Electrochromic properties of Al doped B-substituted NiO films prepared by sol–gel

Xianchun Lou, Xiujian Zhao, Jiamin Feng

Key Laboratory of Silicate Materials Science and Engineering (Wuhan University of Technology), Ministry of Education, 122 Luoshi Road, Hongshan District, Wuhan, Hubei 430070, PR China.

Abstract

In this paper Al doped B-substituted NiO films were prepared by sol-gel method. The effects of Al content on the electrochromic (EC) properties and durability of the AlXB0.15NiO films were studied with X-ray diffraction (XRD), transmission electron microscopy (TEM). The electrochemical and electrochromic properties were examined by cyclic voltammetric (CV) measurements and UV-Vis spectrophotometer, respectively. Al-doped could prevent the crystallization of the films, which exhibited much better electrochemical and electrochromic properties than undoped samples. The bleached-state absorptance could be significantly lowered when the aluminum (a type known to form oxides with large optical band gaps) added. Electrochromic efficiencies measured at λ=500 nm of films with different Al-doped reach ~30 cm^2C^{-1}, with a variation in transmittance up to 70%

Introduction

Electrochromic (EC) materials have being extensively studied by many authors in order to develop high-efficiency, low cost and durable devices that can be used in large area surfaces. Nickel oxides thin films are well suitable for device operations in conjunction with tungsten oxide thin films. Among various mixed oxides, we identified the B_2O_3-NiO system as showing better electrochromic properties than NiO thin films when cycled in KOH liquid electrolyte. However, the films have lower transmittance of the bleached state. In the present work, we have synthesized the B-NiO and Al, B-doped NiO films by sol-gel process. The effect of Al content on the structure, optical and electrochromic properties of (Al)-BNiO xerogels and films was studied.

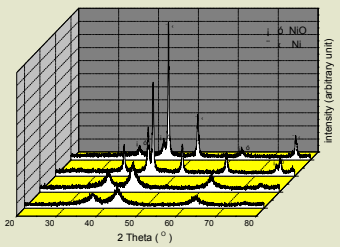
Experimental

The precursor solution was prepared by dissolving nickel acetate powder into 2-methoxyethanol and monoethanolamine mixture at room temperature. The molar ratio of monoethanolamine to nickel acetate was kept at 1.0 with the concentration of nickel acetate in the precursor solution being of 0.5 mol/l. Different amounts of aluminum nitrate and boracic acid dissolved in elthanol and then added to the Ni solution to obtain different $Al_x/B_{0.15}$-Ni solution. Double NiO-based films were deposited on ITO glass by the dip coating technique. The coated film was then sintered at 400 °C for 1h in air. The thin films were characterized by XRD, TEM, UV-Vis-NIR spectrophotometer and CV.

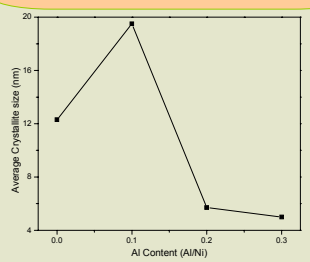
Results and Discussion

XRD patterns

Treated powder with different B content



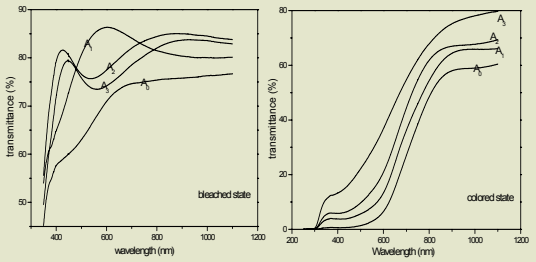
The crystalline size of B_x treated at 400 °C



Tranmittance

Bleached state

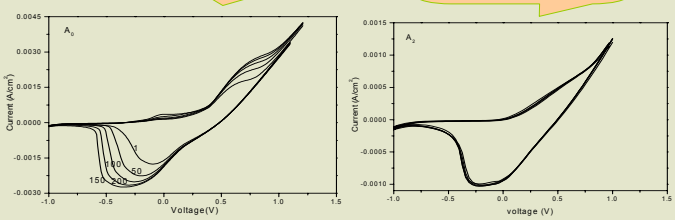
Colored state



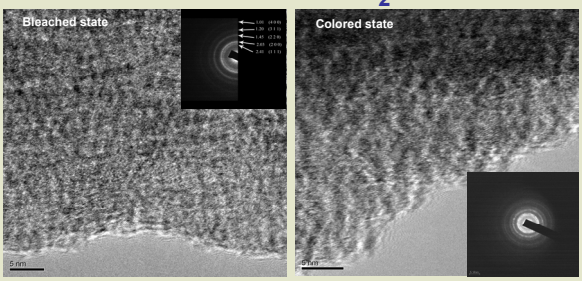
Cyclic coltammograms

B_0 film

B_2 film



HRTEM of B_2 film



Conclusions

In this paper Al doped B-substituted NiO films were prepared by sol-gel method. The effects of Al content on the electrochromic (EC) properties and durability of the $Al_XB_{0.15}NiO$ films were studied. Al-doped could prevent the crystallization of the films, which exhibited much better electrochemical and EC properties than undoped samples. The bleached-state absorptance could be significantly lowered when the aluminum (a type known to form oxides with large optical band gaps) added. The presence of Al was associated with a limited dissolution of the oxidized phases and stabilized the transition of between α-phase $Ni(OH)_2$ and γ-NiOOH, which reduce the volume change during the CV cycles. Electrochromic efficiencies measured at λ=550 nm of films for A_2 reach ~30 cm^2C^{-1}, with a variation in transmittance up to 70~80%.

zhaoxj@public.wh.hb.cn