Nanocomposite Ceramic Based Negative Electrodes for Li-ion Batteries

H. Akbulut[1,2], M. Tokur[1,2], T. Çetinkaya[1,2]

[1]Sakarya University, Engineering Faculty, Department of Metallurgical & Materials Engineering, Esentepe Campus, 54187, Sakarya/Turkey

[2]Sakarya University Research, Development and Application Center (SARGEM), Sakarya/Turkey

akbulut@sakarya.edu.tr

Ceramic based anodes (SiOx, GeO, SnO_2, ZnO, Fe_2O_3 or more complex stoichiometry, etc.) have much higher Li storage capacity than the intercalation-type graphite anode that is currently used in Li-ion batteries (LIBs). However, the practical implementation of metal (M) and metal oxide (MO) anodes is still blocked due to three major problems [1]: poor cycle-life results from pulverization during the huge volumetric fluctuations (>300 %), drastic irreversible capacity loss and low coulombic efficiency, the solid electrolyte interphase (SEI) breaks as the nanostructure shrinks during delithiation [2]. The critical issue of fabricating high specific capacity, high rate capability, and long cycle life LIB device is the advanced nano architectured design and flexible electrode materials with good mechanical deformations [3]. In order to prevent these challenges, most common and effective strategy to adopt nanoscale materials with various morphologies, including nanoparticles and, nanowires, nanotubes and hollow spheres. Compared to bulk active materials, such nanostructured ceramic based oxides, nitrides and carbides are able to accommodate elevated mechanical stress, resulting in prolonged cycling stability. Optimization of ceramic based electrodes can be achieved by incorporating nano structures with various conductive matrixes, such as graphene and, carbon nanotubes, and carbon and to form core-shell and yolk-shell nanocomposites. The introduction of such a carbon architectures with ceramic phases play a key role in alleviating the agglomeration of nano structured active materials [4]. In this review, we summarized the recent progresses on developments of ceramic based nanocarbon supported (CNT, CNF, Graphene etc.) negative electrodes for high performance Li-ion batteries. The synthesis techniques of the 1-D, 2-D and 3-D electrodes has been discussed for special hierarchical structures and free standing electrodes. The main research activities of Sakarya University electrochemical energy storage group has also summarized. The electrochemical performances of the ceramic based active materials and their nanocomposite structures were reviewed.

KEYWORDS
Li-ion batteries, ceramic nanaocomposite electrodes, nanocarbon, metal oxide

REFERENCES

1. Kang, Meng, Breger, Grey and Ceder, Science 311, 977 (2006).
2. Wu and Cui, Nano Today 7, 414 (2012).
3. Tokur, Algul, Ozcan, Cetinkaya, Uysal, Akbulut, Electrochimica Acta 216, 312 (2016).
4. Li, Tang, Kang, Zhang, Yang, Zhu, Zhang and Lee, Small 11, 1345 (2014)