department

GSL, since its birth, has been available to the co-operation with industries for the development of sensors and sensor systems, this is represented by the participation of GSL in many research projects supported by national industries, the Italian government and the EU. GSL has been involved in several EU projects:

ALENIA Facilities

Laboratori, attrezzature (workstations) e servizi presso lo stabilimento Alenia Spazio Torino

7. REPORT AND ESTIMATE OF THE EXPENDITURE FOR THE PROJECT IN MLIT/EURO

	1° YEAR (2001)	2° YEAR (2002)	3° YEAR (....)	4° YEAR (....)	5° YEAR (....)	TOTAL
Consultants/Fellowships	13,5 MLit 6972,17 €	54,357 Mlit 28073,25 €	Percentage not funded in 2° year (*)			
Industrial activities	30 Mlit 15.493,71 €	82,1762 Mlit 42440,47 €	Percentage not funded in 2° year (*)			
Equipment	97,121 MLit 50158,81	130 Mlit 67139,40 €	Percentage not funded in 2° year (*)			
Supplies	23 MLit 11.878,51 €	45,384265 Mlit 23439,02 €	Percentage not funded in 2° year (*)			
Travels	21,6 Mlit 11155,47 €	37 Mlit 19108,91 €	Percentage not funded in 2° year (*)			
Other expenses	5,671 Mlit 2928,83 €	6,539084 Mlit 3377,16 €	Percentage not funded in 2° year (*)			
TOTAL	190,893 Mlit 98588,01 €	355,46594 Mlit 183578,19 €	Percentage not funded in 2° year (*)			

(*) In case the ASI funding for year 2002 will be complete (100%), no other requests will follow on the topics covered by CHECS programme. If the funding for 2002 will be less than 100%, we will submit a further funding request for the year 2003, equal to the percentage not funded in year 2002. The ESA programme will be completed in the June 2003. ASI declared its support to the programme for its complete duration (as stated in ASI ref. pos.ups.01.16, of 22 January, 2001).

10. Proposte "cofinanziate" e "partecipate"

In caso di ricerca "cofinanziata" (una proposta che riceve finanziamenti da ASI e da altri enti, istituti o agenzie diversi dai proponenti) e/o "partecipata" (una proposta che riceve finanziamenti da ASI, e altri enti, istituti o agenzie, diversi dai proponenti, mettono a disposizione strutture e/o attrezzatura e/o personale), si debbono riportare i finanziamenti e/o investimenti e/o entità della partecipazione, espressi in percentuale, dei singoli enti, istituti o agenzie (detta partecipazione può consistere anche nella messa a disposizione di ricercatori).

NB: Intendendo per "Partecipazione" la quota di auto-finanziamento dei gruppi proponenti, le percentuali di partecipazione originali del progetto ESA CHECS sono le seguenti:

	Ente IENGF	Finanziamento
Cofinanziamento (%):	52	ESA
Cofinanziamento (Mlit.):	286,38 (Euros 147901)	ESA
Partecipazione (%):	11	IENGF

	Ente Alenia	Finanziamento
Cofinanziamento (%):	0	
Cofinanziamento (Mlit.):	0	
Partecipazione (%):	50	Alenia

	Ente INFM-GSL	Finanziamento
Cofinanziamento (%):	63,5	ESA
Cofinanziamento (Mlit.):	245,90 (Euros 126995)	ESA
Partecipazione (%):	0	

	Ente BIOVEG	Finanziamento
Cofinanziamento (%):	67,6	ESA
Cofinanziamento (Mlit.):	118,11 (Euros 61000)	ESA
Partecipazione (%):	0	

	Ente Cantone Eng;	Finanziamento
Cofinanziamento (%):	0	
Cofinanziamento (Mlit.):	0	
Partecipazione (%):	57	Cantone Eng.

Technical description (in lingua inglese)**1.1. Overview**

The Closed Habitat Environmental Control Sensor (CHECS) program brings together related technologies in physical, chemical and biological monitoring and advanced environmental control to reach the following objectives:

- A) To define a set of requirements allowing the monitoring of environmental and health parameters for plants and humans, under micro-gravity conditions, inside closed space habitats
- B) To define a technological, multidisciplinary approach for developing a complete system of dedicated micro-sensors, according to objective A)
- C) To realise Flight Models of the defined micro-sensors, integrate the monitoring system, and test it inside a plant facility on ground.

The final aim of this project is thus to obtain Flight Models of the micro-sensors, ready to be integrated in one of the plant facilities being developed by Space Agencies, for successive flight experiments.

1.2. Objective A: Definition of Requirements

The proposed research will focus primarily on the monitoring of plant habitats, and secondarily on manned environments.

Plant health can be monitored in closed habitats by means of a number of critical parameters:

- 1) Illumination conditions, intensity, polarisation, monochromaticity, IR components.
- 2) Humidity
- 3) CO₂, Ethylene and Isoprene concentration
- 4) Air fluxes near the gas sensors (true level of toxicity produced)
- 5) Temperature conditions (0-30 °C)
- 6) Nutrition
- 7) Water transport

1) In this case one of the most immediate and key application has been suggested by the end-user: for a correct photosynthesis process, plants generally absorb in visible, but with two main peak centred at 430 nm and 680-710 nm. In particular, a low absorption of light in the last range is a powerful stress indicator.

2) In a ground or space plant facility, (case of hydroponic culture) humidity have to be monitored in the feeding water compartment (roots) with values ranging from 100% to 80% (alarm threshold) and in the leaves-stylus compartment in a range from 10% to 60-70% maximum.

3) for CO₂ concentration for plants good health ranges typ. >350 and <600 ppm, (for humans <7000 ppm). For Ethylene units of ppm (more for humans) and no information on isoprene, but probably units of ppm.

4) air fluxes detection in proximity of the gas sensing elements to achieve a toxicity or a stress condition map of the hosting volume, taking account the air movements.

6-7) Flow sensors to monitor nutrition and water fluxes must be designed differently from those working with human and animal blood (rings to detect expansions of the stylus)

A subset of the above parameters, of interest for plant habitats, will be of great relevance for the monitoring of manned systems: humidity, selected gases such as CO₂ and air flows. Therefore, care will be observed in defining requirements enveloping the worst cases, in such a way to obtain sensors applicable to manned systems as well.

1.3. Objective B: Definition of Technological Approach

The advances in technology, especially in the case of microminiaturisation of a wide variety of instrumentation enables a completely new approach to the monitoring and control of the spacecraft environments.

The present Objective is to reach miniaturisation of four different sensors for the monitoring and optimisation of the environmental conditions, according to the plant needs.

- 1) Sensors for illumination and colour of the leaves.
- 2) Sensors for detection of humidity levels.
- 3) Sensors for CO₂ concentration.
- 4) Sensors for Ethylene concentration.

B.1) Definition of the state-of-the art of miniaturised sensors

B.2) Integration of innovative (Porous Silicon) and other, well established (Thin Film) technologies into Si technology

1.4 Objective C: Realisation of the monitoring system

The realisation of miniaturised, low power consumption and low cost elements allows for a high degree of freedom for the design and realisation of the monitoring system (Fig. 2).

The innovative content of some of the sensing element, together with the well established and reliable technology of temperature sensors fulfil the following requirements for operation in outer space:

- 1) size reduction;
- 2) weight reduction
- 3) power reduction
- 4) redundancy

- C.1) Realisation of a demonstrator onto Si chips, capable to fulfil the 1)-4) requirements and those of Objective B.
- C.2) Development of a former prototype on control electronics, for signal acquisition, conditioning and pre-processing to be in future developed with C-MOS silicon technology and integrated with the sensing elements.
- C.3) Test in ground plant facility
- C.4) Verification of requirements
- C.5) Realisation of a prototype for flight experiments

12. Detailed report on previous activities (max 2 page)

A more detailed report will be sent to V. Cotronei quarterly and in coincidence of any major programme milestones.

OVERALL ASSESSMENT

Project Manager's Assessment

In the first year of programme activity, actions have been performed, regarding contract status and financial matters and project visibility, as stated in point 1 of KOM minute (available upon request).

Visibility actions (point 2 of the KOM Minute)

Participation to the ASI national congress in Torino, 16-18 may 2001 (poster session)

Participation to the ISS meeting in Berlin, 5-7 june 2001 2001 (poster session)

Seminar on MST at Laben S.p.A., Milano, 13 june 2001 (talk).

Participation to the SGH meeting in Napoli, 14 june 2001 (meeting).

Participation to the MatChem congress in Brescia, 12 september 2001 (poster session).

The CHECS program activities are proceeding to prepare the Requirements Definition, Interface Definition, State of Art Assessment. And Definition of Project Development Metrics.

Problems and risks

At the moment, since the programme is recently started, the major problems are related to the last progresses in science and technology. The initial proposal has been in fact submitted in the last 1999, and since then, at least in some fields or tasks of the project, killer applications or new technological breakthrough could be near to be achieved by firms or academic groups. The risks are on the way to be evaluated and reduced thanks to a detailed research in literature and on the web regarding the State of the Art for each task. The partners agreed anyway on the opportunity to be ready to pursue new directions of research as soon as the effectiveness of a new research topic will become evident.

Schedule

There are no variations nor delays respect to the proposed schedules.

Next future activities (see Annex 3 AIL, available upon request) will be dedicated to:

- Provide feedback on the preliminary requirement document (Annex 2)
- Promoting the program activities in the framework of conferences and in scientific literature
- Development of cooperation with the program MAP AO-99-LSS-019

TECHNICAL STATUS

Overall Technical Assessment

In the past year the technical activities were concentrated mainly on:

- Space Requirements definition
- Plants Requirements definition
- Sensor State of the Art and planning
- Interface and Electronics definition and planning

Requirements Definition

Space Requirements

Performed Activities

The activities performed in the frame of WP 2000 during the reference period are reported as follows, with regard to the

SPECIFIED WORK PACKAGE ITEMS.

A Requirements Definition

- Review of available AEMC, Columbus and ISS relevant documentation
- Preliminary identification of performance requirements considering the scientific objectives for the typical reference missions where the sensor assembly could operate, with particular reference to the human application (airborne gases concentrations and accuracy, humidity ranges, etc.)
- Preliminary identification of space support requirements applicable to the sensor assembly, in the environmental, electrical, product assurance, etc. areas, considering the typical reference missions where the sensor assembly will operate
- Preliminary issue of a CHECS assembly Requirement Specification for the first Progress Meeting

B Interfaces Definition

- Preliminary definition of the functional and electrical interfaces of the sensor assembly with the typical hosting system

C System Design and Development Planning

- Review of available AEMC and Columbus relevant documentation
- Preliminary assessment of design and development planning aspects
- Support to the Principal Investigator for specific co-ordination aspects, as required

Critical Issues

None identified

Plants Requirements

The task is the selection of plants to be used in the project and the evaluation of responses of plants to closed environment (including light and gas responses)

Performed Activities

The first step was the selection of plant species and physiological specifications. In this context, by considering the closed environment and the characteristics of the experimental growth cell, the choice has been focused on two species: Phaseolus lunatus (Lima bean) and Phaseolus vulgaris (bean).

Sensors development

Performed Activities

State of the art for Humidity sensors, Colour, CO2 and Ethylene.

Interfaces and Electronics

Performed Activities

Architectural design of the ground based demonstrator a distributed approach based upon a 485 bus, supervised by a Linux PC. Each sensor will be handled by a simple module composed by a bus interface and an analog board which will amplify the signals coming from sensors, and will supply them. This approach is very simple and flexible: we can use already developed devices, focusing in a first time on sensor integration and analog electronics development. In a second time the system will be shrunk into a single microcontroller supervising all the electronics that will be interfaced to the MIL-STD-1553 bus on the ISS. Thus achieving a simple, rugged and highly integrated system

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- [5] V.P.Bondarenko et al. Microelectronic Engineering 28 (1995) 447-450
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- [Ref 1.1] AEMC Strategic Plan, http://peer1.idi.usra.edu/peer_review/prog/ENVMON.html
- [Ref. 1.2] Life Sciences Program Tasks and Bibliography, <http://csmt.jpl.nasa.gov/environmental/fundedres.html>.
- [Ref. 1.3.] NASA NRA 99-HEDS-01, Research opportunities in life sciences, Jan 1999

14. List of publications of the Principal Investigator (Max 5 in the last 5 years)

IENGF

Journals

P25 G. Amato, G. Benedetto, L. Boarino, N. Brunetto, A. Rossi and R. Spagnolo, "Thermal properties of porous silicon layers" Philosophical Magazine. B, Physics of condensed matter, (1997) v 76 n 3 p 383-393

P39 G. Amato, L. Boarino, S. Borini, A.M. Rossi, Hybrid Approach to Porous Silicon Integrated Waveguides, Physica Status Solidi (a) Vol 182, Issue 1, (2000), 425-430

P40 L. Boarino, M. Rocchia, C. Baratto, A.M. Rossi, E. Garrone, S. Borini, F. Geobaldo, E. Comini, G. Faglia, G. Sberveglieri, G. Amato, Towards a Deeper Comprehension of the Interaction Mechanisms between Mesoporous Silicon and NO₂, Physica Status Solidi (a) Vol 182, Issue 1, (2000), 465-471

P41 C.Baratto, G.Faglia, G.Sberveglieri, L.Boarino, A.M.Rossi, G.Amato, Front-side micromachined porous silicon nitrogen dioxide gas sensor , Thin Solid Films 391-392 (2001) 261-264

P42 A. M. Rossi, G. Amato, V. Camarchia, L. Boarino, S. Borini, High-quality porous silicon buried waveguides, Applied Physics Letters Vol. 78, No. 20, (2001) 3003-3005

Patents

G. Amato, L. Boarino, G. Lerondel, "Dispositivo sensore ottico di gas in materiale poroso", Deposito N. TO98A000706

Alenia Spazio

Space GreenHouse (SGH), Proposta ASI Ricerca Fondamentale 99 (Scienze della Vita), Coordinatore Prof. Ord. Giancarlo Barbieri.

BIOVEG

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AREA: - Scienze dell'ingegneria Line Strategica: Programmi ESA	INDIRIZZO DI RICERCA: Materiali e tecnologie per applicazioni spaziali	Anno 2001
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Il progetto o parte di esso è stato selezionato nell'ambito di bandi internazionali? (specificare)
 Il progetto è stato selezionato nell'ambito del bando MAP, ESA ref. AO-99-LSS-017, sottoposto nel dicembre 1999, accettato nell'aprile 2000 ed avviato nel giugno 2001

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Titolo della proposta:
 CHECS (Closed Habitat Environmental Control Sensors)

Riassunto

Scopo del presente programma è la realizzazione di un sistema di sensori a dimensioni ridotte, basso peso e bassi consumi, per il monitoraggio delle condizioni ambientali di crescita delle piante nelle missioni spaziali.

L'idea è quella di sviluppare un sistema di sensori, basandosi su un'approfondita conoscenza dei bisogni delle piante e del loro tipico comportamento in condizioni vitali critiche.

Le principali caratteristiche del sistema proposto sono la compatibilità con la tecnologia del Silicio. Ciò significa integrabilità con dispositivi e circuiti microelettronici, dimensioni ridotte, basso peso, ridondanza, semplicità ed alta affidabilità. Tutti i sensori che comporranno il sistema verranno prodotti mediante tecnologie dello stato solido a vari livelli di consolidamento, quali ad esempio la Tecnologia dei Microsistemi (MST) e quella del Silicio Poroso (PST). Quest'ultima ha dimostrato negli ultimi anni di possedere considerevoli vantaggi rispetto altri approcci, garantendo allo stesso tempo buona affidabilità.

Il principale vantaggio dell'uso della PST è l'alta sensibilità alle specie gassose che vengono fisisorbite o chemisorbite sull'enorme superficie specifica del materiale (centinaia di m^2/cm^3) influenzando notevolmente le proprietà di trasporto elettrico. Il segnale elettrico modulato dall'interazione col gas può essere successivamente elaborato dall'elettronica di controllo.

La seconda caratteristica interessante è la modulabilità delle proprietà ottiche del materiale, grazie all'ampio intervallo di controllabilità della porosità. Che ha condotto, negli ultimi anni alla produzione di componenti micro-ottici passivi integrati in silicio, quali, riflettori di Bragg, microcavità e guide d'onda a basse perdite di propagazione.

Terza caratteristica è la possibilità di condizionare chimicamente la superficie del PS ossidando, o impregnandolo con specie chimiche reattive e catalitiche, in modo da massimizzare la risposta alla specie gassosa desiderata, o di minimizzarla agli agenti interferenti.

L'elevata integrabilità di un tale sensore su un chip di Silicio è la quarta caratteristica interessante della presente proposta, insieme alla possibilità di applicare tecniche di integrazioni su larga scala (bassi costi del prodotto finale). Un'ulteriore conseguenza di ciò è la possibilità di ottenere ridondanza degli elementi sensibili o dei sensori stessi.

Sulla base di tali caratteristiche, un sensore di umidità al silicio poroso, un sensore di Etilene a film sottile, un sensore di colore micro-ottico (PST) per il monitoraggio dell'assorbimento ottico delle foglie ed un sensore di CO₂ selettivo verranno progettati e prototipizzati.

Parole chiave:
 Microsystems, Sensors, Plant Health, Porous Silicon, Ethylene, Humidity, Colour, CO₂

Luca Boarino, ricercatore

Dott. Paolo Antonio Mastroeni, Direttore Generale

 Firma del coordinatore del progetto
 (specificare statuto o incarico)

 Firma del responsabile amministrativo
 (specificare statuto o incarico)

Redatto il **29/10/2001**

Titolo del progetto: CHECS (Closed Habitat Environmental Control Sensors)

P.I.: *Nome:* Luca *Titolo:* Dott. *Cognome:* Boarino

Descrizione del prodotto - allegato tecnico (MASSIMO una pagina)

Il programma CHECS si prefigge di riunire tecnologie affini nel campo del controllo fisico, chimico e biologico e del controllo ambientale avanzato per il raggiungimento dei seguenti obiettivi:

1. Definire un insieme di requisiti che consentano il monitoraggio dei parametri ambientali e vitali delle piante e umani, in condizioni di microgravità, all'interno di ambienti chiusi.
2. Definire un approccio tecnologico multidisciplinare per lo sviluppo di un sistema completo di microsensori dedicati, in accordo con l'obiettivo 1).
3. Realizzare un prototipo del sistema di sensori di umidità, colore, CO₂, ed etilene, integrare il sistema di monitoraggio, e testarlo all'interno di una Plant Facility a terra.

Il prodotti della ricerca consisteranno nei prototipi dei singoli sensori e nei relativi rapporti di ricerca, che includono i risultati della caratterizzazione e le specifiche finali di tali prototipi.

In particolare i partners italiani del progetto CHECS, svilupperanno in ambito ASI i seguenti prodotti di ricerca:

Progettazione e sviluppo di un sensore selettivo di CO₂ basato su tecnologia del Silicio Poroso e su tecniche di impregnazione, monitorando le variazioni di conduttanza elettrica e mediante realizzazione di strutture ottiche.

Verrà studiato un sensore di Etilene basato su SnO₂ realizzato mediante tecnica R.G.T.O (Rheotaxial Growth Thermal Oxide) utilizzando diversi catalizzatori e droganti per ottenere la detezione selettiva.

Per aumentare la selettività, un sensore basato su TiO₂ drogato W or Mo potrebbe venire aggiunto all'array.

Tale array di sensori verrà depositato mediante tecniche di Sputtering o deposizione da fase vapore su microstrutture in silicio a basso budget termico, in modo da poter essere facilmente interfacciato con elettronica di controllo basato su reti neurali.

Il design dei sistemi di detezione verrà guidato dagli utenti finali (Alenia e Bioveg) mediante definizione delle interfacce elettriche richieste dai sistemi di volo e dalle plant facilities ove i sensori opereranno. Anche lo sviluppo dell'elettronica di controllo e condizionamento del segnale terrà conto della compatibilità con le tecniche correnti dell'IC design e processing, in modo da fornire un sistema di sensori facilmente utilizzabile da centraline intelligenti commercialmente disponibili.

Verranno identificati inoltre i requisiti di acquisizione (e.g. RS422 vs LAN 802.3 10 BASE T), i protocolli di trasmissione ed impacchettamento dati usando standard commerciali e industriali che utilizzano componentistica di grado militare o in via di certificazione spaziale.

Il sistema di sensori verrà testato in un sistema aeroponico in grado di fornire nutrimento a piante soggette a microgravità.

Verranno definite e utilizzate le specie vegetali più adatte agli obiettivi del progetto.

La risposta dei microsensori verrà quindi confrontata con i parametri vitali delle piante quali indici respiratori e fotosintetici, biochimici ed elettrofisiologici.

L'unità, o le sue parti costituenti, è concepita per utilizzo principalmente in:

- Esperimenti a terra e nei racks della Stazione Spaziale, in esperimenti di Scienze della Vita su piante. In quest'ottica, i risultati e le ricadute del progetto sarebbero di beneficio per altri progetti finanziati dalle Agenzie, tra i quali Space Green House.