Applied electrochemistry: from nanomaterials to energy storage

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The seminar covers different aspects of applied electrochemistry.

The first part is dedicated to the synthesis and characterization of nanowires and their applications in the electronic field. In particular, it focuses on the electrochemical synthesis and characterization of metal/oxide/metal (MOM) nanowire (NW) heterostructures. MOM heterostructures show a peculiar electrical resistive switching behavior and could be used as building block for future high density non-volatile random access memory (ReRAM).

The second part explores energy storage world, discussing graphene and its applications in the fabrication of electrodes for supercapacitors. Emphasis will be pointed out on the scale-up processes from laboratory to industrial scale for the production of high-performance graphene based supercapacitors.

Then, the presentation investigates the current development of a new market segments made of implantable medical devices, such as defibrillators and neural stimulators, “smart” cards, radio frequency identification, or RFID, tags and wireless sensors. All of these devices require an energy storage source to work, but in spite of traditional portable devices (for example laptop, smartphone, etc.), their energy needs are order of magnitude lower. Li-ions solid-state microbatteries can serve as ideal power sources for a variety of miniaturized applications such as environmental sensing, RFID tags, smart cards, Internet of Things (IoT) devices, and even micro-spacecraft. Many more applications can be possible when microbatteries are directly integrated with electronic circuitry rather than placed separately on a PCB board.
The last part of the talk serves as an overview on thin-film Li-ion microbatteries: in particular the attention is given to the cathode active material ($LiCoO_2$ and V_2O_5 thin-film), stress-evolution in anode material (Si and Ge thin-film), and to the design and fabrication of a high-capacity thin-solid film Li-ion microbattery prototype.

Daniele Perego received his bachelor degree in Materials Engineering at Politecnico di Milano in September 2008 and his master degree in Materials Engineering and Nanotechnology at Politecnico di Milano in December 2010. During this period his work has been devoted to the electrochemical synthesis of nanomaterials for data storage (*i.e.*, ReRAM memories). After that (2013) Daniele received Ph.D. in Materials Engineering at Politecnico di Milano; he spent one year of his Ph.D. program at Massachussetts Institute of Technology in Cambridge (MA – USA). The Ph.D. program covered energy storage topic both in terms of graphene based supercapacitors and thin-film solid-state Li-ion microbatteries. On January 2014 Daniele joined FIAMM SoNick, a Swiss company manufacturing Sodium-Nickel Chloride batteries, in R&D department as ceramic process engineer. Then, on January 2015, Daniele moved to Singapore joining Singapore-MIT Alliance for Research and Technology (SMART) program within LEES (Low-Energy Electronic Systems) IRG as Associate Postdoc. Currently he is the battery sub-group leader working on the development of thin-film solid-state Li-ion microbatteries.