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Defect-induced plating of lithium metal within porous graphene networks

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Anodes for lithium batteries include a wide variety of hosts capable of electrochemical reactions with lithium such as formation of alloys or intercalates. Conventionally, graphite is the preferred anode material exhibiting an intercalation reaction with lithium to yield LiC_6 (corresponding to a theoretical capacity of 372 mAhg-1). The first such commercial lithium-ion cell constructed with a graphitic anode and $LiCoO_2$ cathode was developed in 1991 by Sony Corporation. Since then, there have been significant advancements in the anode chemistry. One of the major thrusts has been in identifying anodes capable of accommodating more lithium ions and hence, delivering higher energy densities. More recently, there has been a significant effort in identifying composite anodes, especially of carbon–silicon, that can combine the stability and electrical conductivity of carbon with the high specific capacity of silicon. This has enabled a steady capacity in excess of 1,000 mAhg-1 to be achieved over extended cycling. In this study we demonstrate thermally reduced, free-standing porous graphene networks (PGN) as high-capacity anode materials in lithium-ion batteries. We demonstrate a new mechanism in which defects in the graphene lattice act asseed points that initiate plating of lithium metal within the interior of the porous graphene structure. The network acts as a caged entrapment for lithium metal that prevents dendritic growth, facilitating extended cycling of the electrode. This entrapment of lithium metal results in very high specific capacities and energy densities. When compared with graphitic anodes (commonly LiC_6: capacity 372 mAhg-1, energy density 180 Whkg-1), the PGN delivers capacities of 900 mAhg-1 with an energy density of 547 Whkg-1. All such carbon electrodes could potentially offer an environmentally friendly solution that does not utilize hazardous materials such as Co in battery manufacturing.

Biography

Osman Eksik started his master course in 1998 and has occupied a Research Assistant position at the department of Chemical Engineering in the Istanbul Technical University till 2009. After his PhD in Chemical Engineering Istanbul Technical University, Istanbul, Turkey, 2009, he has been a visiting scientist in Materials Research Center Laboratory at Rensselaer Polytechnic Institute (RPI). During his time at RPI he had worked on number of projects about advanced material graphene. He has several papers on this subject. He is currently a member of the academic staff at Istanbul Technical University, where he is senior researcher for synthesis graphene and graphene nanocomposites.

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