Ultra-flexible organic light-emitting diodes (OLEDs) using textile substrates for wearable displays

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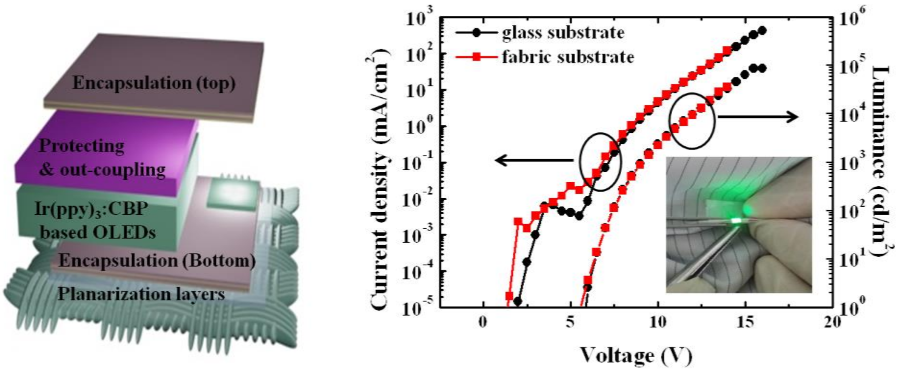
Many engineers are preparing a generation of Internet of everything (IOE) over the Internet of things (IOT). It is based on human desires and expectations for more convenient daily life. To develop human-friendly techniques for IOE, changes from hard electronics to soft electronics are needed, because flexible electronic devices are more suitable for the human body. Accordingly, electronic devices on clothing have started to appear [1]. If people use their clothes as a functional device, a visual display system is the one of the most important parts to communicate with devices on fabric. For this reason, new wearable display designs have been suggested recently [2, 3]. However, the results of previous works still show insufficient device performance for application in everyday life. To be widely used, highly efficient wearable devices with reliable performance are required.



(a) **(b)**

Fig 1. (a) Structure of soft fabric-based OLEDs including protective layers and 3.5 dyads encapsulations, and (b) performance of OLEDs (NPB capping) on glass and fabric substrate

In this study, we report a highly flexible, efficient, and reliable textile-based display using organic light-emitting diodes (OLEDs). A silane-based polymer film for a planarization process was transferred from a guide substrate to a fabric substrate. The OLEDs on a planarized fabric substrate emitted light stably on the condition that the bending radius is within 2 mm. Using a semi-transparent metal electrode in the OLEDs contributed to strong micro-cavity effects which raised the device's efficiency. The insertion of protective layers helped prevent the permeation of water vapor and oxygen during the encapsulation process, and made outcoupling the efficiency high. The encapsulation process consisted of the atomic layer deposition of Al_2O_3 and spin coating of the silane-based barrier solution alternately. The moisture barrier properties of the 3.5 dyads thin film encapsulation showed an extremely low water vapor transmission rate(WVTR) of 4.96 x 10^{-6} g/ m^2/ day by calcium corrosion test. Various applications of the engineering method suggested in this work may lead to advances in next-generation wearable electronics.

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