Anti-reflection Coating of Cerium Oxide on a Plastic Substrate

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Cerium oxide (CeO$_2$) films are suitable for use as anti-reflective coatings for display panels, touch screens, and silicon solar cells. The CeO$_2$ films grown by using a reactive radio frequency sputtering method under various deposition conditions was investigated. The CeO$_2$ films were deposited at room temperature because the plastic substrate was too weak for use at higher temperatures. The films exhibited a strong (111) preferred orientation with properties varying as a function of the process conditions. We present the properties of CeO$_2$ anti-reflective coatings on plastic substrates.

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I. INTRODUCTION

In recent years, anti-reflective (AR) coatings have been increasingly used in a variety of applications, including solar cells, vision lenses and displays panel [1–3]. Display panels require AR films in order to improve the display quality and the back-light efficiency of TFT-LCDs (thin-film transistor, liquid-crystal displays). Many substrates such as a silicon wafers, glass and plastic, can be used for AR coating technology [4–6]. The plastic materials are becoming very useful as substrates for flexible, lightweight, and portable electronics [7–10]. Although plastic substrates have many advantages for applications such as hand-held displays [11] and thin-film solar cells [12–14], the use of plastic limits the temperature, surface hardness and corrosion resistance. CeO$_2$ films have been reported to reduce the surface-state-recombination effect in Si solar cells [15, 16]. CeO$_2$ film was repeatedly deposited while controlling the plasma on and off: the so called time-divided method.

This paper focuses on an analysis of the process used to deposit anti-reflective coating on plastic substrates such as PET (poly ethylene terephthalate) and PC (poly carbonate). We investigated CeO$_2$ films as AR layers because they have a proper refractive index of 2.46 and demonstrate the same lattice constant as silicon [17]. Because all the processes were carried out at room temperature, film growth at one time was not possible. Therefore, we had to develop a novel process for room-temperature deposition on a plastic substrate. In this paper, we present a novel method suitable for depositing a CeO$_2$ film by reactive sputtering, as a single anti-reflective layer.

II. EXPERIMENTS AND DISCUSSION

We deposited a CeO$_2$ film as an anti-reflective coating by using a reactive sputtering method at room temperature. In addition to controlling the substrate heating, we grew the Ce-metal for 10 minutes and then oxidized it for 10 minutes because the Ce-metal serves a significant role as a seed layer in order to oxidize of Ce-metal. The CeO$_2$ film is deposited by using a reactive sputtering method with oxygen gas. Also, CeO$_2$ was oxidized once more in an oxygen gas for 10 minutes because most of the metal-oxide film had a deficiency of oxygen [18]. We summarize the growth conditions of the CeO$_2$ film in Table 1.

The CeO$_2$ anti-reflective layers had a preferentially grown orientation, as shown in Fig. 1. The intensities of the (111) planes of the samples (a) with and (b) without oxidation were lower than these of the samples (c) and (d). The same result was obtained for the (220) and the (311) planes, as well. The angle of the (111) plane, for samples (a) and (b) were different from those for samples (c) and (d). We suggest that a phase change from metal to oxide occurred during oxidation. In particular, samples (c) and (d) had different deposition and oxidation times. Samples (c) was grown by using is cycles of

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