The Liquid Crystal Display:
The Materials in Your TVs and Smartphones

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Abstract
This module provides students with an introduction to liquid crystal display technology, with an introduction to the components of the LCD, including the glass substrates, electronics and liquid crystals. It is based on a number of resources, including material from Samsung Display and Corning Inc.

Student learning objectives: The student will be able to

- Explain the components of an LCD system
- Describe the process for making LCD glass
- Illustrate a typical glassy structure
- Define a liquid crystal
- Discuss the applications of liquid crystal displays

MatEd Competencies Covered

6C	Apply concepts of electricity
6D	Apply concepts of light
7E	Illustrate the general nature of glass
14A	Distinguish structure, properties and behavior of glass
16A	Distinguish effects of processing and manufacturing variables on material properties

Key Words: Liquid crystal, liquid crystal display, glass, glass processing, glass structure

Type of Module: discussion with PowerPoint presentation

Time Required: one 45 min. period; additional time may be used to show the videos in class, or they can be assigned as homework.

Pre-requisite Knowledge Required: None

Target Grade Levels: Advanced high school, introductory college courses

Table of Contents:

Equipment and Supplies Needed: Computer and PowerPoint projector with Internet access

Curriculum Overview and Instructor Notes
This module is focused on liquid crystal displays (LCDs). It provides an introduction to the LCD, and focuses on the glass substrates used in the process along with an overview of the components of an LCD.

The PowerPoint presentation is self-contained. Each slide should be presented and discussed.

Slide 2 introduces the LCD display--ask the class what they know about LCDs.

Slides 3 – 7 discuss glass structure, processing and products. Each can be discussed in terms of what the students know and what their questions are on each of the subjects. Students who want to know more about glass manufacture should be referred to https://www.youtube.com/watch?v=IjNusHQOhTM (video shows process of making standard float glass, different from the fusion process that Corning and others use to make glass for display applications)

Slides 8 and 9 share information about Corning Inc.'s display glass technology. The links to Corning's websites are intended to provide more information about the fusion process (the short video about the fusion process can be shown in class) and about the different types of glass that Corning manufactures for the display industry: Eagle XG^{R} Slim Glass; Lotus^{TM} NXT Glass; Astra^{TM} Glass; and Iris^{R} Glass.

Slides 9 – 16 are a follow up with more details on the LCD and its components. They provide the opportunity to discuss each component of the system. In particular, the information on Samsung's website:
https://pid.samsungdisplay.com/en/learning-center/blog/lcd-structure
and the video about taking apart an actual LCD panel:
https://www.youtube.com/watch?v=lCBhk5rNU9s are excellent references. If time permits, the 5 1/2 minute YouTube video can be shown in class, or students can view on their own time.

Much more detail is available on the Internet for interested students. (See References in this document)

Module Procedure:

1. Ask the students: "What is actually IN an LCD Display?" Discuss
   Definition of LCD—Liquid Crystal Display
   What makes it work?—integrated circuits
   What are the basic substrates for the system?—glass

2. Show the PowerPoint and discuss each slide, as appropriate as discussed in the instructor notes.

3. Conclude with a general discussion. The questions listed under evaluation may be used in this regard, as appropriate for your class.

REFERENCES

1. Understanding Today's LCD Screen Technology
   https://pid.samsungdisplay.com/en/learning-center/blog/lcd-structure

2. LCD Flat Panel TV Deconstructed:
   https://www.youtube.com/watch?v=lCBhk5rNU9s (takes Samsung TV apart … shows layers, explains how the liquid crystal molecules act like tiny lenses that twist the light - each subpixel ….)

3. Corning Incorporated: Enabling the LCD Industry
   https://www.corning.com/worldwide/en/innovation/the-glass-age/science-of-glass/enabling-the-lcd-industry.html

4. Corning Inc. : LCD Display Components
   https://www.corning.com/worldwide/en/products/display-glass.html

5. Adventures in Science: How LCD Works
   https://www.youtube.com/watch?v=VbdhbyiHX-s With Shawn Hymel
6. Anatomy of an LCD: https://www.youtube.com/watch?v=FPz92AQCPlc (Sharp)

7. Dissecting an LCD TV Panel: https://www.youtube.com/watch?v=2q2f0LwAqOc
   (shows layers under microscope)

8. The Glass Age, Part 1: Flexible, Bendable Glass
   https://www.youtube.com/watch?v=12OSBJwogFc

9. The Glass Age, Part 2: Strong, Durable Glass
   https://www.youtube.com/watch?v=13B5K_lAabw

10. Making glass: https://www.youtube.com/watch?v=IjNusHQOhTM
    (video shows process of making standard float glass, different from the fusion process that Corning and others use to make glass for display applications)

11. How LCDs work: https://www.explainthatstuff.com/lcdtv.html

12. Materials Research Science & Engineering Center at University of Wisconsin
    https://education.mrsec.wisc.edu/liquid-crystals/

13. "Chalk Talk" - Liquid Crystals: https://www.youtube.com/watch?v=nAJgchCI3kg

14. Liquid Crystal Displays (using pasta!): https://www.youtube.com/watch?v=iJks-gapzkk

EVALUATION

Student evaluation questions (discussion or quiz):

1. What property of the liquid crystal is essential for LCD operation?
2. Briefly describe the fusion process for making sheet glass. Why did this process revolutionize the display glass industry?
3. Describe the purpose of these components/materials used in an LCD system:
   - Glass
   - Polarized filters
   - Liquid crystals
   - Thin film transistor (TFT)
   - Color filters

Instructor evaluation questions:

1. At what grade level was this module used?
2. Was the level and rigor of the module what you expected? If not, how can it be improved?
3. Did the discussion/PowerPoint work as presented? Did they add to student learning? Please note any problems or suggestions.
4. Was the background material on LCDs sufficient for your background? Sufficient for your discussion with the students? Comments?
5. Did the discussion/PowerPoint generate interest among the students? Explain.
6. Please provide your input on how this module can be improved, including comments or suggestions concerning the approach, focus and effectiveness of this activity in your context.

Module evaluation questions (for the students)

1. Was the discussion/PowerPoint clear and understandable?
2. Was the instructor's explanation comprehensive and thorough?
3. Was the instructor interested in your questions?
4. Was the instructor able to answer your questions?
5. What was the most interesting thing that you learned?

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