STANDARDS NEW ACTIVITY REPORT FORM (SNARF)

Date Prepared: 2019/02/22 *Revised (if Applicable):*

SNARF for: New Standard: Test Method of Sheet Resistance Imaging by Terahertz System

Originating Global Technical Committee: Flat Panel Display (FPD) - Metrology

Originating TC Chapter: Taiwan

Task Force (TF) in which work is to be carried out: Flexible Display Task Force

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Refer to *Procedure Manual* § 2.2.4 for more information on properly filling out the SNARF.

1. Rationale:

a: Describe the need or problem addressed by this activity.

(Indicate the customer, what benefits they will receive, and if possible, quantify the impact on the return on investment [ROI] if the Document is implemented.)

In recently years, flexible and/or wearable devices attract end-users' attentions in many applications. As a result, flexible electrodes became one of key topics related to development of new flexible devices. In addition, the high transmittance of electrodes is necessary for many applications, special in displays. Indium tin oxide (ITO) is one of the most commonly used material for transparent electrodes, yet it has drawbacks due to its lack of flexibility, manufacturing cost and limitation of indium resources. In order to replace ITO, many alternative materials have been developed, such as carbon nanotubes, copper nanowires, graphene, and silver nanowires. Consequently, these materials development have mainly focused on investigating electrical properties and flexibility. Among these characteristics, the electrical conductivity has the greatest effect on the performance of transparent conductive electrodes.

Conventionally, microwave cavity, scanning electron microscopy (SEM), I-V (ohmic) measurement with wires, 4-point probes, eddy current and Hall effect measurements have been applied to flattened electrodes to identify their electrical properties. Most research shows that the conductance of flexible electrodes does not change after bending when using the above methods. However, direct measurement of the electrical properties of flexible electrodes during bending, rolling or stretching has been limitedly reported.

Nevertheless, each of these contact-based techniques places specific requirements on the resistance and nature of the contacts, and requires time-consuming and costly electron beam lithography and device processing. Some of contact-free techniques, such as the eddy current method, there are some drawbacks include lift-off edge effects and poor resolution. As a means of overcoming all these problems, contact-free probes of nanowire electrical properties have attracted significant attention. Terahertz time domain spectroscopy (THz-TDS) is a powerful method to characterize materials or conductive films. It has been used to determine conductivity, carrier concentrations, and other intrinsic parameters of carrier dynamics of various materials without requiring electrical contact. There have been a number of reports regarding the electric properties of various materials used for flat conducting films probed by THz-TDS [1–2].

b: Estimate effect on industry. Check one of the following:

☐ **1: Major effect on entire industry or on multiple important industry sectors**
- identify the relevant sectors: _____

■ **2: Major effect on an industry sector**
- identify the relevant sector: _____

☐ **3: Major effect on a few companies**
- identify the relevant companies: _____

☐ **4: Slight effect or effect not determinable**

c: Estimate technical difficulty of the activity. Check one of the following:

☐ **I: No Difficulty – Proven concepts and techniques exist or quick agreement is anticipated**

■ **II: Some Difficulty – Disagreements on known requirements exist, but developing consensus is possible**

☐ **III: Difficult – Limited expertise and resources exist and/or achieving consensus is difficult**

☐ **IV: Extremely Difficult – Expertise and resources are scarce and/or achieving consensus is very difficult**

2. Scope:

a: Describe the technical areas to be covered or addressed by this Document development activity.

(For Subordinate Standards, list common concepts or criteria that the Subordinate Standard inherits from the Primary Standard, as well as differences from the Primary Standard.)

In this document, the test method will be addressed on measuring the THz properties of the flexible devise by the THz-TDS method and principle of THz-TDS as well. The transmission type TDS system by the general photoconductive antenna detection. The electrical property is calibrated by a simple formula for the applications and reasonable agree with the general 4-point probe technique.

THz radiation is generated from laser excitation and a voltage-biased photoconductive antenna with a gap size around 5 μm. The excitation and sampling laser source is the mode-locked Ti: sapphire laser with the pulse width, the center wavelength and the average power of around 100 fs, 840 nm and 50 mW, respectively. The THz radiation was guided and focused on the sample by a pair of gold-coated off-axis parabolic mirror. It was then focused on the other similar photoconductive antenna detector by another pair of the gold-plated off-axis parabolic mirror. It is equivalent to imposing a THz frequency voltage on the detector, resulting in a photocurrent. The detected current signal is proportional to the THz electric field, and the THz radiation waveform could be read out through the lock-in amplifier by the mechanical movement induced optical delay between the excitation and detection laser. After using the Fourier transform of the THz waveform, various optical-electronic parameters of thin films could be derived by the theoretical formula. With regarding to the sample preparation, The flexible display substrate sample is a commercial ITO thin film with thicknesses of ~50 nm, deposited on PET substrate is as an example of a flexible display component. The half of the sample was etched with a solution of HCl:H_2O (1:1) for exposing the PET substrate. In addition, the microstructure of the THz microprobe consists of a tapered pair of electrodes is investigated The tip is held in approximately 5-10 μm distance above the sample which is scanned in xy-direction during the measurement to obtain the sheet resistance distribution.

The major difference between this document and IEC TC113 works [3–4] is that this document will cover other materials e.g. ITO and silver nanowires, not only graphene; it will include procedures from mechanical test to measurement the sheet resistance distribution as well.

References

[1] B. J. Wen, T. A. Liu, H. C. Yu, S. F. Chen, and Y. C. Cheng, “Non-contact resistance measurement of transparent electrodes deposited on flexible display substrates under repetitive bending test by

terahertz time domain spectroscopy," Displays, 45, 58–62 (2016).

[2] G. Hwang, S. Balci, M. Z. Güngördü, A. Maleski, J. Waters, S. Lee, S. Choi, K. Kim, S. Cho, and S. M. Kim, "Flexibility and non-destructive conductivity measurements of Ag nanowire based transparent conductive films via terahertz time domain spectroscopy", Optics Express, 25(4), 4500-4508 (2017).

[3] IEC TS 62607-6-4:2016 Nanomanufacturing - Key control characteristics - Part 6-4: Graphene - Surface conductance measurement using resonant cavity.

[4] PNW 113-434 ED1: IEC TS 62607-6-10: Nanomanufacturing - Key control characteristics - Part 6-10: Graphene - Measurement of sheet resistance by terahertz time-domain spectroscopy. (New Work Item Proposal)

b: Expected result of activity

■ New Standard or Safety Guideline (including replacement of an existing Standard or Safety Guideline)

☐ New Subordinate Standard to an existing Standard or to a new Primary Standard to be developed concurrently with this new Subordinate Standard

☐ New Preliminary Standard

☐ Major revision to an existing Standard or Safety Guideline

☐ Line-item revision to an existing Standard or Safety Guideline

☐ Line-item revision to two or more existing Standards or Safety Guidelines

☐ Reapproval of a Standard or Safety Guideline

☐ Removal of a Standard or Safety Guideline

☐ Withdrawal of a Standard or Safety Guideline

☐ Reinstatement of a Standard or Safety Guideline

☐ Publication of an existing Standard or Safety Guideline as an American National Standard

☐ New Auxiliary Information

☐ Modification of existing Auxiliary Information

For a new Subordinate Standard, identify the Primary Standard here: _____

For revision of existing Standard(s) or Safety Guideline(s), identify the Standard(s) or Safety Guideline(s) that are to be revised here: _____, and identify which parts of the Standard(s) or Safety Guideline(s) that are to be revised. (Check all that apply.)

☐ **Modification of an existing part of Standard(s) or Safety Guideline(s) including Appendices, Complementary Files, and Supplementary Materials**

☐ **Addition of one or more Appendices or Complementary Files to an existing Standard or Safety Guideline**

☐ **Addition of one or more Related Information sections or Various Materials to an existing Standard or Safety Guideline**

☐ **Revision or addition of one or more Subordinate Standards to an existing Primary Standard**

For Standards, identify the Standard Subtype below:

☐ Classification

☐ Practice

■ Test Method

☐ Guide

☐ Specification

☐ Terminology

☐ Miscellaneous (describe:) _____

3. Projected Timetable for Completion:

a: General Milestones

a. Activity Start: 2019.04.15 b. 1st Draft by: 2019.12.01

c. (Optional) Informational Ballot by: _____ d. Letter Ballot by: 2020.07.01

e: TC Chapter Approval By: 2020.12.31

4. Liaisons with other Global Technical Committees/TC Chapters/Subcommittees/TFs:

a: List Global Technical Committees, TC Chapters, Subcommittees, or Task Forces in your or other Regions/Locales that should be kept informed regarding the progress of this activity.

(Refer to SEMI Standards organization charts and global technical committee charters as needed.)

Japan FPD Metrology / Materials & Components Committee

Korea FPD Metrology Committee

b: Intercommittee Ballots (check one):

☐ **will be issued – identify the recipient global technical committee(s):** _____

■ **will not be issued**

5. Safety Considerations:

The resulting Document is expected (Check one):

☐ **to be a Safety Guideline**

■ **NOT to be a Safety Guideline**

NOTE FOR 'to be a Safety Guideline': When all safety-related information is removed from the Document, the Document is NOT technically sound and complete – Refer to § 15.1 of the *Regulations* for special procedures to be followed.

NOTE FOR 'NOT to be a Safety Guideline': When all safety-related information is removed from the Document, the Document is still technically sound and complete.

6. Intellectual Property Considerations:

a: For a new Standard or Safety Guideline and for any part to be modified or added in a Revision of published Standards and Safety Guidelines (Check one):

■ **the use of patented technology is NOT required.**

☐ **patented technology is intended to be included in the proposed Standard(s) or Safety Guideline(s).**

(If the second box is checked, check one):

□ **Letter of Intent received**

□ **Letter of Intent not received**

b: For Revision, Reapproval, Reinstatement, or Withdrawal of existing Standard(s) and Safety Guideline(s) (Check one):

☐ **there is no known material patented technology necessary to use or implement the Standard(s) and Safety Guideline(s)**

☐ **there is previously known material patented technology necessary to use or implement the Standard(s) and Safety Guideline(s)**

c: The body of the Document and any Appendices, Complementary Files, Related Information sections, or Various Materials that may or may not be a part of the Document by reference (Check one):

☐ **will include reproduced copyrighted material**

■ **will NOT include reproduced copyrighted material**

NOTE FOR 'the use of patented technology or a copyrighted item(s) is NOT required': If in the course of developing the Document, it is determined that patented technology or copyrighted item(s) must be used to comply with the Document, the provisions of *Regulations* § 16 must be followed.

NOTE FOR 'will include reproduced copyrighted material': A copyright release letter must be obtained from the copyright owner.

7. Comments, Special Circumstances:

8. TC Member Review (Check one):

■ **took place between (*put dates here:* 03/19/2019 and 04/02/2019) before approval at the TC Chapter Meeting, or**

☐ **took place between (*put dates here:* MM/DD/YYYY and MM/DD/YYYY) before approval by the GCS, or**

☐ **is not required for this SNARF.**

NOTE FOR 'TC Member Review': A TC Member Review is required by the *Regulations* for a period of at least two weeks before approval of a new, or a major revision of an existing, Standard or Safety Guideline. (See *Regulations* ¶ 8.2.1)

9. Approval Dates:

TC Chapter or GCS: _____

Recorded in TC Chapter Minutes: _____

If you do not have email capability, you may fax this form to the nearest SEMI office:

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