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LB법으로 제작한 MIM 구조 유기 박막의 전자특성

(Electronic Properties of MIM Structure Organic Thin-films that Manufacture by LB method)

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요 약

전기 · 전자 소자를 제작하는 방법으로 Langmuir-Boldgett(LB)법이 많은 관심을 받고 있다. 수면위에 형성된 단분자막을 압축 또는 확장하면, 분자가 배향하는 과정에서 맥스웰 변위전류(MDC)가 흐른다. MDC는 전속밀도의 변화에 기인해서 흐르므로 MDC를 측정하는 것에 의해 분자의 동적 거동 관찰할 수 있다. 단분자막을 압축하는 속도와 분자면적은 서로 선형적인 관계를 갖고 있다. 본 연구에서는 압축속도를 30, 40, 50mm/min으로 달리하여 단분자막의 동적 거동을 관찰하였으며 LB법을 이용하여 Arachidic acid 단분자를 slide glass 위에 Y-type으로 9~21층의 다층막을 누적하여 Au/Arachidic acid/Al 소자를 제작하였다. 또한 Metal-Insulator-Metal(MIM) 소자의 I-V 특성을 측정하여 전극간의 거리가 커질수록 절연특성이 좋아짐을 확인하였다.

Abstract

The Langmuir-Blodgett(LB) technique has attracted considerable interest in the fabrication of electrical and electronic devices. Maxwell displacement current (MDC) measurement has been employed to study the dielectric property of Langmuir-films. MDC flowing across monolayers is analyzed using a rod-like molecular model. A linear relationship between the monolayer compression speed α and the molecular area Am. Compression speed α was about 30, 40, 50mm/min. Langmuir-Blodgett(LB)layers of Arachidic acid deposited by LB method were deposited onto slide glass as Y-type film. The structure of manufactured device is Au/Arachidic acid/Al, the number of accumulated layers are 9~21. Also, we then examined of the Metal-Insulator-Metal(MIM) device by means of I-V. The I-V characteristics of the device are measured from -3 to +3[V]. The insulation property of a thin film is better as the distance between electrodes is larger.

Keywords : Maxwell displacement current (MDC), Langmuir-films, MIM device

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I. Introduction

In the Langmuir-Boldgett(LB) technique, a monolayer on the water surface is transferred on to a substrate, whichis raised and dipped through the surface, and one can obtain multilayers in which constituent molecules periodically are arranged in layer. The LB technique has attracted considerable interest in the fabrication of electrical and electronic device, e.g.. Many researchers have investigated the electrical properties of monolayer and multiplayer films.[1][2]

Measures of physical properties by phase transfer phenomenon using organic matter material that have conductivity, propensity of dielectric, insulation and wish to do manufacture device of metal/organic thin film/metal structure and measure space charge of contact interface and interface potential and evaluate physical properties in this study. Do manufacture organic thin film device by results of measurements and detect electrical properties. Wish to present organic thin film communication device's application possibility.

We used Langmuir-Blodgett(LB) method of organic thin film and measure phase transfer phenomenon and displacement current, dipole moment and evaluate basis properties of matter. Wish to manufacture device of metal/organic thin film/metal (MIM) structure by valued result.

In this paper, we give pressure stimulation into organic thin films and then manufacture a device under the accumulation condition that the state surface pressure is 2, 10, 30[mN/m](gas state, liquid state, and solid state).[3] Also, we then examined of the Metal-Insulator-Metal(MIM) device by means of I-V.

II. Analysis

Figure 1 shows a model of a floating monolayer on a water surface. For simplicity, we confine our discussion to monolayers in the isotropic polar orientational phase. Briefly, the monolayer consists of rodlike polar molecules with a length *l*. Each molecule has a permanent electric dipole moment μin the direction along the molecular long axis, and it stands at a tilt angle θ away from the normal direction to the water surface. The motion of rodlike polar molecules is restricted within $0<\theta<\theta_A$, where $\theta_A = \sin^{-1}\sqrt{A/A_0}$ $(A_0 = \pi l^2)$. Here A is the molecular area and A0 is the critical molecular area.

The monolayer film is sandwiched between

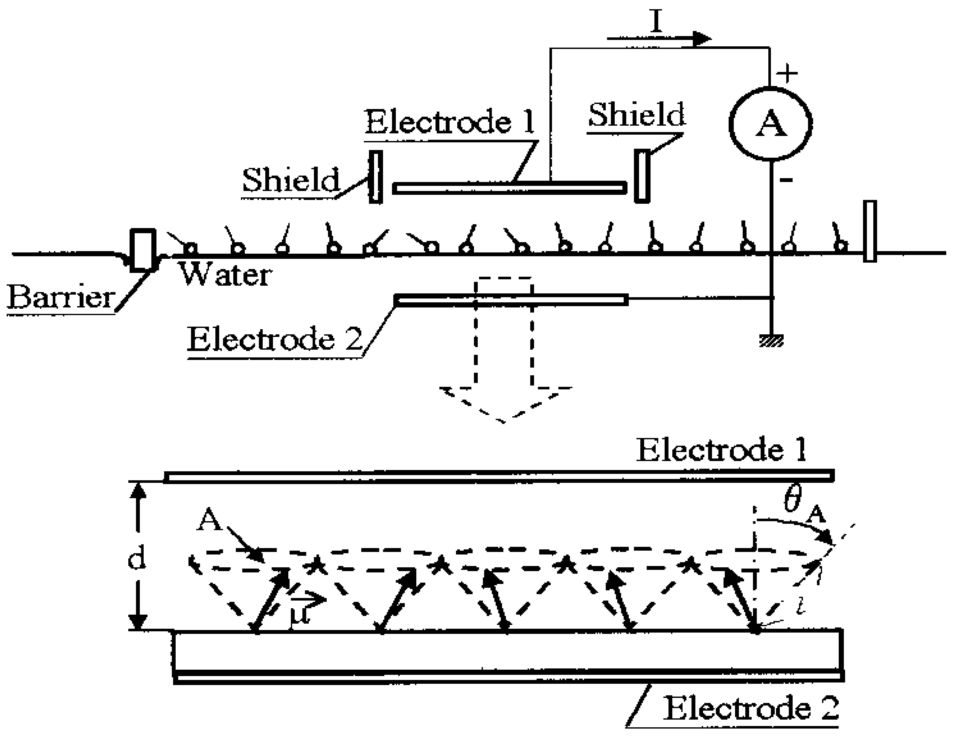

그림 1. 수면 위 분자 모델.
Fig. 1. Molecular model on the water surface.

electrodes 1 and 2.

Electrode 1 is suspended in the air parallel to and at a distance d from the water surface. The orientational order parameter S(t) of the organic monolayers on electrode 2 is given by

$$S(t) = \int_0^{\theta_A} \cos\theta f(\cos\theta,t)\sin\theta d\theta \qquad (1)$$

Here $f(\cos\theta,t)$ denotes the orientational distribution function at t=t.

Assuming that the orientational motion of molecules satisfies the Debye-Brownian motion equation, we obtain the following rate equation.

$$\frac{d}{dt}(S(t)-S_{eq}) = -\frac{S(t)-S_{eq}}{\tau} + \frac{1-<\cos^2\theta>}{\xi}RU(t) \qquad (2)$$

Here τ is the dielectric relaxation time of monolayer films, and given by

$$\tau = \frac{\xi}{kT}\frac{<(\cos\theta-<\cos\theta>)^2>}{1-<\cos^2\theta>} \qquad (3)$$

Where < > represents the thermal average, k is the Boltzmann constant, is the frictional constant of monolayer, R is the external stimulation, and U(t) is a step function.

In the MDC measurement, monolayers are compressed at a monolayer compression speed of α from the molecular area A = Ai. Electronic charges are induced on electrode 1 due to the presence of polar molecules on the water surface, and the magnitude of these electronic charges by monolayer compression. As a result, MDC flows through an ammeter. MDC is expressed as

$$MDC = I = -K\frac{d}{dA}\left(\frac{S}{A} - \frac{S_{eq}}{A_i}\right) \tag{4}$$

with $K = \frac{\alpha\mu}{d}B$. Here B is the working area of electrode 1. Therefore the following relation is easily obtained by integrating the MDC with respect to the molecular area

$$\frac{S}{A} - \frac{S_{eq}}{A_i} = -\frac{1}{K}\int_{A_i}^{A} I dA \tag{5}$$

Substituting Eq. (5) into Eq. (4), the following equation is obtained

$$I = \frac{1}{\tau\alpha}\int_{A_i}^{A} I dA + K\frac{S_f}{\tau\alpha} - \frac{1}{A}\int_{A_i}^{A} I dA \tag{6}$$

assuming $S_{eq}(A_i) = 0$. It should be noted here that rod-like polar molecules lie on water surface at the molecular area $A>A_0$, due to the Coulomb attractive force working between polar molecules and the water surface. That is $S_{eq}(A_i) = 0$ for $A>A_0$. Usually in the MDC measurement, the monolayer compression starts at $A=A_i>A_0$. At the molecular area $A=A_m$ MDC reaches maximum, therefore $dI/dA=0$ at $A=A_m$. The dielectric relaxation time τ(A) of monolayers can be determined as a function of the molecular area.[4][5]

Ⅲ. Experiment

Chemical structure of a Arachidic acid monomer shows in Figure 2. Monolayers of arachidic acid were spread from dilute chloroform solutions (0.5 *mmol*) onto the surface of pure water. The working area of electrode 1 was 45.6 [cm^2]. The distance d between electrode 1 and the water surface was 1 [mm]. The displacement current I was measured by an electrometer (Keithley 6517).

Arachidic acid was spread on pure water(pH 6.0, 18.2 M・cm) and maintained at 20 [℃]. After a

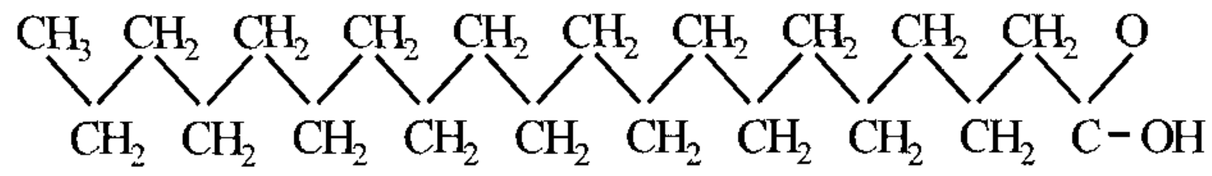

그림 2. Arachidic acid 분자 구조.
Fig. 2. Molecule structures of Arachidic acid.

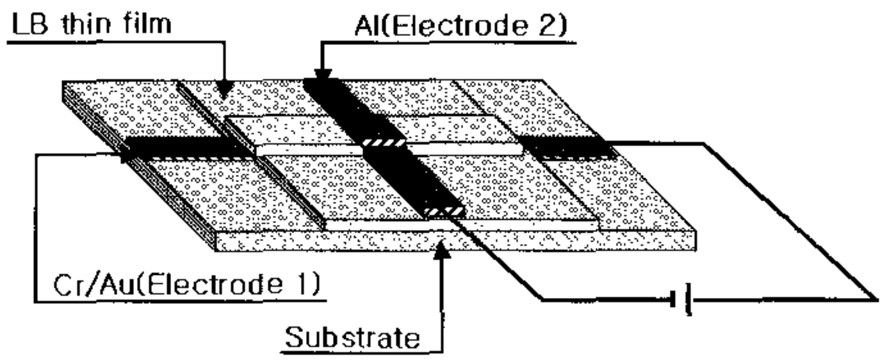

그림 3. MIM 구조.
Fig. 3. Structure of MIM.

monolayer was rested for 5 minutes, the monolayer was compressed at a compression speed of 30, 40, 50 [mm/min]. MDCs were measured during monolayer compression.

LB layers of Arachidic acid deposited by LB method were deposited onto slide glass as Y-type film. The structure of manufactured device is Au/Arachidic acid/Al, the number of accumulated layers are 9~21. Also, we then examined of the Metal-Insulator-Metal(MIM) device by means of I-V. The I-V characteristic of the device are measured from -3 to +3[V].

Ⅳ. Result and Discussion

Figure 4 shows a typical example of MDCs, where MDCs were initiated to flow at the molecular area $A=A_0$, due to the phase transition from the isotropic planar alignment phase on water surface (Range 1) to the polar orientational isotropic phase (Range 2). MDC peaks appear in the range of molecular area A between 51 and 25[Å^2](Range 2) by monolayer compression. We plotted the vertical component m_z(= μS) of the dipole moment of monolayers determined by Eq. (5), assuming S_{eq} (A_i)=0.

Figure 5 shows Y-type 21 layer when do deposition for surface pressure and area per molecule by time measure.

Compressed 30 [mN/m] that is deposition condition and surface pressure is regulated minutely approaching to depositioncondition, dipper can see as

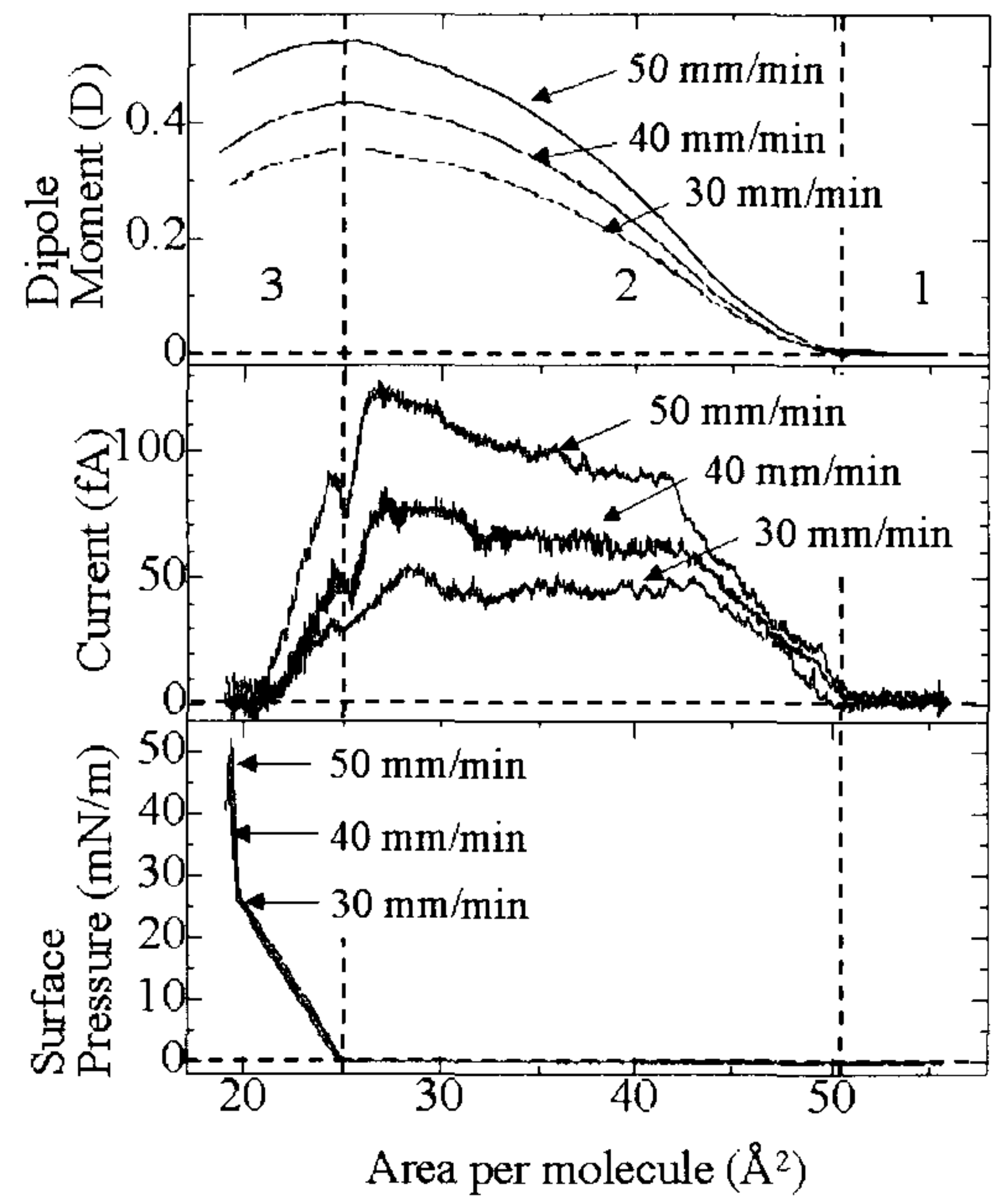

그림 4. 베리어 압축에 따른 π-A, I-A, D-A.

Fig. 4. π-A, I-A, D-A of barrier compress.

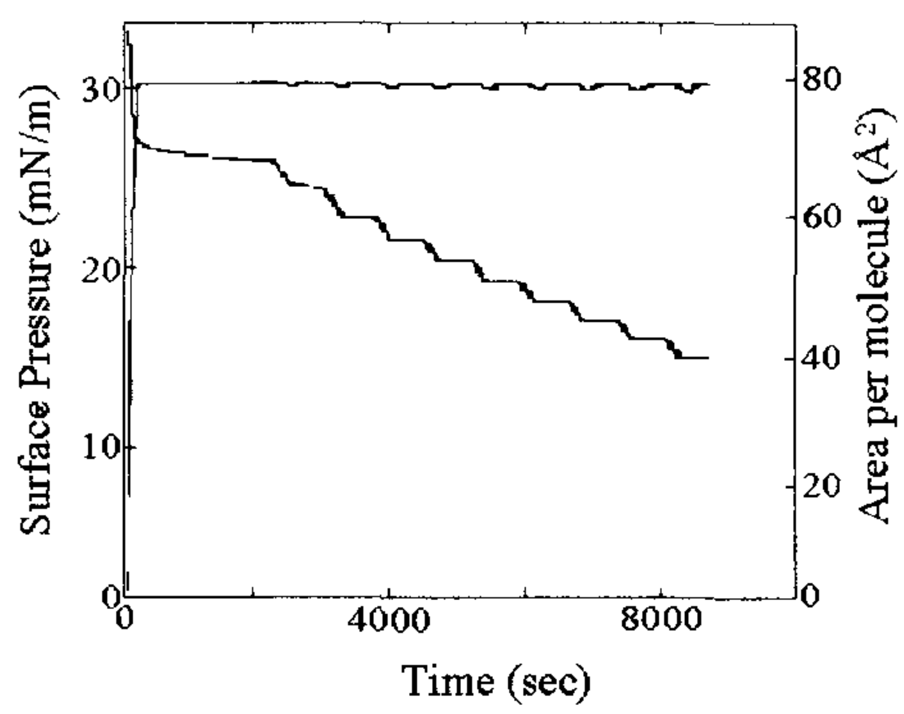

그림 5. 누적 전이비 .

Fig. 5. Deposition of transfer ratio.

board doing up, down stroke action that molecules are changed. Could know organic molecular film changed well in board seeing that decrease from of possession area per molecule shows lineally on water surface.

Figure 6 is I-V characteristics that approve voltage to Cr-Au/Arachidic acid/Al device that deposition each 9, 13, 17, 21 layers and is detected. we then examined of the Metal-Insulator-Metal(MIM) device by means of I-V. The I-V characteristic of the device is measured from -3 to +3[V]. In figure, current about voltage, deposition number of layer is much, could know that appear as size of current that happen in equal apply voltage is small. Also,

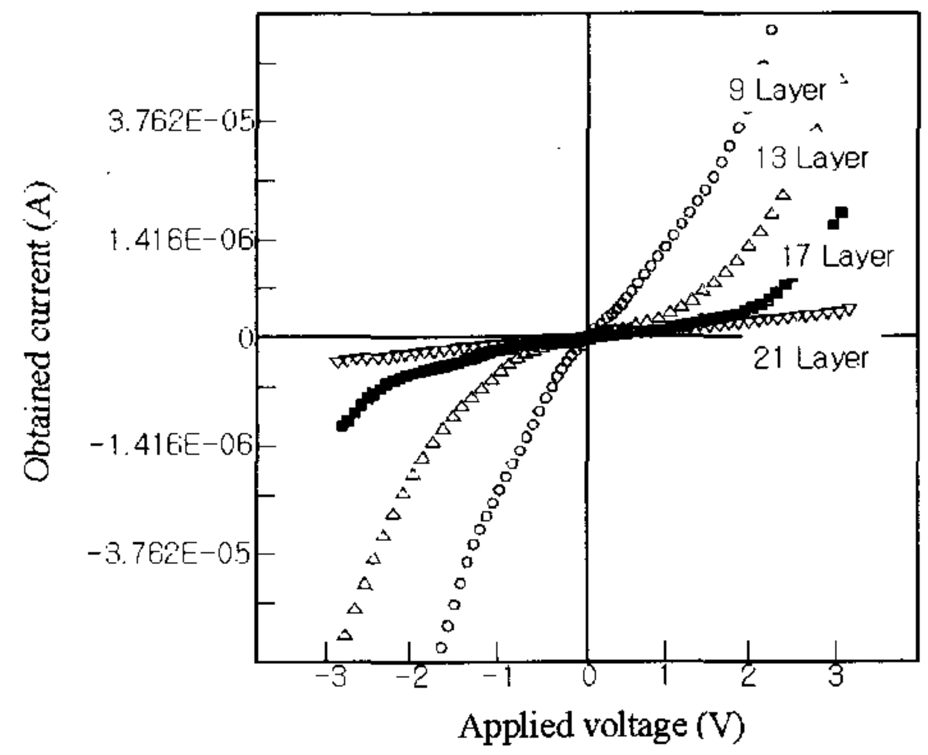

그림 6. I-V 특성.

Fig. 6. I-V characteristics.

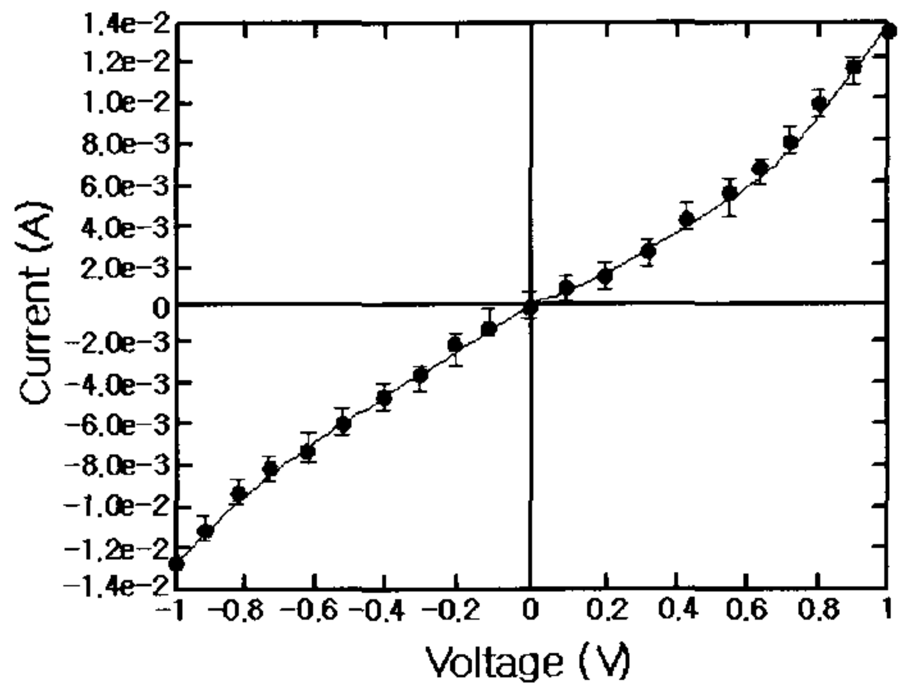

그림 7. I-V 특성(array type).

Fig. 7. I-V characteristics(array type).

deposition layer is small, increased with exponential function, if thickness great, curved line expressed direct ohmic characteristics. This is the insulation property of a thin film is better as the distance between electrodes is larger.

Figure 7 is I-V characteristics that approve voltage to array type device to know application possibility of organic nano thin films. By the result, current by approve voltage could see that is proportionally increases in voltage similarly with single MIM device, current dimension of happened current could confirm that appear more greatly about quadruple than single MIM device. These result can know that LB organic thin film is possible application to communication device.

V. Conclusion

The LB films during barrier compression with the initial rise in surface pressure. The surface pressure change was generated at A=24[Å^2] and see gas state(56-24 [Å^2]), liquid state(24-20 [Å^2]), solid state(20-19 [Å^2]).We give pressure stimulation into organic thin films and then manufacture a device under the accumulation condition that the state surface pressure is 2, 10, 30[mN/m](gas state, liquid state, solid state). The stable images are probably due to a strong interaction between the monolayer film and glass substrate. Formation that prevent when gas phase state and liquid phase state measure but could know organic matter that molecules form equal and stable film when molecules were not distributed evenly, and accumulated in solid state only.

LB layers of Arachidic acid deposited by LB method were deposited onto slide glass as Y-type film. The structure of manufactured device is Au/Arachidic acid/Al, the number of accumulated layers are 9~21. The insulation property of a thin film is better as the distance between electrodes is larger. Also, result that manufacture array type device, know that LB organic thin film is possible application to communication device.

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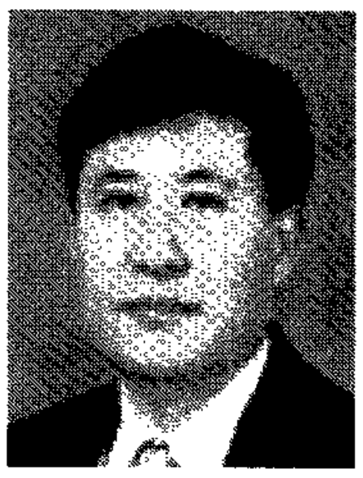
저 자 소 개



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