Control of molecular orientation and refractive index - New degrees of freedom for advanced optical design of OLEDs and OPVs -

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In device design of organic optoelectronic devices, such as OLEDs and OPVs, optical design is very important for deriving the full potential of organic semiconductor materials. Since the optical thickness of these organic devices has the same order as the wavelength of visible light, the device performance is sensitive to the optical multilayer structures. However, we have not had many degrees of freedom for the optical design of organic semiconductor devices because we have long assumed random molecular orientation, isotropic optical properties, and similar refractive indices of around 1.7–1.8 in vacuum-deposited amorphous organic semiconductor films.

In this presentation, we will demonstrate control of molecular orientation and refractive index for advanced optical design of the devices with amorphous films. First, we will discuss the effects of molecular orientation on optical properties of OLEDs and OPVs. We have demonstrated the generality of horizontal molecular orientation in amorphous organic semiconductor films[1,2] and first proposed the guideline that horizontal orientation of emitters can be used to enhance outcoupling efficiency even of small-molecule OLEDs.[2] This is important for further enhancing OLED efficiency and also for discussing the upper limit of OLED efficiency.[3] Also, horizontal orientation of dipoles of OPV materials is preferable for efficient absorption of vertically incident light. We have demonstrated horizontal orientation of some amorphous OPV materials in neat and co-deposited films.[4]

Next, we will introduce some results of refractive index control of vacuum-deposited organic films.[5] Using birefringence caused by molecular orientation, we can control refractive indices for horizontally and vertically polarized light. Moreover, the introduction of structures with high and low molar refractions makes it possible to further control refractive index efficiently. An organic semiconductor DBR (distributed Bragg reflector) with a large refractive index difference of 0.58 was achieved, demonstrating light control by organic films themselves.

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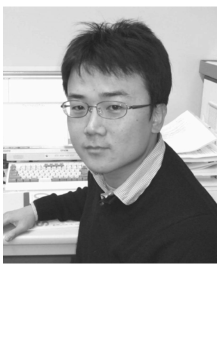

Daisuke Yokoyama obtained his BS and MS in Physical Chemistry from The University of Tokyo in 1998 and 2000, respectively. After working in Fuji Film Corporation for six years, he joined Kyushu University and obtained his Ph.D degree in Engineering in 2009. He is currently working at Yamagata University as an assistant professor. His research interest is in molecular physics in organic semiconductor devices, especially analysis and control of molecular orientation and refractive index.