

Displacement Current Measurement (DCM) System

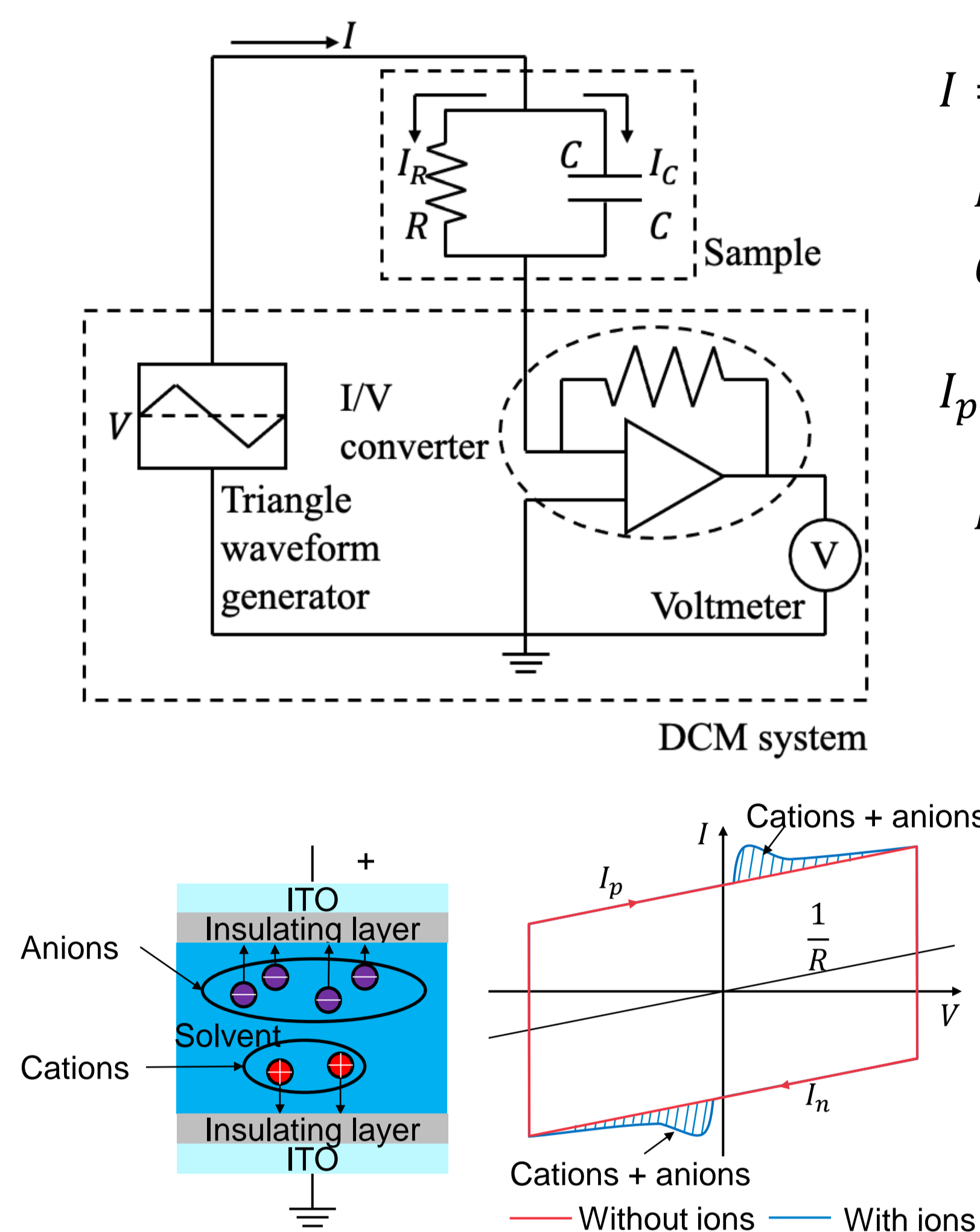
Overview

In liquid crystal industries, it is well known that unexpected ion contaminations cause display defects such as flicker, image sticking, and display mura [1]. We proposed an ion impurity measurement system to manufacture high-quality LCDs for a long time. By using our know-how, we are developing a novel displacement current measurement (DCM) system for organic material, process, and device evaluations. DCM is a next-generation product to measure ion impurities and charge injection and device characteristics with high sensitivity.

Features

- **Ion impurity measurement**
 - Powder materials by using a solvent
 - Use reliable disposable empty cell
 - Thin film on an insulation layer
 - Judgement of an ion polarity
- **Charge injection measurement**
 - Hole and electron injections
- **DCM-JV measurement**
 - Frequency: 1 mHz – 100 Hz
 - Auto range
- **High sensitivity**
 - Ion charge: 1 pC
- **Compact system size**
 - Setup in a glove box

The measurement principle of DCM



$$I = I_C + I_R = C \frac{dV}{dt} + \frac{V}{R}$$

I_C : Displacement current (A), I_R : DC current (A)
 C : Capacitance (F), R : Resistance (Ω)

$$I_p = C \frac{dV}{dt} + \frac{V}{R}, I_n = -C \frac{dV}{dt} + \frac{V}{R}$$

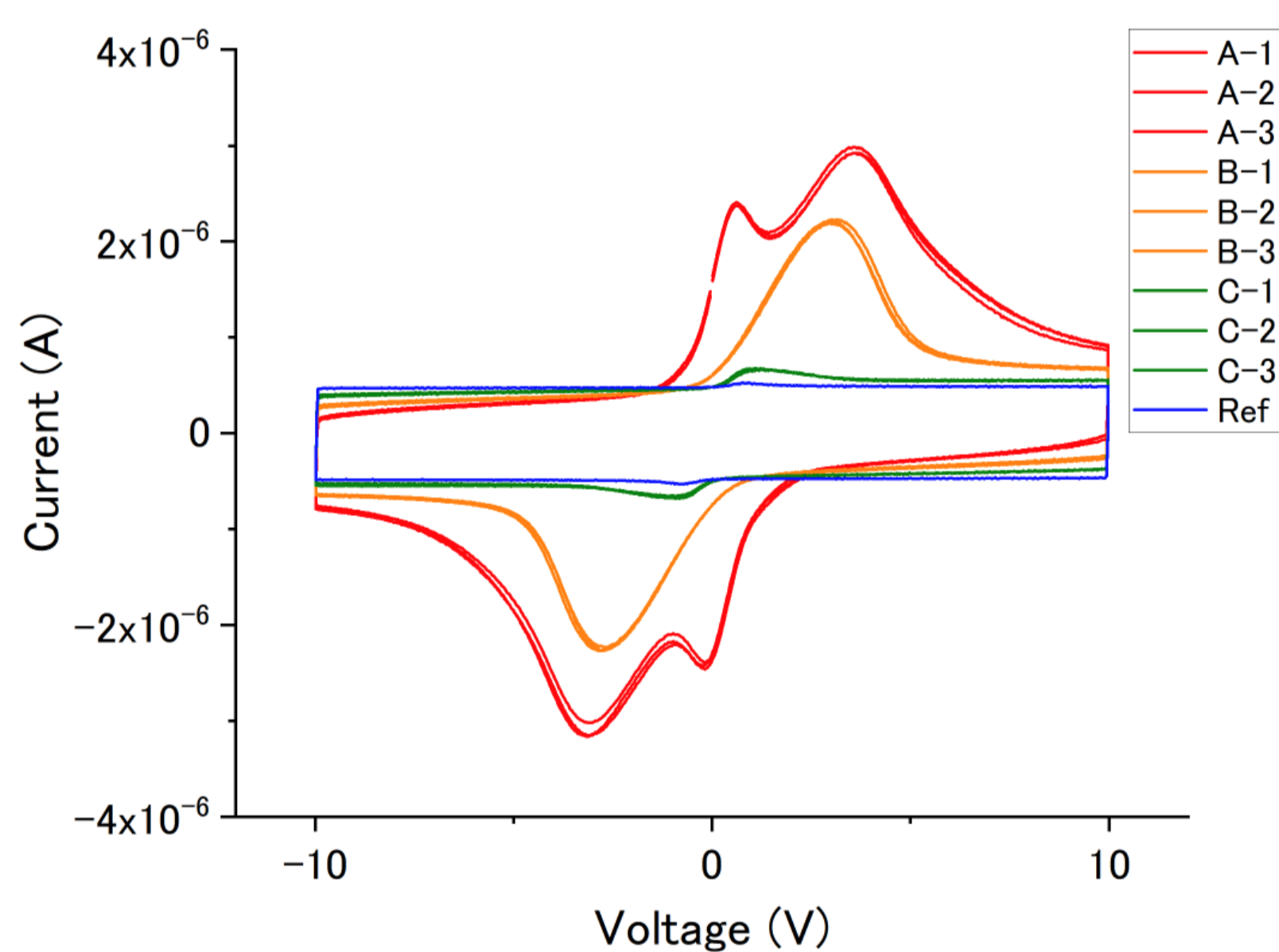
I_p : Current when $\frac{dV}{dt} > 0$ (A),

I_n : Current when $\frac{dV}{dt} < 0$ (A)

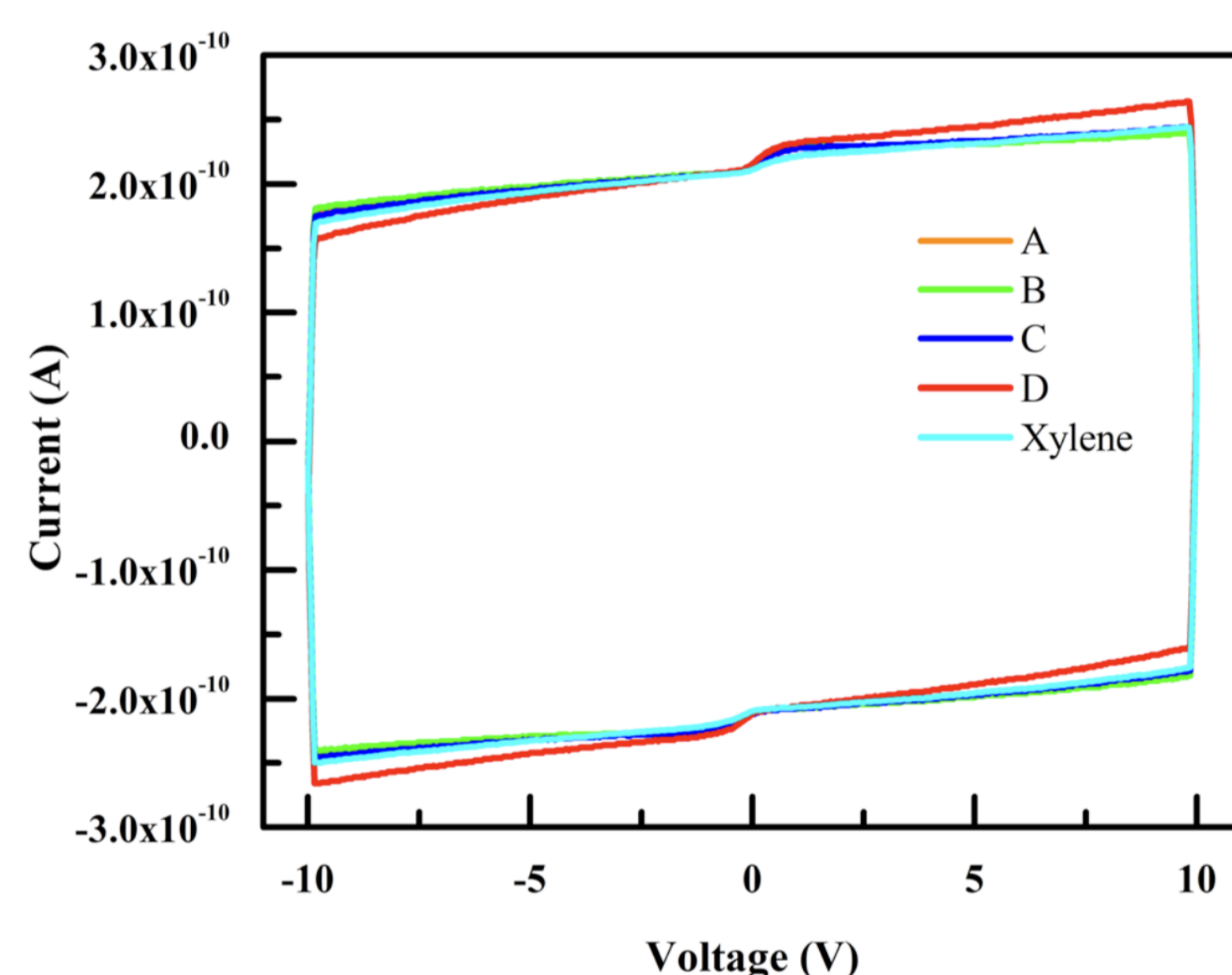
- Capacitance and resistance measurement from the distance between I_p and I_n , and the slope
- Moving ions measurement in a solvent from the current peak area

Measurements

■ Ions in organic powder materials [2] [3]



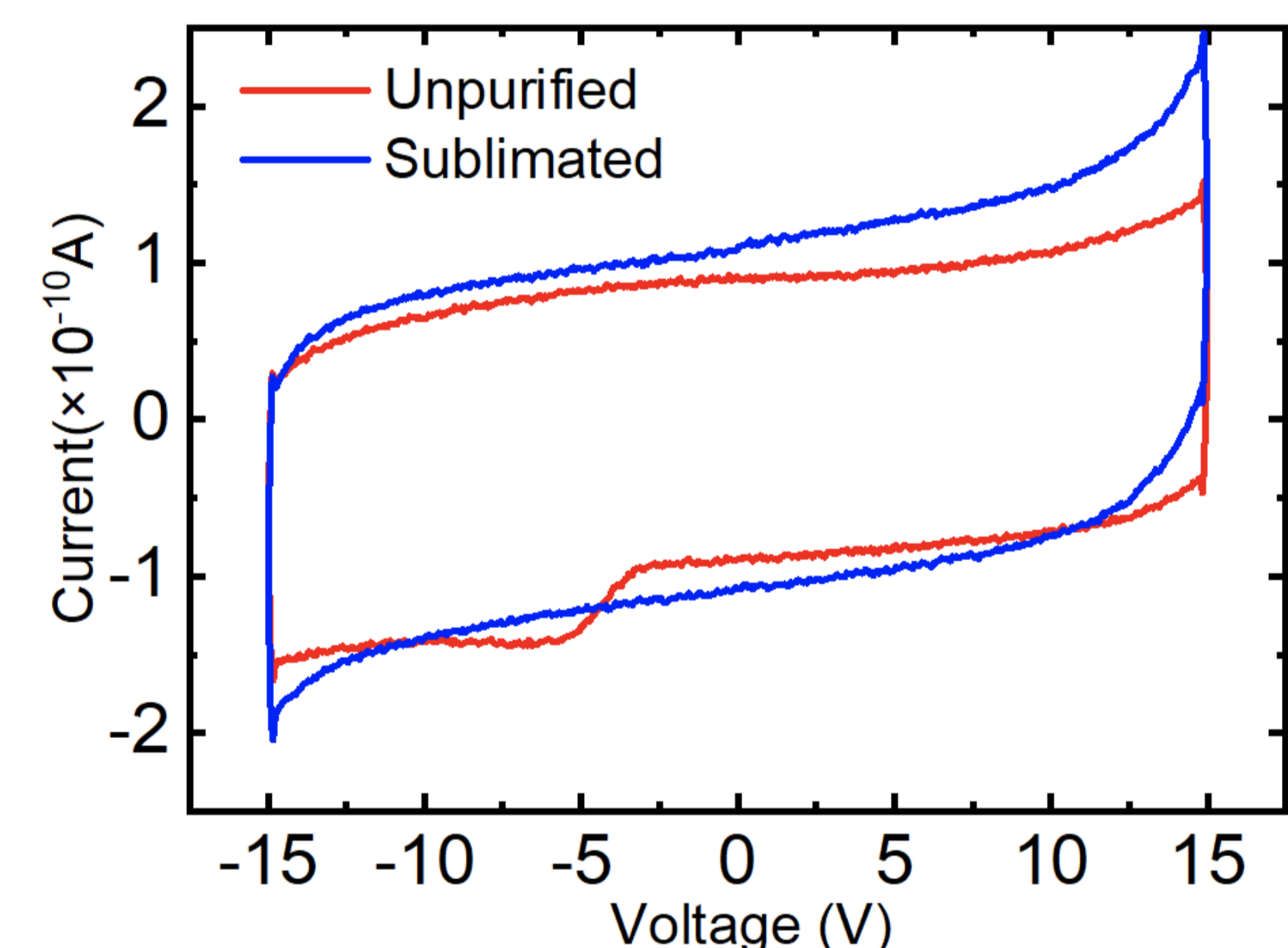
[OPV] P3HT difference in chlorobenzene



[OLED] TADF difference in xylene

- The amount of ion in P3HT and TADF supplier difference has a strong correlation with power conversion efficiency and device lifetime, respectively

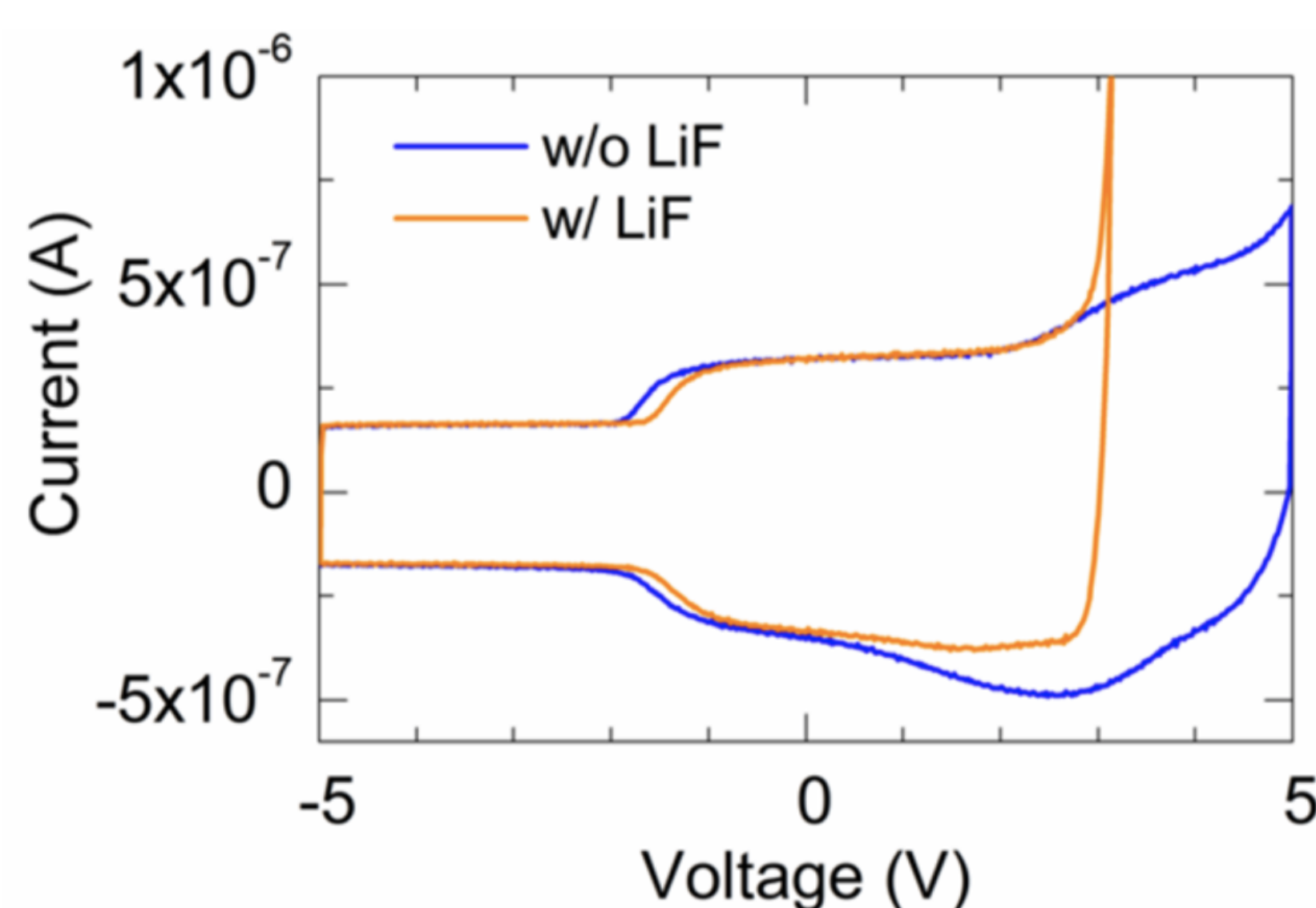
■ Ions in organic thin film [4] [5]



[OLED] α -NPD on SiN before/after sublimation

- There are cations in the unpurified α -NPD
- Cations in α -NPD contribute to improve lifetime

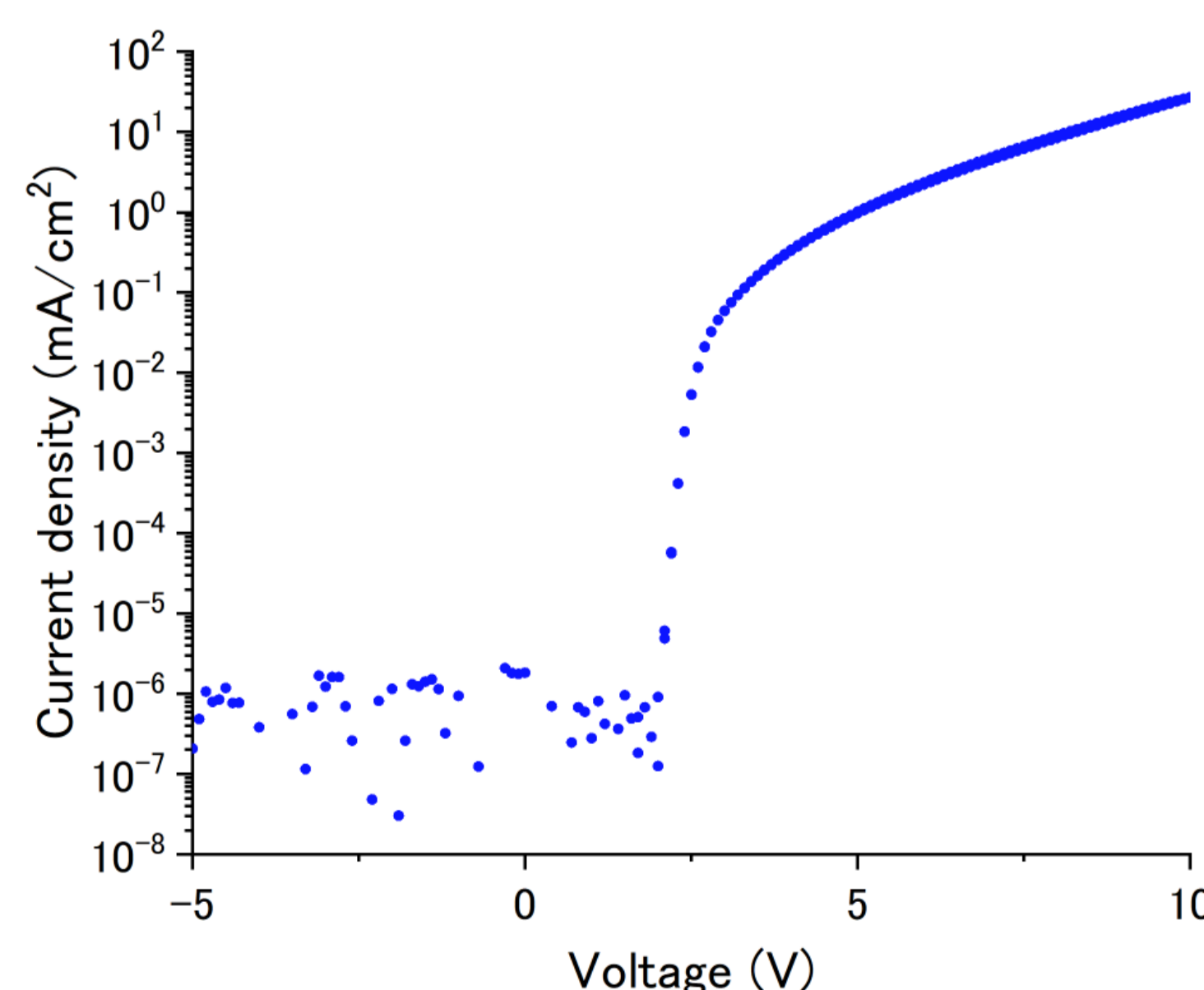
■ Charge injections measurement [6]



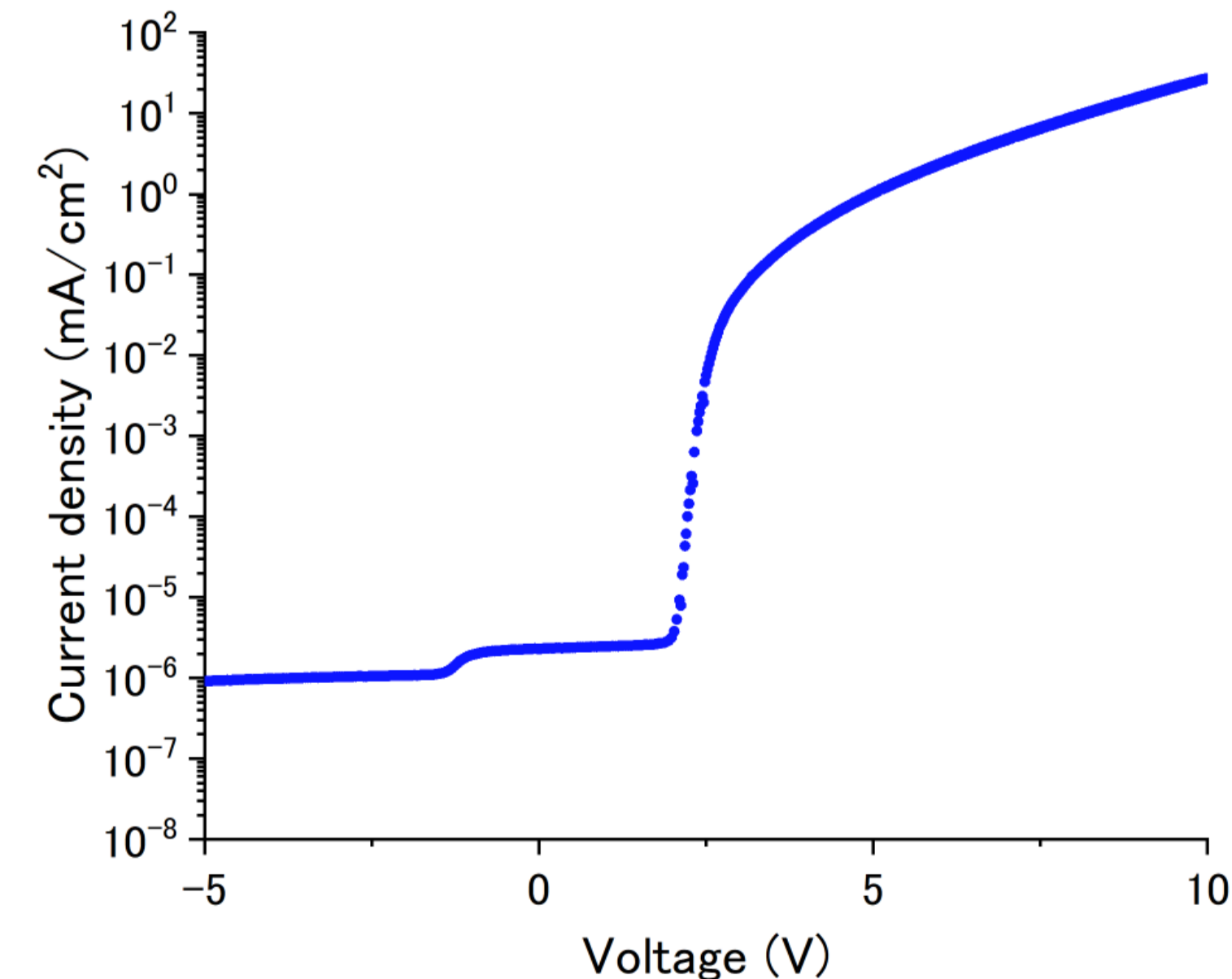
[OLED] Hole and electron injections

- LiF could decrease the electron injection voltage

■ DCM-JV measurement



A source meter for J-V measurement



DCM-JV auto range measurement

- DCM-JV can obtain DCM and J-V characteristics simultaneously

References

1. Inoue M. Review of various measurement methodologies of migration ion influence on LCD image quality and new measurement proposal beyond LCD materials. J Soc Inf Disp. 2020; 28(1):92–110.
2. Inoue M, Oyabu N, Kumoda Y, Suenaga Y, Ishii T, Naito H. Novel measurement method of ion impurity in OPV materials. Proc of AM-FPD'19, P-14; 2019.
3. Inoue M, Oyabu N, Kaneko Y, Kim JY, Yang JH. Correlation between ion impurity in TADF organic light-emitting diode materials and device lifetime. J Soc Inf Disp. 2020;28(11):905–10.
4. Iwata T, Inoue M, Oyabu N, Ohdaira K, Murata H. Detection of Ion Impurities in Organic Thin Films by Displacement Current Measurement Method. Dig Tech Pap - SID Int Symp. 2022;53(1):1513–16.
5. Inoue M, Oyabu N, Iwata T, Ohdaira K, Murata H. Ion Impurity Measurement in Organic Thin Films on High Voltage Application. Proc of IMID2022, P2-165; 2022
6. Inoue M, Kaneko Y, Fujimoto H, Miyazaki H, Adachi C. Evaluations of LiF behavior in OLEDs by means of cyclic DCM method. Dig Tech Pap - SID Int Symp. 2020;51(1):2107–10.