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Flat Panel Display Development Activities at Sandia National Laboratories

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Abstract:

The flat panel display development activities underway at Sandia National Laboratories are described. Research is being conducted in the areas of glass substrates, phosphors, large area processes, and electron emissions. Projects are focused on improving process yield, developing large area processes, and using modeling techniques to predict design performance.

Key words: glass substrates, phosphors, large area processes, electron emissions

a) Oral/poster preference: Consider for either
b) Applications session: No
c) Symposium topic: Display manufacturing

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DISCLAIMER

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Objective and Background

In this paper we will describe the flat panel display (FPD) development activities underway at Sandia National Laboratories. Projects include work sponsored through Department of Energy Cooperative Research and Development Agreements (CRADAs) and Advanced Research Project Agency (ARPA) programs. The ARPA sponsored programs are conducted through the National Center for Advanced Information Components Manufacturing (NCAICM). All projects are focused on solving specific manufacturing issues as identified by the industrial partners.

Results

The Sandia research effort is primarily directed towards emissive display technologies; that is, electroluminescent, plasma and field emission displays. Sixteen different projects covering many areas of flat panel display manufacture are in progress. Many of the projects require Sandia to sign non-disclosure agreements with the industry partner, so detailed results cannot be discussed in the open literature. However, broad areas of research emphasis are described in the following paragraphs.

Glass Substrate Characterization:

During the flat panel display manufacturing process, the glass substrate goes through many thermal exposures where the temperature of the glass comes close to its softening point. This can cause distortion and stress to be built up in the glass which can affect the flatness of the glass substrate and positioning accuracy of the pixels. The goal of our research is to predict both stress and structural relaxation during arbitrary temperature histories that the substrate may go through during the manufacturing process or operation. In this way we can optimize the process to reduce distortion or be able to predict them for better patterning accuracy. By using precision measuring equipment capable of 8 microinch resolution, such as a Zeiss UPMC550 coordinate measuring machine, we can measure glass substrate material properties such as viscosity, shrinkage and modulus properties as a function of exposure temperature and time. The parameters can then be fit to a viscoelastic model. This allows us to perform a finite element analysis of the glass to predict residual stress and deformations which might occur during the manufacture and operation of the flat panel displays. Sandia has expertise in 3-D finite element analysis which uses an iterative process to analyze large area substrates. The viscoelastic model provides a new capability to analyze and design actual manufacturing processes by predicting, a priori, the effects of temperature history on the residual stress state.

Phosphor Characterization:

The characterization of phosphors for plasma displays is an area of expertise. The power required to drive a color plasma display depends largely on the efficiency of the phosphors used in the display. We want to match the plasma excitation spectrum to the

UV radiation generated by the plasma. To do this we can select the high efficiency phosphors and/or change the gas composition of the plasma gas. Using a GEC cell light source and vacuum UV spectrometer we can measure the phosphor properties over a wide frequency range as well as analyze the gas excitation spectrum of the gas plasma used in the display. The quantum efficiency varies over a wide range of excitation wavelengths, from 100 nm which is in the vacuum UV range to 325 nm which is close to the visible range. The efficiencies are compared to a standard which is sodium salicylate. This allows us to select the best phosphors for the gas used in the plasma display. The GEC light source and spectrometer capabilities are summarized in Table 1.

Table 1 - GEC Cell Light Source and Vacuum UV Spectrometer
Multiple gas composition and pressure capability (e.g., He, Xe, Ar, Ne).
Range from 50 nm to 330 nm, uses monochrome light as light source.
By measuring light output from a phosphor relative to a known standard such as sodium salicylate we can determine the quantum efficiency of phosphors.

Another aspect of phosphor characterization work is conducted at the NCAICM Phosphor Characterization Facility (PCF). The PCF includes state-of the-art equipment to measure cathodoluminescence, photoluminescence and electroluminescence as a function of excitation energy, sample temperature, time, etc. The PCF test station consists of standard vacuum hardware large enough to accommodate samples up to 6 inch diameter. A hot filament, low-energy electron gun (5-1000 ev) is used for accurate excitation energy measurements. A hollow cathode plasma source provides high current density low-energy (but less mono-energetic) electrons for life- and accelerated degradation tests. A mass spectrometer monitors the ambient vacuum environment before tests, as well as to detect phosphor or binder degradation products during tests. A spectroradiometer measures phosphor emission spectra as a function of excitation intensity and time, to determine phosphor performance limits, and to identify degradation processes both by phosphor cathodo-/photo luminescent emission changes, and by changes in screen reflectivity properties. The PCF effort is coordinated with the army research laboratory at Fort Monmouth and with the Phosphor Technology Center of Excellence at the Georgia Institute of Technology.

Electron Emission Characterization

The Electron Emission Characterization Facility (EECF) provides both one and two-dimensional characterization of electron emission from samples provided by NCAICM partners. Equipment currently available includes a surface analysis/emission characterization system (SAECS), and an electron emission microscope (EEM). One dimensional work is carried out in the SAECS. The two dimensional work is performed on the EEM system. Both systems allow rapid sample change out and sample modification.

The first of these two systems is set up for measuring emission from gated field emitter arrays and for characterizing outgassing from the devices. Alternate sample mounts enable measurements of film cathode materials (e.g., diamond) or thermionic emission sources (e.g., tungsten filaments). The chamber also contains auger electron spectroscopy to monitor surface condition and retarding field analysis. The second system contains an EEM, which analyzes the two-dimensional emission from samples. Emission is characterized with the EEM and sample morphology is determined with in-house scanning electron microscopes.

Large Area Manufacturing Processes

Another area of emphasis is large area processing techniques. We are developing an integrated screen manufacturing process capable of achieving both large area print uniformity and thickness control for color ac-plasma display panels (AC-PDP). The process will incorporate FPD manufacturing modeling software, part tracking, and non-contact thick film uniformity measurement techniques for production. We are demonstrating a selective electroplating technique to replace a complex and expensive electrode metallization process for production level fabrication of high resolution large flat panel displays. We are also involved in the development of an adaptive laser direct write tool. The tool consists of an ultraviolet direct imager coupled with a limited automatic optical inspection system for the manufacture of large area flat panels. Testing metrologies will be developed to measure the capabilities of the equipment and the laser-imaging processes. Photoresists will be evaluated to determine compatibility with laser-imaging and processes. The capabilities of the laser direct write tool will be evaluated. Equipment, materials, processes, and process parameters required for large area FPD production will be identified.

Impact

Sandia researchers are concentrating on improving flat panel manufacturing technologies. Each project is focused on attacking specific technology issues. However, there are some common themes that characterize the projects:

- Improving material performance
- Developing more efficient manufacturing processes
- Improving process yield
- Developing larger area processes
- Sensing manufacturing contaminants and reducing their impact
- Improving test metrology capabilities
- Use modeling techniques to predict design performance
- Analyzing and reducing manufacturing costs

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References

The National Center for Advanced Information Components Manufacturing Program Update, James L. Jorgensen, Defense Manufacturing Conference '93, November 1993.

Flat Panel Display Development Activities at Sandia, Walter Worobey, Technology Awareness Mini-Series (Instructional Television Course) sponsored by NIST, June 1994.

Prior Publications

This paper has not previously been published. The intent is to provide an update on current research activities and report results.