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Graphene-based nanocomposite for lithium-ion batteries anodes

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Abstract

Lithium-ion batteries (LIBs) are one of the most popular secondary batteries for consumer electronics and, lately, for electric vehicles application. Their main advantages over other rechargeable batteries are high energy density, good cycle life, high coulombic efficiency, low self-discharge rate, low maintenance and high cell voltage. The increasing demand for high performance LIBs entails large number of scientific researches focused on developing new electrode materials with better cyclability and high-energy storage capacity.

In terms of capacity enhancement, the most promising material for the anode is silicon which theoretical capacity is 4200 $mAhg^{-1}$ (in comparison to 372 $mAhg^{-1}$ for the commercially most widely used graphite). Unfortunately, its implementation is limited due to the safety issue related to the huge volume expansion that takes place during charge/discharge cycle. One approach that addresses the mentioned problem is nanotechnology. Recently, in situ HRTEM observation of Si nanoparticles during lithiation process showed that there is a critical particle size for which the mechanical fracturing of the SEI layer can be avoided.

Graphene, a single layer of hexagonally arranged sp^2 carbon atoms, attracts a great interest as a material that can replace graphite as an active material in anodes of LIBs. Its properties like high theoretical specific surface area, intrinsic carrier mobility, great mechanical strength could significantly increase performance of batteries. In this research graphene-based nanocomposite was synhtesized for application as the anode active materials in lithium-ion battery. Three methods were employed: (a) mechanical mixing of reduced graphene oxide (rGO) powder with silicon nanopowder, (b) mixing of rGO with Si nanopowder in isopropyl alcohol and (c) spatial functionalization of graphene oxide using hydrazine. The molecular systems with variable silicon content and, in the case of cross-linked structures, variable hydrazine content were produced. FTIR, Raman, SEM, TEM investigations as well as galvanostatic charge/discharge and cyclic voltammetry measurements.

Biography:

Piotr Zawadzki finished Materials Engineering at Lodz University of Technology and started work at LUT on March 2020. From PhD studies till now he is focused on nanomaterials, especially on graphene. He works on many projects connected with graphene functionalization, including creating ultralight bicycle frame and desalination of water. He has 8 publications connected with graphene modification and increasing aluminum mechanical properties. On conference he will show results on graphene-based nanocomposite synhtesized for application as the anode active materials in lithium-ion battery. Three methods were employed: (a) mechanical mixing of reduced graphene oxide (rGO) powder with silicon nanopowder, (b) mixing of rGO with Si nanopowder in isopropyl alcohol and (c) spatial functionalization of graphene oxide using hydrazine. The molecular systems with variable silicon content and, in the case of cross-linked structures, variable hydrazine content were produced. the research was financed by Mechanical Faculty internal grant for young scientists at LUT.

Speaker Publications:

1. P. Kula, Ł. Kaczmarek, P. Zawadzki et al. „Functionality of graphene by means of its heterogenic growth on SiC molecules basing on the reversible hydrogen storage" International Journal of Hydrogen Energy
2. K. Dybowski, P. Kowalczyk, P. Kula et al. „Graphene-Based Composite Membrane For Water Desalination", Archives Of Metallurgy And Materials, 63 (2018), 3, 1379-1383
3. K. Dybowski, G. Romaniak, P. Kula, et al. „Impact of the method of separating graphene from the growth substrate on the quality of the 2D material obtained", Archives Of Metallurgy And Materials, volume 64 (2019),
4. Ł. Kaczmarek, T. Warga, P. Zawadzki et al. „The influence of the hydrogenation degree on selected properties of graphene as a material for reversible H2 storage", International Journal of Hydrogen Energy, Volume 44, Issue 41, 30 August 2019, Pages 23149-23159 liczba punktów MNiSW: 140, IF 4,084

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