This article was downloaded by:
On: *25 January 2011*
Access details: *Access Details: Free Access*
Publisher *Taylor & Francis*
Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK

Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713926090

IPS mode investigation of liquid crystal alignment on organic hybrid overcoat layer via ion beam irradiation

Chul-Ho Ok[a]; Byoung-Yong Kim[a]; Byeong-Yun Oh[a]; Young-Hwan Kim[a]; Kang-Min Lee[a]; Hong-Gyu Park[a]; Jeong-Min Han[a]; Dae-Shik Seo[a]; Dong-Ki Lee[b]; Jeong-Yeon Hwang[c]
[a] Information Display Device Laboratory, School of Electrical and Electronic Engineering, Yonsei University, Seoul 120-749, Korea [b] Samsung Electronics Co. Ltd., Suwon, Gyunggi-Do, Korea [c] Liquid Crystal Institute, Kent State University, Kent, OH 44242, USA

Online publication date: 06 July 2010

To cite this Article Ok, Chul-Ho , Kim, Byoung-Yong , Oh, Byeong-Yun , Kim, Young-Hwan , Lee, Kang-Min , Park, Hong-Gyu , Han, Jeong-Min , Seo, Dae-Shik , Lee, Dong-Ki and Hwang, Jeong-Yeon(2008) 'IPS mode investigation of liquid crystal alignment on organic hybrid overcoat layer via ion beam irradiation', Liquid Crystals, 35: 12, 1373 — 1377

To link to this Article: DOI: 10.1080/02678290802617716

URL: http://dx.doi.org/10.1080/02678290802617716

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: http://www.informaworld.com/terms-and-conditions-of-access.pdf

This article may be used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan or sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

Liquid Crystals,
Vol. 35, No. 12, December 2008, 1373–1377

Taylor & Francis
Taylor & Francis Group

IPS mode investigation of liquid crystal alignment on organic hybrid overcoat layer via ion beam irradiation

Chul-Ho Ok[a], Byoung-Yong Kim[a], Byeong-Yun Oh[a], Young-Hwan Kim[a], Kang-Min Lee[a], Hong-Gyu Park[a], Jeong-Min Han[a], Dae-Shik Seo[a]*, Dong-Ki Lee[b] and Jeong-Yeon Hwang[c]

[a]*Information Display Device Laboratory, School of Electrical and Electronic Engineering, Yonsei University, Seodaemun-Gu, Seoul 120-749, Korea;* [b]*Samsung Electronics Co. Ltd., Yeongtong-Gu, Suwon, Gyunggi-Do, Korea;* [c]*Liquid Crystal Institute, Kent State University, Kent, OH 44242, USA*

(Received 28 August 2008; final form 12 November 2008)

The nematic liquid crystal alignment capability and electro-optical (EO) performance characteristics of in-plane switching (IPS) cells were first demonstrated on organic hybrid overcoat layers via ion beam irradiation. Usually the organic hybrid overcoat is used as the material for making a plate alignment layer in a colour filter process. To characterise the organic hybrid overcoat layer, we analysed the surface composition of the organic hybrid overcoat by X-ray photoelectron spectroscopy. The results show that the intensity of C=O and C–O bonding undergoes a change corresponding to the changes in energy of the ion beam exposure. Moreover, EO performance characteristics of IPS cells on the organic hybrid overcoat layer via ion beam irradiation were observed to have similar characteristics to the polyimide.

Keywords: organic hybrid overcoat; ion beam irradiation; liquid-crystal alignment; IPS mode; XPS analysis

Downloaded At: 14:59 25 January 2011

1. Introduction

The liquid-crystal display (LCD) industry has undergone considerable growth in recent decades. LCD TVs with screen sizes up to 100 inches have now been introduced. The uniform alignment of liquid-crystal (LC) molecules on treated surfaces is very important for many applications. However, the current rubbing manufacturing process (*1–6*) for LC alignment has a number of drawbacks, including the generation of contaminating particles and electrostatic charges. In addition, the washing process required one to remove debris and the baking required for imidisation slowed down production and decreased cost-effectiveness (*7*). Thus, non-contact alignment methods are highly desirable. A number of alternative alignment techniques have been reported, including ultraviolet exposure, oblique deposition, and nanoimprint lithography, which have attracted attention from industry and research organisations (*8, 9*). However, none of these has been applied in large-surface LCD manufacturing. Ion beam (IB)-induced alignment methods that provide controllability, non-stop processing, and high-resolution display have been investigated intensively in conjunction with inorganic and organic materials with the aim of enhancing LC product quality and reducing the problems with non-contact methods. Organic overcoating is usually used to make a plate alignment layer in the colour filter process. We created the in-plane switching (IPS) mode using an organic hybrid overcoat (*10*) that is transparent and also has good heat resistance properties that are better than the organic imide or acryl overcoat. An additional polymer is not necessary for LC orientation because the overcoat layer functions as an alignment layer in the upper substrate of IPS mode (*11, 12*), which has the potential of simplifying the manufacturing process and reducing costs. The use of organic hybrid overcoat materials for LC alignment layers has not been reported previously. We fabricated an IPS cell with a low pretilt angle, and measured the electro-optical (EO) performance characteristics of an ion beam-aligned IPS cell on an organic hybrid overcoat layer via ion beam exposure based on LC alignment. The pretilt angles generated on the organic hybrid overcoat layer were measured under conditions of controlled energy, incident angle, and exposure time. The EO performance characteristics of the IPS cell formed on the organic hybrid overcoat layer *via* ion beam irradiation were similar to those of the polyimide (PI) (*11*). The spectra of the organic hybrid overcoat as a function of energy intensity of the ion beam were analysed by X-ray photoelectron spectroscopy (XPS) to determine the mechanism of LC alignment (*13*).

2. Experiment

The organic hybrid overcoat materials were synthesised so that each R1 is independently a hydrogen or

*Corresponding author. Email: dsseo@yonsei.ac.kr

ISSN 0267-8292 print/ISSN 1366-5855 online
© 2008 Taylor & Francis
DOI: 10.1080/02678290802617716
http://www.informaworld.com

a methyl group; R2 is an alkyl group of four to 16 carbon atoms; R3 is an alkyl group of one to seven carbon atoms, a cyclooxyalkyl group of one to seven carbon atoms, a benzyl group, or a phenyl group; 1, *m*, and *n* represent molar ratios of polymerisation units and are, respectively, from about 0.01 to about 0.50, from about 0.10 to about 0.60, and from about 0.03 to about 0.50, as shown in Figure 1. Figure 2 shows the structure of the IPS cell employed in this study. The electrode width and electrode spacing were 10 µm.

The organic hybrid overcoat was uniformly prepared by spin-coating on indium-tin-oxide (ITO) electrodes, and imidisation at 200°C for 60 min. The thickness of the hybrid organic overcoat layer was set to 1000 Å. Before spin-coating, the ITO-coated glass was cleaned with a supersonic wave in a trichlor-oethyl-acetone-methanol–de-ionised water solution for 10 min and then air-dried. The organic hybrid overcoat layers were exposed to the IB at energy intensities in the range 600–2400 eV in increments of 600 eV using a DuoPIGatron-type IB system. The glass substrates with the organic hybrid overcoat layer were assembled in an antiparallel configuration with a cell gap of 50 µm to observe the pretilt angles, and the IPS cells were prepared with a cell gap of 5 µm to examine the EO characteristics. The test samples were assembled together and filled with the NLC (T_c=72°C, $\Delta\varepsilon$=8.2, Δn=0.0987, MJ001929 from Merck). The LC alignment characteristics were observed using a photomicroscope. The pretilt angles of the NLC were measured using the crystal-rotation method (TBA 107 tilt-bias angle evaluation device; Autronic Co.) at room temperature. Voltage–transmittance (*V–T*) and response time characteristics of the IPS cell were obtained using an LCD evaluation system (LCD-700; Otsuka Electronics).

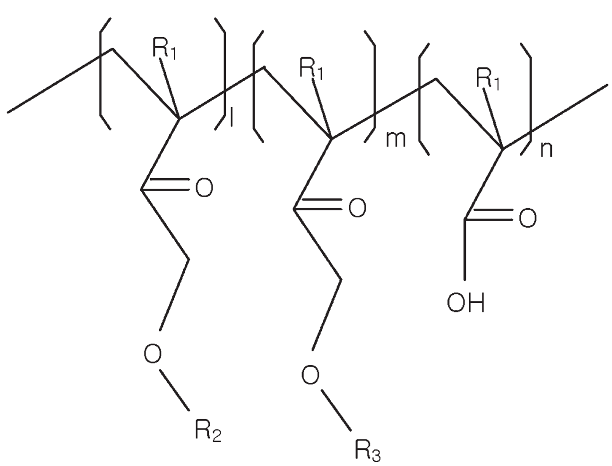

Figure 1. Chemical structure of the organic hybrid overcoat.

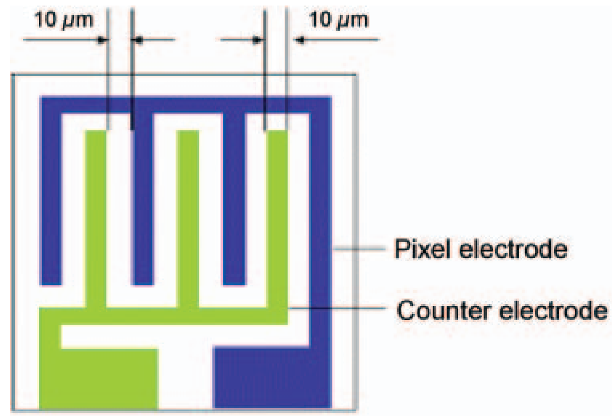

Figure 2. Structure of IPS test cell.

3. Results and discussion

Figure 3 shows micrographs of the ion beam-exposed nematic liquid crystal (NLC) cells for various levels of energy intensity for an incident angle of 45° and an exposure time of 1 min. A uniform switching characteristic was achieved without defects in the alignment. Moreover, the LC alignment capability of the organic hybrid overcoat layers was the same as that of the PI. Figure 4 shows the measured pretilt angles of LC cells on the organic hybrid overcoat as a function of the energy density of the IB with respect to the plane of the substrates for an incident angle of 45° and an exposure time of 1 min. The resulting values were built up in a low range of angles from 0.05° to 0.55°, including adaptability to LC modes with a low pretilt angle, such as the IPS mode. The XPS analysis was used to analyse the effect of the IB on the pretilt angle. The chemical binding characteristics of the atoms on the organic hybrid overcoat layer were analysed based on their XPS spectra. The changes in the peaks of the organic hybrid overcoat layer are shown in Figure 5 before and after IB irradiation. All binding energies were corrected with reference to the C 1s line at 284.6 eV. In addition, each of the peaks showed the core-level XPS spectra of C 1s that were decomposed into four components centred at 284.7, 285.5, 286.3, and 288.6 eV. Component peak 1 at 284.7 eV in the C 1s peak is attributable to the C=C bond, component peak 2 at 285.5 eV is related to the C–C bond, peak 3 at 286.3 eV corresponds to a C–O or C–N single bond, and peak 4 at 288.6 eV corresponds to a C=O bond.

The results of XPS analysis showed that the atomic percentage of the C=O bond after IB irradiation decreased and the atomic percentage of the C–O or C–N bond increased significantly. The carbon introduced in the collision following IB irradiation reforms a complex carbon network because the disordered carbons are orientated. In

Downloaded At: 14:59 25 January 2011

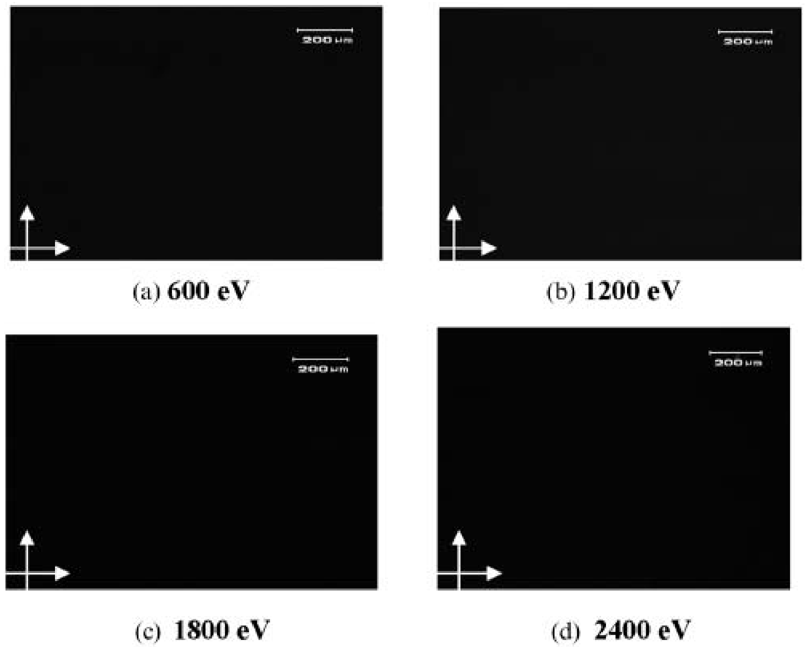

Figure 3. Microphotographs of the LC cells aligned on the organic hybrid overcoat layer by the density of ion beam (IB) irradiation in crossed Nicols for (a) 600 eV, (b) 1200 eV, (c) 1800 eV, (d) 2400 eV. (The microphotograph of the LC is black when the LC alignment is good; when the alignment is not good, the microphotograph is not black.)

Downloaded At: 14:59 25 January 2011

addition, the preferential orientation of the carbon network parallel to the density of IB irradiation on the organic hybrid overcoat layer is estimated from the remaining interactions with the benzene ring of the LC molecules. Therefore, the LCD alignment capability is attributable to the unidirectional ordering of the carbon network from bond-breaking

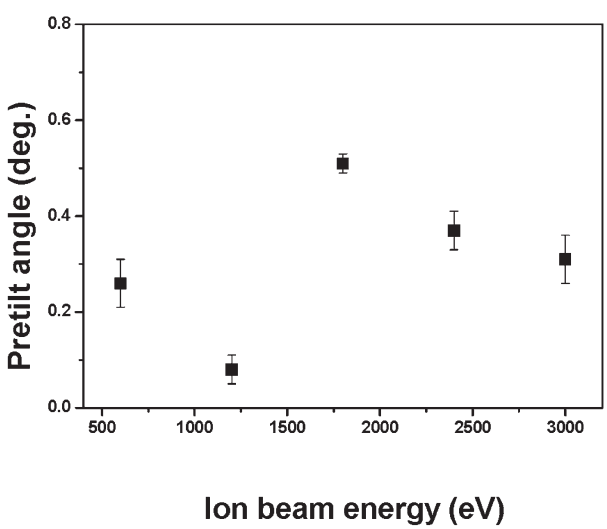

Figure 4. Pretilt angles on the ion beam (IB)-irradiated organic hybrid overcoat as a function of the energy intensity of IB at an IB incident angle of 45° and exposure time of 1 min.

(Figure 5). Figure 6 shows a plot of the *V–T* characteristics in the IPS cell homogeneously aligned on the IB-irradiated organic hybrid overcoat layer. The transmission characteristic was for the alignment method when applying 10 V to the cell. The threshold voltage of the IB-irradiated organic hybrid overcoat was 3.8 V. Figure 7 shows the response time characteristic of the IPS cells with the ion beam-aligned organic hybrid overcoat layer. Superior performance was obtained in the IB-irradiated organic hybrid overcoat with a rise time of 7.5 ms and decay time of 8.5 ms. The IPS cell exhibited rapid and stable response time characteristics.

The effect of continuous display is of the image 'sticking'. In the case of thin film transistor (TFT)-LCD, increased resistance of gate TFT due to pixel TFT variation prevents the capacitor full addressing and this results in the image sticking effect. In addition to this, the instant image sticking effect can be shown when the response time increases. However, this can be ignored because the ion beam-treated organic hybrid overcoating layer has the same level of response time as PI. Also, in the case of manufacture in the IPS cell, liquid crystal alignment angle of 17°C from IPS electrode was formed and the crossed upper and lower polarizer were attached to the direction of liquid crystal alignment. However, all requirements were exactly not needed because of the hand manufacturing. Although tiny light can be

Downloaded At: 14:59 25 January 2011

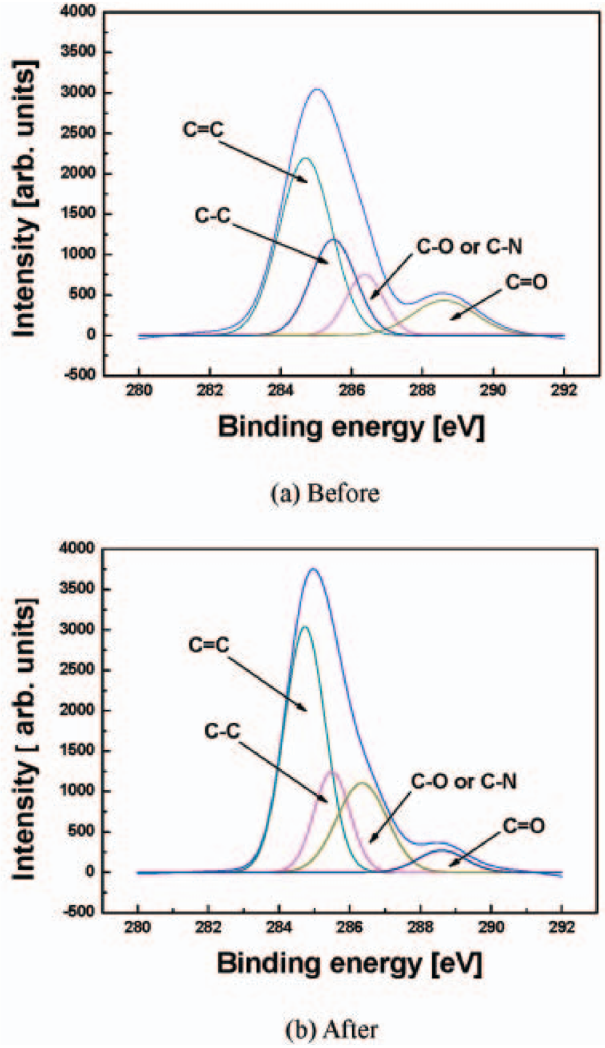

Figure 5. The XPS spectra for the C 1s from the organic hybrid overcoat layer (a) before, (b) after ion beam (IB) irradiation for an energy intensity of 2400 eV and an incident angle of 45°.

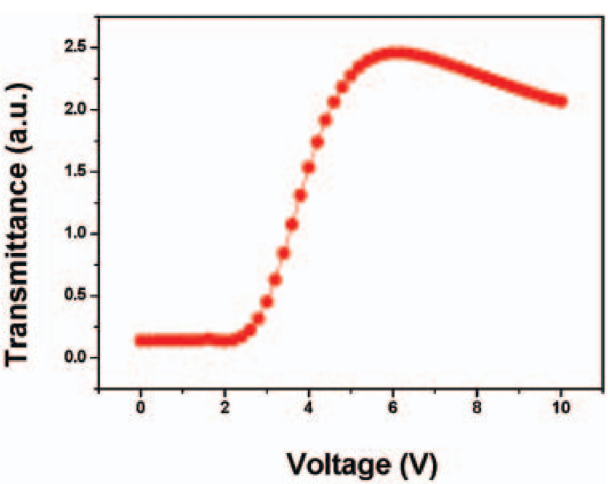

Figure 6. Voltage–transmittance characteristic of IPS cell with the ion beam-aligned organic hybrid overcoat layer.

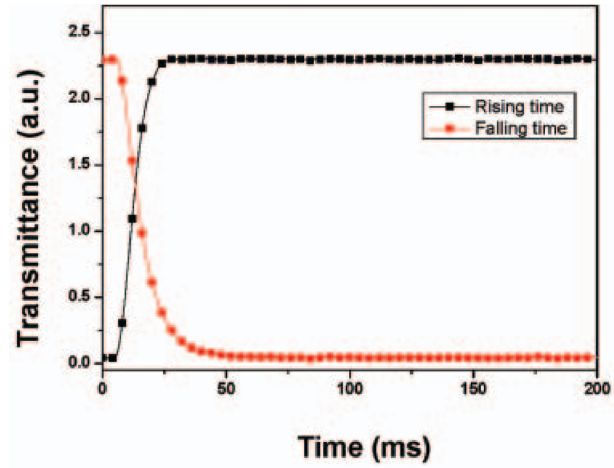

Figure 7. Response time characteristic of IPS cell with ion beam-aligned organic hybrid overcoat layer.

injected to a plane of polarization of cell upper when measuring the Data, it can't affect the analysis of this experiment. In addition, the thermal stability of the IB-irradiated organic hybrid overcoat was measured, and showed stable alignment up to 120°C.

4. Conclusion

n this study, the organic hybrid overcoat irradiated by the IB was first introduced as an LC alignment layer. The LC alignment effects and the EO performance characteristics of the IB-aligned IPS cell with the organic hybrid overcoat were investigated. Favourable pretilt angles were obtained, which were a function of the energy density. The orientation order for the IB-treated surface was attributable to the breaking of C=O bonds relative to the energy density of the IB. Therefore, the organic hybrid overcoat layer in which the orientation order has been generated by directional irradiation with an IB can be used for LC alignment. Moreover, the EO performance characteristics of the IPS cell formed on the organic hybrid overcoat layer by ion beam irradiation were found to have characteristics similar to those of the PI.

Acknowledgements

This work was supported by MIC, Korea, under the ITRC support program supervised by the IITA (IITA-2006-1090-0603-0018).

References

(1) Geary J.M.; Goodby J.W.; Kmetz A.R.; Patel J.S. *J. Appl. Phys.* **1987**, *62*, 4100.
(2) Matsuda H.; Seo D.-S.; Yoshida N.; Fujibayashi K.; Kobayashi S. *Mol. Cryst. Liq. Cryst.* **1995**, *264*, 23.

(3) Seo D.-S.; Muroi K.; Kobayashi S. *Mol. Cryst. Liq. Cryst.* **1992**, *213*, 223.
(4) Seo D.-S.; Araya K.; Yoshida N.; Nishikawa M.; Yabe Y.; Kobayashi S. *Jpn. J. Appl. Phys.* **1995**, *34*, L503.
(5) Seo D.-S.; Kobayashi S.; Nishikawa M. *Appl. Phys. Lett.* **1992**, *61*, 2392.
(6) See, for example, Seo D.-S.; Matsuda H.; Ishizaki J.; Lamura Y.; Kobayashi S. *SID Dig.* **1993**, p. 953.
(7) Chaudhari P.; Doyle J.; Galligan E.; Lien S.-C.A.; Callegari A.; Hougham G.; Lang N.D.; Andry P.S.; John R.; Yang H.-H.; Lu M.; Cai C.; Speidell J.; Purushothaman S.; Ritsko J.; Samant M.; Stohr J.; Nakagawa Y.; Katoh Y.; Saitoh Y.; Sakai K.; Samant H.; Stohr J.; Nakagawa Y.; Katoh Y.; Saitoh Y.; SaKai K.; Satoh H.; Odahara S.; Nakano H.; Nakagaki J.; Shiota Y. *Appl. Phys. Lett.* **2001**, *411*, 56.
(8) Kim J.-Y.; Oh B.-Y.; Kim B.-Y.; Kim Y.-H.; Han J.-W.; Han J.-M.; Seo D.-S. *Appl. Phys. Lett.* **2008**, *92*, 043505.
(9) Kobayashi K.; Limura Y. *SPIE* **1994**, *2175*, 123.
(10) Ju J.-H.; Lee D.-K.; Lee H.-K.; Kim S.-Y.; Lee J.-H., US Patent, 2007-0042136 A1, 2005.
(11) Kim S.-H.; Choi S.-H.; Lee S.-K.; Ok C.-H.; Hwang J.-Y.; Kim B.-Y.; Han J.-M.; Kang D.-H.; Han H.-W.; Ryu J.-H.; Jang J.; Seo D.-S. *Jpn. J. Appl.* **2007**, *46*, 4225–4227.
(12) Sun Y.; Zhang Z.; Ma H.; Zhu X.; Wu S.-T. *J. Appl. Phys.* **2003**, *93*, 3920.
(13) Ektessabi A.M.; Hakamata S. *Thin Solid Films* **2000**, *621*, 377–378.

Downloaded At: 14:59 25 January 2011