

High Performance Supercapacitor Electrode from Conducting Polymer/Graphene Composite

Won Ho Jo, Kyung Tae Kim, Jin Woo Lee

Department of Materials Science and Engineering, Seoul National University, Seoul 151-744, Korea

Abstract: Among various energy storage devices, lithium ion batteries (LIBs) and supercapacitors are at the most effective and forefront one. Although LIBs achieve the power energy density as high as 180 Wh/kg, they suffer from a slow power delivery or uptake. Hence, the energy-storage devices which require fast and higher power storage need to develop another storage device, i.e. supercapacitor. In this study, a water-soluble conducting polymer, poly(styrene sulfonic acid)-*graft*-polyaniline (PSSA-*g*-PANI), was synthesized and used to directly exfoliate graphite into graphene layers in aqueous media, because PANI in PSSA-*g*-PANI is strongly physisorbed onto graphene surface via strong π - π interaction while PSSA in PSSA-*g*-PANI enhances water solubility (Bae *et al.*; 2003). Hence, PSSA-*g*-PANI is expected to exfoliate directly graphite into graphene layers and thus to disperse effectively the layers in aqueous media. As a consequence, PSSA-*g*-PANI/graphene composite films are easily fabricated by a solution process and used for supercapacitor electrode. The capacitances of the composites depend upon the length and composition of PANI in PSSA-*g*-PANI. When the capacitances of the composites with different PSSA-*g*-PANIs (different ratio of aniline (ANI) to styrene sulfonic acid (SSA) in polymer) were measured by cyclic voltammetry and Galvanostatic method, the composite with the ratio of ANI/SSA (50/50) in PSSA-*g*-PANI exhibits the highest specific capacitance of 820 F/g and 850 F/g when the capacitance was measured by cyclic voltammetry at a scan rate of 50 mV/s and Galvanostatic curve at a current density of 0.5 A/g, respectively, which are among the highest values of EDLC type

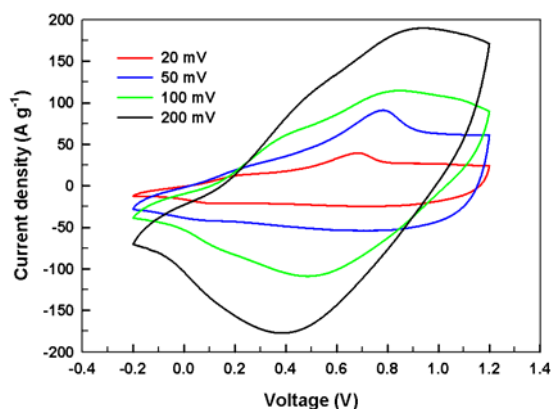


Figure 1: Cyclic voltammetry curves of PSSA-*g*-PANI/graphene composites at various scan rates.

supercapacitor, and the composite also shows superior cycle life with 90% retention of the initial specific capacitance after 1000 cycles as compared to pseudo supercapacitor (Lee *et al.*; submitted).

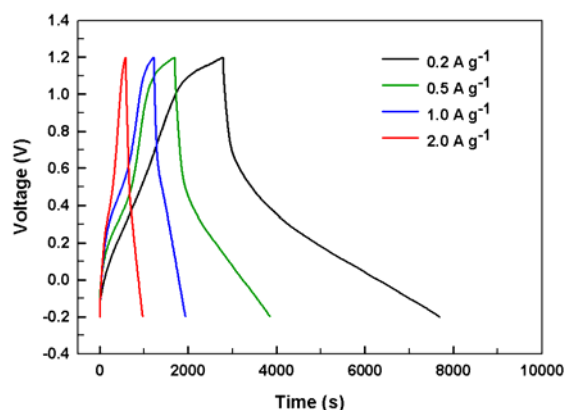


Figure 2: Galvanostatic charge-discharge curves of PSSA-*g*-PANI/graphene composite at current density from 0.2 to 2.0 A/g.

Keywords: conducting polymer, poly(styrene sulfonic acid)-*graft*-polyaniline, composite, supercapacitor.

References:

- Bae, W.J., Kim, K.H., Park, Y.H., Jo, W.H. (2003), A novel water-soluble and self-doped conducting polyaniline graft copolymer, *Chem. Commun.*, 2768-2769.
- Lee, J.W., Jo, J.W., Lee, J.U., Kim, K.T. Jo, W.H. (2015), Conducting polymer/graphene composite for supercapacitor, submitted for publication.



Scientific Program

Advanced Materials

World Congress

www.vbripress.com/amwc

Venue : Baltic Sea
(Stockholm-Helsinki-Stockholm)

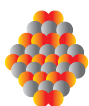
on

Viking Line Cruise, Stockholm, Sweden
23-26 August 2015

Organised and sponsored by



IAAM
International Association of Advanced Materials



VBRI Press
a rapid publication platform

li.u LINKÖPING
UNIVERSITY



sensors



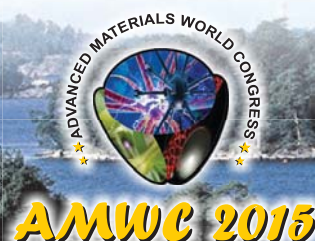
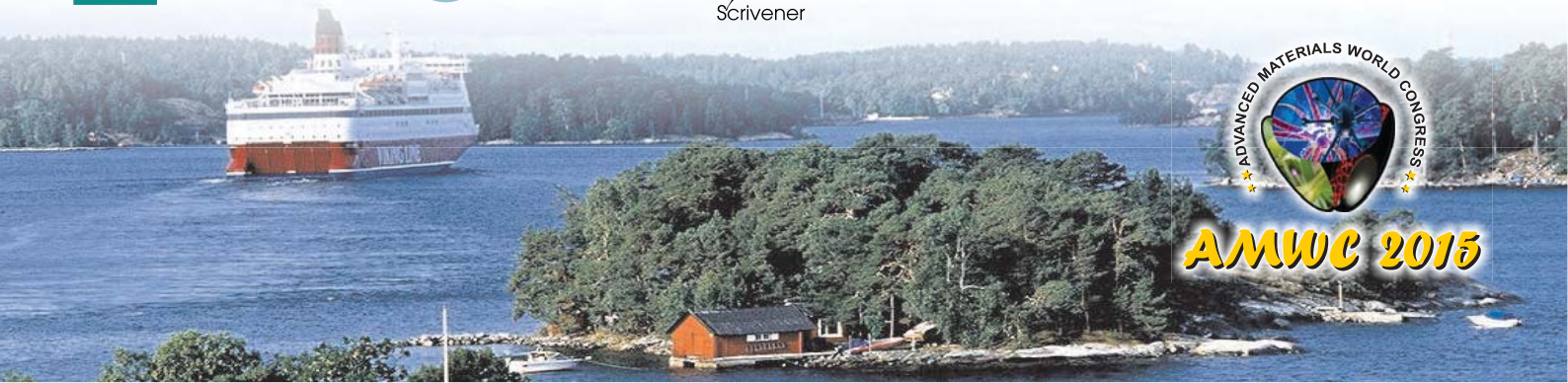
SETCOR
Conferences & Events



Scrivener

simpleware

TEKIDAG
Intelligent technology



24th August, Monday (Day - 2)

- 06.30-08.00 Sea Breakfast, Deck 7
 08.00-08.30 Poster Setup, Venue: Conference Centre, Deck 8
 08.30-10.00 Main Session, Venue: Seaside Auditorium, Deck 7
 08:30-09:15 Felicitations and Award Ceremony by IAAM bearers - Hisatoshi Kobayashi and Ashutosh Tiwari
 09:15-10:00 Advanced Materials Award Lecture: Kazunori Kataoka, Japan - Supramolecular nanosystems from functionalized block copolymer for smart targeted therapy of intractable diseases
 Chair: Anthony P. F. Turner, Sweden
 10.00-10.30 Coffee Break and Poster Session, Venue: Conference Centre, Deck 8
 10.30-12.00 Parallel Sessions 1-2-3-4, Venue: Conference Centre, Deck 8

Session I	Session II	Session III	Session IV
Venue: Auditorium Marina A	Venue: Auditorium Marina B	Venue: Seaside Auditorium A	Venue: Seaside Auditorium B
Nanomaterials and Nanotechnology	Biomaterials and Biodevices	Environment and Green Materials	European Graphene Forum
Chair: Xixiang Zhang, Saudi Arabia Co-chair: Byeong-Soo Bae, Korea 10.30-10.50 - IAAM Scientist Award Lecture: Xuemei Wang, China - Ultrasensitive in vivo bio-imaging of cancers based on novel nanoscaled probes 10.50-11.10 - Invited Lecture: Furong Tian, Ireland - Surface enhanced raman scattering with gold nanostar as an early diagnostic tool for oral cancer 11.10-11.30 - Invited Lecture: Haruhisa Kato, Japan - Characterization of secondary nanoparticle structure using pulsed field gradient nuclear magnetic resonance 11.30-11.45 - Oral: Ulviya Bunyatova, Turkey - Multifunctional PVA/ODA-MMT-poly (MA-alt-1-octadecene)-g-graphene oxide e-spun nanofiber semiconductors and their response to bone cancer cells 11.45-12.00 - Oral: Yongmei Zheng, China - Bioinspired multi-gradient surfaces with smart wettability for water collection/repellency	Chair: Ales Iglcic, Slovenia Co-chair: Bora Garipcan, Turkey 10.30-10.45 - IAAM Scientist Award Lecture: Yasushi Tamada, Japan - Changes of the outermost surface of silk fibroin films by ethanol treatments 10.45-11.00 - Oral: Mehrdad Rafat, Sweden - Rational development of a bioengineered carbon nanotube-reinforced cardiac patch 11.00-11.15 - Oral: Laura Cordoba, Portugal - Hybrid bi-layered multifunctional coatings to control biodegradation of commercial Mg alloys 11.15-11.30 - Oral: Masaya Yamamoto, Japan - Design of a sugar-responsive sacrificial template to create cell scaffolds with vascularized channel structures 11.30-11.45 - Oral: Krishna Bisetty, South Africa - Construction of chymotrypsin and L-amino acid oxidase dual enzyme based biosensor for the detection of neotame 11.45-12.00 - Oral: Yuichi Ohya, Japan - Functionalization of biodegradable polymeric micelles by coating with polyion complex	Chair: Ingemar Lundstrom, Sweden Co-chair: Chee Wee Liu, Taiwan 10.30-10.45 - Oral: Sanhita ray, India - Green immobilization of graphene using biofilms 10.45-11.00 - Oral: Dai Yaodong, China - Nuclear emergency wastewater treatment with prussian blue / carbon nanotube sponge absorbing material and performance 11.00-11.15 - Oral: Ana Marta-nez-Hernandez, Mexico - Membranes based on polyurethane and keratin materials obtained from chicken feathers to remove Cr (VI) of water 11.15-11.30 - Oral: Manoj Pandey, India - Copper and iron exchanged montmorillonite clay: A promising catalyst for benzoyloxylation of N,N-Dimethylaniline 11.30-11.45 - Oral: Arenst Andreas Arie, Indonesia - Activated carbons from KOH activation of salacca peels as low cost potential adsorbents for dye removal 11.45-12.00 - Oral: Parag Nimishe, India - Photoluminescence study of novel LiLa (WO ₄) ₂ :Pr ³⁺ red emitting phosphor for eco-friendly LEDs	Chair: Ashutosh Tiwari, Sweden Co-chair: Jannie Swarts, South Africa 10.30-10.40 - Opening remarks by EGF chairmans - Prof. Ashutosh Tiwari and Prof. Mikael Syväjärvi 10.30-11.00 - Keynote Lecture: D. Kurt Gaskill, USA - Applications driven development of graphene for sensors 11.00-11.30 - Keynote: Aleksandr Lebedev, Russia - Epitaxial graphene grown on 6H-SiC (0001) substrate: size confinement effect 11.30-11.45 - Oral: Byeong-Ju Park, Korea - Wrinkle-free monolayer graphene transferred onto the Ti adhesion layer 11.45-12.00 - Oral: Chong-yun Park, Korea - Fabrication and characterization of graphene transistor with gate dielectrics of h-BN/graphene/h-BN structure 12.00-12.15 - Oral: Gao Feng Zeng, China - Sharp dehydration of alcohols over graphene oxide framework (GOF) hybrid membrane

12.00-13.20 Lunch to the restaurant "Buffet", Deck 7

13.30-15.30 Sightseeing to Helsinki
Parliament Building, Museum of Modern Art
The stunningly designed Rock Church
Olympic Stadium from the 1952 games
Helsinki Lutheran and Uspenski Orthodox Cathedrals

15.30-16.30 Coffee Break and Poster Session, Venue: Conference Centre, Deck 8

16.30-19.30 Parallel Sessions 1-2-3-4, Venue: Conference Centre, Deck 8

Session I	Session II	Session III	Session IV
Venue: Auditorium Marina A	Venue: Auditorium Marina B	Venue: Seaside Auditorium A	Venue: Seaside Auditorium B
Nanomaterials and Nanotechnology	World Technology Forum	Structural, Constructional and Engineering Materials	European Graphene Forum
Chair: Debes Bhattacharyya, New Zealand Co-chair: R. Vasant Kumar, UK 16.30-17.00 - Keynote Lecture: Li-Chyong Chen, Taiwan - Graphene oxides and their nano-hybrids with metals and metal sulfides for solar fuels and CO ₂ conversion 17.00-17.15 - Oral: Yimin Chao, UK - Effects of ligand doping on the electrical conductivity of organic-silicon nanocomposite materials based on terphenylene capped silicon nanoparticles 17.15-17.30 - Oral: Sandra Noehren, Germany - Structural characterization of Si microwire anodes by in-situ synchrotron radiation 17.30-17.45 - Oral: Xiaodan Hu, China - The synthesis and characterization of Fe ₃ O ₄ /bentonite nanocomposite 17.45-18.00 - Oral: Kaho Kamada, Japan - Control of charging energy in carbon nanotube single electron transistor by electric-double-layer gate with ionic liquid 18.00-18.15 - Oral: Hyung-Jin Choi, Korea - Finding of new materials for both electromagnetic shielding and antibacterial effect using multi-layer thin films 18.15-18.30 - Oral: Yoko Matsuzawa, Japan - Reversible tuning of solubility of single-walled carbon nanotubes using a photofunctional dispersing agent 18.30-18.45 - Oral: Evgen Prokhorov, Mexico - Determination of optimum concentration of conductivity nanoparticles in polymer nanocomposites 18.45-19.00 - Oral: Danushika Manantunga, Sri Lanka - Facile synthesis and characterization of natural polysaccharide hydroxyapatite nanobiocomposite 19.00-19.15 - Oral: Alexander Schoth, Germany - Tailoring the structure of polymer/inorganic hybrid nanomaterials 19.15-19.30 - Oral: Naoki Toyama, Japan - Control of pore size of hollow silica-alumina composite spheres prepared using L(+)-arginine and their activity for hydrolytic dehydrogenation of ammonia borane	Chair: Anthony P. F. Turner, Sweden Co-chair: Jiuzhou Zhao, China 16.30-17.00 - Keynote Lecture: S. J. Dhole, India - Synthesis of power saving materials for near UV excited LED applications 17.00-17.20 - Invited Lecture: Biplab Paul, Sweden - Tailoring electronic and phononic properties: Towards ideal thermoelectricity 17.20-17.40 - Invited Lecture: Yasushi Iwata, Japan - EELS imaging studies for the electronic states of silicon cluster superlattice 17.40-18.00 - Invited Lecture: Pramod Kumar Jain, India - Improvement of durability of hot mix asphalt by chromium containing solid wastes from leather industry 18.00-18.15 - Oral: Rui Wang, China - Bamboo charcoal/Fe ₃ O ₄ -KNO ₃ composite as efficient and recoverable catalyst for biodiesel production 18.15-18.30 - Oral: Hiroshi Endo, Japan - Bioinspired multifunctional wrinkle surface 18.30-18.45 - Oral: Rafael Torres Mendieta, Spain - Fabrication of high stable gold nanofluid by pulsed laser ablation in liquids 18.45-19.00 - Oral: Jagriti Narang, India - Electrochemical impedimetric detection of anti-HIV drug taking gold nanorods as a sensing interface 19.00-19.15 - Oral: Nitika thakur, India - Effect of organic manures and biofertilizers in combination with technological intervention through different systems of cultivation on quality attributes of tomato (cv. <i>Solan lalima</i>) grown under mid-hill conditions of Himachal Pradesh 19.15-19.30 - Oral: Wu Weite, Taiwan - Effects of different refining slag and CaO content on desulfurization and dephosphorization during steelmaking process	Chair: Rosario Gerhardt, USA Co-chair: Koushik Biswas, India 16.30-17.00 - Keynote Lecture: Istvan Halasz, USA - Elucidating causes of hydrophobicity difference between siliceous Y zeolites 17.00-17.15 - Oral: Nicola Everitt, UK - Nanoindentation investigates the effect of grain size and chemical composition across melt-pools produced during selective laser manufacture of aluminium alloy 17.15-17.30 - Oral: Nawawi Chouw, New Zealand - Dynamic behaviour of natural fibre reinforced polymer-concrete bridge piers 17.30-17.45 - Oral: Ami Kohri, Japan - Experimental investigation of X-rays stress measurement device for expansion joints 17.45-18.00 - Oral: Basem Alsawy, UK - Multiscale deformation and failure in aluminium alloy 6082-T6: Experiments and modelling 18.00-18.15 - Oral: Osama Hassan, Sweden - Experimental verification of static buckling of partially composite beams and beam columns 18.15-18.30 - Oral: Erkut Findik, Turkey - Fracture toughness of talc filled polypropylene block copolymer composites stored long term without any daylight 18.30-18.45 - Oral: Jitendra Ramekte, India - Ultrasonic investigation of excess thermo acoustic parameters in binary liquid mixture at various temperatures 18.45-19.00 - Oral: Zdenka Prochazkova, Czech Republic - Recycled plastic material properties defined by nanoindentation 19.00-19.15 - Oral: Levent Sozen, Turkey - Effect of calcium carbonate filler content on the hoop stress of high density polyethylene pipes 19.15-19.30 - Oral: Rajendra Sonkawade, India - Fabrication of organo-metallic composites as a radiation sensor	Chair: Seong-Chan Jun, Korea Co-chair: Mohammad Alenezi, Kuwait 16.30-16.55 - Graphene Award Lecture: Ashutosh Tiwari, Sweden - Smart graphene materials - tools for super-thin biotechnology 16.55-17.15 - Invited Lecture: Debes Bhattacharyya, New Zealand - Influence of surface topology and thickness of reduced graphene oxide film on its electrical conductivity 17.15-17.30 - Oral: Carlos Velasco-Santos, Mexico - Thermo-mechanical properties of nylon 6,6 polymer nanocomposites with functionalised carbon materials of 1 and 2 Dimensions: Electrospinning and injection molding 17.30-17.45 - Oral: Won Ho Jo, Korea - High performance supercapacitor electrode from conducting polymer/graphene composite 17.45-18.00 - Oral: Timofey Chekalkin, Russia - Effect of gases on the surface formation of gradient structure in porous TiNi-based alloy 18.00-18.15 - Oral: Sibel Ozkaya, Turkey - Polypyrrole on graphene a density functional theory study 18.15-18.30 - Oral: Po-Yuan Teng, Taiwan - Ultrasensitive graphene image sensor 18.30-18.45 - Oral: Mahesh Matt, India - Thickness optimization of As ₂ Te ₃ thin film as back contact for CdTe solar cell 18.45-19.00 - Oral: Stefanie Freitag, Germany - Engineered graphene characterized by means of highly sensitive and 3D microscopic methods 19.00-19.15 - Oral: Néstor David Espinosa-Torres, Mexico - Theoretical survey of luminescence observed in nanostructured silicon rich oxide films attributed to annealing processes 19.15-19.30 - Oral: Mohsen Adeli, Iran - A facial method for controlled functionalization and post functionalization of graphene in ambient conditions to produce a wide range of nanodevices

19.30-20.30 Coffee Break and Poster Session, Venue: Conference Centre, Deck 8

20.30-23.30 Gala dinner to the restaurant "Buffet", Deck 7