Percorso Autonomo Autorizzato

Title (Titolo)	**Computational models in electronics and biomathematics (CMEB) (Modelli computazionali in elettronica e biomatematica)**
Chief (Referente responsabile)	· DMAT, PoliMi: prof. Riccardo Sacco
Supporting Coordinators (Altri referenti)	· DMAT, PoliMi: prof. Maurizio Verri · Micron Technology Italia: dr. Aurelio G. Mauri
Scientific collaborations and partnerships (Collaborazioni scientifiche nazionali ed internazionali)	· Department of Mathematical Sciences and School of Medicine, IUPUI, Indianapolis, IN, USA: prof. Giovanna Guidoboni, prof. Alon Harris, dr. Lucia Carichino, Daniele Prada e Simone Cassani · Department of Mathematics and Advanced Mathematics Research Institute (IRMA), University of Strasbourg, France: prof. Christophe Prud'homme, dr. Marcela Szopos, prof. Giovanna Guidoboni, dr. Lorenzo Sala · Department of Physiology & Biophysics, Rush University Medical Center, Chicago, IL 60612, U.S.A.: prof. Robert S. Eisenberg · Department of Mathematics, North Carolina State University, Raleigh, NC, USA: prof. Lorena Bociu · Dept. of Mathematics, Northwestern University, Evanston IL, USA: prof. Joseph W. Jerome (presently at George Washington University, Washington D.C.) · School of Mathematics, University of Minneapolis, Minneapolis MN, USA: prof. Bernardo Cockburn, PhD., M.D. Yoichiro Mori · Modeling and Simulation Group, Micron Technology, Vimercate (MB), Italy: dr. Aurelio G. Mauri, dr. Claudio Lombardi, dr. Chandra Mouli · CNST@PoliMi: prof. Guglielmo Lanzani, dr. Maria Rosa Antognazza · IIT, NBT / Neuro Technology , Genova: dr. Thierry Nieus, dr. Francesco Di Fato · DEIB, PoliMi: prof. Marco Sampietro, prof. Dario Natali · CNR, Ist. di Neuroscienze. Divisione di Farmacologia Cellulare e Molecolare, Milano: prof. Bice Chini · Dipartimento di Matematica, Università degli Studi di Milano: prof. Giovanni Naldi, prof. Paola Causin, prof. Giacomo Aletti
Description and goals (Descrizione ed obiettivi)	Electronic and biological systems share unexpected structural similarities that make them amenable to a unified mathematical and numerical treatment. As a matter of fact, transmembrane ion flow regulating the functional response of a neuronal or a cardiac cell, as well as the motion of electric charge transporting current in a nanoscale-sized transistor, obey the *same* phenomenological description, the so-called *Nernst-Planck* transport model (in Biology) and the *Drift-Diffusion* transport model (in Electronics). Under this unifying perspective, the programme of studies in CMEB has the objective of providing the common mathematical and computational foundations to modeling and simulation of specific problems in cellular biology and solid-state electronics, the final scope being to couple the two classes of problems in the study of bio-hybrid devices in which *both* components (cellular and solid-state) coexist in a dynamically interacting operating mode. This final goal reflects the state-of-the-art in modern Neuroscience and represents an original attempt to confront the student with the frontiers of research in Life Sciences of our times.
Study Plan (Piano di studi	The programme of studies in CMEB belongs to the Major in "Computational Sciences" with additional foundations in quantum theory, solid state physics in electronic devices and their application in Life Sciences. The list of courses can be found in a separate document.
Past MSc theses (Alcune Tesi discusse)	· M. Favino, *Mathematical modeling and numerical simulation of third generation solar cells*, 2009 · D. Colombo, *Un modello matematico per la simulazione della crescita di biomassa in Ingegneria dei Tessuti*, 2010

	· M. M. Cogliati and M. Porro, *Third generation solar cells: modeling and simulation*, 2010 · L. Carichino, *Computational models for power electronics cooling systems*, 2010 · A. Sacconi, *Elementi Finiti Discontinuous Galerkin Ibridizzabili per problemi ellittici in 3D*, 2011 · D. Prada, *Multiobjective optimization for parameter extraction of power electronic devices*, 2012 · G. Novielli, *Numerical models for mass transport in phase change materials*, 2013 · S. Sorbello, *Electro-thermal computational modeling for 3D heterogeneous memory devices*, 2013 · F. Manganini, *Thermo-Electro-Chemical Modeling and Simulation of Ion Transport in Nanochannels*, 2013 · S. Terragni, *Poroelastic Computational Modeling of Biological Tissues: Application to the Mechanics of the Eye* , 2013 · E. Abbate, *Hierarchical Multiscale Modeling and Simulation of Bio-Electronic Interfaces*, 2014 · A. Bortolossi, *3D Finite Element Drift-Diffusion Simulation of Semiconductor Devices*, 2014 · Giada Guaraldi, *3D Thermo-Mechanical Models for Applications in Nanoelectronics*, 2014 · Paolo Airoldi, *3D Velocity-Extended Poisson-Nernst-Planck Model for Biological and Electronics Applications*, 2014 · Stefano Pellegrini, *Monotonicity-Preserving Finite Element Schemes for Convection-Diffusion Equations*, 2014 · Elisa Pirovano, *Ion Electrodiffusion for Calcium Dynamics in Myocytes*, 2014 · Alessandra Cardani, *Theoretical Analysis of Neurovascular Mechanisms Contributing to Retinal Blood Flow Regulation,* 2015 · Lorenzo Sala, *A Cellular Scale Model of Aqueous Humor Production,* 2016 · Claudio Tribbia, *3D Transient Drift-Diffusion Simulation of Semiconductor Devices in Presence of Impact Ionization*, 2016 · Andrea Parini, *Dual-Mixed Hybridized Approximation of Parabolic Problems in Domains with Active Interfaces*, 2017
Available subjects for a MSc thesis (Tesi disponibili)	· *Multi-physics models in 3D for the simulation of memories in Nanoelectronics* · *Multi-physics 0D-1D-2D-3D models for the simulation of: mass transport, fluidmechanics, electrochemistry and neurovascular coupling in the eye and the brain* · *Mechanophysiological models in regenerative medicine* · *Advanced discontinuous and hybrid discretization finite element methods for PDEs*
Internships (Tirocini)	· L. Carichino: 6-month internship at ABB Switzerland Corporate Research, CH-5405 Baden-Dattwil, Aargau Switzerland, 2010; title: *Simulation development for thermal systems* · D. Prada: 9-month internship at ABB Switzerland Corporate Research, CH-5405 Baden-Dattwil, Aargau Switzerland, 2011; title: *Lumped models for high-voltage power devices* · G. Novielli: 9-month internship at Micron Technology, Agrate Brianza (MB); 2012-2013; title: *Physically-based model of chalcogenide alloy electromigration for phase change material engineering and optimization* · S. Sorbello: 9-month internship at Micron Technology, Agrate Brianza (MB); 2012-2013; title: *Thermal and electronic modeling for carrier and material transport using Mixed Element methodology* · A. Bortolossi*:* 7-month internship at Micron Technology, Agrate Brianza (MB); 2014; title*:3D Finite Element Drift-Diffusion Simulation of Semiconductor Devices* · G. Guaraldi*:* 10-month internship at Micron Technology, Agrate Brianza (MB); 2014; title*: 3D Thermo-Mechanical Models for Applications in Nanoelectronics* · P. Airoldi: 10-month internship at Micron Technology, Vimercate (MB); 2014-2015; title*: 3D Poisson-Nernst-Planck Model for Biological and Electronics Applications* · S. Cassani: 1-month internship at Micron Technology, Vimercate (MB); 2015; title*: Boundary Conditions for 3D Poisson-Nernst-Planck Models for Biological and Electronics Applications* · *F. Vaccaro: 9-month internship at Micron Technology, Vimercate (MB); 2016-2017; title: Modeling of tunneling and charging dynamics*

Job opportunities (Sbocchi lavorativi)	Companies and research laboratories in the areas of Electronics (semiconductor memories, integrated circuits), Renewable Energy (solar cells) and Biotechnology (biosensors, bio-compatible prostheses, regenerative medicine, lab-on-chips, bio-hybrid interfaces)