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Enhanced Si based negative electrodes using RF/DC magnetron sputtering for bulk lithium ion batteries

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The capacity of the carbonaceous materials reached ca. 350 mAhg^{-1} which is close to theorestical value of the carbon intercalation composition LiC_6, resulting in a relatively low volumetric Li capacity. Notwithstanding the capacities of carbon, it will not adjust well to the need so future devices. Silicon shows the highest gravimetric capacities (up to 4000 mAhg^{-1} for $Li_{21}Si_5$). Although Si is the most promising of the next generation anodes, it undergoes a large volume change during lithium insertion and extraction. It results in pulverization of the Si and loss of electrical contact between the Si and the current collector during the lithiation and delithiation. Thus, its capacity fades rapidly during cycling. We focused on electrode materials in the multiphase form which were composed of two metal compounds to reduce the volume change in material design. A combination of electrochemically amorphous active material in an inert matrix (Si-M) has been investigated for use as negative electrode materials in lithium ion batteries. The matrix composited of Si-M alloys system that; active material (Si)-inactive material (M) with Li; M is a transition metal that does not alloy with Li with Li such as Ti, V or Mo. We fabricated and tested a broad range of Si-M compositions. The electrodes were sputter-deposited on rough Cu foil. Electrochemical, structural, and compositional characterization was performed using various techniques. The structure of Si-M alloys was investigated using X-ray Diffractometer (XRD) and transmission electron microscopy (TEM). Surface morphologies of the electrodes are observed using a field emission scanning electron microscopy (FESEM). The electrochemical properties of the electrodes are studied using the cycling test and electrochemical impedance spectroscopy (EIS). It is found that the capacity is strongly dependent on Si content and cycle retention is also changed according to M contents. It may be beneficial to find materials with high capacity, low irreversible capacity and that do not pulverize, and that combine Si-M to improve capacity retention.