



Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and
subscription information:

<http://www.tandfonline.com/loi/gmcl19>

Estimation of the Static Electricity and Optical Retardation Produced by Rubbing Polyimide and Polyamide Films with Different Fabrics

H. Matsuda^{a b}, D.-S. Seo^a, N. Yoshida^a, K. Fujibayashi^a, S.
Kobayashi^a & Y. Yabe^c

^a Division of Electronic and Information Engineering, Faculty of
Technology, Tokyo University of Agriculture and Technology, 2-24-16
Nakamachi, Koganei, Tokyo, 184, Japan

^b Device Center, Central Research Institute, Nikon Co. Ltd., 1-6-3
Nishi-ooi, Shinagawaku, Tokyo, 140, Japan

^c Development Engineering Department, Fujitsu Kiden Co. Ltd., 1776
Yanokuchi, Inagi, Tokyo, 206, Japan

Version of record first published: 23 Sep 2006.

To cite this article: H. Matsuda , D.-S. Seo , N. Yoshida , K. Fujibayashi , S. Kobayashi & Y. Yabe
(1995): Estimation of the Static Electricity and Optical Retardation Produced by Rubbing Polyimide
and Polyamide Films with Different Fabrics, Molecular Crystals and Liquid Crystals Science and
Technology. Section A. Molecular Crystals and Liquid Crystals, 264:1, 23-28

To link to this article: <http://dx.doi.org/10.1080/10587259508037298>

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: <http://www.tandfonline.com/page/terms-and-conditions>

This article may be used for research, teaching, and private study purposes. Any
substantial or systematic reproduction, redistribution, reselling, loan, 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.

Estimation of the Static Electricity and Optical Retardation Produced by Rubbing Polyimide and Polyamide Films with Different Fabrics

H. MATSUDA,* D.-S. SEO, N. YOSHIDA, K. FUJIBAYASHI, and S. KOBAYASHI

Division of Electronic and Information Engineering, Faculty of Technology, Tokyo University of Agriculture and Technology, 2-24-16 Nakamachi, Koganei, Tokyo 184, Japan

and

Y. YABE

Development Engineering Department, Fujitsu Kiden Co. Ltd., 1776 Yanokuchi, Inagi, Tokyo 206, Japan

(Received March 4, 1994; in final form April 18, 1994)

We have studied the static electricity and optical retardation generated by rubbing the surfaces of polyimide (PI) and polyamide (PA) films. The static electricity increases with the Rubbing Strength (RS) and varies with the different PI films.

We also investigated how the differences in the rubbing fabric affects the magnitude of the induced static electricity; the order of this effect is nylon > rayon > cotton. The induced static electricity is not only directly related to the values of the specific resistivity of the rubbed PI films, but also the RS and the ability of the rubbing fabric to generate and add a static electric charge.

The order of the optical retardation produced by the rubbing fabric on rubbed PI films is nylon > rayon > cotton, coinciding with the order of the generated static electricity.

Keywords: *Polyimide, rubbing strength, static electricity, rubbing fabric, optical retardation*

INTRODUCTION

Surface alignment of liquid crystals (LCs) on treated substrate surfaces is required to produce LC electro-optic devices.¹

Most LC displays, such as twisted nematic (TN),² super twisted nematic (STN),³ and surface-stabilized ferroelectric LC (SSFLC),⁴ are prepared using various surface alignment techniques: oblique evaporation of SiO films,⁵ rubbed polyimide (PI) films,^{6–11} PI Langmuir–Blodgett (LB) films,^{12,13} polypyrrole (PP) films,¹⁴ and so forth.

The rubbing method is the most widely utilized alignment technique, both in laboratories and factories, even though non-rubbing techniques have been demonstrated.¹⁵

* *Present address:* Device Center, Central Research Institute, Nikon Co. Ltd., 1-6-3 Nishi-ooi, Shinagawa-ku, Tokyo 140, Japan

Thin Film Transistors (TFTs), used in active matrix LCDs are degraded or damaged by the induced static electricity produced during rubbing, but the detailed mechanism of the static charge generation is not clear.

In this paper, we report the static electricity generated on the surface of the rubbed PI films in conjunction with the optical retardation induced in these films. We show how the results depend on the difference of the PI films and rubbing buffs. We studied three different kinds of PI films and three different kinds of rubbing buffs.

EXPERIMENTAL

The PI materials and polyamide (PA) materials, studied were:

RN-305 (PI, Nissan Chemical Industries Co. Ltd.)
:alkyl-branchless and highest polarization;
specific resistivity is $5 \times 10^{14} \Omega \text{ cm}$.

RN-713 (PI, Nissan Chemical Industries Co. Ltd.)
:alkyl-branch and medium polarization;
specific resistivity is $2 \times 10^{16} \Omega \text{ cm}$.

HL-1110 (PA, Hitachi Chemical Co. Ltd.)
:alkyl-branchless and highest polarization;
specific resistivity is $2 \times 10^{16} \Omega \text{ cm}$.

The PI films prepared by polyimidization at 250°C for one hour, while the PA was prepared by polyimidization at 150°C for one hour. The PI and PA films were coated on indium-tin-oxide (ITO) coated glass substrates. The definition of the RS is reported in a previous paper.^{8,10,11)}

The rubbing fabrics studied were:

Cotton: with cellulose structure, natural fiber.
Rayon: with cellulose structure, synthetic fiber.
Nylon: with polyamide structure, synthetic fiber.

The system used to measure the static electricity is shown in Figure 1. After preparing the orientation film on ITO, we removed a part of the orientation film. We placed the ground electrode of the static electricity measuring instrument into contact with the stage of the rubbing machine. After rubbing, we immediately placed the positive electrode of the static electricity measuring instrument into contact with the ITO, and read the electrical charge [Coulomb] from the meter. We report the charge per unit area [Coulomb/m²].

RESULTS AND DISCUSSION

Figure 2(a) shows the generated static electric charges produced using different fabrics to rub PI film (RN-305). The static charge increases with the RS for the nylon fabric,

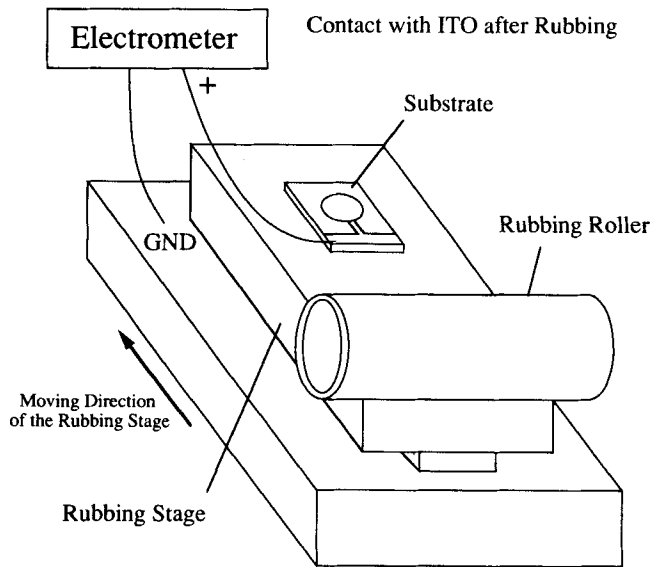


FIGURE 1 Static electricity measuring system.

however no substantial change is observed for the other two fabrics. Rubbing with nylon generates significantly more static charge than rubbing with rayon or cotton.

Almost the same result is obtained for RN-713 film rubbed with nylon. A small increase of static charge is generated by rayon and cotton (Fig. 2(b)).

In the case of HL-1110 as shown in Figure 2(c), nylon generates a large static charge as well. In the same fashion cotton and rayon also generate a great deal of static electricity.

Figure 3 shows the static electricity as a function of RS for different PI films rubbed with nylon fabric. The static electricity increases with the RS of nylon on HL-1110 and to a lesser extent on the two PI films.

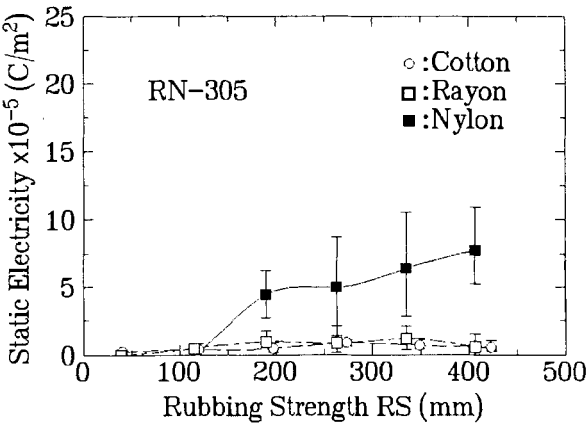
We conclude, from the above results, that the largest amount of static electricity is generated with the combination of nylon buff and HL-1110. Independent characterization of the orientated films demonstrated that the specific resistivity of both rubbed HL-1110 and RN-713 films is high. We therefore conclude that materials with higher resistivity are capable of holding larger static electrical charges.

For rubbing fabrics, we observed that the order of the fabrics ability to hold a static charge that is most easily obtained is the same as the order of their ability to generate static electricity.

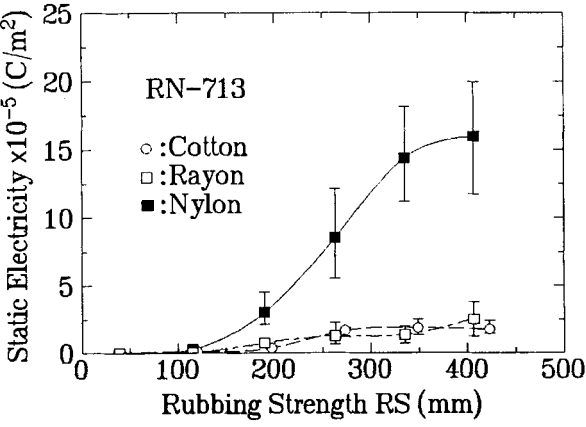
We expect high resistivity fabrics to produce the most static electricity.

In this experiment, when HL-1110 (polyamide orientation film) was rubbed with nylon, the most static electricity is observed. We consider that it is due to the difference of the condition that one side is a buff and the characterization of the films.

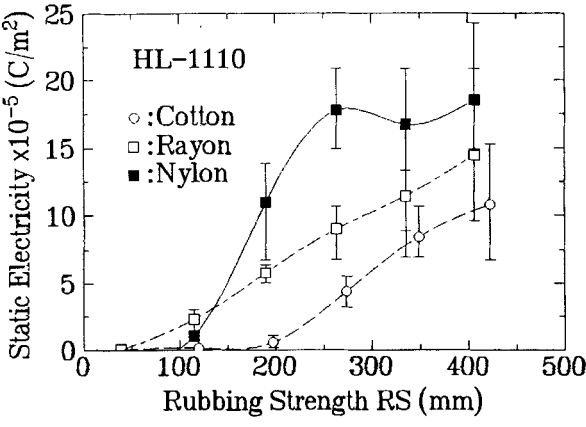
In general, when the same materials rub each other, static electricity doesn't occur. But, if the temperature increases, transformation, destruction of surface layer and the like produce differences between the material allowing the production of a charge because of the asymmetry.



(A)



(B)



(C)

FIGURE 2 The generated static electricity produced using different fabrics to rub polyimide films ((A) RN-305, (B) RN-713, (C) HL-1110).

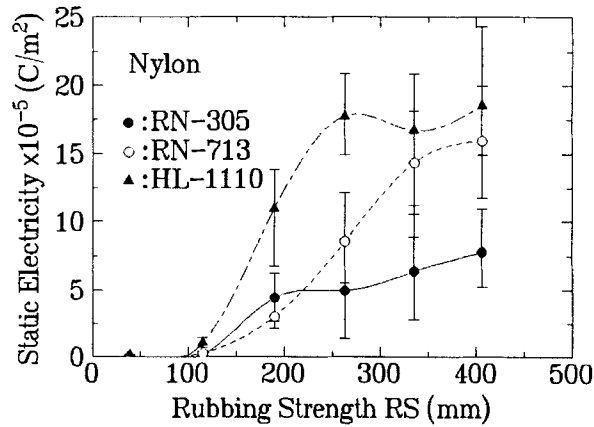


FIGURE 3 Static electricity as a function of RS for different polyimide films rubbed with nylon fabric.

We show the optical retardation with different kinds of rubbing fabrics on rubbed PI films (RN-713) in Figure 4.

The magnitude of the optical retardation as a function of the fabric is:

nylon = rayon > cotton

The optical retardation increases with the RS of nylon on PI film (RN-713). The optical retardation is larger with nylon than with the other two fabrics.

Nylon and rayon are synthetic fibers. The tips of these fibers are uniform and sharp, while cotton, a natural fiber, has unequal and disheveled tips.

Therefore, the static electricity is strongly correlated with the optical retardation.

We conclude that differences in the optical retardation on rubbed PI films is caused by differences in the structure of the fiber tips.

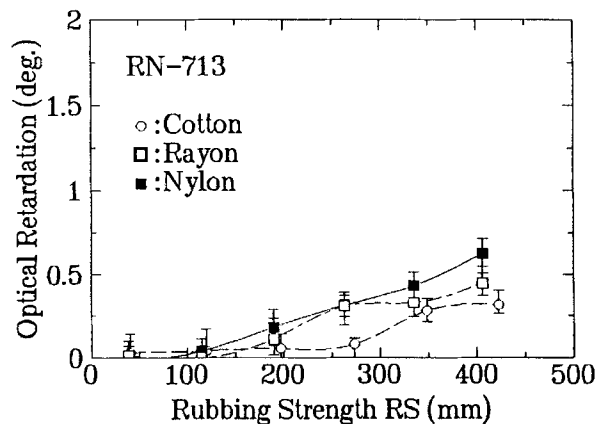


FIGURE 4 Optical retardation with different kinds of rubbing fabrics on rubbed polyimide films.

CONCLUSIONS

We investigated the static electricity and optical retardation generated by rubbing PI and PA films with three kinds of rubbing fabrics.

The results in this work can be summarized as follows:

- 1) Static electricity increase with the RS with all three rubbing fabrics and rubbed PI films.
- 2) The order of the static electricity on rubbed PI films in this work is: nylon > rayon > cotton.
- 3) We conclude that the static electricity on rubbed PI films is directly related to the specific resistivity of the orientated films and the ability of the fabric to hold a charge.
- 4) Optical retardation increases with the RS on rubbed PI films.
- 5) The order of the optical retardation in rubbed PI films in this work is: nylon > rayon > cotton.
- 6) We conclude that the static electricity is strongly correlated with the optical retardation, which is a measure of the flow (deformation) occurring on the surfaces of substrate polymer films.

Acknowledgments

The authors wish to acknowledge H. Fukuro of Nissan Chemical Industries Co. Ltd. for providing materials and Dr. J. West of Liquid Crystal Institute of Kent State University for the critical reading of the manuscript and his suggestions. This research was supported in part by a Grant-in-Aid for Encouragement of JSPS Junior Scientists from the Ministry of Education, Science, and Culture of Japan.

References

1. J. Cognard, *Mol. Cryst. Liq. Cryst. Supplement*, **1**, 1 (1982).
2. M. Schadt and W. Helfrich, *Appl. Phys. Lett.*, **18**, 127 (1971).
3. T. J. Scheffer and J. Nehring, *Appl. Phys. Lett.*, **45**, 1021 (1984).
4. N. A. Clark and S. T. Lagerwall, *Appl. Phys. Lett.*, **36**, 899 (1980).
5. J. Janning, *Appl. Phys. Lett.*, **21**, 173 (1972).
6. M. E. Becker, R. A. Kilian, B. B. Kosmowski and D. A. Milynski, *Mol. Cryst. Liq. Cryst.*, **130**, 167 (1986).
7. S. Kuniyasu, H. Fukuro, S. Maeda, K. Nakaya, M. Nitta, N. Ozaki and S. Kobayashi, *Jpn. J. Appl. Phys.*, **27**, 827 (1988).
8. D.-S. Seo, K. Muroi and S. Kobayashi, *Mol. Cryst. Liq. Cryst.*, **213**, 223 (1992).
9. D.-S. Seo, Y. Iimura and S. Kobayashi, *Appl. Phys. Lett.*, **61**, 234 (1992).
10. D.-S. Seo, H. Matsuda, T. Oh-ide and S. Kobayashi, *Mol. Cryst. Liq. Cryst.*, **224**, 13 (1993).
11. D.-S. Seo, S. Kobayashi and M. Nishikawa, *Appl. Phys. Lett.*, **61**, 2394 (1992).
12. H. Ikeno, A. Ohsaki, M. Nitta, N. Ozaki, Y. Yokoyama, K. Nakaya and S. Kobayashi, *Jpn. J. Appl. Phys.*, **27**, 475 (1988).
13. D.-S. Seo, T. Oh-ide and S. Kobayashi, *Mol. Cryst. Liq. Cryst.*, **214**, 97 (1992).
14. D.-S. Seo, S. Kobayashi and A. Mochizuki, *Appl. Phys. Lett.*, **60** (8), 1025 (1992).
15. Y. Toko, T. Sugiyama, K. Katoh, Y. Iimura, and S. Kobayashi, *J. Appl. Phys.*, **74**, 2071 (1993).