

# 工業技術研究院

Industrial Technology  
Research Institute

## Overview of Standard Activities for Display Industry in Taiwan

Chao-Hua Wen, Ph.D.

Manager, Electrical and Optical Metrology Lab  
Center for Measurement Standards

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ICC Display and 3D Print Meeting – Taipei 2016

# Speaker Introduction

- Name: Chaohua (Charles) Wen
- Education
  - Ph.D., Industrial Engineering and Engineering Management, National Tsing Hua University, Taiwan
  - M. S., Industrial Engineering, National Tsing Hua University, Taiwan
  - B. S., Industrial Engineering, Chung Yuan Christian University, Taiwan
- Present Position
  - Manager, Electrical and Optical Metrology Lab, CMS/ITRI (2016–now)
- Experiences
  - Assistant Professor, National Taiwan University of Science and Technology (2010–2014)
  - Manager, TPO Display Corp. (2007–2010)
  - Manager, Display Technology Center of ITRI (2005–2007)
  - Program Manager, subprogram “Human Factor and Image Quality Technology,” Research Alliance of Taiwan TFT LCD Association (TTLA) (2003–2006)
  - Section Manager, Color Technology Section, Opto-Electronics & Systems Lab of ITRI (2002–2005)
- Professional Specialty
  - Human factors in display and illumination, Image quality assessment, Image processing



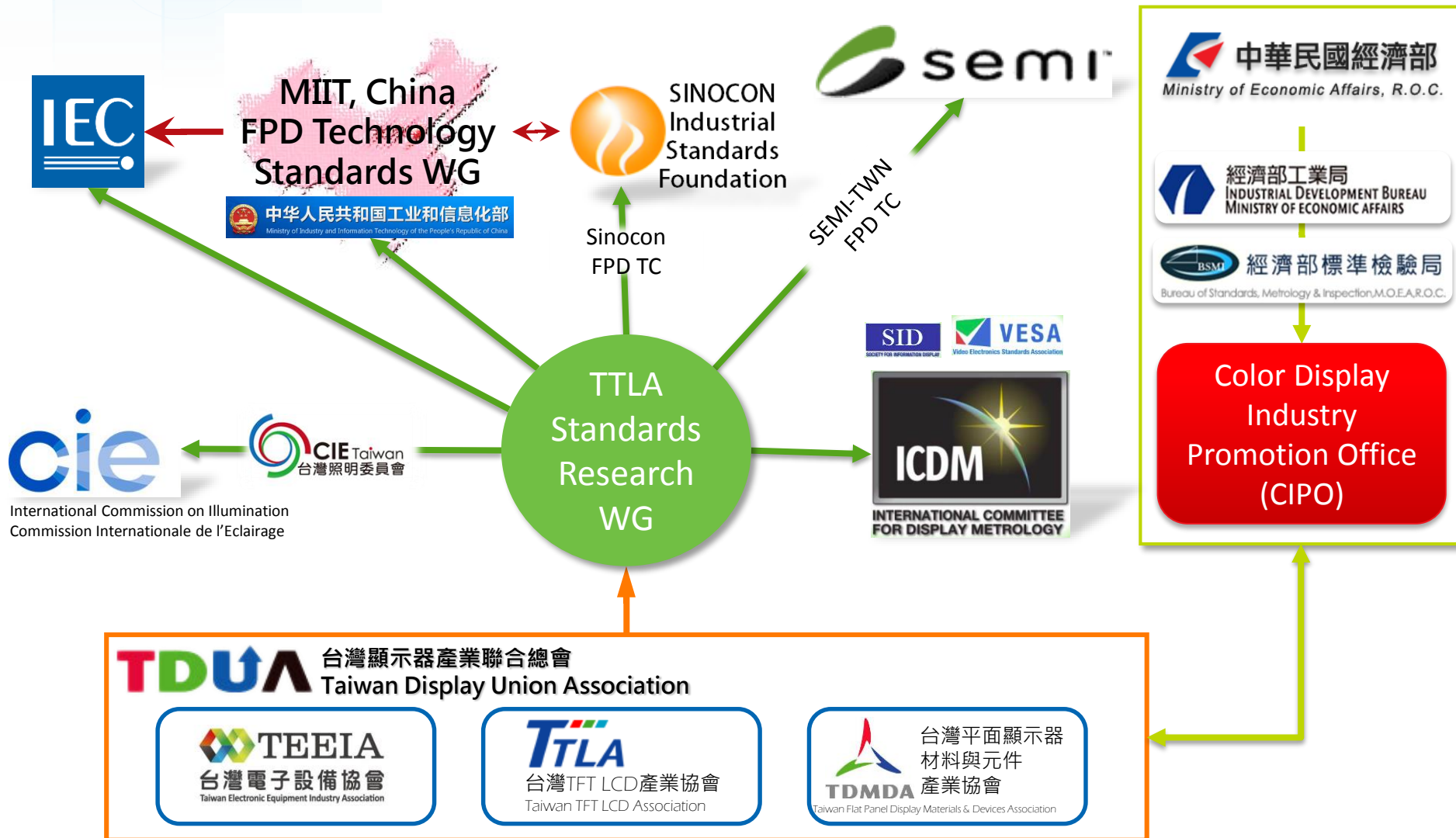


# Outline

- FPD Standards Developing Organizations in Taiwan
- SEMI-TWN FPD Standard Activity
- SID/ICDM Standard Activity
- Cross Strait Correspondence Standard Activity
- State-of-the-art Flexible Displays by ITRI

# FPD Standards Developing Organizations in Taiwan

# FPD Standards Developing Organizations in Taiwan



# Notable Companies Involved in Developing FDP Standards

- SEMI
  - Acer, AUO, CPT, E-ink, i-Boson, Innolux, ITRI,...
- IEC
  - AUO, Innolux,...
- ICDM
  - AUO, Innolux, ITRI, Wistron,...
- Cross-Strait
  - AUO, Innolux, i-Boson, E-ink, ITRI, Wistron,...
- CIE
  - NCU, NTUST, PCCU, ITRI

# SEMI-TWN FPD Standard Activity

# SEMI-TWN FPD Standards History

Cochair: Tzeng-Yow Lin, CMS/ITRI; Cochair: Jia-Ming Liu, TDMDA

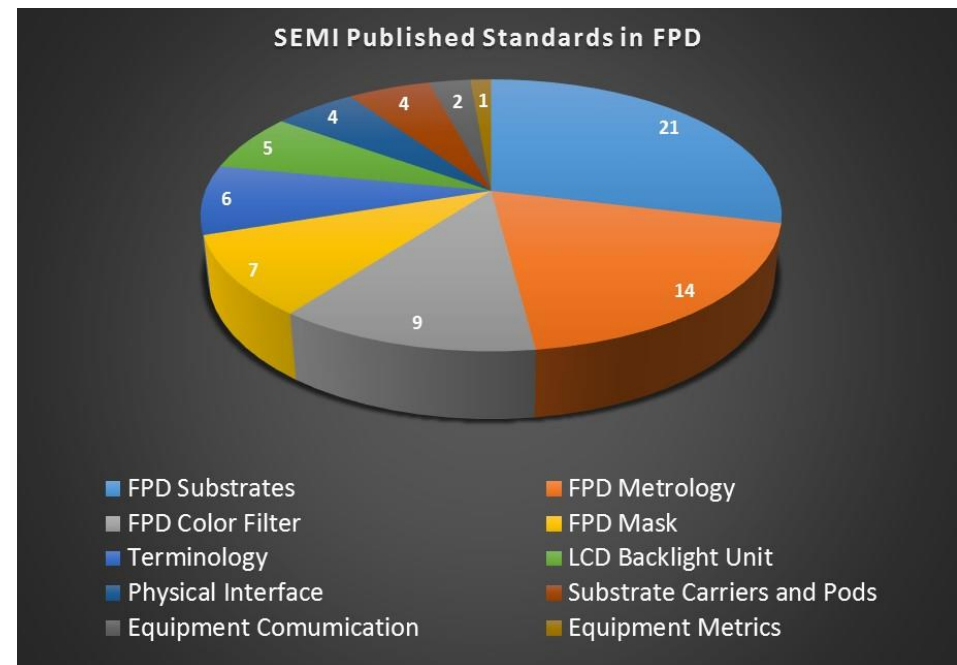
- Formation date: July, 2008
  - Mission: Focus on standards for materials and equipment used in the manufacture and test methods of TFT-LCD
- LCD Subcommittee
  - Disbanded on April, 2016
- Task Force
  - Ambient Color Gamut Task Force
    - a) June, 2010
  - e-Paper Display Task Force
    - a) September, 2009 → April, 2016 (disbanded)
  - Touch Screen Panel Task Force
    - a) September, 2010 → April, 2016 (disbanded)
  - Flexible Displays Task Force
    - a) November, 2012
  - Transparent Displays Task Force
    - a) April, 2016



# 11 Published Standard Doc by SEMI-TWN FPD TC

~ 15% (11 out of 73)

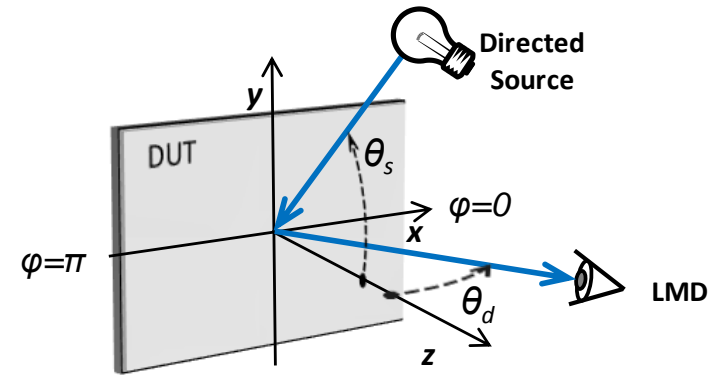
- 1) SEMI D56-0310 Measurement for Ambient Contrast of Liquid Crystal Displays
- 2) SEMI D57-0310 Definition of Measurement Index (VCT) for Mura in FPD Image Quality Inspection
- 3) SEMI D58-0310 Terminology and Test Pattern for the Color Breakup of Field Sequential Color Display
- 4) SEMI D59-0710 3D Display Terminology
- 5) SEMI D62-0611 Measurement Method of LED Light Bar for Liquid Crystal Displays
- 6) SEMI D65-1011 Measurement Method for the Color Breakup of Field Sequential Color Display
- 7) SEMI D68-0512 Test Method for Optical Properties of Electronic Paper Displays
- 8) SEMI D69-0314 Test Method of Flat Panel Display-Based Stereoscopic Display with Active Glasses
- 9) SEMI D70-0314 Test Method of Flat Panel Display-based Stereoscopic Display with Passive Glasses
- 10) SEMI D72-1014 Test Methods for Color Properties of Electronic Paper Displays
- 11) SEMI D73-1014 Test Methods for Positional Accuracy of Capacitive Touchscreen Panel



Total of 73 SEMI standard docs related to display industry (May 2015)

# Recently Approved Document

- Doc # 5533A passed publication proof as D072-00-1014
  - E-paper Display TF: “New Standard: Test Methods for Color Properties of Electronic Paper Displays”
- Doc # 5293C passed publication proof as D073-00-1014
  - Touch Screen Panel TF: “New Standard: Test Method for Positional Accuracy of Touch Screen Panel”



Horizontal viewing direction geometry

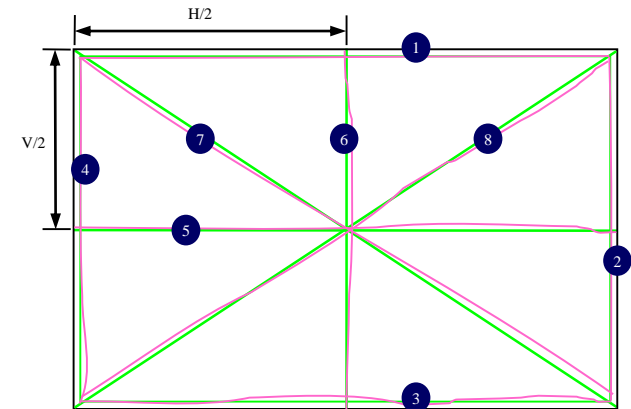


Illustration of drawing lines(green) and reported data(red)

# Flexible Display Task Force

- Formation date: November, 2012
- Cochairs
  - Sheng-Po Wang (ITRI)
  - Scott Tu (AUO)
- Charter
  - To develop standards for the performance related testing method of devices, components and systems of flexible displays.
- Scope
  - To focus on the performance related testing method of devices, components and systems of flexible displays.
    - a) Terminology
    - b) Measuring methods, including flexibility test and optical measuring geometries

# Current Activities

- Flexible Display TF
  - Two SNARFs
    - a) Doc# 5948:               New Standard: Guide for Mechanical Stress Test Methods in the Measurement of Gas Barrier Performance for Flexible Display Components and Devices under a Normal Usage Condition
    - b) Doc# 5949:               New Standard: Test Method of Flicker Measurement for Flexible Displays
  - A topic under discussion
    - a) Waviness Test Method for Flexible Displays

# SEMI Draft Doc# 5948: New Standard

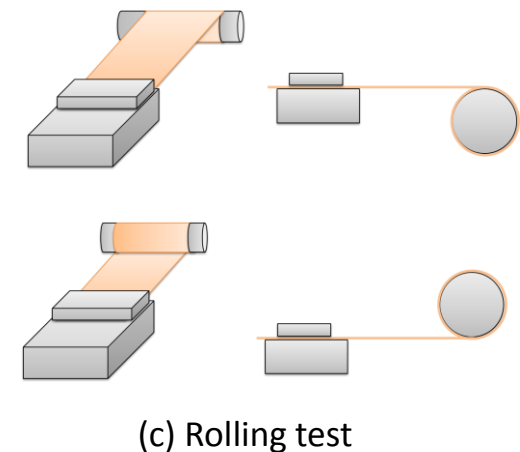
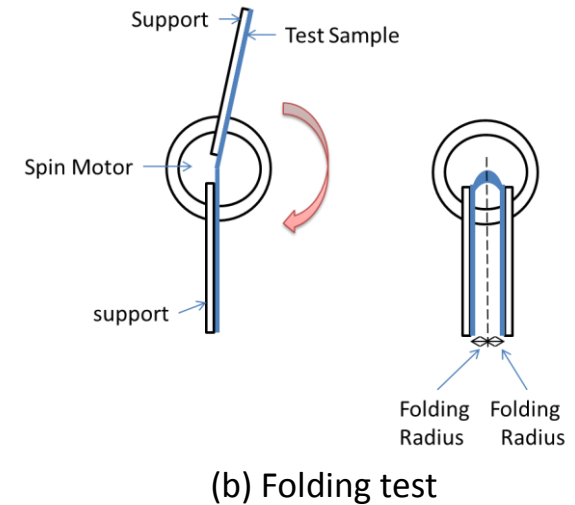
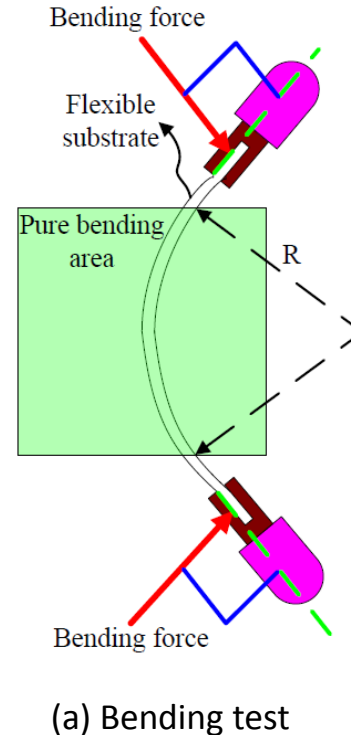
- Title: Guide for Mechanical Stress Test Methods in the Measurement of Gas Barrier Performance for Flexible Display Components and Devices under a Normal Usage Condition
- Description
  - A suitable guide of standardized mechanical stress testing methods in the measurement of gas barrier performance should be proposed, e.g. measuring water vapor and oxygen transmission rate, for flexible display components or devices under a normal usage condition.
- Scope
  - To standardize the testing methods of gas barrier films, including mechanical test methods including bending, torsion, rolling, tension, shocking, and quasi-static strength.

## Remark:

The major difference between this document and Doc. #5551 is that this document will **focus on the process of reliability test**; it will include **procedures** from mechanical test to measurement of Water Vapor Transmission Rate or Oxygen Transmission Rate under a normal usage condition. And the **environment condition setting** will also be discussed.

# Major Discussion Items

- Mechanical Test
    - Bending test
    - Folding test
    - Rolling test
  - WVTR Evaluation
    - Definition of specimen structure for WVTR test
  - Calibration and Standardization
  - Procedure
  - Reporting Results
- 
- There are several mechanical test methods defined in IEC 62715-6-1: 2014, Flexible display devices - Part 6-1: Mechanical stress test methods.
  - Three typical test methods are suggested in this standard, including bending, folding and rolling.

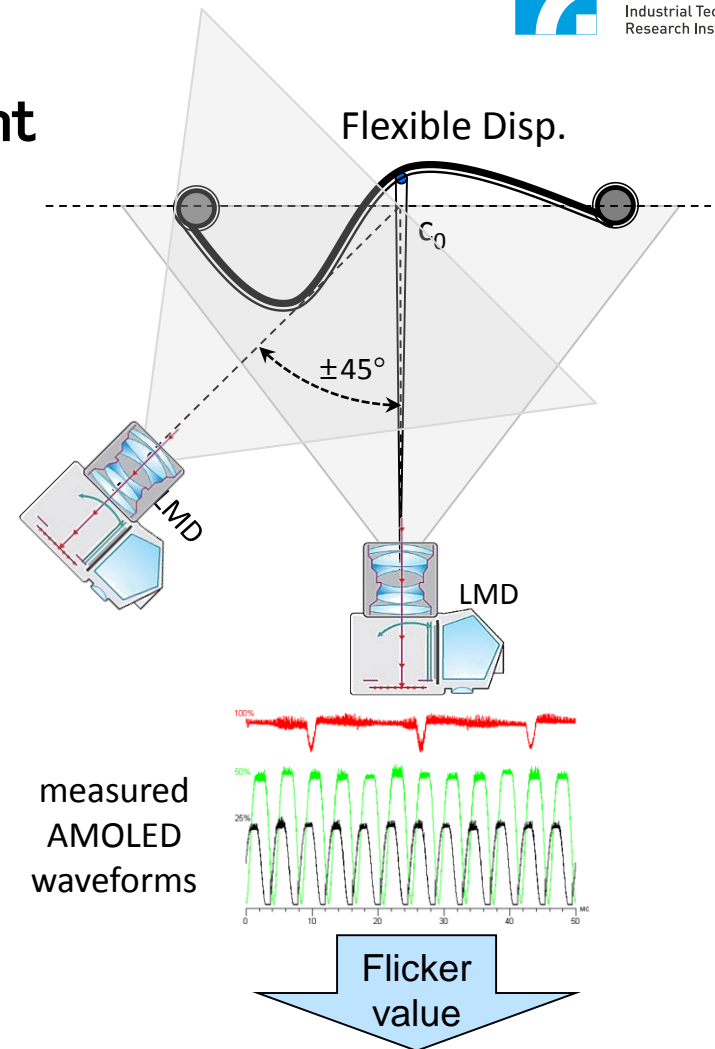


# SEMI Draft Doc# 5949: New Standard

- Title: Test Method of Flicker Measurement for Flexible Displays
- Description
  - In contrast to the level of flicker visibility is well defined in flat-panel-displays, flexible display makers are in an urgent need of the methods of flicker measurement for the freeform surface in terms of flicker-free displays. Hereby, new methods of measuring **overall flicker** and **local flicker** are proposed to quantify the flicker visibility of the flexible displays.
- Scope
  - To standardize the test methods for measuring the flicker visibility of flexible electronic displays.

# Method of overall flicker measurement

- Main concept:
  - Aperture covers whole display
  - Angular measurement
  - Luminance or vertical illuminance (LMD)
- Test pattern
  - Full screen white
  - White window
  - Black window
  - Checkboard
  - Line grid
  - Others...



Report

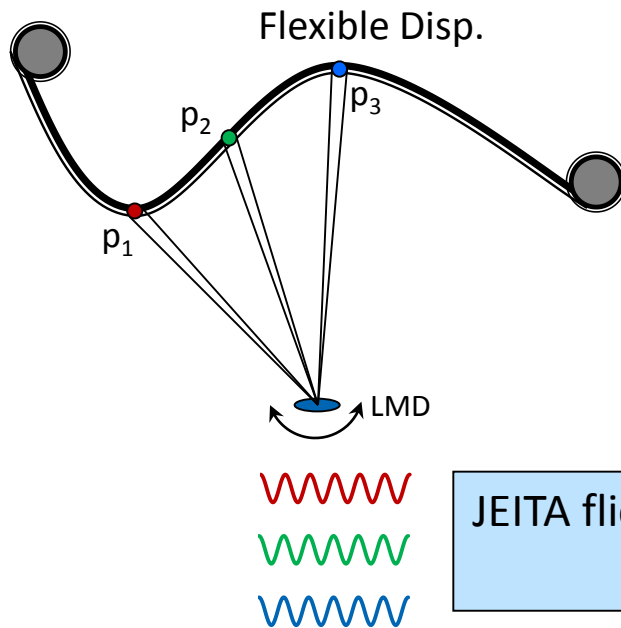
Angle	L45°	0°	R45°
Fundamental freq. (Hz)			
Flicker level (dB)			



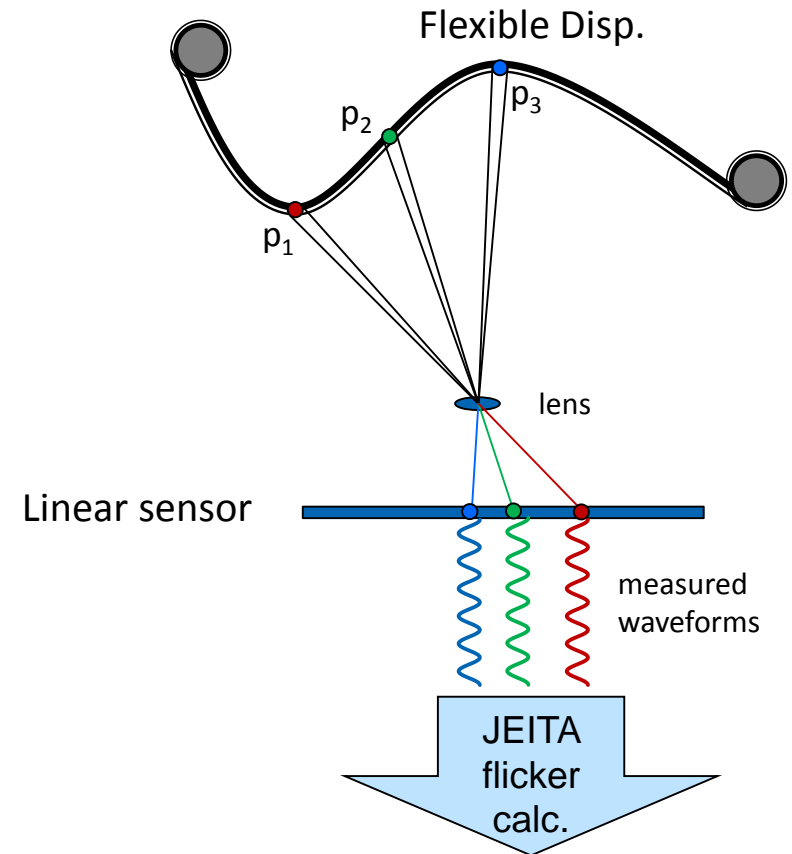
# Methods of local flicker measurement

- Main concepts
  - Best observer distance (BOD)
  - Measuring for turning points

## Method 1



## Method 2



### Report

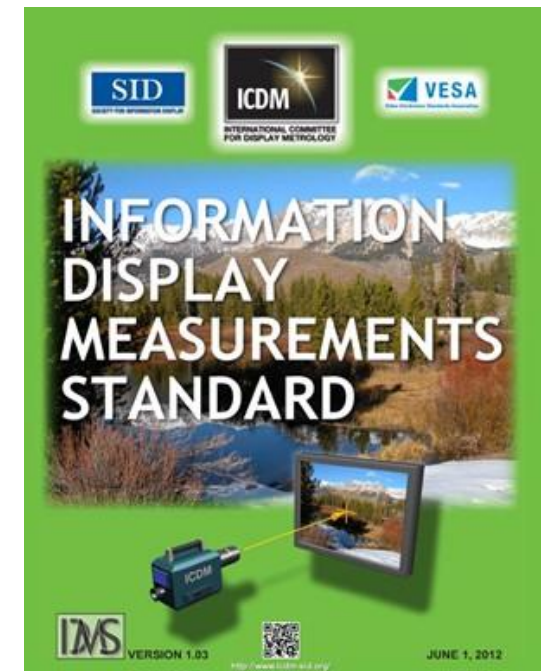
Turning point	$p_1$	$p_2$	$p_3$
Fundamental freq. (Hz)			
Flicker level (dB)			

# SID/ICDM Standard Activity

# ICDM Working Meeting

Feb. 22–25, Boulder, Colorado

- To work on the version 2 of the ICDM display measurement standard
- Agenda topics:
  - **Spatial Subcommittee:** Specifications for and definitions of pixel configurations, geometry, resolution, etc. of modern displays for various pixel types.
  - General identification of needs of version 2 by review of the chapters of the IDMS
  - ICDM File Formats
  - **3D–Stereo Subcommittee**
  - **HDR – Metrology for High Dynamic Range Displays**
  - **Fundamentals Subcommittee**
    - a) **Contrast ratio for HDR displays, Flat Panel TV's, and Projectors**
    - b) **Color Volume Metrology**
  - **Workgroup 1, Specification Reform**
  - **Reflections and Transmission Subcommittee**
  - **Metrology for Curved Displays**
  - **Various new proposals and ideas for metrology items for version 2**



IDMS Version 1.03

# ICDM Subcommittees and Chairs

IDMS Chapter	IDMS Title	Subcommittee Chair	Company
6	Gray- & Color-Scale Measurements	Don Gyou Lee	LG Display
8	Uniformity Measurements	Jens Jensen	Radiant Vision System
9	Viewing Angle-Measurements	Thierry Leroux	Eldim
10	Temporal Measurements	Mike Wilson	Westar
11	Reflection and Transmission Measurements	John Penczek	NIST
12	Motion Artifacts	Andrew Watson	NASA
15	Front Projector Measurements	Joe Kane <sup>new</sup>	JKP
16	Front Projector Screen Measurements	Karl Lang <sup>new</sup>	Lumita Inc.
17	3D & Stereoscopic Displays	Adi Abileah	Adi-Display
18	Touch Screens and Surface Displays	Peggy Lopez	CSA Group
New	Spatial Subcommittee	Ed Kelley	

# Interesting Topics

- Reflections and Transmission Subcommittee
  - add transmission part in reflection chapter
  - consider display under ambient lighting
  - setup general viewing scenario
  - focus on transparent display measurement
  - general formalism
- Grayscale / Gamma subcommittee
  - important relate to image quality
  - new measurement method related to Gamma
  - new gray level spacing method was suggested
  - test pattern issue: constant APL test pattern
- Metrology for High Dynamic Range Displays
- Colour Volume Metrology

# Spatial Committee

## Related contents in IDMS v1.03

- 7.1 Line Luminance & Contrast
- 7.2 Grille Luminance & Contrast
- 7.8 Resolution from Contrast Modulation
- 13.1.1 Size of Viewable Area
- Glossary- Pixel definition

## Calculation

- NxN grille luminance, Michelson contrast

$$C_m = \frac{(S_h - S_g) - (S_d - S_g)}{(S_h - S_g) + (S_d - S_g)} = \frac{S_h - S_d}{S_h + S_d - 2S_g}$$

$S_h$ : white line average (high);  $S_d$ : black line average (dim);  $S_g$ : glare correction

- For Text (graphic) · contrast threshold  $C_T = 0.5 \uparrow$ , Effective Resolution

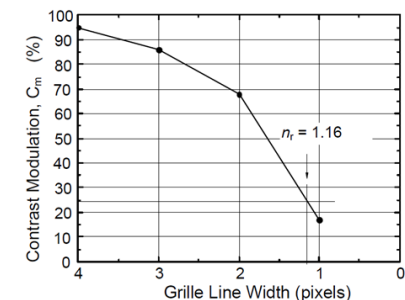
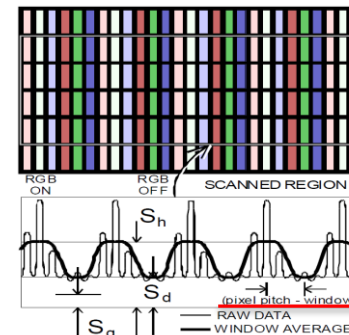
$$\text{Resolution} = \frac{\# \text{ of addressable line}}{n_r}$$

$$n_r = n + \frac{C_T - C_m(n)}{C_m(n+1) - C_m(n)}, \text{ for } C_m(n) < C_T < C_m(n+1)$$

In case of RGBW, different test results from test center!!!

→ Width of moving-window-average-filter is a key

- Comment for Section 7.8 proposed by Jens Jensen:
  - “New display technologies (pixel layouts) make **the current measurement and calculation of display resolution, according to 7.1, 7.2 and 7.8, incomplete**. Care should be taken when interpreting the results. New resolution measurement methods should be added.”
  - 16 out of 21 spatial subcommittee members voted YES.
  - LG has open motions.



# Cross Strait Correspondence Standard Activity

# The 12th Forum of Cross-Strait Information Industry & Technology Standards

## FPD Sub-forum

- Two published documents
  - GT032-2015 Technical requirement & methods of measurement for ultrahigh definition (UHD) TV
  - GT033-2015 Measuring methods and specification requirements of LCD modules for 4K UHD TV
- Reached Consensus
  - Test methods for Flexible Display
  - Test methods for Curved Display
  - Intensive discussion of IEC TC110 documents
  - Feasibility study of Digital Terrestrial Multimedia Broadcast (DTMB)



Signing Ceremony of 2015 Cross-strait Correspondence Standards

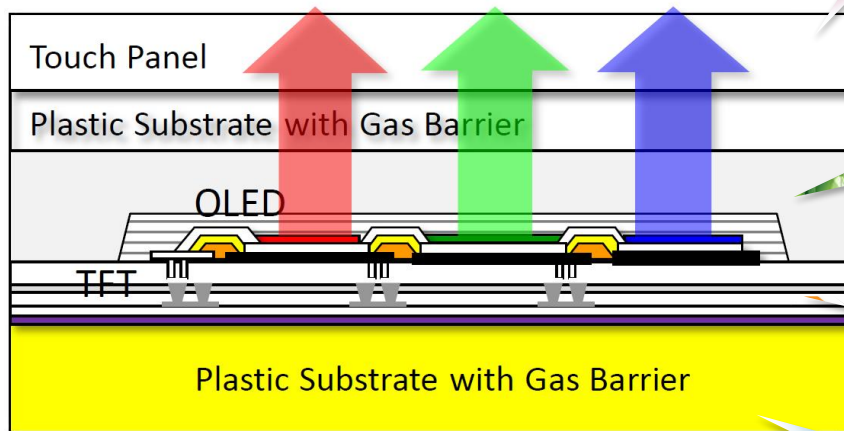


# Cross Strait Correspondence Document List

Doc #	Title
GT 002-2012	Stereoscopic display devices: Cross Strait Correspondence Table of Terms
GT 005-2012	Stereoscopic display devices: Measuring methods of optical parameters for stereoscopic display devices using glasses ( I )
GT 006-2012	Stereoscopic display devices: Terms and definitions
GT 010-2013	Stereoscopic display devices: Measuring methods of optical parameters for stereoscopic display devices using glasses ( II )
GT 024-2014	Electronic paper display device: The measuring methods of the optical performance
GT 025-2014	Electronic paper display device: The measuring methods of the electro-optical performance
GT 026-2014	Stereoscopic display devices: Measuring methods for autostereoscopic displays-optical and electro-optical
GT 027-2014	Flexible display devices: Terminology and letter symbols
GT 028-2014	Flexible display devices: Cross Strait Correspondence Table of Terms
GT 032-2015	Technical requirement & methods of measurement for ultrahigh definition (UHD) TV
GT 033-2015	Measuring methods and specification requirements of LCD modules for 4K UHD TV

# State-of-the-art Flexible Displays by ITRI

# Challenges of Flexible AMOLED Display



- Durability of touch panel
- Flexibility of touch panel
- On-cell touch panel

- Barrier for gas and water
- Flexibility of OLED
- Thinner polarizer

- TFT process on plastic
- TFT's performance on plastic
- Flexibility of TFT

- Substrate material
- Substrate handling
- Barrier for gas and water

# ITRI's Inward Foldable On-cell Touch AMOLED

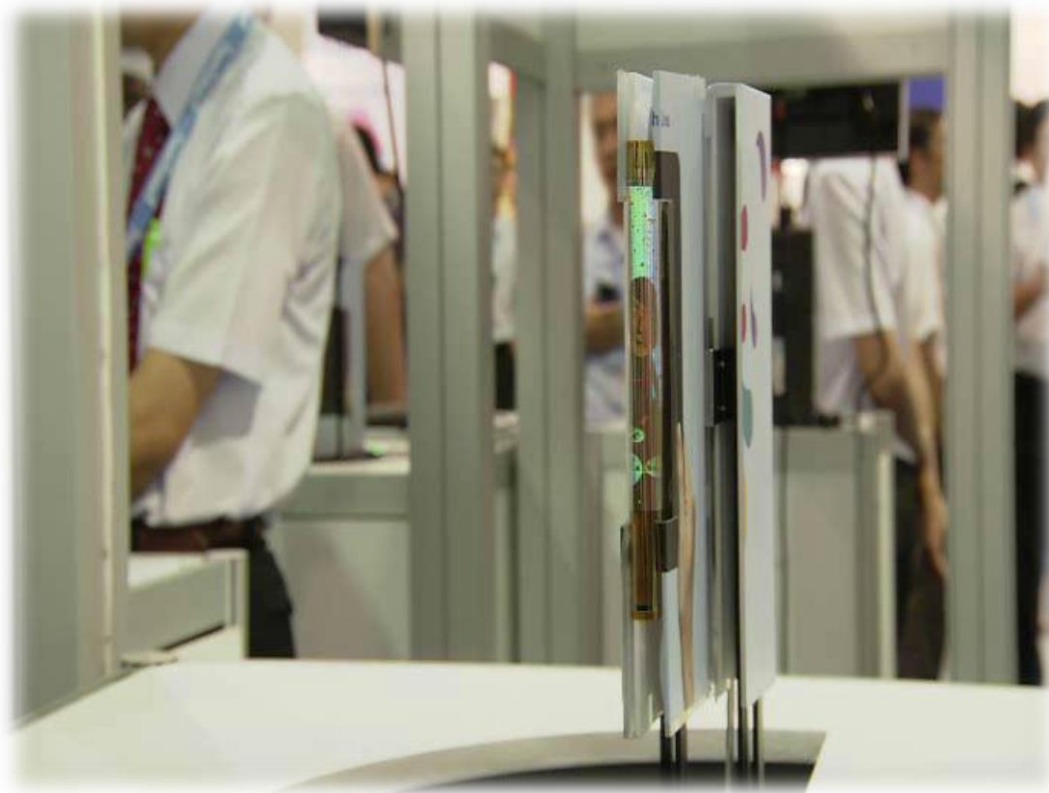
Folding @ 7.5mm



Touch Taiwan Exhibition 2014

# ITRI's Outward Foldable AMOLED

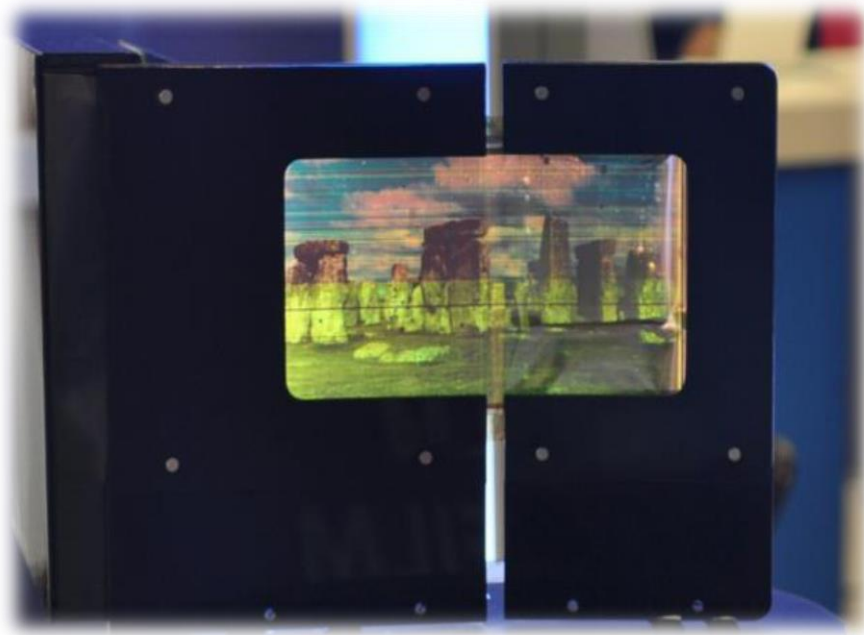
Folding @ 7.5mm



Touch Taiwan Exhibition 2014

# ITRI's Foldable AMOLED with on-cell touch panel

Folding 100k times @  $r = 5\text{mm}$

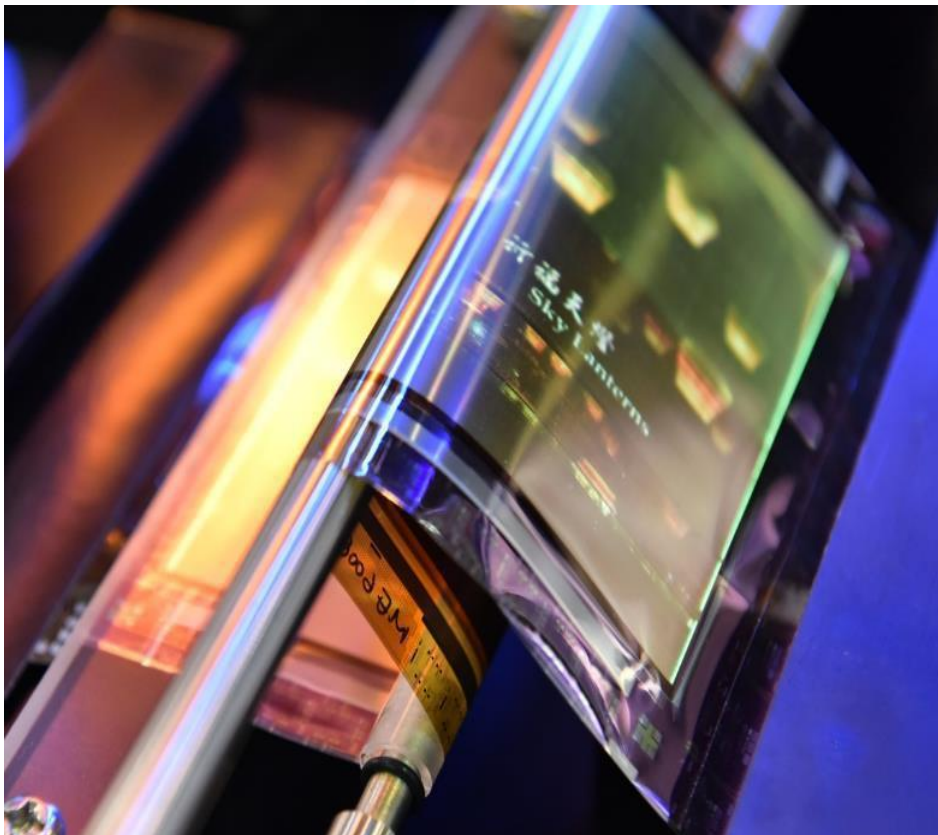


- ✓ Size : 7.1" (16:9)
- ✓ Resolution : FHD (310 ppi)
- ✓ Multi-Touch : 5 points
- ✓ Reliability Test : 85oC/85%RH for 500hrs

Touch Taiwan Exhibition 2015



# ITRI's 7.1" 310ppi Z-Fold Foldable AMOLED

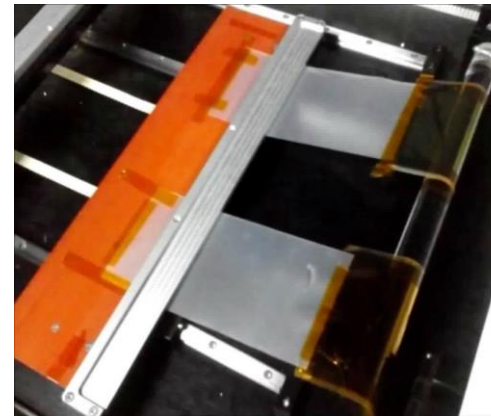
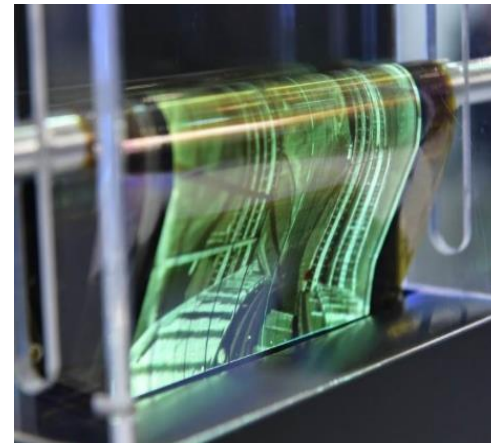


- ✓ Size : 7.1"
- ✓ Resolution: 310 ppi
- ✓ Bending Radius: 5 mm

Touch Taiwan Exhibition 2015

# ITRI's 7.1" 310ppi Rollable AMOLED

Rollable (r@ 5mm)



Touch Taiwan Exhibition 2015



# Summary

- Update about FPD standard activities in Taiwan
  - Status of 2 SEMI draft documents, #5948 & #5949
  - Interesting topics according to the working version 2 of SID/ICDM display measurement standard
  - Glance over Cross-Strait Correspondence standards
- Recent Development of Flexible Displays in ITRI



# Thank you for your pay attention!