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Spray-gun deposition method for nanomaterials and its application in different high-impact field

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This contribution deals with the fabrication of devices based on graphene based nanomaterials using dynamic spray gun deposition method implemented through roll-to-roll. We used this technique to fabricate supercapacitors, flexible memories and conformable electro-magnetic shielding (EMS) layers. In the first case we exploited the nanostructuration mixtures of graphene and carbon nanotubes to achieve electrodes for supercapacitors (Fig.1). Indeed the carbon nanotubes (Multi-Walled Carbon Nanotubes that are metallic and so conductive) are used as sort of spacers to avoid the restacking of graphene. Thanks to that we can exploit the huge surface of graphene to store charges and at the same time we create channels between the layers allowing the rapid charge and discharge of the device. The use of high quality graphene (<5 layers) and MWCNTs, with a diameter of around 20 nm also improve the conductivity for the electrodes and allows us in obtaining an impressive specific power value of around 100 kW/kg using an industrially suitable technique not only a lab based one. In order to increase the energy storage we have used ionic liquid which are more viscous, having large charges. In this case as spacers we have used carbon nanofibers with larger diameters (10 nm -100 nm). The spray-gun deposition method has also been implemented in the fabrication of graphene oxide and carbon nanofibers oxidized based memories. In this case we spray nanomaterial water based suspensions on a flexible layer which are previously metallized. The total thickness is around 100 nm. After contacting the top with metallic contacts we are able to achieve flexible non-volatile memories by simply applying a bias (<3V). These memories show bipolar behavior and have been cycled 10000 times (Fig. 2). They constitute one of the first examples of information storage devices that can be fabricated using a roll-to-roll implementable method. These devices can open new horizons in the integration of memories for example in RFID tags or in packages. Finally, we have achieved EMS architectures using nanostructuration of graphene, MWCNTs and carbon nanofibers between polymer layers in order to exploit the Maxwell-Wagner-Sillars effect to absorb X-band frequencies. Thanks to this nanostructuration as we are able to trap the charges in sort of micro-capacitors created in the layers. This is a real breakthrough considering that usually heavy metal based layers are used and that in this case mm based conformable layers can be obtained opening the route for new kinds of applications. Also in this case the fabrication will be implemented by roll-to-roll fabrication. During the presentation we will show all the details on the first characterization of devices and we will also show perspectives for other potential fields of applications.

Recent Publications

1. P Bondavalli, C Delfaure, P Legagneux and D Pribat (2013) Supercapacitor electrode based on mixtures of graphite and carbon nanotubes deposited using a new dynamic air-brush deposition technique. Journal of The Electrochemical Society 60(4):A1-A6.
2. P Bondavalli, D Pribat, C Delfaure, P Legagneux, L Baraton, L Gorintin and J P Schnell (2012) Non-faradic carbon nanotubes based supercapacitors:state of the art. Eur. Phys. J. Appl. Phys. 60:10401.

Biography

Paolo Bondavalli is incharge of the nanomaterial transverse topic at Thales Research and Technology. In the last years, he has been the first author of several scientific papers dealing with CNTFET based sensors, supercapacitors and several patents dealing with gas sensors, thermal management through CNTs, nanomaterials deposition, supercapacitors and memristors like structures. Presently, his work is focused on the development of new materials (e.g., graphene, CNTs and nanowires) for the new generation of electronics devices and for energy storage applications and memristors. He is EU expert and Vice-Chairman for Marie Curie Fellowships (EIF, IIF, OIF, CIG, IRSES), NMP and ICT panel for the French National Research Agency (ANR), EDA, Eureka and reviewer for IOP, ACS, IEEE, ECS, Elsevier, EPJ B, Bentham, Taylor & Francis, etc. During the last five years he also participated as coordinator in several EU projects (concerning MEMS, MO-EMS, CNTs, graphene, spintronics) and ANR projects. He is involved in the Graphene Flagship initiative.

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The effect of Cr concentration on displacement cascades in Fe-Cr binary alloys

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Displacement cascades in random Fe-Cr binary alloys with a wide range of Cr concentration from 2% to 20% were simulated by using the molecular dynamics method and the effect of Cr concentration on cascade damage was carefully investigated. The results showed that the average number of surviving Frankel pairs is approximately the same in Fe-Cr alloys and the average fraction of vacancies in clusters is roughly constant, within scatter, over the whole range of Cr concentration. The average fraction of self-interstitial atoms (SIAs) is slightly bigger in a lower Cr concentration alloy than in a higher Cr concentration alloy. The number of Cr atoms associated with survived self-interstitial defects was analyzed. The data show that the content of Cr in interstitials approximately exceeds two or three times the matrix content, which indicated that there is a significant enrichment of SIA defects by Cr.

Recent Publications

1. Malerba L, Bonny G, Terentyev D, Zhurkin E E, Hou M, Vörtler K and Nordlund K (2013) Microchemical effects in irradiated Fe–Cr alloys as revealed by atomistic simulation. Journal of Nuclear Materials 442:486–498.
2. Tikhonchev M, Svetukhin V, Kadochkin A and Gaganidze E (2009) MD simulation of atomic displacement cascades in Fe–10 at.%Cr binary alloy. Journal of Nuclear Materials 395:50–57.
3. Vörtler K, Björkas C, Terentyev D, Malerba L and Nordlund K (2008) The effect of Cr concentration on radiation damage in Fe–Cr alloys. Journal of Nuclear Materials 382:24-30.
4. Björkas C, Nordlund K, Malerba L, Terentyev D and Olsson P (2008) Simulation of displacement cascades in Fe90Cr10 using a two band model potential. Journal of Nuclear Materials 372:312–317.
5. Shim J H, Lee H J and Brian B D (2006) Molecular dynamics simulation of primary irradiation defect formation in Fe–10%Cr alloy. Journal of Nuclear Materials 351:56–64.

Biography

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Plasmonic curved waveguide sensor with ultrabroad detection range

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Plasmonic sensors have been the promising structure to provide high sensitivity on refractive index detection. However, their sensitivity is limited within the narrow bandwidth of device near resonance. Herein we introduce a novel structure about the improvement in detecting range of the refractive index through a high-contrast-index curved waveguide surrounding with an outer gold ring. The proposed detection technique is based on the output power measurement of the curved waveguide that offers a linear response over an ultra-broad range of the refractive index of a surrounding medium from n = 1 to 2.21. Meanwhile, the high refractive index resolution of 4.03×10-10 RIU is achievable for such the broad testing range. The application could be gas or aqueous chemical sensing. Furthermore, the proposed detection approach based on the optical power measurement is achievable by the integration with an on-chip photodiode so that such a compact design could be a multifunctional and high sensitive sensor-on-chip device.

Biography

Chii-Chang Chen received his PhD in Université de Franche-Comté (France) in 1998. In 1998, he worked in Laboratoire d'Optique P.M. Duffieux of Besançon to study high-speed LiNbO3 modulators. In 2002, he joined Institute of Optical Sciences of NCU as an Assistant Professor. He joined Friedrich-Schiller-Universität Jena (Germany) as a visiting researcher in 2005. He joined Université Paris 13 (France) as a visiting researcher in 2006, 2007, 2011 and 2018. He became Professor and Distinguished Professor of NCU since 2009 and 2010, respectively. His current research interests are nano-optics, photonic neural networks, photonic crystals and bio-sensors.

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