The discharge characteristic of Li ion doped MgO film in a flat fluorescent lamp structure

Si Hong Ryu, Seong Eui Lee, Sung Il Ahn[1], Kyung Cheol Choi[2]
Dept. of Advanced Materials Engineering in Korea Polytechnic Univ. Korea
Phone: +82-31-8041-1945, E-mail:ongsiong@kpu.ac.kr.
[1]Dept. of Electrical and Electronic Engineering, Kyungwon Univ.
Seongnam-Si 461-706, Korea
[2]Dept. of Electrical Engineering and Computer, Korea Advanced Institute of Science and Technology, Daejeon 307, Korea

Keywords: MgO, Sol-gel process, Li^+ doping, Porous, F^+ center

Abstract

This paper investigates how various concentrations of lithium ion influence on crystallization of MgO in thin films formed by spin coating and on the discharge characteristic in a flat fluorescent lamp structure. The XRD results indicate Li^+ ion enhances the growth of MgO crystal in a spin coated thin film. The discharge property with the Li^+ ion doped MgO films show the lithium ion in MgO film clearly reduce the initial discharge voltages of test devices. Interestingly, the test panels with various doped MgO film have somewhat higher static memory margin of than that of pure-MgO owing probably to the pore structure of spin coated MgO films. The CL spectra, which confirm that the doping creates defects energy levels in the band gap of MgO, show the F^+ center is the main defects in doped MgO films.

1. Introduction

MgO thin film is widely used in the ac-PDP area and flat fluorescent lamps to improve the luminous efficiency and firing voltage because of its high secondary electron emission characteristics. The initial discharging voltage that occurs during the operation of those devices is influenced by the secondary electron coefficient of MgO; furthermore, the discharging voltage depends on the crystalline structure, as well as defect sites of the MgO and so on. [1]-[3] By the addition of doping elements into MgO materials, many reports have shown that the secondary electron coefficient can be increased and thus leading to reduce the firing voltages in plasma devices. [4] According to the report on the addition of hydrogen during an e-beam process of MgO, the hydrogen acts as dopant in MgO film and thus improves the luminance efficiency. [5] This improvement, which is believed to be related to the creation of deep donor energy levels in the MgO band gap, increases the residence time of electrons trapped in excited states.

The use of thin film deposition via vacuum technology to control the formation of vacancy levels is difficult because the evaporation rates of the doping compound and MgO are different. In contrast MgO films formed by sol-gel precursors have an advantage in controlling the doping contents of MgO thin films. From this viewpoint, the sol-gel route for researching ion-doped MgO films is very useful if we can produce MgO films that have the moderate roughness of an MgO surface. In this study, we introduce spin-coated MgO films with lithium ion as an impurity and we control its doping level by varying the concentration of the sol-gel precursor. After fabricating a flat fluorescent lamp with those materials, we examined how the Li^+ ion doping influences on the crystallization of the MgO in the films and on discharge property in a flat fluorescent lamp structure.

2. Experimental

An MgO precursor was prepared from the stabilized magnesium hydroxide sol that was derived from the starting material of magnesium methoxide. Sol is highly stable due to the polymerization of $Mg(OH)_2$, even with a strong base such as lithium butoxide, which is a source of Li^+. The prepared precursor sol was reacted with an Li^+ source in mole ratios of 1000 to 2.5, 5, 10, and 15 respectively and then spin coated on a structure of fluorescent lamp. Fig. 1 shows the details and conditions used for producing the spin-coating solutions of MgO. After firing, the MgO films were inspected by XRD (D/MAX-220, Rigaku), SEM(S-4700, Hitachi), CL (XL-30 FEG, FEI)

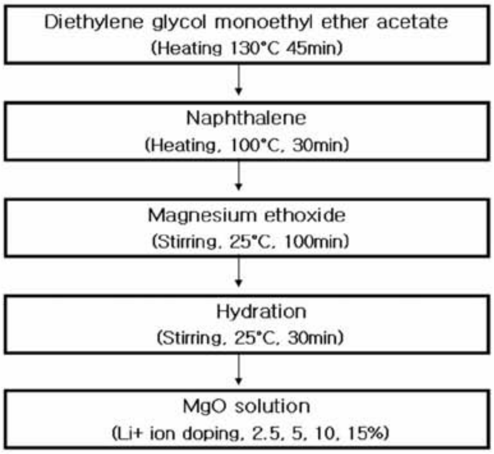


Fig. 1. Process flow of MgO sol-gel precursor

In order to investigate the discharge characteristics, the various concentrations of lithium doped MgO solution were applied to the structure of fluorescent discharge lamp shown in Fig. 2.

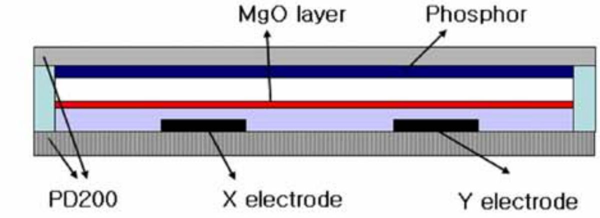


Fig. 2. Schematic structure in flat fluorescent discharge panel with MgO solution coating

The electrode lines in bottom plate were formed by an Ag conductive paste with the gaps of 200um and then dielectric layer was formed with 30um thickness. After dielectric layer formation, we deposited various concentration of lithium doped MgO solution and calcined at 833K for 1 hour.

The height of sealing frame, the width and length of electrodes were fixed as 0.7, 1, 60 mm, respectively. The phosphor layer was printed with green (Zn_2SiO_4:Mn) phosphor on a front plate. The front and rear plates were 2.8 mm thick PD200 glasses. The processed panels were filled with Ne-Xe (5%) discharge gas at pressure of 100 torr. The luminance of the panels was evaluated by applying a square pulse wave form with a frequency of 40 kHz and a 20% duty ratio.

3. Results and discussion

The XRD patterns in Fig. 3 of MgO films formed by spin coated and calcined at 883 K show clearly a trend of enhanced or reduced crystallinity by the Li ion content. The diffraction peaks increase with an increase in Li^+ content up to 5% and decreases with an increase in Li ion content over 5%.

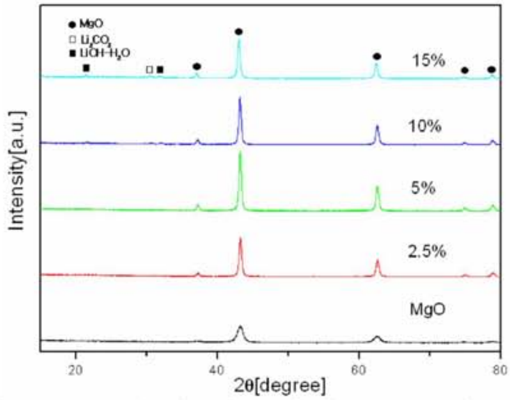


Fig. 3. XRD analysis of MgO films deposited with various lithium dopant content

The morphologies of MgO layers formed by spin coating method are shown in fig. 4. As you can see, the more increased the Li^+ concentration, the more increased the micro crack. Furthermore, a lot of small pores were observed on the surface of doped MgO films.

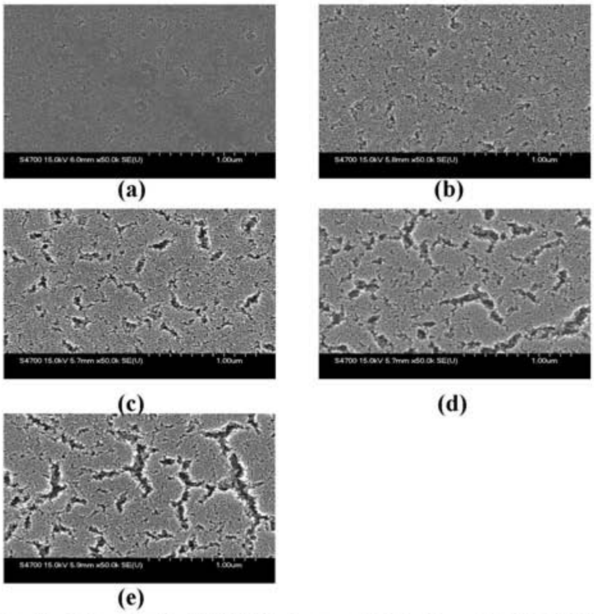

(a) (b) (c) (d) (e)

Fig. 4. Figure 2. SEM image of Li doped MgO (a) MgO, (b) 2.5 % Li, (c) 5% Li, (d) 10% Li, (e) 15% Li

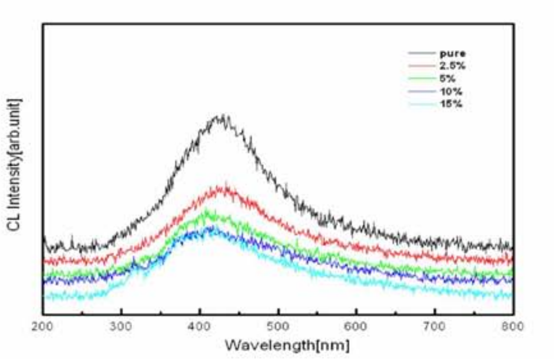
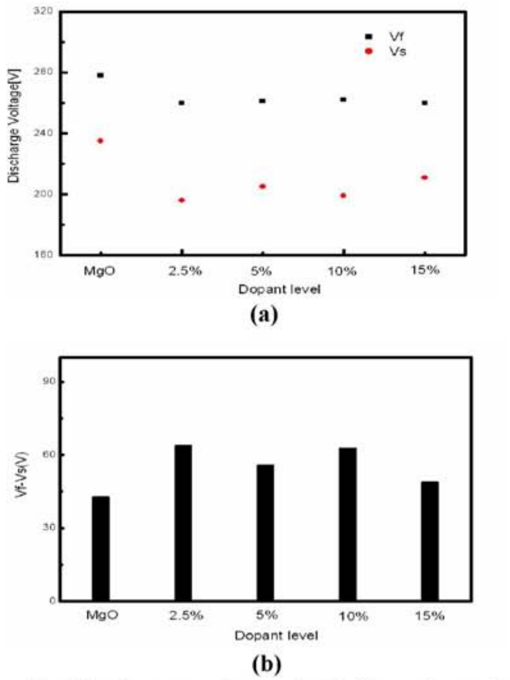


Fig. 5. CL spectra of lithium ion doped MgO film with different dopant contents

The CL spectra in Fig. 5, which confirm that the doping creates defects energy levels in the band gap of MgO, show the F^+ center is the main defects in doped MgO films and increased as the concentration of lithium ion is increased. This result is somewhat different from the results of the XRD. The excess of Li ion seems to cause greatly increasing the F^+ center in MgO although it doesn't seems to incorporate with the MgO lattice.



(a)

(b)

Fig. 6. Discharge characteristics of various Li+ doped MgO thin film on test panels at 100 Torr: (a) firing voltage and sustain voltage, and (b) static memory margin

The discharge characteristics of test panels with different dopant contents showed that the Li^+ doped MgO clearly reduced the firing voltages of test panels compared to pure MgO. Interestingly, the static memory margin are somewhat increased owing probably to the influence of cracks and a lot of small pores.

4. Summary

We observed the influence of Li^+ ion on the growth of MgO crystal in a spin coated thin film. The crytallinity of MgO in spin coated MgO film was increased as the increasing of Li ion concentration up to around 5%. Ordinary the static memory margin of doped MgO were decreased as the increasing doping concentration. However, the margin in this experiment was observed higher in comparison to pure MgO film. Reports on secondary electron emission (SEE) from porous MgO layers suggest that the growth of strong electric fields throughout the pores produces higher SEE yields than those of bulk materials. From this viewpoint, the increased static memory margin is suspected to the micro crack, which can act as a large storage of charged particles on the surface of spin-coated MgO film.

5. References

1. Seong Eui Lee, Ho Nyeon Lee, Tae Sik Oh, Young Mo Kim, Sung Kee Kang, Do young Park, and Yong Seog Kim: Jpn. J. Appl. Phys. **44** (2005) 8646.
2. Hyoung Bin Park, Seong Eui Lee, Gi Young Kim, Young Dong Lee, and Kyung Cheol Choi: J. of Display Technology **2** (2006) 60.
3. Eun-Ha Choi, Hyun-Joo Oh, Young-Guon Kim, Jae-Jun Ko, Jae-Yong Lim, Jin-Goo Kim, Dae-Il Kim, Guangsup Cho, and Seung-Oun Kang: Jpn. J. Appl. Phys. **37** (1998) 7015.
4. Lawrence A. Kappers, Roger L. Kroes, and Eugene B. Hensley.: Phys. Rev B. **1**(1970) 4151.
5. Kyung Hyun Park, Yong Seong Kim: IMID/IDMC'06 Digest, 2006, p. 375.