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Effect of MWNTs on the Electrochemical Reduction Processes of Bi^{3+}, $HTeO_2^+$, and Their Mixtures

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The effect of multiwalled carbon nanotubes (MWNTs) on the electrochemical behaviors of the Bi and Te unitary systems and the Bi–Te binary system was investigated by means of cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS). Energy-dispersive x-ray spectroscopy (EDS) and x-ray diffraction (XRD) analyses of the deposits were also conducted to confirm the analysis of the reduction processes. The results show that, when MWNTs were added into each solution, the shape and number of peaks on each voltammogram remained unchanged, but the reduction peaks all shifted positively, and the peak current of each reduction peak increased slightly. The variation trends of the Nyquist plots in each system did not change with the addition of MWNTs. However, the same process occurred at more positive potentials, and the radius of the semicircle decreased at the same potentials compared with blank solutions. All these results indicate that addition of MWNTs into these electrolytes did not change the electrochemical reduction mechanisms of Bi^{3+}, $HTeO_2^+$, and their mixtures, but let the reduction processes of Bi^{3+}, $HTeO_2^+$, and their mixtures become easier. The results reveal that the presence of MWNTs can promote electrodeposition of Bi_xTe_y compound.

Key words: Electrochemical behavior, Bi_xTe_y, carbon nanotubes, electrochemical impedance spectroscopy (EIS)

INTRODUCTION

Thermoelectric materials and cells have attracted considerable interest due to requirements for environmental protection and military applications. Good thermoelectric materials should possess large Seebeck coefficient (S), low thermal conductivity (κ), and high electrical conductivity (σ). Generally, the performance of thermoelectric materials can be expressed by the dimensionless quantity $ZT = S^2\sigma T/\kappa$, where T is the temperature and Z is the thermoelectric figure of merit.[1,2] The thermoelectric conversion efficiency of thermoelectric materials increases with the increase of ZT. As a green power source, the greatest virtue of thermoelectric power generators is that they can make use of all kinds of heat (solar heat, ocean heat, geothermal heat, waste heat, body heat, etc.) to transform them into electric power with great efficiency. They have long working life (over 20 years) over a wide temperature range with highly stable performance.

Bi_2Te_3-based materials are of great interest for thermoelectric applications in the temperature range of 200 K to 400 K. In general, Bi_2Te_3-based film materials can be fabricated by chemical vapor deposition (CVD),[3] physical vapor deposition (PVD),[4] the high-pressure injection method,[5] electrodeposition,[6–8] etc. Compared with traditional techniques, electrodeposition shows many advantages, including use of a simple device, low cost, and easy operation. The most advantageous point of electrodeposition is the high controllability of the doping concentration and that the crystalline state of the thermoelectric films can be easily controlled by adjusting the electrodeposition. Recently, electrodeposition of bismuth

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