Application of Neodymium Oxide into Transparent Dielectric Materials for PDP

Byung-hae Jung, Hyung-sun Kim
Dept. Materials Science & Metal. Eng. Sunchon National University, Sunchon, 540-742 Korea,
Ki-sung Lee, Sang-ho Sohn
Dept. of physics, Kyungbuk National University, Daegu, 702-701 Korea
Tae-In Kwon and Sung-wook Lee
Digital Display Research Lab.,LG Electronics Inc.,16 Woomyeon-Dong, Seocho-Ku, Seoul 137-724, Korea

Abstract

For purer images in plasma display panel, a new dielectric compositions containing neodymium oxide were studied. In the present study, Pb-based compositions were used as mother glasses (PbO-B_2O_3-SiO_2-Nd_2O_3) and thermal, dielectric, and optical properties were measured. As a result the new dielectric with a rare-earth oxide made selectively visible light penetrated and showed especially noticeable absorption properties at 585 nm that is surely related to the erroneous gas from Ne discharge. Thus, this light purple colored glass composition will help PDP to come true to get better imaging process.

1. Introduction

Historically glasses containing neodymium oxide (Nd_2O_3) has been used for the purpose of absorbing ultra-violet lay that is harmful for human in halogen lamp [1]. Other than that, neodymium containing glasses, they were found that the intrinsic absorbing property at 585nm wavelength would play a beneficial role in improving color purity in PDP (plasma display panel) use. Especially by substituting the normal dielectric layer located in front substrate when the rare-earth oxide has been co-melted with dielectric glass composition [2]. In the process of gas discharging, the erroneous gas, mostly from Ne gas, was an obstacle for purer image in PDP.

So far, there have been a few trials for compensating for poor image, such as thin color pigments layer and CCF (capsulated color filter) by some PDP companies[3]. For good images in PDP, a glass composition with rare-earth oxide was studied. In this work, the thermal, dielectric and optical influence of Nd_2O_3 on the PbO-B_2O_3-SiO_2 glasses was investigated. As optical properties, roughly three absorption zone was detected in the visible region (300~800nm).

In a tentative conclusion, this paper will examine the properties of neodymium oxide when it has been employed with normal dielectric compositions and its function as a potential material for color filter in PDP.

2. Experimental method

Conventional PDP dielectric systems, PbO-B_2O_3-SiO_2, PbO-B_2O_3-SiO_2-ZnO, were mainly applied to this study and Nd_2O_3 were selectively used.

A batch of each composition (Table 1), consisting of high purity raw materials was well mixed with a mortar and a pestle. The batches were melted very carefully in a platinum crucible at 1100-1200 for 1h as homogenously as possible with several times of stirring and the melts were very fluid. Each glass melts were quickly poured and quenched into distilled water to get glass flakes. These flakes were ground by a vibration mill for 4h to make them glass powder. The mean particle size distribution was shown around 3-8μm and then this glass powder was mixed with an organic vehicle which consists of ethyl cellulose(EC), α-terpineol and butyl carbitol acetate to make it into paste state. The paste was coated on the air side (opposite one is tin side named from the process of making glass substrates) of soda-lime and PD200 substrate.

About the preparation of bulk specimen, the glass melts from furnace was poured into a graphite mold, heated at the temperature of 10 above Tg of each glass and the mold was moved into a furnace back to anneal the glass for 1 h then cooled very slowly in the furnace. The glass removed from the mold for the measurement of CTE, dielectric constant was carefully polished to have the required size. Thermal expansion coefficient was measured using a vertical type of TMA with a heating rate 10/min. The glass transition temperature (Tg) was determined with a differential thermal analyzer (DTA-TA 1600, USA)

Table1. Composition of glasses (in wt%)

Glass	PbO	B_2O_3	SiO_2	Al_2O_3	ZnO	Nd_2O_3	Total
A1	65	20	15	-	-	-	100
A2	65	20	15	-	-	10	110
A3	65	20	15	-	-	20	120
A4	65	20	15	-	-	25	125
B1	68	15	5	2	10	-	100
B2	68	15	5	2	10	5	105
B3	68	15	5	2	10	10	110
B4	68	15	5	2	10	15	115
C1	45	18		8	5	20	100

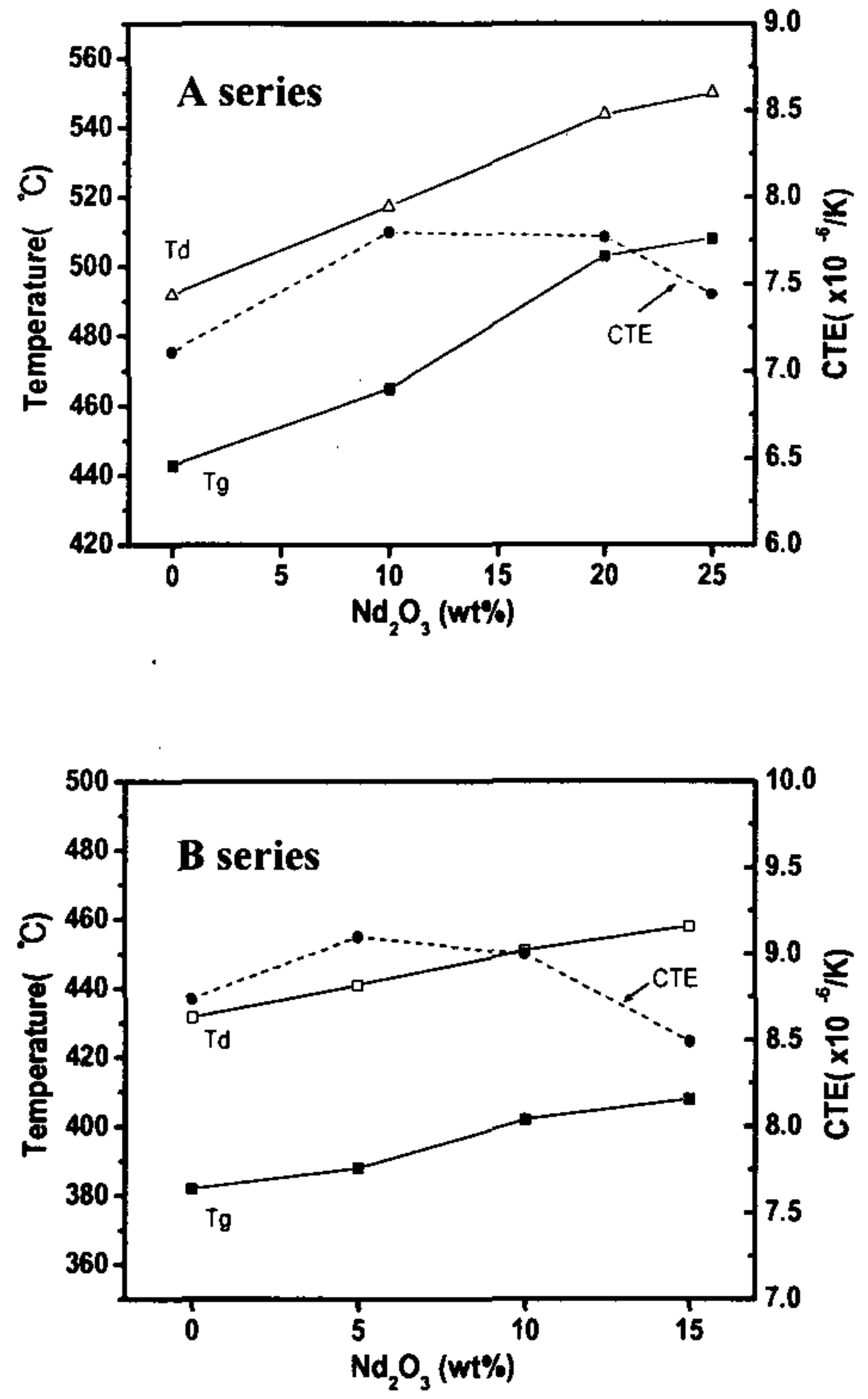

Fig. 1. DTA and TMA results of A, B series.

3. Results and Discussion

3.1. Thermal properties

As shown in Fig. 1, A series (65 PbO· 20 B_2O_3· 15 SiO_2 plus 0~25 Nd_2O_3 in wt%) showed increasing trend of Tg and Td results from 443 to 508℃ and the temperature gap was around 50℃. B series (68 PbO· 15 B_2O_3· 5 SiO_2· 2 Al_2O_3 · 10 ZnO plus 0~15 Nd_2O_3 in wt%) also increased with increasing Nd_2O_3 content from 382 to 408℃. As for thermal expansion coefficient, in the case of A series, the results were distributed around 7.1~7.8 and 8.8~9.1/K for B ones.

A series has much lower Tg (about 60℃) and Td properties than the B series. The primary reason for this is probably related to the cooperative glass modifying components' role: PbO and ZnO in the case of F series. By adding extra ZnO to replace some SiO_2 as compared with the B series, the glasses of A series probably formed more non-bridging oxygen that is known to decrease Tg.

3.2. Dielectric properties

As for A series, the relative dielectric constant (ε_r) increased from 11.4 to 13.0 at 1 ㎒ with increasing Nd_2O_3 content, while B series showed slightly higher value from 14.9 to16.0 at the same frequency (Fig. 2).

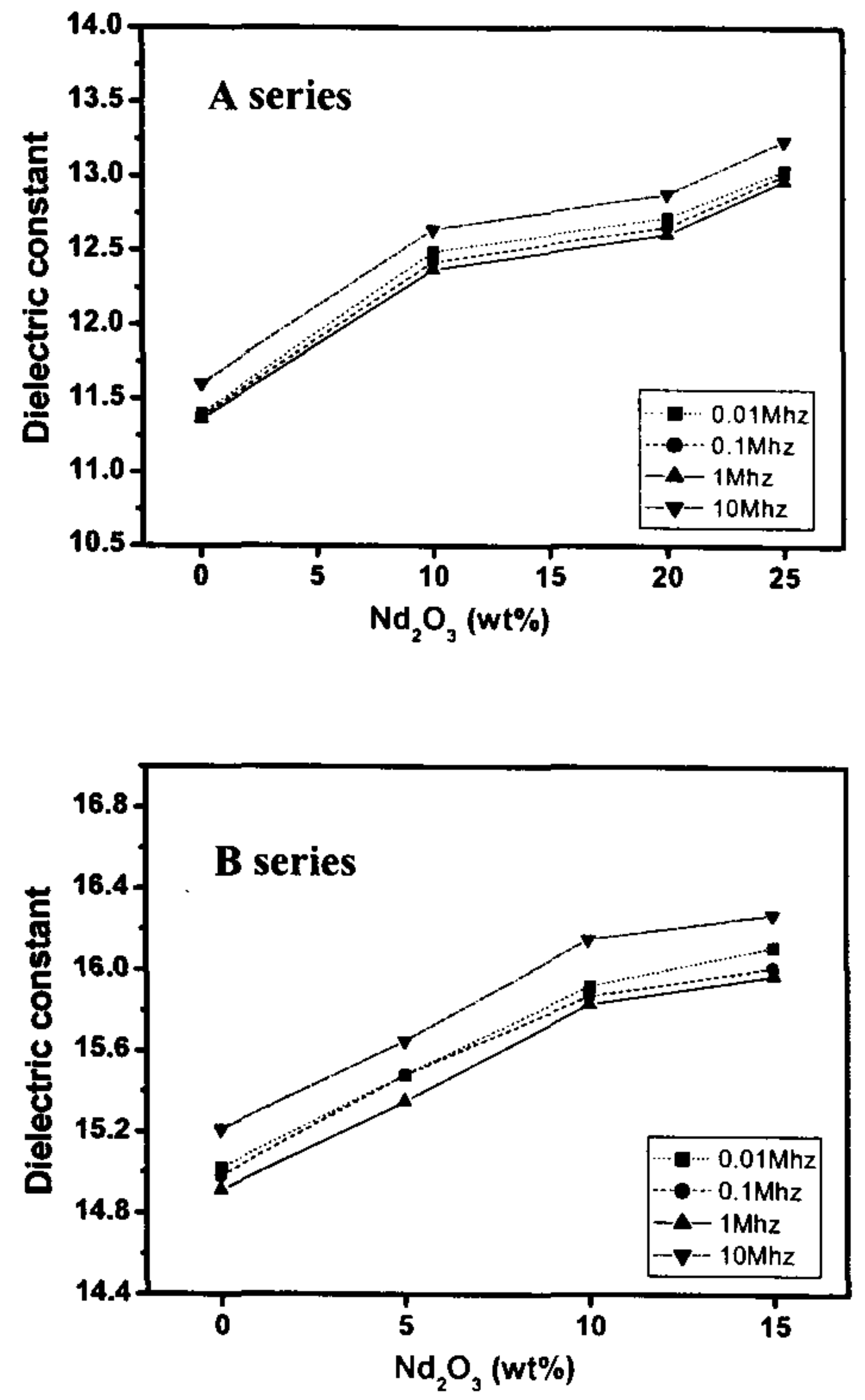

Fig. 2.Dielectric constant at diverse frequency.

Generally the relative dielectric constant of the compositions with high PbO content like A, B series show a little higher values compared with other glass systems such as silicate, borate ones. The reason could be that the lead ion's deformability is much larger than that of barium ion and zinc ion even though Pb^{2+} has second largest ionic size among zinc, barium, neodymium and lead ions (Ba^{2+}=1.42 □, Pb^{2+}=1.29 □, Zn^{2+}=0.75 □, Nd^{3+}=1.04□)[5] . The lead ion's great polarizability (Pb=29.3, Ba=4.67, Zn=0.71, Nd=1.41) [5] introduces a high deformability.

3.3. Optical properties

Optical properties was measured in the visible light region (300~800nm). The total each three layers coated by manual screen printing method was conducted for transmittance. B3 showed almost similar transmittance about 80% regardless of the thickness of layers (Fig. 3). It might be resulted from the glass composition had very low Tg (Fig .1).

In the case of B4 (68 PbO· 15 B_2O_3· 5 SiO_2· 2 Al_2O_3 · 10 ZnO· 15 Nd_2O_3 in wt%) , its transmittance result especially of three layers decreased a little compare with one or two layers.

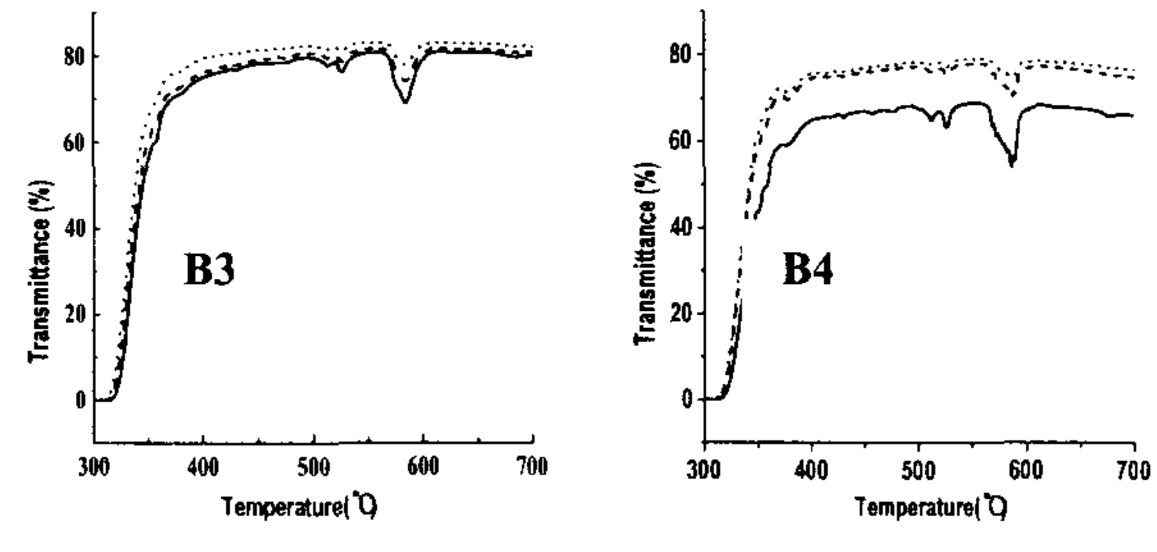

Fig. 3. Transmittance results of B3, B4.

**Dot line is one, dash is two, and solid line represents three layers.*

Figure. 4 shows transmittance result of C1 (45 PbO· 18 B_2O_3· 8 Al_2O_3· 5 ZnO · 20 Nd_2O_3 in wt%). Since the content of Nd_2O_3 was large compared with A and B series, the absorption characteristic was dominant in all cases (1~3layers). Noticeably, the absorption peak at 585nm became deep as the layer became thicker. Except for the absorption at 585nm, there are two extra absorption peaks at 513, 526nm. In Fig. 4(b), the comparison of how much a light was absorbed in the condition of different thickness and wave number. From the results, as the thickness became higher, the absorption properties at all wave numbers became dominant.

In conclusion, the two absorption peaks (513, and 526nm) are related to the green color that may come from green phosphors while 585nm is beneficial one because this peak could compensate color deterioration resulted from Ne discharge.

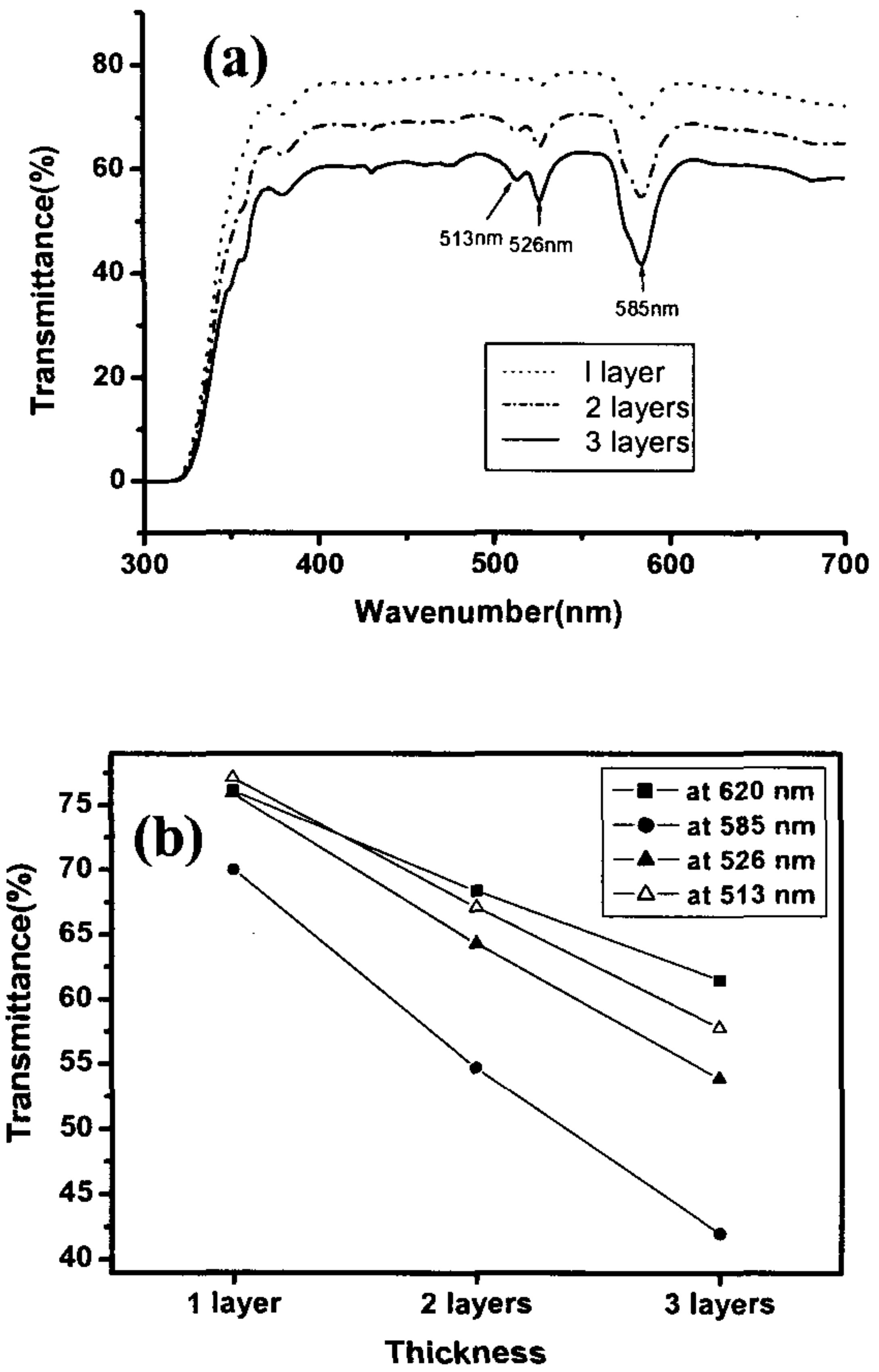

Fig. 4. Transmittance result of Cl and three absorption characteristics.

(a) Transmittance at the whole region (300~700nm)

(b) Transmittance at each wavelength

4. Conclusion

After being made a coated layer by screen printing method, the color dielectric layer containing Nd_2O_3 (usually light purple) could conduct an important role by absorbing erroneous gas (generally orange light). Therefore, PDP with the dielectric can produce better image resolution.

5. Acknowledgement

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6. Reference

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