Novel Nanomaterials for Organic Photovoltaics

Abstract

Organic solar cells based on conducting polymers have been developing over the past twenty years, but it is only in the last decade that they have attracted scientific and economic interest because of a rapid increase in performance with a new world record of 12% efficiency in 2013 [1].

The use of carbon nanomaterials in organic solar cells is increasing because of the ease of production and low cost of materials. Carbon nanotubes have been proposed for organic solar cells as electrodes [2, 3] or in order to replace the fullerenes as an acceptor material [4, 5]. The recent discoveries of the electronic and optical properties of the graphene and graphene oxide have made them the latest novel materials for organic solar cells [6, 7]. In 2012, an efficiency of 1.3% was achieved with a solar cell containing an active layer composed of only carbon nanomaterials [8] and an efficiency of 0.1% was achieved with a solar cell made entirely of carbon nanomaterials [9].

Not only carbon nanomaterials but also recent discoveries of the strong interaction between the light and small metallic structures are already influencing the research in the solar cell field. The idea is to include these structures inside an organic solar cell without compromising the architecture and the cost. Research groups around the world are demonstrating how it is possible to boost the performance of the organic solar cells by incorporating metallic nanoparticles with a resulting increase in the efficiency of up to 30% compared to the standard efficiency of an organic solar cell [10, 11].

Nanomaterials of this kind can generate a number of important physical effects, opening up new avenues in the photovoltaics field. For this reason, it is important to investigate the electronic properties of these materials in the organic solar cells to understand if they can be the right candidates for the new generation of organic solar cells.

Specifically, we are investigating the electronic properties of doped and bulk graphene oxide, graphene and gold nanoparticles by combining microscopy studies (AFM, TEM, UHV-STM, KPFM, SEM), spectroscopy studies (UPS, XPS, UV-Vis) and electrical studies in order to understand how these materials can be incorporated into the organic solar cells and into which step of the fabrication process. We are also fabricating and testing devices with these novel materials focusing on understanding how they influence the performance of the organics solar cell from an electrical and physical point of view.

References

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Biography

Marco Notarianni received his Bachelors degree with full marks in Electrical Engineering in 2008 from The University of Rome "La Sapienza". He obtained his Masters degree with summa cum laude in Nanotechnology Engineering from the same university in 2010. In order to complete his Masters degree, he spent six months in Professor Matteo Pasquali's group at Rice University in Houston, Texas, as a Visiting Researcher and four months at the Minas Lab at The University of Rome "Tor Vergata". In this period, he worked on the synthesis, morphological and electronic characterizations of carbon nanotube fibers for field emission applications. In January 2011, he moved to Miami, Florida to work as a Solar Design and Sales Engineer for Sunelectronics International. As a Solar Design and Sales Engineer, Marco designed and sold nearly half a million dollar of photovoltaic systems for commercial and residential applications all around the world with a specific focus in the Caribbean market.

He moved to Brisbane, Australia in March 2012, where he joined the group of Professor Nunzio Motta at Queensland University of Technology (QUT) as a PhD student. Currently, he is studying the electronic properties of novel nanomaterials such as graphene, graphene oxide and gold nanoparticles for organic photovoltaics. As a part of his PhD work, he is co-teaching and tutoring an energy course for undergraduate students and an advanced materials course for graduate students.

List of Publications

1. **M. Notarianni**, K. Vernon, A. Chou, M. Aljada, N. Motta, "Au nanoparticles grown on ITO: enhanced performance of a bulk heterojunction solar cell" (in preparation)
2. **M. Notarianni**, B. A. Chambers, G. Andersson, D. Galpaya, J. Liu, C. Yan, N. Motta, "XPS and UPS studies of nitrogen doped and bulk graphene oxide at different annealing temperatures" (in preparation)
3. J. Liu, V.T. Tiong, H. Wang, **M. Notarianni**, N. Motta, "Electrochemically exfoliated graphene for transparent conducting films: effect of graphene flake thickness on the sheet resistance", *Nanotechnology,* submitted
4. L. Persichetti, A. Capasso, A. Sgarlata, A. Quatela, S. Kaciulis, A. Mezzi, **M. Notarianni**, N. Motta, M. Fanfoni, and A. Balzarotti "Fabrication of SiGe rings and holes on Si(001) by flash annealing" *Applied Physics Letters*, submitted

5. V. Guglielmotti, E. Tamburri, S. Orlanducci, M. L. Terranova, M. Rossi, **M. Notarianni**, S. B. Fairchild, B. Maruyama, N. Behabtu, C. C. Young, and M. Pasquali, "Macroscopic self-standing SWCNT fibres as efficient electron emitters with very high emission current for robust cold cathodes", *Carbon,* vol. 52, pp. 356-362, 2013.
6. M. Salvato, M. Lucci, I. Ottaviani, M. Cirillo, E. Tamburri, S. Orlanducci, M. L. Terranova, **M. Notarianni**, C. C. Young, N. Behabtu, and M. Pasquali, "Transport mechanism in granular Ni deposited on carbon nanotubes fibers", *Physical Review B - Condensed Matter and Materials Physics,* vol. 86, 2012.