Infrared ellipsometric spectroscopy of $Mn_{1.56}Co_{0.96}Ni_{0.48}O_4$ thin films with different layers

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***Abstract*—High quality $Mn_{1.56}Co_{0.96}Ni_{0.48}O_4$ films with different layers have been prepared on Pt//Ti/SiO_2/Si substrate. Infrared optical properties of the films have been investigated using infrared spectroscopic ellipsometry. The optical constants have been obtained by fitting the measured ellipsometric parameter data with classical infrared model.**

I. INTRODUCTION

SPINEL compound manganese cobalt nickel oxides $Mn_xCo_yNi_{3-x-y}O_4$ have been widely utilized for negative temperature coefficient (NTC) thermistor device such as temperature compensation devices, temperature sensor devices, surge protection devices, and infrared detecting bolometer[1]. From the earlier investigations, $Mn_{1.56}Co_{0.96}Ni_{0.48}O_4$ (MCN) showed appropriate resistance, high temperature coefficient of resistance (TCR), broad band optical response, and was suitable for infrared detection devices. The thermal, electrical, and mechanical properties of MCN have been studied extensively[2]. To obtain the optical parameters of the noncrystalline and crystalline MCN films, we investigated ultraviolet-near-infrared optical properties of MCN films by spectroscopic ellipsometry[3]. In spite of these work, there are scarce open literatures on the optical characteristics, especially in the infrared range, which is very important in the application of infrared optical detectors. In aim to fulfill the above, the optical properties of MCN films in the mid-infrared range were investigated by transmittance spectroscopy and spectroscopic ellipsometry, and calculated the optical parameters by fitting the experimental data.

II. RESULTS

MCN films with 20 layers [MCN(20)] and 60 layers [MCN(60)] have been prepared on Pt//Ti/SiO_2/Si substrate by chemical solution deposition method. The measured and fitted ellipsometric spectra of the MCN films with different layers in the wavelength range of 2-13 μm are shown in Figure 1 by symbols and solid lines, respectively. We use ambient/MCN/Pt three-phase model to represent the samples, and adopt the classical middle infrared dispersion relation to describe the dielectric function of the MCN films in infrared region[4]. A best fit is obtained between the experimental data and fitted data in the entirely measured wavelength range. By fitting, the thickness of MCN (20) is 455.57 nm, and the thickness of MCN (60) is 1452.1 nm.

The evaluated optical constants n and k of the MCN(20) and MCN(60) films are shown in figure 2, which illustrate that the refractive index n of the MCN films decreases as the wavelength increases, but the extinction coefficient k monotonously increases in the wavelength range of 2-13 μm. In addition, the maximal n value of MCN(20) is 2.54, and the minimal value of MCN(60) is 1.88. The extinction coefficient is very small at short wave lengths.

Figure 1: Experimental (symbols) and fitted (solid lines) ellipsometric spectra (a) TanΨ and (b) CosΔ of the MCN(20) and MCN(60) films at the incidence angle of 75°.

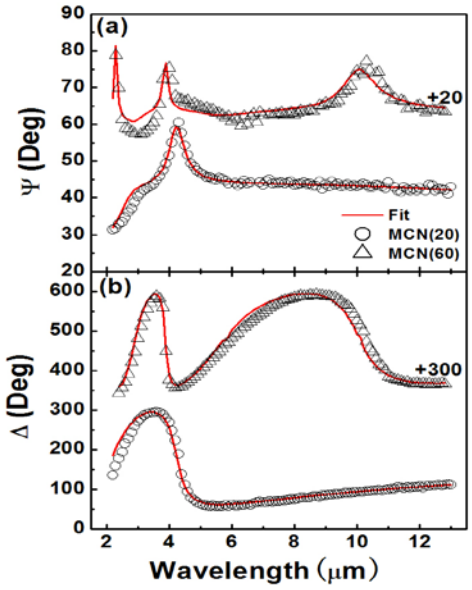
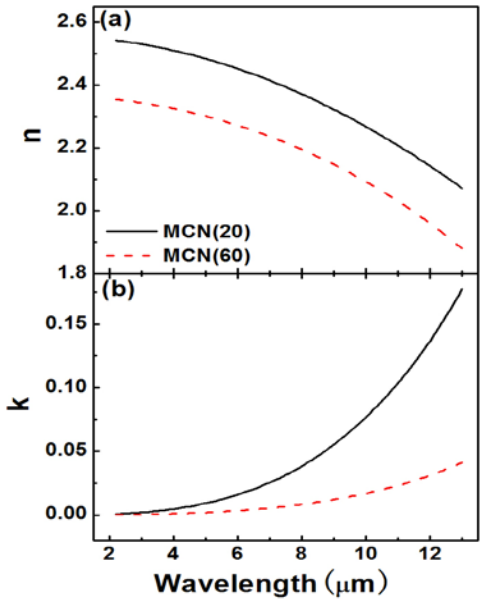


Figure 2: Evaluated refractive index n and extinction coefficient k of the MCN(20) and MCN(60) films.



The optical constants of n and k of the MCN (20) are larger

than the MCN (60). With the film thickness increase, both the crystalline quality and the grain size improve. Then the optical properties of the MCN films may relate to its crystallinity.

III. Summary

In summary, we have prepared MCN films with different layers on Pt//Ti/SiO_2/Si substrate by chemical deposition method, and investigated the infrared ellipsometric spectra. The refractive index n of the MCN films decreases as the wavelength increases, but the extinction coefficient k monotonously increases in the wavelength range of 2-13 μm. In addition, the maximal n value of MCN(20) is 2.54, and the minimal value of MCN(60) is 1.88. The extinction coefficient is very small at short wave lengths. The presented results especially the infrared optical properties of the MCN films are instructive further understanding the physical properties of spinel oxides in theory.

IV. Acknowledgement

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