



Contest

COLLABORATIVE NETWORK FOR TRAINING IN ELECTRONIC SKIN TECHNOLOGY

PROJECT COORDINATORS

LEANDRO LORENZELLI, FBK
PROJECT COORDINATOR

RAVINDER DAHIYA, UoG
SCIENTIFIC COORDINATOR



Leandro is a senior researcher at the Fondazione Bruno Kessler in Trento. He is coordinator of the Microsystems Technology (MST) research unit at FBK of the Center for Materials and Microsystems.

Group webpage:

<http://mst.fbk.eu/>



Ravinder is Reader and EPSRC Fellow in the Electronics and Nanoscale Engineering Division at School of Engineering, University of Glasgow, UK. He is leading the Bendable Electronics and Sensing Technologies (BEST) group.

Personal website:

<http://rsdahiya.com/>

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CONTEST NETWORK

- Fondazione Bruno Kessler, Trento, Italy - FBK
- Technical University Munich, Germany -TUM
- Fraunhofer EMFT, Germany -EMFT
- University of Glasgow, UK- UoG
- Imperial College London, UK
- Shadow Robot Company, UK
- University College London, UK-UCL

Associated partners

- University of Tokyo, Japan
- University of Cambridge, UK
- ST Microelectronics, Italy



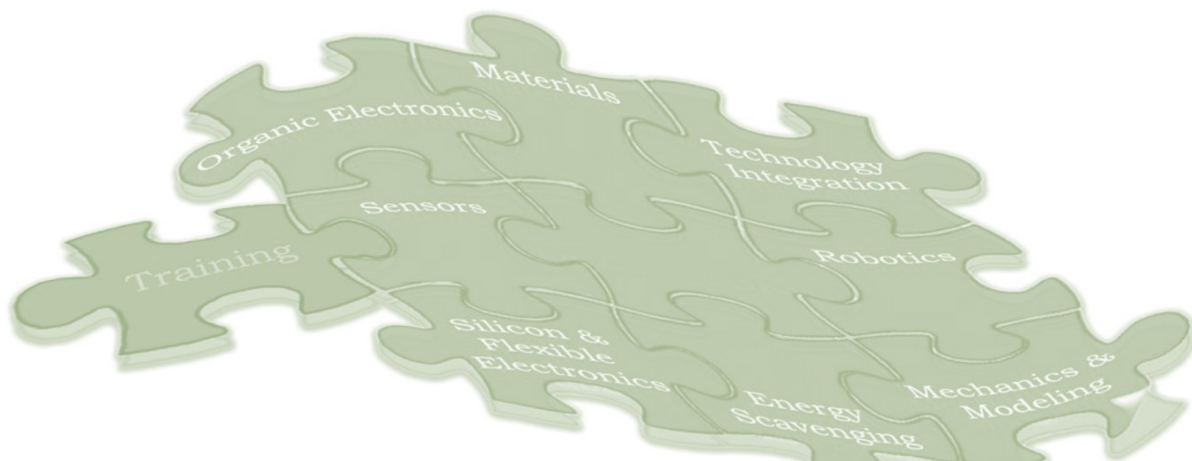
ITN TRAINING NETWORK

Marie Skłodowska-Curie actions (MSCA) support researchers at all stages of their careers, irrespective of nationality. Researchers working across all disciplines, from life-saving healthcare to 'blue-sky' science, are eligible for funding. The MSCA also support industrial doctorates, combining academic research study with work in companies, and other innovative training that enhances employability and career development.

Funded under European Community's 7th Framework Programme
(FP7-PITN-GA-2012-317488-CONTEST)

<http://www.contest-itn.eu/>

Contest



COLLABORATIVE NETWORK FOR TRAINING IN ELECTRONIC SKIN TECHNOLOGY

MAIN FACTS

TECHNOLOGIES FOR HOMOGENOUS/HETEROGENEOUS INTEGRATION OF MULTIFUNCTIONAL COMPONENTS

The silicon and organic materials based solutions will be investigated, yielding systems with the advantages of both. CONTEST brings together complementary expertise in flexible electronics, sensors, system integration, and robotics from nine key academic and research institutes, and industry. CONTEST will push research frontiers towards:

- Multifunctional Electronics.
- Bendable and stretchable electronic systems over large areas.
- Integration of organic and inorganic materials based components.
- Gathering “contact information” from large areas simultaneously, creating opportunities to extend the cognitive capabilities of robots, and in human-environment interfaces.

480 PERSON MONTHS OF RESEARCH TRAINING

The CONTEST programme will provide multidisciplinary research training to young researchers in relevant fields such as flexible/bendable systems integration, fabrication technologies, new materials, robotics and human-environment interaction. The research training will be supplemented with a variety of complementary courses such as IPR, grant writing and exploiting the scientific results.



E-SKIN AND ADVANCED ROBOTICS

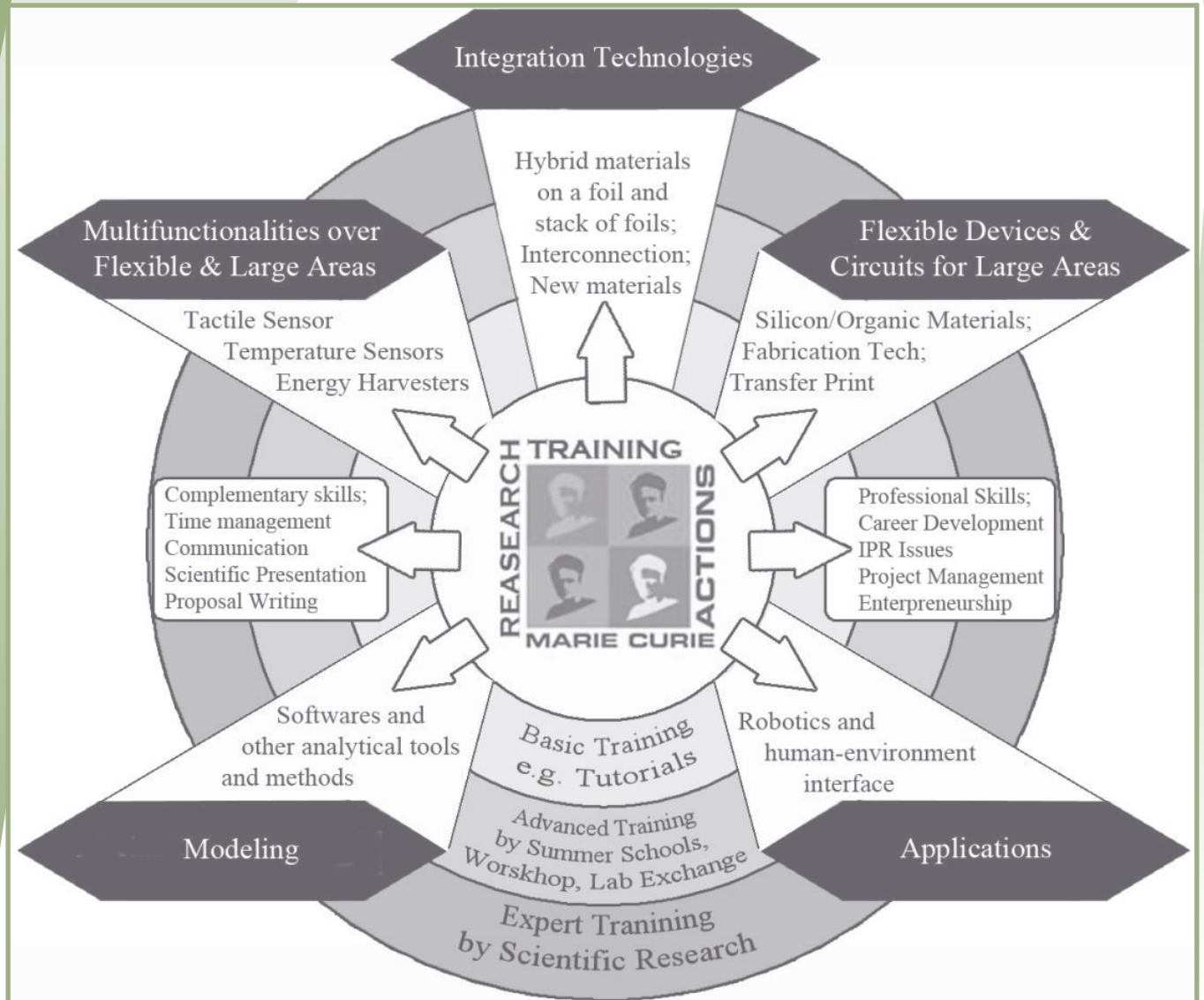
CONTEST is a multi-site initial training network (ITN) funded by European Commission to work in the fast expanding field and applications. The CONTEST programme involves investigating various critical aspects of flexible electronics - all converging towards obtaining an electronically-enhanced and wearable smart skin.



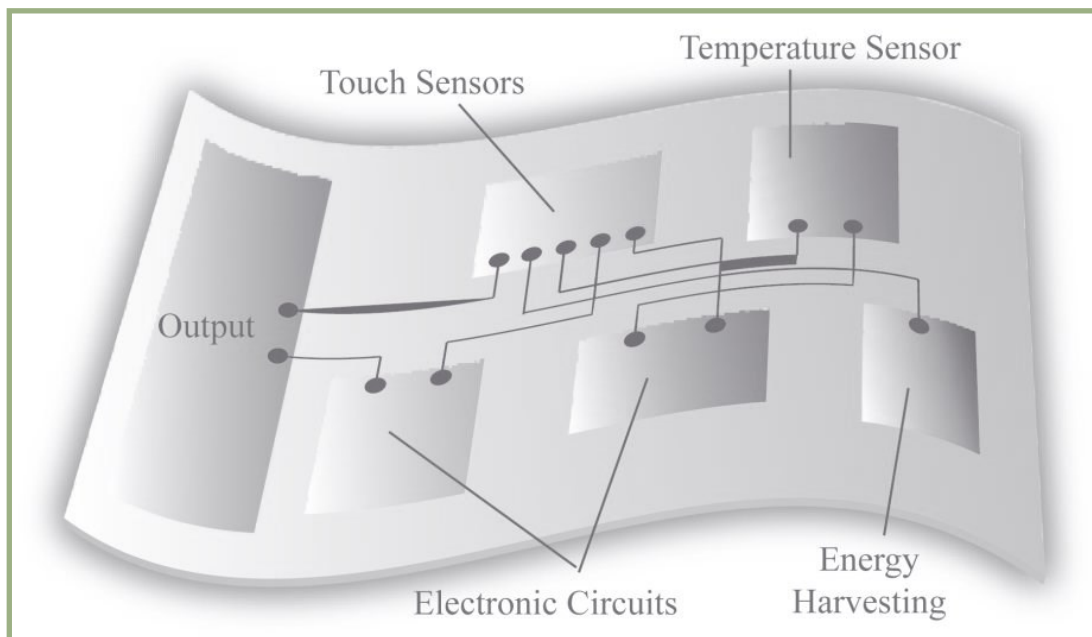
DIRECT INVOLVEMENT OF STAKEHOLDERS

The project envisages the participation of two companies as partners to provide technical and operational support and to support the technological transfer of the research results. More information on the companies website: Shadow Robot Company (<http://www.shadowrobot.com/>) and ST microelectronics (<http://www.st.com/web/en/home.html>)

SUMMARY OF CONTEST



CONTEST MAIN ACTIVITIES



WP2: Electronic devices and circuits in flexible substrate

TUM

RP1 Flexible electronic devices and circuits using SI-NW approach

Saleem Kahn FBK

RP2 Flexible electronic devices and circuits using organic semiconductors

Engin Cagatay TUM

RP3 Modelling of flexible devices and sensors

Simone Colasanti TUM

RP4 Signal conditioning, data acquisition and system integration

Emre Oğan Polat UoG

WP3: Sensors & Actuators over large and flexible substrate

FBK

RP5 Sensor using organic semiconductors

Valentina Robbiano UCL

RP6 Chemical and physical sensors on flexible/conformable substrates

Nivasan Yogeswaran FBK

RP7 Flexible POSFET tactile sensing chips using Chip-on-Flex

Shonbhik Gupta, FBK

WP4: Integration technologies for flexible electronic

EMFT

RP8 Metal/organic patterned substrates for sensor and actuator integration

Wenting Dang FBK

RP9 Assembly on film substrates and reliability testing

Nagarajan Palavesam, EMFT

RP10 Investigation of ESD damaging of components during flex integration

Tekfong Lim, EMFT

RP11 Interconnections using nano-materials and patterning of e-skin

Luca Santarelli UCL

WP5: E-skin for robotics & human-environment interface

Imperial

RP12 Electronic skin suit for robots and handling of objects

Mohsen Kaboli TUM

RP13 Handling of objects with close contact in humans

Carlo Bagnato, Imperial

RP14 Skilful object manipulation and adaptive haptic exploration

Matjaz Ogrinc, Shadow

WP6: Training and dissemination activities

UCL

INTRODUCING CONTEST RESEARCHERS

Fondazione Bruno Kessler, Trento-Italy

The MicroSystems Technology (MST) Research Unit activity at FBK is oriented to the design and fabrication of microsystems, microdevices and sensors. The main activities are concentrated on one side on biomedical, environmental and agrofood applications and on the other side on MEMS devices development for radiofrequency transmission and control. The area is coordinated by **Dr. Leandro Lorenzelli**.

<http://mst.fbk.eu>



Saleem Kahn



Email: skhan@fbk.eu

Role:
Early Stage Researchers
ESR1

Saleem Khan received his B.S. degree in Engineering Sciences with specialization in Lasers and Optoelectronics from the GIK Institute of Engineering Sciences and Technology, Topi, Pakistan and a master degree in Electronic Engineering from Jeju National University, Jeju, South Korea. He is currently working towards the Ph.D. degree at the University of Trento, Trento, Italy, and his research is based within the Microsystems Technology research unit at Fondazione Bruno Kessler, Trento, under the supervision of Dr. R. Dahiya.

Flexible electronic devices and circuits using SI-NW approach

His research focus is on the development of technology route for realizing multifunctional flexible micro/nanoelectronic devices through heterogeneous integration of organic/inorganic materials on polymeric substrates. Interesting results have been achieved by developing a cost-effective way of manufacturing screen-printed flexible pressure sensors using piezoresistive based MWCNT/PDMS nanocomposites.

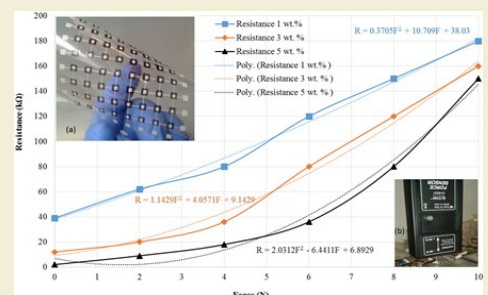


Figure: Screen-printed MWCNT/PDMS modules

Main publications and awards

1. S. Khan, W. Dang, L. Lorenzelli and R. Dahiya, "Flexible Pressure Sensors based on Screen Printed P(VDF-TrFE) and P(VDF-TrFE)/MWCNTs" IEEE, Transactions on Semiconductor Manufacturing, Accepted for Publication, (In Press).
2. S. Khan, S. Tinku, L. Lorenzelli and R. Dahiya, "Flexible Tactile Sensors using Screen Printed P (VDF-TrFE) and MWCNT/PDMS Composites", IEEE Sensors J. Vol. 15, no. 6, PP (862-865), 2015.

Shoubhik Gupta



Email : sgupta@fbk.eu

Role:
Early Stage Researchers
ESR6 enrolled for PHD
at University of Glasgow

Shoubhik is a second year PhD student in the Department of Electronics and Nano-Scale Engineering, University of Glasgow, UK. He obtained his Bachelor's degree in Electrical Engineering from Indian Institute of Technology Kanpur, India in 2014 where he worked on Quantum-dot Cellular Automata technology and low power electronics. Currently, he is working as a Marie Curie fellow at Fondazione Bruno Kessler, Italy on flexible tactile sensors for electronic skin application under framework of CONTEST project. His areas of interest are flexible electronics and quantum electronics.

Flexible POSFET tactile sensing chips using Chip-on-Flex

His work is focused on fabrication of flexible tactile sensors using chip on flex approach. Until now, extensive literature study has been carried out. Achieved silicon membrane of thickness 18 um using TMAH wet etching. Also, analytical modelling of piezoelectric FET is done based on BSIM model.

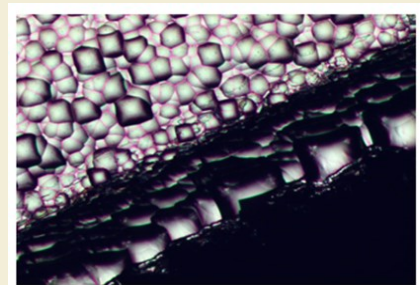


Figure: Optical image of Silicon membrane

Main publications and awards

1. Shoubhik Gupta was part of the winning team of the Water Challenge issued by the University of Glasgow, UK.



INTRODUCING CONTEST RESEARCHERS



Nivasan Yogeswaran



Email: yoges@fbk.eu

Role:

Early Stage Researchers
ESR7 enrolled for PHD
at University of Glasgow



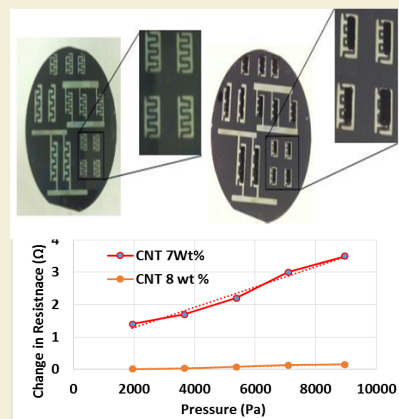
Nivasan received his B.Eng. (Hons) degree in Electronic engineering from University of Surrey, UK where he specialized in devices. He pursued a MSc in Nanoelectronics and Nanotechnology at University of Southampton, UK. He is a Ph.D. student at University of Glasgow and is carrying out his research activities at University of Glasgow and FBK. As part of his CONTEST training program he had a secondment at STMicroelectronics, Catania.

Chemical and physical sensors on flexible/conformable substrates

His project focuses on the development of physical and chemical sensors based on carbon nanotube or/and graphene on flexible and stretchable substrate. He developed a stretchable pressure sensors consisting of an interdigitated silver electrode with a resistive layer (CNT-PDMS composite) printed on top of it as pressure sensitive layer. The application of force causes the resistance of the layer change which was used as the key criteria for the development of the sensor.

Main publications and awards

1. Stretchable Resistive Pressure Sensor based on CNT-PDMS Nanocomposites- IEEE PRIME, Glasgow 2015.
2. Tuning Electrical Conductivity of CNT-PDMS Nanocomposites for Flexible Electronic Applications.- IEEE Nano, Rome 2015.



Figures shows the developed sensor and sensor response on application of force.

Wenting Dang



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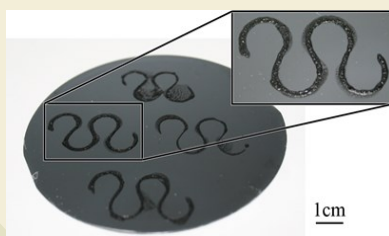
Role:

Early Stage Researchers
ESR5 enrolled for PHD at
University of Glasgow



Wenting is the second year PhD student at University of Glasgow and supervised by Dr. Ravinder Dahiya and co-supervised by Dr. Leandro Lorenzelli and Dr. Vincenzo Vinciguerra. She obtained the Master's degree in Microsystems Engineering at University of Freiburg, Germany and Bachelor's degree in Electrical & Computer Engineering with a joint program between New York Institute of Technology, U.S and Nanjing University of Posts and Telecommunications, China. Wenting's research is focused on developing stretchable interconnects.

Metal/organic patterned substrates for sensor and actuator integration



In Figure serpentine shape interconnects

This work includes the investigation of stretchable and conformable substrate, the integration of printing process and the integration of sensors/ electronics components on flexible/ stretchable substrates. Wenting fabricated the stretchable interconnects by MWCNTs-PDMS nanocomposite. This material has the advantage of maintaining both highly stretchable property and electrically conductive property.

Main publications and awards

1. W. Dang, S. Khan, L. Lorenzelli, V. Vinciguerra and R. Dahiya, "Stretchable Interconnects using Screen Printed Nanocomposites of MWCNTs with PDMS and P(VDF-TrFE)" in 11th Conference on Ph.D. Research in Microelectronics and Electronics (PRIME), Glasgow, UK, 2015 (**Silver leaf award**)

INTRODUCING CONTEST RESEARCHERS

Technical University Munich, Germany

The Institute for Nanoelectronics is coordinated by **Prof. Paolo Lugli** and provides education and training in the field of Nanoelectronics and Nanotechnology as well as on organic and molecular electronics, with particular emphasis on devices, circuit and system applications.

<http://www.nano.ei.tum.de/>



Engin Cagatay



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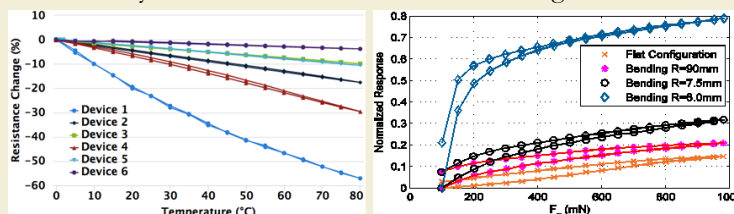
Role:

Early Stage Researchers
ESR2

Engin received the B.Sc. degree in metallurgical and materials engineering from the Middle East Technical University, Ankara, Turkey, in 2009, and the M.Sc. degree in materials science and nanotechnology from the National Nanotechnology Research Centre at Bilkent University, Ankara, Turkey, in 2012. He is currently working toward the Ph.D. degree at the Institute for Nanoelectronics of Technische Universität München, Munich, Germany.

Flexible electronic devices and circuits using organic semiconductors

The aim of his project is to develop temperature sensors (Left) and tactile sensors (Right) on flexible substrates using carbon nanotube (CNT) networks. The fabricated sensors utilize the CNTs as the active sensing material realized using spray coating technique. Moreover, integrability of these devices with other technologies and devices is being explored. Finally, prototype devices and systems based on such devices are being built.



Main publications and awards

1. E. Cagatay; A. Falco; A. Abdellah and P. Lugli, Carbon Nanotube Based Temperature Sensors Fabricated by Large-scale Spray Deposition, 10th Conference on Ph.D. Research in Microelectronics and Electronics (IEEE PRIME 2014), pp.1-4, June 30 2014-July 3 2014, Grenoble, France. **Gold Leaf award**
2. E. Cagatay; P. Kohler; P. Lugli; A. Abdellah, Flexible Capacitive Tactile Sensors Based on Carbon Nanotube Thin Films, Sensors Journal, IEEE, vol.15, no.6, pp.3225-3233, June 2015.

Simone Colasanti



Email: Simone.Colasanti@nano.ei.tum.de

Role:

Early Stage Researchers
ESR3

Simone Colasanti received the M.Sc. degree in Electronic Engineering from the University of Rome "Tor Vergata", Italy, in 2012. He is now pursuing the Ph.D. degree at the Institute for Nanoelectronics at the Technical University of Munich (TUM), Germany. His current research interests include the developing of theoretical models and simulation tools for electronics devices on flexible substrates which employ organic semiconductors and carbon nanotubes.

Modeling of flexible devices and sensors

The aim of the project is to develop theoretical models and simulation tools for electronic devices and active circuit elements on flexible substrates based on carbon nanotubes thin films.

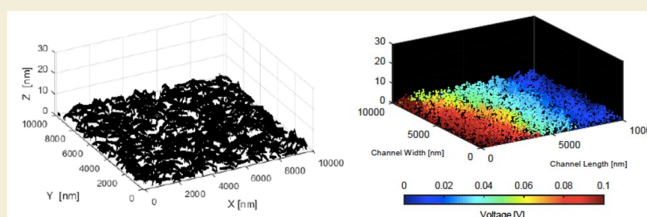


Figure: (a) Three dimensional representation of a generated network with a density of 18 CNT/ μm^2 . (b) Potential distribution of the same network.

Main publications and awards

1. S. Colasanti, V. Deep Bhatt, and P. Lugli, "3D Modeling of CNT Networks for Sensing Applications", PRIME 2014 - 10th Conference on Ph.D. Research in Microelectronics and Electronics.
2. S. Colasanti, H. Nesswetter, C. G. Zimmermann, and P. Lugli, "Modeling and Parametric Simulation of Triple Junction Solar Cell for Space Applications", PVSC 2014 - 40th IEEE Photovoltaic Specialists Conference.

INTRODUCING CONTEST RESEARCHERS



The Institute for Cognitive Systems of TUM, directed by **prof. Grodon Cheng**, deals with the fundamental understanding and creation of cognitive systems. <http://www.ics.ei.tum.de/>

Mohsen Kaboli



Email: mohsen.kaboli@tum.de

Role:
Early Stage Researchers
ESR10

Mohsen received his B.Sc. degree in Electrical and Electronic Engineering and his M.Sc. degree in Signal Processing and Machine Learning from the Royal KTH University in Stockholm, Sweden in 2011. In 2012 he was awarded the research scholarship from the Swiss National Science Foundation (SNSF) to continue his research in the field of robot learning and transfer learning at EPFL university/Idiap Lab in Switzerland. Since April 2013, he is working as a research assistant and Ph.D. candidate at the Institute for Cognitive Systems (ICS) at the Technical University of Munich (TUM) in Germany.

Electronic skin suit for robots and handling of objects

His research focus is robot learning from multi-modal sensory artificial robotic skin or tactile sensors. He is using feedback information from electronic skin provided on humanoid robots, to teach the robot to acquire human-like skills for environment exploration and safe interaction with human through learning algorithms.

Main publications and awards

1. M. Kaboli, P. Mitendorf, V. Hugel and G. Cheng Humanoids learn object properties from robust tactile feature descriptors via multi-modal artificial skin, IEEE-RAS International Conference on Humanoid Robots-2014
2. M. Kaboli and G. Cheng Dexterous hands learn to re-use the past experience to discriminate in-hand objects from the surface textures, 33rd Annual Conference of the Robotics Society of Japan- 2015

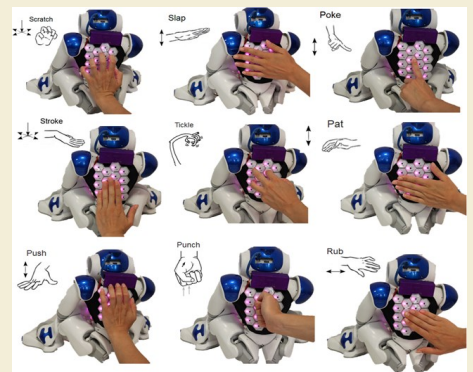


Figure: Social touch identification by NAO via cellular skin at the Institute for Cognitive Systems at TUM

University of Glasgow, UK

The research interests of Bendable Electronics and Sensing Technologies (BEST) group (Dr. **Ravinder Dahiya**) include Flexible and Printable Electronics, Electronic Skin, Robotic Tactile Sensing, and System Integration. BEST research philosophy is to enhance understanding of the fundamental issues and orientation towards applications. <http://www.gla.ac.uk/>



Emre Ozan Polat



Email: emreOzan.Polat@glasgow.ac.uk

Role:
Experienced Researchers
ER1

Emre O. Polat received his BSc. degree in physics from Izmir Institute of Technology, Turkey in 2009. And he got his Ph.D. degree in physics from Bilkent University, Turkey in 2015. His research covers the graphene based optoelectronics. He is with the "Bendable Electronics and Sensing Technologies (BEST) Group" in University of Glasgow and he is currently working on the heterogeneous integration of Si to graphene based ultra-thin and flexible devices. He holds three patents and more than 10 publications in high impact factor journals.

Electronic skin using graphene based sensors

His main focus in the CONTEST project is integration of graphene on unconventional substrates which enables electronics and optoelectronic devices with new mechanical functionalities.

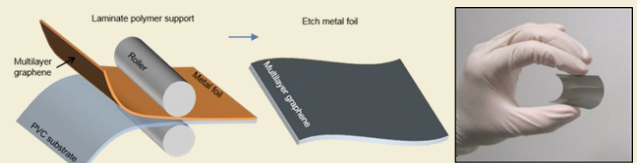


Figure: Fabrication of graphene based sensors

Main publications and awards

1. Emre O. Polat, and Coskun Kocabas. "Broadband Optical Modulators Based on Graphene Supercapacitors" Nano Letters 13, no. 12: 5851-57 (2013).
2. Emre O. Polat, Osman Balci, and Coskun Kocabas "Graphene Based Flexible Electrochromic Devices" Scientific Reports, 4, 6484. (2014).
3. He is awarded for the "Young Scientist Award" of European Material Research Society (E-MRS) in 2014, and "Silver Leaf Award" of IEEE Prime in 2015.

INTRODUCING CONTEST RESEARCHERS

University college London, UK

The UCL Organic Semiconductors group, led by **Prof. Franco Cacialli**, works on organic semiconductors and related nanostructures. Experimental facilities include those for processing and characterisation of organic semiconductors devices as well as for fabrication and investigation of organic semiconductors nanostructures.

<http://www.cmmmp.ucl.ac.uk/>



Valentina Robbiano



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Role:

Early Stage Researchers
ESR4

Valentina is a third year PhD student at University College London (UCL). She obtained a Master degree in Material Science and Engineering at University of Genova. Her work in the organic semiconductors and nanostructures group (Professor Franco Cacialli) is focused on the preparation and characterization optoelectronic devices.

Sensors using organic semiconductors

The aim of the project is to develop optoelectronic devices suitable for e-skin applications. The devices exploit organic semiconductors as active materials. This work includes the preparation of near-infrared (NIR) organic light emitting diodes (OLEDs) and organic-

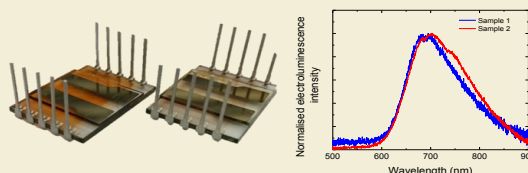


Figure: photo of two OLEDs and their emission spectra

hybrid photovoltaic solar cells. Both these devices are of great interest as sensors in electronic skins modules. Furthermore, the optimization of the transparent electrodes used in the devices has been carried out.

Main publications and awards

1. V. Robbiano, F. Di Stasio, S. Surdo, S. Mian, G. Barillaro, F. Cacialli Chapter 15 "Hybrid-organic photonic structures for light emission modification" In "Organic and Hybrid Photonic Crystals", Springer (2015)
2. V. Robbiano, A. Abdellah, L. Santarelli, A. Falco, S. El-Molla, L. V. Titova, D. N. Purschke, F. A. Hegmann, F. Cacialli, P. Lugli "Analysis of Sprayed Carbon Nanotube Films on Rigid and Flexible Substrates". Proceedings IEEE Nano, Toronto, Canada, 2014

Winner of the prize for the best poster presentation in the Science and Engineering of Molecular Electronic Materials at the [12th European Conference on Molecular Electronics](#), London 2013

Luca Santarelli



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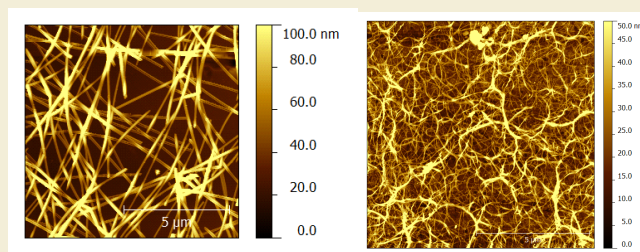
Role:

Early Stage Researchers
ESR9

Luca Santarelli is a second year PhD student at University College London (UCL) in Prof. Franco Cacialli's group. Luca is part of the project CONTEST (COLlaborative Network for Training in Electronic Skin Technology) Marie Curie Initial Training Network (ITN).

Interconnections using nano-materials and patterning of e-skin

The development and characterization of flexible and stretchable transparent electrodes, suitable for optoelectronic devices such as organic emitting diodes (OLEDs) and organic photovoltaics (OPVs), is the main Luca's interest together with the investigation of electrostatic discharge (ESD) effects on the electrical and optical properties of conjugated polymers. Flexible/stretchable devices can be embedded into robotic or medical applications, hence the mechanical and electrical long-term reliability of these, along with a characterisation of their response to ESD events, is matter of great importance.



In Figure Atomic force microscope of flexible electrodes

Main publications and awards

1. L. Santarelli, T. Lim, H. Wolf, H. Gieser, F. Cacialli, "The Resilience Poly Field-Effect Transistors with respect to ESD Effects", 14. ESD-FORUM, Nov. 2015.

INTRODUCING CONTEST RESEARCHERS



Fraunhofer EMFT, Munich-Germany

The ATIS (Analysis & Test Integr. Systems) group (dr. **Horst Gieser**) focuses in electrostatic discharges issues in every step of an integrated circuit (design, measurements on wafer and package level, failure analysis). The Substrate Preparation and Handling Group (Dr. **Christof Landesberger**) is well-known for the wafer thinning concept (Dicing-by-thinning). The activities of the group are focused on heterointegration of thin, flexible components in foils and their reliability analysis.

<http://www.emft.fraunhofer.de>

Tekfouy Lim



Email: Tekfouy.Lim@emft.fraunhofer.de

Role:
Experienced Researchers
ER2

Tekfouy Lim received the BSc. degree in Electrical and Electronics Engineering and the MSc. degree from the Lille 1 University, France, in 2007 and 2009 respectively. He completed the Ph.D. degree in 2013 from the University of Grenoble, France, in collaboration with STMicroelectronics, Crolles and IMEP-LAHC lab., Grenoble, France. Since 2013, he is a Post-doctoral Researcher at Fraunhofer EMFT, Munich, Germany. His main research interests involve exploring ESD protection solutions and mmW integrated circuits designs.

Investigation of ESD damaging of components during flex integration

His task is to evaluate the effect on the electrostatic discharges on a large scale electronics, based on flexible technology. A first collaboration has been established with UCL. The main investigation focused on the influence of the electrostatic discharges on a polymer material. A second collaboration has been set up with the TUM, on the effect of the electrostatic discharge on an electronic skin called *CeLLuARSkin*, which was develop in TUM

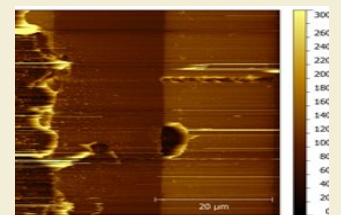


Figure: Damages caused on a polymer transistor by an ESD test

Main publications and awards

1. T. Lim, L. Santarelli, F. Cacialli, H. Gieser, "Electrostatic discharge sensitivity investigation on organic field-effect thin film transistors", 2015 IEEE 13th International New Circuits and Systems Conference, Jun. 2015.
2. T. Lim, P. Mittendorfer, F. Bergner, H. Wolf, G. Cheng, H. Gieser, "System-level Electrostatic Discharge Investigation of a Multi-modal, Modular Artificial Skin", 14. ESD-FORUM, Nov. 2015.

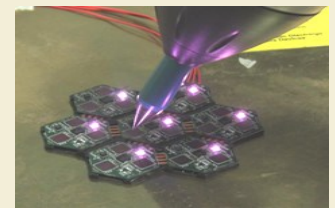


Figure: The electronic skin *CeLLuARSkin* during an ESD test

Nagarajan Palavesam



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Role:
Early Stage Researchers
ESR8

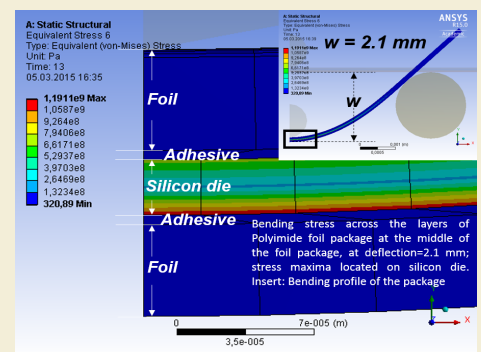
Nagarajan Palavesam received his B.Eng. degree in Electrical and Electronics Engineering from Anna University and International M.Sc. degree in Nanotechnologies for Integrated systems from EPFL, INP Grenoble and Politecnico di Torino. Since August 2013, he is a Marie Curie Researcher at Fraunhofer EMFT and he is working on his Doctoral Thesis at Dresden University of Technology.

Assembly on film substrates and reliability testing

The research work focuses on the development of new packaging technologies for components on flexible and stretchable film substrates as well as on reliability testing. The main results include: Experimental demonstration of increase in Fracture Strength of ultrathin Silicon chips due to embedding in flexible foil substrates; Increase in Fracture Strength supported and verified by numerical Finite Element Analysis (FEA); Critical Stress of ultrathin Silicon chips in flexible foil substrates calculated using FEA.

Main publications and awards

1. C. Landesberger, A. Drost, R. Faul, W. Hell, G. Klink, C. Kutter, N. Palavesam, S. Scherbaum, H.-P. Spöhrle; "New processing scheme for embedding and interconnection of ultra-thin IC devices in flexible chip foil packages." SEMICON Europa 2015 (Accepted).
2. N. Palavesam, C. Landesberger, C. Kutter, K. Bock; "Finite Element Analysis of uniaxial bending of ultra-thin Silicon dies embedded in flexible foil substrates." Microelectronics and Electronics (PRIME), 2015 11th Conference on Ph. D. Research in. IEEE, 2015.



INTRODUCING CONTEST RESEARCHERS

Imperial College of London, UK

The Human Robotics Group at Imperial (HRG), coordinated by **Prof. Etienne Burdet**, uses an integrative approach of neuroscience and robotics to investigate human motor control and to design efficient assistive devices and virtual reality based training for rehabilitation and surgery.

<http://www.imperial.ac.uk/>

**Imperial College
London**

Carlo Bagnato



Email: carlo.bagnato12@imperial.ac.uk

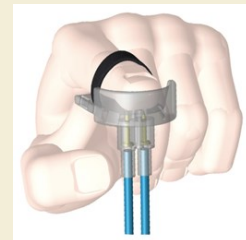
Role:

Early Stage Researchers
ESR11

Carlo received my BSc in Bioengineering from Polytechnic of Turin, and my MSc in Neuroengineering and Cognitive Sciences from University of Genoa. He joined CONTEST in March 2013; I am carrying out my research under the supervision of Professor Etienne Burdet at the Human Robotics Group of Imperial College London. As part of his training he spent a secondment at Shadow Robotics.

Handling of objects with close contact in humans

He is investigating the physiology of pain to develop computational models for artificial discrimination between noxious and innocuous contacts. He also carries out behavioural experiments on humans to shed light on typical motor responses to pain for robotic implementation. Understanding the mechanisms of pain can give insight into the implementation of artificial pain for robots. Identification of noxious contacts could help robots elicit appropriate reactions to avoid or minimise damage to the robot and the environment.



Left: A PC-controlled MR-safe pneumatic system



Right: Functional MR image

Main publications and awards

These concepts will be presented at the 37th Annual International Conference of the IEEE Engineering in Medicine and Biology Society this September; journal publications on these topics are in preparation.

Shadow Robot Company, London-UK

Shadow Robot company designs and manufactures state-of-the-art anthropomorphic robot hands & related systems. The Shadow Dexterous Hand is sold globally and is used by clients in cutting edge research and industry.

<http://www.shadowrobot.com/>



Matjaž Ogrinc



Email: matjaz@shadowrobot.com

Role:

Early Stage Researchers
ESR12

Matjaz obtained his University Diploma in Electrical Engineering from University of Ljubljana in November 2012. He joined the ITN in August 2013 as a researcher with Shadow Robot Company and Imperial College. He obtained his MR degree in Bioengineering in October 2014. He is working with Prof. Burdet's group in the field of haptics and sensory substitution. He is also active in Shadow's collaborative work on pressure and proximity sensing.

Skilful object manipulation and adaptive haptic exploration

He is investigating a technique for creating haptic stimuli using a series of vibrating motors (tactors). The perception of spatio-temporal varied vibrotactile stimuli using an array of motors was evaluated by carrying out psychophysical experiments. He found that spatio-temporal variations improve the discrimination of stimuli compared to vibration amplitude variations alone. The developed interface will enable future experiments on sensory substitution and illusions with applications in telerobotics and spatial awareness. He has been testing the interface as a feedback device for rendering interaction forces while operating tools and manipulating objects.

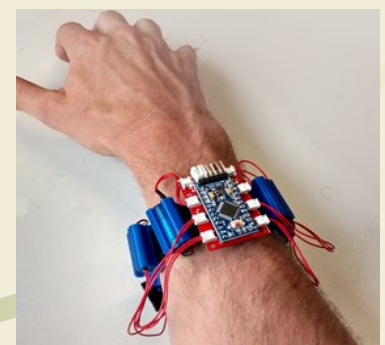


Figure: Vibrating motors on the wrist

QUOTES

In this Marie Curie ITN fellowship, I expected to get training on design of POSFET sensors, CMOS fabrication, and wafer thinning, and testing of sensors. I also expected to meet the experts in these fields and develop good network. Until now, I have received hands-on training on many CMOS fabrication steps including wafer thinning. .. In the meanwhile, I attended summer school, workshops and conferences very relevant to my field of work. In coming months, I will be entering the clean room for the fabrication of the chips and will be doing electrical and mechanical characterization.

Shoubhik Gupta

Marie Curie ITN program provided me with an exceptional opportunity to work with top researchers in the field of tactile sensing which brings high impact in my future scientific career.

Mohsen Kaboli

The ITN-CONTEST project provided me with an excellent opportunity to develop my knowledge in my area of research and also improve my interpersonal skills. Furthermore, unlike the general PhD ITN gave me an opportunity in gaining experience ranging from an academic to industrial experience through secondments.

I hope to further enhance my interpersonal skills and networks in future by collaborating with various partners within the network.

Nivasan Yogeswaran

I expect to gain a comprehensive knowledge of carbon-based organic materials including the physical background, process technology and integration technology with present electronic design and MEMS fabrication technologies. The CONTEST INT project provides me the opportunity to be in collaboration with researchers with variant background. Also, by arranging conferences and summer schools, the project offers me a lot of opportunities to present my work and discuss my research with peers all over the world. In the future, I hope to enhance my problem solving skills with the help of further trainings.

Wenting Dang

From the ITN, the main experience was to be able to build up some collaborations: understanding the expertise of scientists of another field and trying to find a common area of work. The Marie Curie ITN is a unique opportunity to develop a network and to visit through the different secondment periods the other institutions.

Lim Tekfouy

The ITN has provided me the magnificent opportunity to comprehend and conduct interdisciplinary research with top-notch researchers in various disciplines from Academia as well as Industry. The expertise and experience I have acquired from the interactions with them have helped me hone both my research and interpersonal skills. I am forever indebted to the European Commission and Fraunhofer EMFT for supporting me during these pivotal years, thus founding the bedrock on which my research career will be built.

Nagarajan Palavesam

Being part of CONTEST ITN gives me the possibility to work within a network of top organizations and interact with both universities and companies. The multidisciplinary approach of this network together with the valuable training aimed to improve communication and scientific skills, provided by my host organization, are proving fundamental to my career development.

Carlo Bagnato

Being part of an international project, such as CONTEST, enormously improves the skills of researchers involved. Furthermore, this experience provides an important professional network that opens interesting partnerships between different research groups and institutes.

Luca Santarelli



Marie-Curie ITN project has provided an excellent opportunity to excel my capabilities as a researcher and gave me a chance to grow my career in a very positive and progressing way.

It is an effective platform to meet and network with the experts in the similar field of research and creating a good professional career. The various opportunities to explore and travel to attend the conferences not only provide the technical knowhow but also beneficial for development of the soft skills. In my opinion, Marie Curie ITN covers all the career development aspects and is the ideal program amongst the available list of such schemes. It has provided me a strong basis where I can build upon my career and I will continue my research activities in a more professional and effective way by contesting for the individual Marie Curie fellowship in the next phase.

Salcem Kahn

The ITN has given me an opportunity to improve my research skills and join an experienced and established group of researchers in a very interesting field. By being part of Shadow Robot and working in the academic environment of Imperial College, I'm gaining valuable knowledge and connections for my future career.

Matjaž Ogrinc

CONTEST SUMMER SCHOOLS

Summer School 2013, 11-13 September. Catania, Italy

"Flexible Sensors and Electronics - Materials Methods & Technologies"

The summer school on materials, methods and technologies for flexible electronics dealt with the latest developments in the area of flexible and bendable electronics. In particular, various materials (e.g. organic/inorganic), methods (e.g. flexible PCBs), and technological approaches (e.g. printing) for flexible electronics were discussed. The summer school offered an outstanding international representation of developers of flexible electronics technologies and users of the exciting new solutions



Summer School 2014, 26-28 May. Fraunhofer EMFT, Germany

"System integration"

The 2014 Summer School was held in Munich, Germany during 26-28 May 2014. This year the summer school was organized by CONTEST network jointly with Olimpia ITN (<http://www.olimpiaproject.eu/>) and the NSF-Eager project. The summer school was open for all students.



Summer School 2015, 18-22 May. Lille, France

"Human sensing and applications to robotics and haptic displays"

The Summer School 2015 was organised at Université Lille 1 (France) and sponsored by ITN PROTOTOUCH and CONTEST project. The school enabled interested students and researchers to learn from all modalities of biological sensing with the opportunity to network and present their research at the poster sessions.



CONTEST DISSEMINATION

Organized events

- **2012-Taiwan**
Workshop on bendable sensors and systems
- **2015 Busan, South Korea**

IEEE sensors



- **2015-Trento**
Workshop "Towards bendable systems"

AISEM



- **2014-Grenoble**
Special Session on Sensors on Flexible Substrates
- **2015 Glasgow**

IEEE PRIME



- **2015-Rome**
Special session on conformable electronic and e-skin

IEEE NANO



- **2013-Karlsruhe**
Workshop on "Research Frontiers in Electronic Skin Technology: Multifunctional Bendable and stretchable electronic skin for robots and beyond".

ICRA



- **2015-Munich**
Organized by fraunhofer EMFT to discuss the development of thin semiconductor devices and flexible electronic systems since the year 2000.

be-flexible forum



Prizes and awards



E. Cagatay was awarded "gold leaf" at PRIME 2014



W. Dang and E. Ozan Polat received the "Silver leaf award" at PRIME 2015



N. Palavesam received Excellent Poster Award for Young Scientist in SIITME 2014

Outreach events

- **November 24 2014** ICS-TUM presented Nao Robots at the at Deutsches Museum München.
- **May 10 2015** ICS-TUM demonstrated Nao robots at the Kunstareal Festival in the museum Pinakothek der Moderne.
- **September 25 2015** Contest will be preseted at the European researcher night 2015
- **2015** Presentation in "Impression of the Future Council of the Bavarian Conference" with the president of Bavaria-Germany
- **2015** Presentation in Munich Center for Technology in Society



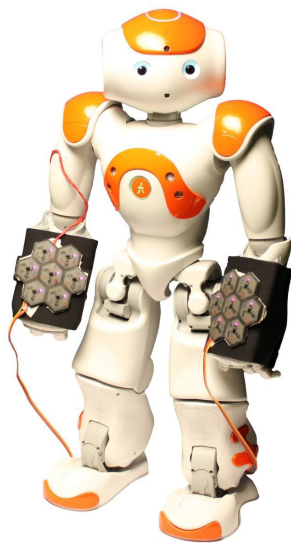


Image of Nao Robot with
Hex-o-Skin (courtesy TUM)



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