Innovative Network for Training in wAter and Food QUality monitoring using Autonomous SENSors and IntelligEnt Data Gathering and Analysis

AQUASENSE SUMMER SCHOOL 2019

on

Sensor Technologies for Water Monitoring

25th - 27th September 2019

Fondazione Bruno Kessler, Trento, Italy

Final Program and Book of Abstract

Grant agreement 813680

https://cordis.europa.eu/project/rcn/218049/factsheet/en

Innovative Network for Training in wAter and Food QUality monitoring using Autonomous SENSors and IntelligEnt Data Gathering and Analysis

Summer School

Motivation and Description

Technologies for the fabrication of devices and systems at micro - and nano-scales continue to advance and diversify due to the rising demands for miniaturisation, cost reduction, functional integration and performance enhancement. This summer school will provide a broad overview of sensors, microfluidics and biosystems technologies as an enabling technology for new product development in environmental monitoring and water analysis. The Summer School organised by FBK, and University of Glasgow is a training action of the project AQUASENSE (H2020-MSCA-ITN-2018) targeted to strengthen collaboration, sharing new ideas and knowledge transfer from research to market in the field of biosensors for the water quality assessment. The objective of the workshop is to illustrate the technological orientations and future challenges offered by the connection between innovative materials and micro/nanotechnologies. The involvement of representatives of key research disciplines will offer a podium to enable community building and networking, the sharing of progress in both technology and application development, and the identification of common interests. The emphasis will be on the complete development process for microfluidics/biosystems devices, covering aspects of design, manufacturing technologies, materials for sensors and latest trends in the personalized medicine. Finally, application case examples and experimental lessons (hands-on-MEMS) on classic MEMS and Microfluidics devices and the related technologies will complete the summer school with a basic training for early stage researchers that do not have access to large fabrication facilities.

Aquasense Project

Objective

The deterioration of water quality, caused by climatic/seasonal changes, or industrial waste etc. is a major global concern. Over the last decade, water quality observing technology has risen to the challenge of scientists to identify and mitigate poor water quality by providing them with cost-effective tools that can take measurements of essential biogeochemical variables autonomously. Yet, despite these options becoming more readily available, there is a gap between the technology and the end-user (including the investigators and technicians that deploy these technologies) due to a collective lack of training, in-depth knowledge, and skilled workers who can meet new and emerging challenges. There is also a disconnect between data quality, data gathering by autonomous sensors and data analysis, which is a major obstacle, as the sensors are already being deployed (e.g. through buoys, boats etc.). AQUASENSE will address these challenges through 15 early stage researchers (ESRs), who will receive 540 person-month of unparalleled multidisciplinary training in the field of water quality monitoring. Each ESR will be mentored by carefully selected experts from academia and industry in 9 European countries (UK, Germany, Ireland, Serbia, Sweden, Italy, Poland, Austria, Estonia) and will have access to state-of-the-art equipment to develop autonomous sensors for improved data quality. The autonomous underwater robots and drones will be used to improve the data gathering and AI methods will be used to improve the data analysis. Hands-on project training will be supplemented with formal training courses in relevant fields such as new materials, sensors fabrication, wireless communication, system integration, and robotics, and a variety of complementary courses such as IPR, grant writing and exploiting the scientific results. Mobility within the network will ensure exposure to complementary academic and industrial research environments.

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AQUASENSE Project Fact Sheet

Coordinator

UNIVERSITY OF GLASGOW, UK

Participants

- UNIVERZITET U NOVOM SADU FAKULTET TEHNICKIH NAUKA, Serbia
- THE UNIVERSITY OF EDINBURGH, UK
- INSTYTUT TECHNOLOGII ELEKTRONOWEJ, Poland
- UNIVERSITY COLLEGE CORK - NATIONAL UNIVERSITY OF IRELAND, CORK, Ireland
- FONDAZIONE BRUNO KESSLER, Italy
- CTR CARINTHIAN TECH RESEARCH AG, Austria
- EVOLOGICS GMBH, Germany
- WEST AQUILA SRL, Italy
- AKTSIASELTS TOIDU- JA FERMENTATSIOONITEHNOLOOGIA ARENDUSKESKUS, Estonia
- LINKOPINGS UNIVERSITET, Sweden
- THE UNIVERSITY OF EXETER, UK

Partners

- SCOTTISH ENVIRONMENT PROTECTION AGENCY
- PLYMOUTH MARINE LABORATORY

Project information

AQUASENSE

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813680

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30 September 2022

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€ 4 064 583,24

SUMMER SCHOOL PROGRAM

25 September 2019 **Materials for sensors**	26 September 2019 **Sensors and Technologies**	27 September 2019 **Systems and applications**
8.30 – 8.45 Welcome: AQUASENSE Project and summer school overview *(Chairs: Leandro Lorenzelli, Ravinder Dahiya)* **8.45 - 9.00 PhD Program at FBK** (*Bernardo Magnini)*	**8.45 - 9.00 Introduction to the program of the day** *(Chair: Andrea Adami, Fondazione Bruno Kessler, Italy)*	**8.45 - 9.00 Introduction to the program of the day** *(Chair: Viviana Mulloni, Fondazione Bruno Kessler, Italy)*
9.00 – 10.00 New materials for micro-scale sensors and actuators *(Magnus Willander, University of Linkoping, Sweden)*	**9.00 – 10.00 Optofluidic micro and nanostructured devices and systems for (bio)sensing** *(Giuseppe Barillaro, University of Pisa, Italy)*	**9.00 - 10.00 Rationale and application of high throughput sequencing approaches in the study of biodiversity and water quality assessment** *(Nico Salmaso, Fondazione Edmund Mach, Trento, Italy)*
10.00-10.15 **TEA/COFFEE BREAK**	**10.00 -10.15** **TEA/COFFEE BREAK**	**10.00 -10.15** **TEA/COFFEE BREAK**
10.15 - 11.15 Fabrication of integrated sensor and actuator platforms by Supersonic Cluster Beam Deposition *(Paolo Milani, University of Milano, Italy)*	**10.15-11.15** **Printed sensors: technologies and applications** *(Paolo Lugli, Free University of Bozen-Bolzano, Italy)*	**10.15 – 11.15 - Water quality monitoring in rivers and lakes of Trento province** *(Catia Monauni, APPA Trento – Trento Province Environmental Protection Agency)*
11.15-12.15 **Microfluidics: an overview** *(Andrea Adami, Fondazione Bruno Kessler, Italy)*	**11.15 – 12.15** **Label free biosensors for environmental monitoring based on silicon technology** *(Georg Pucker, Fondazione Bruno Kessler, Italy)*	**11.15-12.15 Chemical gas sensors for agri-food water management** *(Barbara Fabbri, University of Ferrara, Italy)*
12.15-13.15 **Surface treatments for biosensing** *(Cecilia Pederzolli, Fondazione Bruno Kessler, Italy)*	**12.15-13.15** **Machine Learning methods for data analysis** *(Marco Cristoforetti, Fondazione Bruno Kessler, Italy)*	**12.15-13.15 Multifunctional micro- and nanosystems for chemical and physical sensing** *(Luca Francioso, CNR-IMM, Italy)*
13.15- 14.30 **LUNCH & POSTER SESSION**	**13.15 -14.30** **LUNCH & POSTER SESSION**	**13.15 -14.30** **LUNCH & POSTER SESSION**
14.30 -15.30 FBK Facility Tour LABSSAH and CLEAN ROOM	**14.30-15.30 Silicon-based microfabrication technologies** *(Benno Margesin, Fondazione Bruno Kessler, Italy)*	**14.30 - 15.30 Statistical process optimization through design of experiment** *(Alessio Bucciarelli, Fondazione Bruno Kessler, Italy)*
15.30– 17.30 3D PROM Mechatronics Pole (lab visit) in Rovereto City	**Group 1 - 15.30 – 17.30 Hands on MEMS** (lab visit and experimental lessons) *(Viviana Mulloni, Fondazione Bruno Kessler, Italy)*	**Group 1 - 15.00-17.30 Ink Jet printer – How does it works?** *(Matteo Ghittorelli, Andrea Adami, Fondazione Bruno Kessler, Italy)*
	Group 2 - 15.30- 17.00 Ink Jet printer – How does it works? *(Andrea Adami, Matteo Ghittorelli, Fondazione Bruno Kessler, Italy)*	**Group 2 - 15.00-17.30 Hands on MEMS** (lab visit and experimental lessons) *(Viviana Mulloni, Fondazione Bruno Kessler, Italy)*
	20.00- 22.00 **Workshop Social Dinner**	**17.30 - 24.00 Conclusion of the School with the visit at the Researchers' Night at MUSE** (free visit)

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Summer School Program

Fondazione Bruno Kessler Via Sommarive, 18—Trento, Italy

25 September 2019

8.30 - 8.45

AQUASENSE Project and summer school overview

L. Lorenzelli, R. Dahiya

8.45 - 9.00

Introduction to PhD Program at FBK

B. Magnini, FBK PhD Program Chair

SESSION I

Materials and Sensors

(Chairs. L. Lorenzelli, R. Dahiya)

9.00 – 10.00
Magnus Willander - Linköping University, SWEDEN

New materials for microscale sensors and actuators

This talk deals with different nanomaterials and devices for energy, enviromental and chemical sensing. We will mainly talk about different water applications. We start with some different materials for mechanical energy harvesting for driving the sensors etc. Then we continue with materials and devices for water splitting and hydrogen/oxygen evolution reaction in water. An important area is water cleaning. We will show some of our results; electrochemical (self-powered) desalination, sterilization, algae, Rhodamine B and copper ions removal. Also photo-degradation (sun driven) of toxic molecules (dyes) in water is discussed from materials and device point of view. Finally, chemical sensors on different solid substrates and flexible substrates (paper and textile) for measuring in water etc will be demonstrated.

Magnus Willander *is an expert on materials and their physical and chemical properties. He is also an expert on devices electrical, optical devices and systems and sensors. He has been working both experimental and theoretical on problems. In the 80s he did pioneering works on polymer devices (transistors and sensors) and semiconductor devices (Si/SiGe, SiC, III-V materials). In the beginning of 2000 he started to do chemical synthesis of different materials for sensor applications (for single molecule detection etc), LEDs optical detectors etc. Willander has be leading several EU projects and participate in numerous EU funding projects. Finally Willander has been chair professor in Linköping and Gothenburg Universities, Guest professor in Tokyo Institute of Technology, professor in National Institute of Nanoscience and Nanotechnology, Beijing, CAS, etc*

25 September 2019 - MORNING - SESSION I Materials and Sensors

Novel 1D photonic metal oxide nanostructures for early stage cancer detection

25 September 2019 - MORNING - SESSION I Materials and Sensors

Summer School Program

Fondazione Bruno Kessler, Via Sommarive, 18—Trento, Italy

10.15 – 11.15
Paolo Milani - University of Milano, ITALY

Fabrication of integrated sensor and actuator platforms by Supersonic Cluster Beam Deposition

The convergence of top-down microfabrication with bottom-up assembling of nano-objects makes compatible different length scales, architectures, materials, manufacturing methods. In particular the integration of nanoparticles and/or nanostructured layers on microfabricated platforms and polymeric substrates is the basis for the production of a novel class of devices capable of sensing, data and energy storage, actuation [1]. The use of supersonic cluster beam deposition (SCBD) and implantation (SCBI) is currently an enabling tool for the large-scale integration of nanoparticles and nanostructured films on microfabricated platforms and smart nanocomposites [1].

Here I present the synthesis, fabrication and characterization of different systems obtained with SCBD and SCBI such as electroactive soft actuators [2], planar microsupercapacitors [3], cluster-assembled films with sensing properties. These elements can be integrated in a single platform paving the way to the production of a new class of multifunctional devices.

REFERENCE

[1] P. Milani, L.G. Bettini, Nano- and Micro-manufacturing with nanoparticles produced in the gas phase: an emerging tool for function and length scale integration in Y. Huttel (ed.), Gas-Phase Synthesis of Nanoparticles, Wiley-VCH (2017)

[2] Y. Yan, et al., Adv. Mater. 29, 1606109 (2017)

[3] L.G. Bettini, et al., Flex. Print. Electron. 2, 025002 (2017)

Paolo Milani is Full Professor at the Department of Physics of the University of Milano. He graduated in Physics from the University of Pavia (Italy) in 1984 and he received his Docteur es Sciences (PhD) in 1991 from the Ecole Polytechnique Federale of Lausanne. He founded in 1992 the Molecular Beams and Nanocrystalline Materials Laboratory at the University of Milano. His research focuses on cluster-assembled nanostructured materials for neuromorphic systems, stretchable electronics, biomedicine, soft robotics. He has published more than 250 papers on refereed journals, several review papers and a monograph on supersonic cluster beam deposition for the synthesis of nanostructured thin films. Milani is the recipient of the U. Campisano Award from the Italian Institute for the Physics of Matter in 2000 for his contributions to the field of the synthesis and characterization of nanostructured materials. In 2006 he received the L. Tartufari Prize awarded by the Lincei National Academy. Currently, Milani serves as Director of the Interdisciplinary Center for Nanostructured Materials and Interfaces of the University of Milano. He is co-editor of the Springer book series Carbon Materials Chemistry and Physics, regional editor for Europe of the Journal of Nanoparticle Research, member of the editorial boards of Advances in Physics X, KONA Powder and Particle Journal, and Journal of Aerosol Science. He holds twenty patents in the field of nanotechnology and he is co-founder of three companies: TETHIS spa active in the field of nanostructured devices for cancer diagnostics, WISE srl producing implantable electrodes for neuromodulation, EOS srl producing optical diagnostic systems for nanoparticles in complex biological fluids.

Novel 1D photonic metal oxide nanostructures for early stage cancer detection

Summer School Program

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25 September 2019 - MORNING - SESSION I Materials and Sensors

11.15 – 12.15
Andrea Adami - Fondazione Bruno Kessler, ITALY

Microfluidics: an overview

Microfluidics are opening new opportunities in analytical systems by the exploitation of micro- and nano- scale phenomena. The small dimensions and integration techniques are enabling new concepts, where the use of very high fields, controlled diffusion, as well as the high parallelization of analysis allow new opportunities for analytical procedure, which would be not possible with conventional methods.

In addition, microfluidic systems can be also used to miniaturize and automatize a laboratory procedure on a chip to be used especially by unskilled operators, possibly on remote and low-resource locations, where sample preparation on real samples is sometimes more challenging than the analysis itself.

This talk will introduce the basic concepts of microfluidics, as well as an overview of a few case studies to show the potential of microfluidic devices.

Andrea Adami (MD in Materials Engineering: 2003, PhD in ICT: 2010) has been holding a researcher position at FBK on the topic of Sensors and Microsystems since 2003.

His research activities have been focused on the development of microfluidics and microsystems for several applications, in particular chemical sensors, micromechanical sensors and microfluidic devices. In the field of microfluidics, his interest is particularly focused on miniaturized modules for sample preparation and separation methods for real applications.

He is author of more than 70 papers in International Conferences and Scientific Journals; and he has been technical manager in several European and Italian project and industrial contracts.

Novel 1D photonic metal oxide nanostructures for early stage cancer detection

Summer School Program

Fondazione Bruno Kessler, Via Sommarive, 18—Trento, Italy

25 September 2019 - MORNING - SESSION I Materials and Sensors

12.15 – 13.15
Cecilia Pederzolli - Fondazione Bruno Kessler, ITALY

Surface treatments towards smart biointerfaces in sensing applications

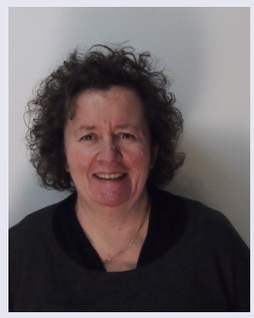
The research activities in the area of bio interfaces and surfaces, connecting material science and biology, are continuously growing due to their vast applications ranging from medical science to environmental biotechnology. The outer layer of materials is where many interactions take place and this is especially true for biomaterials since the surface is the only part of a biomaterial/biodevice that comes in contact with the biological system. The methods for the introduction of biological functionalities for the efficient signal capture of biological recognition events on inorganic/organic materials, and tailoring their surface properties to improve their biocompatibility, constitutes a core activity on which the successful development of the next generation of bioanalytical devices is based. Here the work of design, fabrication, testing and validation of technological platforms performed by our research group will be presented as well as examples of nanomaterials for biosensing enabling the monitoring of interesting parameters related to water quality.

REFERENCES

Surface Analysis and Techniques in Biology, Editor Vincent S. Smentkowski, Springer International Publishing Switzerland, 2014

Microfluidic solutions enabling continuous processing and monitoring of biological samples: A review, Marc Karle el al., Analytica Chimica Acta, Vol. 929, pp 1-22, 2016

SPAD aptasensor for the detection of circulating protein biomarkers, L. Pasquardini et al., Biosensors and Bioelectronics, Elsevier, Vol. 68, pp 500-507, 2015.



Cecilia Pederzolli is team leader of the Biofunctional Surfaces and Interfaces research group and coordinator of the FBK-UNITN-CNR joint Bio nano science and technology laboratory (LaBSSAH) at the Bruno Kessler Foundation. Her interest is the development of biofunctional materials applied to the micro-nanotechnologies for biomedical devices; she spent the last 10 years in the development of microdevices for research and molecular diagnostics. Her own research activity has been focused on the following themes: 1) spectroscopic techniques for the study of bacterial toxins as transmembrane proteins; 2) immunolysins and lytic peptides in oncological treatments; 3) drug delivery systems for oncological applications; 4) development of biointerfaces for biosensors and biomedical applications. She was graduated in Biology at the University of Padova, since then she worked mainly in the biochemical and biophysical fields first at the Department of Physics of the University of Trento and subsequently in the area of Surface Science at the FBK. Since 1998, she has coordinated research teams based on multi-disciplinary competencies comprising members with biological, physical and chemical expertise. Coordination: in the last 10 years, she has coordinated 14 scientific projects funded by local and national agencies. Co-organizer of 8 congresses and 4 international schools. Publications of over 80 papers on international peer reviewed journals. Academic activity: supervisor of several laurea students and PhD students (University of Padova, Torino and Trento).

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25 September 2019 - AFTERNOON - Facilities Tour

Summer School Program

Fondazione Bruno Kessler Via Sommarive, 18—Trento, Italy

13.15- 14.30 LUNCH & POSTER SESSION

14.30 - 15.30
FBK Facility Tour:

- **LABSSAH**
- **NanoMicroFabrication Facility**

15.30 - 17.30
3D PROM Mechatronics Pole in Rovereto City

The result of collaboration between Trentino Sviluppo, Fondazione Bruno Kessler and the University of Trento, provides businesses in the mechatronics industry an integrated platform for the design, development, implementation, verification and validation of systems and manufacturing processes.
According to the principles of "Industry 4.0", development time/ prototyping can be reduced through technology in the following areas:

- *mechanical: 3d printing, AM-machining*
- *electronics: boards and integrated systems*
- *ICT: simulation, networking, the Internet of Things*
- *system integration: Product prototyping*
- *metrology: accurate measurement of the product, qualifications and certification*

The ProM (Prototyping Mechatronics) Facility laboratories are available also for the specialized training of students of technical and professional schools, for degree and doctoral dissertations, and for technical staff training for companies in the mechanical and mechatronic sector.

FBK Facilities at glance

LABSSAH

The Laboratory of Biomolecular Sequence and Structure Analysis for Health was established in July 2012 as a partnership among the Trento University - Centre for Integrative Biology (CIBIO), and two Research Institutions: the B. Kessler Foundation (FBK) and the CNR-Institute of Biophysics, Unit at Trento (IBF-TN). Deep strengths of LaBSSAH are in key research areas such as genomics, biophysics, bioimaging, bionanotechnology and bioinformatics. The Laboratory enjoys a place where biologists, physicists, chemists and bioinformatic people work together every day sharing instrumentation, experiences, research themes, scientific perspectives and ideas with the common aim of meeting research challenges in life sciences.

NanoMicroFabrication Facility

MNF, the Micro-Nano characterization & fabrication Facility of Fondazione Bruno Kessler, groups laboratories and competences of the Centre for Materials and Microsystems in two main areas:: microfabrication and materials analysis. The Microfabrication Area runs two separate cleanrooms: the Detector Cleanroom, dedicated to the development of radiation sensors, and the MEMS cleanroom, where micro devices and sensors for different applications are developed.
It also includes a Testing Area for the automatic and manual parametric/functional device testing, and a packaging cleanroom with tools for device bonding, and for the enclosure of the devices in specific housings. The Materials Characterization Area runs different laboratories for the physical/chemical analysis of materials, surfaces and interfaces.

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10.15 – 11.15
Paolo Lugli - Free University of Bozen-Bolzano, Italy

Printed sensors: technologies and applications

Semiconductor devices have been proven in recent years excellent candidates for a variety of applications due to their reliability, reduced size and the computational strength of CMOS circuitry. Since cost is often a critical factor, a large research effort has been dedicated to the development of printed devices which could guarantee low costs and environmental friendliness. The low cost is guaranteed by the use of production techniques based on printing methods. In this context nanomaterials such carbon nanotubes or metallic nanostructures are promising materials for electronic devices. They can be dispersed in a solvent to form an ink which in turn can be easily printed. Such sensors can also find application in agriculture, allowing a direct monitoring of the characteristics of fields and plants. Such sensors can be a useful component for the establishment of smart farming, that is of monitoring technologies that decrease the impact of treatments such as herbicides or fertilizers. A further advantage of solution-based printable materials comes from their biocompatibility, which is a necessary requirement in several biological and medical applications. A necessary condition for biomedical use is the stability of the active material when it interacts directly with an electrolyte. Thus, new types of components and transistors have been realized, such as the solution-gated field-effect-transistors, where the gating effect is achieved via an electrode immersed in the solution. Such transistors can potentially work as biosensors. The lecture will give a review of the different materials and techniques available for printed electronics. It will concentrate on some applications such as biological and environmental sensors and energy harvesting systems.

Paolo Lugli graduated in Physics at the University of Modena, Italy, in 1979. In 1985 he received his Ph.D. in Electrical Engineering from Colorado State University, Fort Collins. From 1988 to 1993 he was Professor at the "Engineering Faculty" of the 2nd University of Rome "Tor Vergata". In 2002 he joined the Technical University of Munich where he was appointed head of the Institute for Nanoelectronics. In January 2017 he became Rector of the Free University of Bozen-Bolzano in Bolzano, Italy. His current research interests involve printed electronics, the modeling, fabrication and characterization of organic devices for electronics and optoelectronics, the design of circuits and architectures for nanostructures and nanodevices. He is author of more than 450 scientific papers and co-author of the books "The Monte Carlo Modelling for Semiconductor Device Simulations" (Springer, 1989). He is IEEE Fellow and member of the German National Academy of Science and Engineering (ACATECH).

26 September 2019 - MORNING - SESSION II Sensors and Technologies

Innovative Network for Training in wAter and Food QUality monitoring using Autonomous SENSors and IntelligEnt Data Gathering and Analysis

Summer School Program

Fondazione Bruno Kessler Via Sommarive, 18—Trento, Italy

26 September 2019
SESSION II
Sensors and Technologies
(Chairs. A. Adami)

8.45 - 9.00 Introduction to the program of the day

9.00 – 10.00

Giuseppe Barillaro — University of Pisa, Italy

Optofluidic micro and nanostructured devices and systems for (bio) sensensing

When dealing with sensing of (bio)molecules the length scale of targets may vary over more than 2 orders of magnitude moving from elementary ions and molecules (about 0.1 to 1 nm) to complex proteins and virus (about 1 to 100 nm). A number of technologies have been proposed over the years to prepare fluidic structures and systems with length scales enabling an effective interaction with the specific molecular target. Among these, electrochemical micro and nano structuring of silicon is increasingly attracting attention at research level for biosensing and microfluidics. In this talk, state-of-the-art research on the use of silicon nano-micro structures and systems prepared through electrochemical etching for high-sensitivity (bio)sensing, among which, nanostructured devices for ultra-high-sensitivity ion measurements in water, nanostructured optical platforms for point-of-care clinical diagnostics, drop-and-measure photonic crystal systems for in-field optical biosensing, microneedles for transdermal electrochemical biosensing, is presented and discussed.

REFERENCE

1. S.Mariani et al., Layer-by-layer biofunctionalization of nanostructured porous silicon for high-sensitivity and high-selectivity label-free affinity biosensing, Nat. Communications, 9, 5256, 1-13 (2018)
2. V. Robbiano et al., Room-Temperature Low-Threshold Lasing From Monolithically Integrated Nanostructured Porous Silicon Hybrid Microcavities, ACS Nano 12, 4536−4544 (2018).
3. S. Mariani et al., Electrical Double Layer-Induced Ion Surface Accumulation for Ultrasensitive Refractive Index Sensing with Nanostructured Porous Silicon Interferometers, ACS Sensors, 3, 595-605 (2018).
4. S. Mariani et al., Femtomole Detection Of Proteins Using A Label-Free Nanostructured Porous Silicon Interferometer For Perspective Ultra-Sensitive Biosensing, ACS Analytical Chemistry, 88 (17), 8502-8509 (2016).
5. S. Mariani et al., 10000-Fold Improvement in Protein Detection Using Nanostructured Porous Silicon Interferometric Aptasensors, ACS Sensors, 1, 1471-1479 (2016).

Giuseppe Barillaro is Associate Professor at the Information Engineering Department of the University of Pisa.

Research at Barillaro's group is focused on the preparation of novel inorganic and organic materials, structures, and systems at the micro and nanoscale with applications in the fields of (nano)photonics, microelectronics, (bio)sensing, and (nano)medicine.

G. Barillaro is author of more than 90 papers on peer-reviewed international journals and holds over 20 patents pending (6 issued). He led more the 20 research project, both at international and national levels on micro and nanostructured materials and platforms for (bio) sensing and (nano)medicine, He is an associate editor of the IEEE Sensors Journal and of Scientific Report NPG.

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Summer School Program

Fondazione Bruno Kessler Via Sommarive, 18—Trento, Italy

11.15 – 12.15
Georg Pucker - Fondazione Bruno Kessler, Italy

Label free biosensors for environmental monitoring based on silicon technology

The seminar will cover fundamentals and trends in label free biosensing based on photonic systems. The label free biosensor market represent an important part of the biosensor and environmental sensor market with a size of about 800 Million USD in 2017 at a CAGR of 8.5%.

After an introduction to the principles of evanescent wave sensing the main technologies such as interferometric sensors, grating sensors, photonic crystal based sensors, microcavity sensors and localized surface plasmon resonance sensors will be introduced and reviewed. The principle figures of merit for the different technologies will be given and recent advances will be highlighted.

In the second part of the seminar a summary of the work performed in FBK-CMM in the field of label free biosensing with whispering gallery mode sensors will be given. We will describe and explain the motivations behind the development of a platform based on silicon oxy nitride waveguides, show the performance and figures of merit of the single optical experiments and discuss the advantages and constraints of the platform in the context of portable and point-of-care sensor systems. As an application example we will show the results obtained on the problem of Aflatoxin M1 sensing which was argument of an recent project (FP7-Symphony) supported by the European commission.

Finally, a brief outlook of future opportunities and main constraints for successful commercialization will be given.

Georg Pucker is expert in the field of silicon photonics and integrated optics. He is head of the research unit Functional Materials and Photonic Structures of the Center for Materials and Microsystems within the Bruno Kessler Foundation. His research focuses – among others - on the development of materials and components for applications in silicon photonics such as generation of photons (e.g. based on silicon nanocrystals, non-linear optical processes or hetero-integration of optical active materials), routing of optical signals in the visible and near infrared, integration of light detectors in optical circuits for applications in sensing and quantum optics. He contributed to different European projects also in the field of miniaturized optical biosensors (H2020-MSCA CANBIOSE - Novel 1D photonic metal oxide nanostructures for early stage cancer detection, FP7 -ICT-SYMPHONY - Integrated SYsteM based on PHOtonic Microresonators and Microfluidic Components for rapid detectioN of toxins in milk and dairY products). He is author or co-author of more than 100 scientific publications in peer reviewed journals, inventor of 5 patents and author of a book chapter.

26 September 2019 - MORNING - SESSION II Sensors and Technologies

Innovative Network for Training in wAter and Food QUality monitoring using Autonomous SENSors and IntelligEnt Data Gathering and Analysis

Summer School Program

Fondazione Bruno Kessler Via Sommarive, 18—Trento, Italy

26 September 2019 - AFTERNOON - SESSION II Sensors and Technologies

14.30 – 15.30
Benno Margesin - Fondazione Bruno Kessler, Italy

Silicon-based microfabrication technologies

Microfabrication technologies based on silicon have been and still are widely used for the development and fabrication of new microsystems and sensors. Combining well known and reliable silicon technologies developed for the MOS devices with dedicated processes for micromachining and new materials allows to build powerful and versatile technologies for the fabrication of MEMS and sensors. After an introduction on micromachining and typical materials an overview on common MOS and micromachining techniques is given. An example of a simple fabrication process is discussed together with the principles on how to guide and control a process.

Lab visit and experimental lessons

15.30 – 17.30 Group 1 - Hands on MEMS
Viviana Mulloni, Fondazione Bruno Kessler, Italy

15.30- 17.00 Group 2 - Ink Jet printer – How does it works?
Matteo Ghittorelli, Fondazione Bruno Kessler, Italy

Benno Margesin is an expert in MEMS technologies and MEMS design. He joined the "Istituto Trentino di Cultura" of Trento in 1982 and started his activity as a researcher of the ion implantation group. Within the ion implantation group, he was involved in the design and development of heavy ion sources and of electron-optical elements for heavy ion implanters.

In 1987 he get involved in the Integrated Circuits Fabrication Laboratory, now the Micro Fabrication Facility of FBK, where he led the ion implantation and furnace group. Since 1992 he is also involved in the development of sensors and the study of micromechanics. In 1997 he became the leader of the "BioMEMS" group at ITC-irst. In 2006 he becomes the head of the "MEMS" group of the MIS (MicroSystems) Division at ITC-irst. Since the beginning of 2008 he was responsible for the MEMSRaD Research Unit of FBK, which in 2010 became the MEMS Research Unit which he led till 2013.

At present, as a Senior researcher of FBK, his scientific interest is in the development of RF passive components on silicon (switches), cavity microwave filters, capacitive silicon microphones, cryogenic bolometers and cQED for basic science and physical sensors for consumer and industrial applications.

Innovative Network for Training in wAter and Food QUality monitoring using Autonomous SENSors and IntelligEnt Data Gathering and Analysis

Summer School Program

Fondazione Bruno Kessler Via Sommarive, 18—Trento, Italy

27 September 2019
SESSION III
Systems and Applications
(Chairs. V. Mulloni)

8.45 - 9.00 Introduction to the program of the day

9.00 – 10.00

Nico Salmaso - IASMA Research and Innovation Centre, Fondazione Mach - Istituto Agrario di S. Michele all'Adige. Via E. Mach, 1 - I-38010, S. Michele all'Adige (Trento), Italy

Rationale and application of high throughput sequencing approaches in the study of biodiversity and water quality assessment

The lecture is aimed to provide the rationale and examples of applications of high throughput sequencing (HTS) technologies in aquatic ecology, with a focus on the analysis of environmental DNA (eDNA) in biological and environmental samples (aquatic environments and biological hosts). These topics are relevant not only for the advancement of freshwater ecology, but also for the monitoring and management of water resources and the associated biological communities. HTS approaches in ecology have a wide range of applications, for example in the quantitative assessment and biodiversity in a variety of ecosystems and habitats; in the evaluation of the impact of climate change, anthropogenic stressors and pollutants on biodiversity and ecosystem functionality; in the early identification of alien species and monitoring of toxigenic cyanobacteria. Specific topics of the lecture include: i) the state of the art of modern HTS technologies and their role in the advancement of aquatic ecology; ii) the field of application of HTS approaches, with practical applied ecological case studies from aquatic microbiota and "algal culture" ecosystems; iii) identification of pros and cons of different methods and their possible combinations; iv) the inclusion of HTS in research projects and in different ecological / environmental "problem solving" issues, complementing or challenging traditional monitoring approaches. In this regard, the lecture will provide a broad overview of the project Eco-AlpsWater (Interreg Alpine Space). The project is based on a wide EU collaboration among 6 participating countries. One of the main objectives of the project is to develop and apply state of the art methods for the monitoring of cyanobacteria and bacteria, microalgae and fish based on the use of HTS techniques, complementing traditional approaches and anticipating the route in the development of next generation water monitoring systems.

Senior Researcher and head of the "Hydrobiology" Research Group at the Edmund Mach Foundation (FEM) - Agricultural Institute of S. Michele all'Adige (Trento, Italy). Nico Salmaso coordinated numerous scientific investigations in freshwater ecosystems in the Alpine and subalpine region. He is currently coordinator of the project Eco-AlpsWater (2018-2021; 6 member states), funded by the Interreg Alpine Space program. The project is focused on the application of high throughput sequencing techniques in the study of aquatic biodiversity and assessment of water quality. Further research interests include the study of anthropogenic and climate change impact on planktic communities and toxigenic cyanobacteria. The results of the scientific activities have been published in several international journals and book chapters. Co-Editor in Chief for Advances in Oceanography and Limnology; associated Editor for Cryptogamie Algologie; review Editor for Frontiers Microbiology; member of the Editorial Board of the Journal of Limnology; guest editor in Special Issues of Hydrobiology (2012 and 2018) and Journal of Great Lakes Research (in progress). He has worked as a referee for over 50 international journals and for the evaluation of national and international research projects. Member of the Board (2004-2015) and vice-president (2016-2019) of AIOL, Italian Association of Oceanology and Limnology. Organizer of the "1st Meeting of the Italian PhD students in Ecological and Environmental Sciences" (Padua, 2003). Chair in the organization of international congresses (International Association of Phytoplankton Taxonomy and Ecology, S. Michele all'Adige, 2012) and several special sessions. Since 2006, responsible of the limnological research station LTER (Long Term Ecological Research) Lake Garda. Since 2013, contact person of the macrosite "IT08-000-A" "Laghi Sudalpini" (Garda, Maggiore, Como, Iseo, Orta, Candia). He was a member of the group of experts coordinated by the Ministry of Health for the definition of the "Guidelines on cyanobacteria in bathing waters", and Italian member of the Management Committee of COST action CYANOCOST (2012-2016).

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27 September 2019 - MORNING - SESSION III Systems and Applications

10.15 – 11.15
Catia Monauni APPA Trento – Trento Province Environmental Protection Agency

Water quality monitoring in rivers and lakes of Trento province

General objectives of Water Directive 2000/60/EC are to establish a framework for the protection of inland surface, transitional, coastal and groundwater waters, to prevent further deterioration and protect and enhance the status of aquatic ecosystems: furthermore, WFD promotes sustainable water use based on a long-term protection of available water resources.
One of the missions of APPA Trento (Environmental Agency of Trento province) is to classify water bodies to attest their good quality.
Water bodies which don't reach good quality have to be improved through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances.
The monitoring network of surface waters has been designed so as to provide a coherent and comprehensive overview of ecological and chemical status within each river basin and permits classification of water bodies into five classes consistent with the normative definitions.
Methods used by APPA to evaluate ecological and chemical quality of surface waters will be illustrated in this presentation.

Catia Monauni is working for Environmental Agency since 2000.
She is an environmental biologist: she deals with biological monitoring of rivers (macrobenthos and diatoms), biotic indexes application and provides opinions on minimum in-stream flow and environmental interest on freshwater ecosystems.

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27 September 2019 - MORNING - SESSION III Systems and Applications

11.15-12.15
Barbara Fabbri - University of Ferrara, Italy

Chemical gas sensors for agri-food water management

The application of Site Specific Crop Management consists of the knowledge on the soil variability. In particular, for a sustainable water management is fundamental to obtain differentiated response in terms of selective irrigation, analyzing and evaluating the water content of the soil or the water requirement of the plants. Although the technological science provides several tools and analysis techniques for the remote sensing, a well-structured system has not been widely documented for the parallel evaluation of the soil-atmosphere moisture status and the monitoring of emissions variability of the crops over a whole growing season. In fact, on one side the majority of studies on volatile gases profile in the soil atmosphere, i.e. gas fingerprints, are pointed towards the soil microbial metabolic activity. On the other hand, the monitoring of Volatile Organic Compounds (VOCs) secreted by plants is mainly focused on the control of their health status, which can be affected by insects or disease. An innovative approach lies in designing, developing and validating a technology platform consisting of a hardware for monitoring VOCs emissions from the soil-plant-atmosphere system of intensive crops in order to evaluate the water content of these systems. Analyzing experimental data acquired in-situ by portable sensing units based on Metal-OXide (MOX) gas sensors, thus comparing the results with meteo-sat data and farming operations, one can prove a dependence of gaseous emissions on the hydric/metabolic status of the plants together and a correlation between sensor signals collected and significant events for the crops.

Barbara Fabbri obtained her Master's Degree in Physics in March 2011 at University of Ferrara. Then, she finished her PhD in Physics in March 2015 at the same University, defending her thesis on the use of innovative organic-inorganic hybrids as sensing materials. From 2015, she is a PostDoc researcher in Sensors Group at Department of Physics and Earth Science of Ferrara.

Her research activity has involved all the key aspects concerning the study and implementation of chemoresistive devices for gas detection: the use of innovative sensitive materials, such as organic-inorganic hybrids and non-oxide semiconductors, but also the deepening of new properties of well-known metal oxides; the study of deposition techniques and the design of alternative substrates to alumina to implement the sensitive device on technological platforms; and the study of new applications for chemical gas sensors, such as agri-food and medical diagnosis.

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27 September 2019 - MORNING - SESSION III Systems and Applications

12.15-13.15
Luca Francioso — CNR-IMM, Italy

Multifunctional micro- and nanosystems for chemical and physical sensing

The talk presents a comprehensive review of the actual research lines at the Multifunctional Devices Design and Characterization Laboratory of CNR-IMM institute (M2DCL Lab), with particular focus on micro- and nanotechnologies for fabrication of chemical sensors, piezoelectric sensors on flexible substrates and microfluidic actuators with embedded sensors. Recent developments on ultra-low power chemical sensors realized with mixed micro/nanofabrication techniques are presented, with special focus on autonomous systems and energy harvesting devices.

Luca Francioso received the M.Sc. degree in Physics 2001 at the University of Lecce. Since 2001 he joined the Institute for Microelectronic and Microsystems (CNR-IMM) of the National Research Council of Italy in Lecce (Italy), working in the field of silicon micromachined systems and solid state thin film chemical sensors. Since 2003 he is a permanent staff researcher, devoted to silicon technology development and MEMS devices fabrication. In 2006 he takes the PhD degree with a thesis on application of miniaturized gas sensors for combustion and cabine air quality assessment in the automotive field. Current research interests are related to: i) flexible thermoelectric and piezoelectric generators (ii) Design and manufacturing of MEMS chemical sensors (iii) Organ-On-Chip platforms. He is currently the head of the M2DCL - Multifunctional Devices Design and Characterization Laboratory at CNR-IMM in Lecce and co-authored more than 103 peer-reviewed papers on international journals, 2 book chapters, 14 invited talks and several communications to national and International Conferences.

Innovative Network for Training in wAter and Food QUality monitoring using Autonomous SENSors and IntelligEnt Data Gathering and Analysis

27 September 2019 - AFTERNOON - SESSION III Systems and Applications

Summer School Program

Fondazione Bruno Kessler Via Sommarive, 18—Trento, Italy

14.30 - 15.30
Alessio Bucciarelli — Fondazione Bruno Kessler, Italy

Statistical process optimization through design of experiment

Design of experiment (DOE) is a powerful statistical method that allows to predict and optimize one of multiple yields in dependence to the process variables. The use of DOE allows to switch from the usual approach of one yield - one variable optimization to an approach that takes into account a multitude of variables and their mixed effect on the yield. An efficient design consents to obtain a large amount of information with a restricted number of trials. The full factorial design is the most common DOE method to conduct an explorative analysis of the process and understand which variables have more impact on the selected yields. The significance of each variable and of each combination of variables is evaluated by the analysis of variance (ANOVA). In a first approximation, to build a reliable model only 2 levels for each variable are needed, the basic assumption is the linearity of the yield in the considered range. However, a curvature could be present if one of more mixed terms resulted to be significant. Once the model is built, the test of the curvature, on trials conducted on the center of the variables space, gives a hint about the necessity to conducts other trials. In fact, if the curvature results to be significant, an additional point should be taken for each variable in order to extend the design and take into the account the second-order effects. In the other case, the model built can be considered as definitive. In this seminar the basic concept behind the DOE method will be presented. Some preliminary basic statistics will be discussed, with a focus on how to choose the most proper statistical measures in accordance with the yield distribution. The ANOVA will be explained focusing on its usage to include or exclude a process variable in the model. Finally, the application of a full factorial DOE will be presented on two case studies: a sintering process conducted on silk protein and an inkjet deposition of a silver ink for microfabrication.

Lab visit and experimental lessons

15.30- 17.00 Group 1 - Ink Jet printer – How does it works?
Andrea Adami - Fondazione Bruno Kessler, Italy

15.30 – 17.30 Group 2- Hands on MEMS
Viviana Mulloni - Fondazione Bruno Kessler, Italy

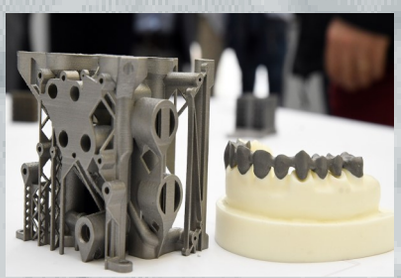
Dr. Alessio Bucciarelli received his M.Sc in Material Science at the University of Venice and currently completing his PhD at the Industrial Engineering Department in Trento. During his academic career he collaborated with several research groups, among them the Bio-nano Lab of Virginia Commonwealth University (USA), the Gilson Lab of Chonbuk National University (South Korea), and the Rizzoli orthopedic institute (Italy). His research interest is mainly related to the optimization and standardization of processes on biomaterials with applications in micro and macro fabrication. He worked on protein-made photoresists (silk and keratin) developing a technique to obtain optical grade patternable films. Recently, he started implementing the statistical analysis on material fabrication, with the effort to standardize the processing of raw materials to make their use reliable. In this context he developed a low temperature sintering to produce a solid bulk silk material by the use of Design of Experiment (DOE). He recently joined the Microsystem Technology Group of Fondazione Bruno Kessler and is currently optimizing an inkjet microfabrication process.

EDUCATIONAL AND SOCIAL EVENTS

25 September 2019, 15.30 — 17.30

Visit at the 3D PROM Mechatronics Pole in Rovereto city

(Lab Visit with FBK Shuttle)

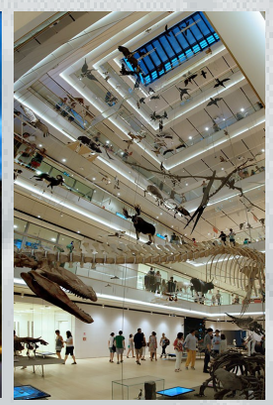


26 September 2019, 20.00 — 22.00

SOCIAL DINNER IN TRENTO CITY

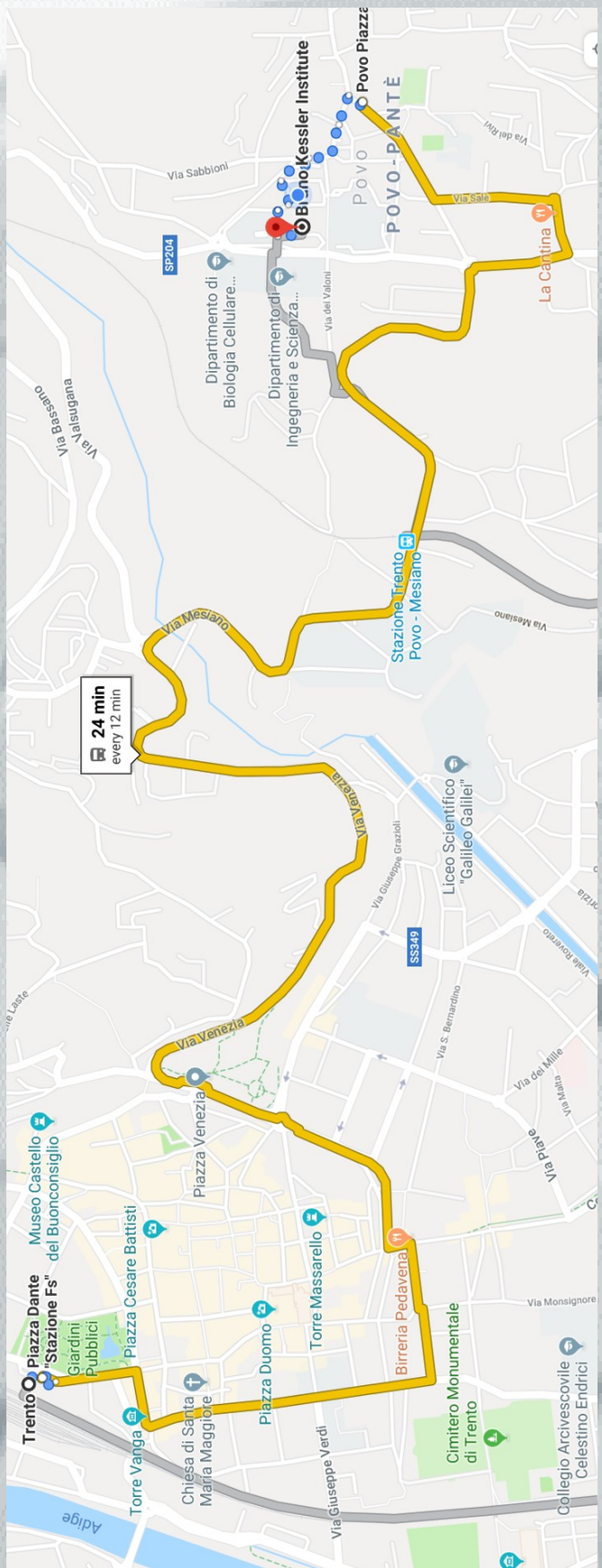
27 September 2019, 17.30 — 24.00

Conclusion of the Summer School with the free visit at the Researchers' Night Event at the Science Museum of Trento (MUSE)

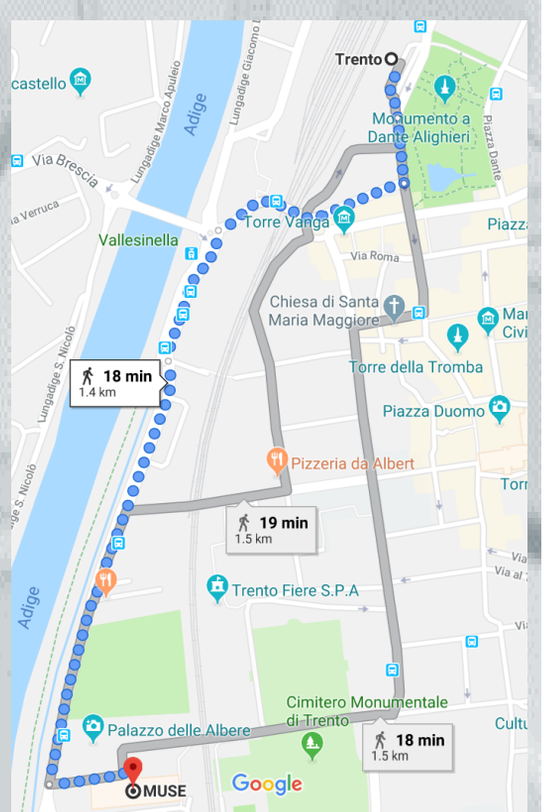


DIRECTIONS

FROM RAILWAY TRENTO STATION TO FBK HUB BY BUS LINE 5



FROM RAILWAY TRENTO STATION TO MUSE—MUSEUM OF SCIENCE BY WALKING



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