CURIOSITY-DRIVEN RESEARCH

LCD TECHNOLOGY

LIQUID-CRYSTAL DISPLAYS

- Physicist Otto Lehmann's invention, the heating state microscope, revolutionizes liquid-crystal research
- UK physicists George Gray and Ken Harrison of the University of Hull are instrumental in developing the materials that make the production of LCDs possible
- LCDs have only come into their own in recent decades, and research is still needed to advance the technology further

What is it

Although you might not be familiar with the underlying technology, you probably use liquid-crystal displays every day. Simply put, an LCD is a thin, flat display made up of any number of pixels (picture elements) which use light to create colours. In today's world they are all around us: in home-electronics displays, microwaves, watches, TVs and computer screens.

LCDs have become very popular because they are thinner, lighter and use much less power than other display technologies; perfect for battery-powered devices for example. The term "liquid crystal" might seem like a contradiction. However, it was coined because research showed that some substances can exist in an odd state that is part liquid and part solid.

Just as there are many varieties of solids and liquids, there are also a variety of liquid-crystal "phases". These have been discovered over years of research, and certain types are now used to make LCDs possible.

One of the features discovered during research was that liquid crystals are affected by electric current. A particular phase of liquid crystal, "twisted nematics", is naturally twisted. Applying an electric current to these liquid crystals will untwist them to varying degrees, depending on the current's voltage. LCDs use these liquid crystals because they react predictably to electric current in such a way as to control the passage of light. This in turn creates the possibility of controlling the arrangement and colour of the displays; perfect for displaying images!

The science

The origins of LCDs were discovered accidentally by botanist Friedrich Reintzer during his experimentation on cholesterol in plants. This in turn led to the identification of a new phase of matter called the liquid-crystal phase. Later, in 1890, the first synthesized liquid crystal was produced, and it is now possible to produce liquid crystals with predetermined properties.

An important aid to liquid-crystal research at the time was the invention of the heating state microscope by physicist Otto Lehmann. This allowed control of the temperature of a sample, and over time became the standard equipment in every liquid-crystal research lab.

Research into this new phase of matter took off from there, and although there were sceptics, development of basic theories continued steadily until the 1940s when interest in the subject began to wane. No research at all was carried out for over a decade as scientists believed there was nothing left to learn. Liquid crystals were not even mentioned in textbooks, and many scientists training at the time knew nothing about the topic. This is remarkable when you consider how much LCDs are used today.

In the late 1950s, physicists George Gray and Ken Harrison of the University of Hull were instrumental in developing the materials that made LCDs possible, and by the early 1970s consumer products such as watches and calculators containing small LCDs flooded the marketplace. For this work, the University of Hull, the Ministry of Defence and BDH Chemical Co. won the Queen's Award for Technological Achievement in 1979.

In the last 50 years, research has progressed to such an extent that many different types of displays are now possible using liquid-crystal technology. These include backlit, reflective, colour and (only recently) zero-power and paper-thin displays.

LCD timeline

1888	Botanist Freidrich Reinitzer discovers liquid crystals.
1890	The first synthesized liquid crystal is produced.
1890s	Physicist Otto Lehmann creates the heating state microscope, revolutionizing liquid-crystal research.
1958	An article published in *Chemical Reviews* referencing the liquid-crystal phase reignites interest in LCDs and drives research.
1950s	Physicists George Gray and Ken Harrison of the University of Hull become instrumental in developing the materials that makes LCD possible.
1967	The "twisted nematic" liquid-crystal phase is discovered, and the first practical LCD screens made.
1972	The International Liquid Crystal Company (ILIXCO) produces the first modern LCD watch.
1973	Sharp produces the first portable calculator, using an LCD screen.
1979	The first colour display using a lightweight thin-film transfer (TFT) LCD is made.
1985	Seiko-Epson unveils the first commercial LCD colour TV set, which has a 2 inch view.
2004	Philips demonstrate a 20 inch 3D LCD at the CeBIT technology conference in Hanover.
TODAY	Samsung develops the world's largest Full HDTV TFT-LCD at 82 inches.

Augmentative alternative communication (AAC) devices

Touch-sensitive LCD screens have helped many people with communication difficulties "talk" to their friends, families and colleagues. Such devices have traditionally helped those with limited movement to generate sentences and even whole lectures can be delivered by a computer-generated voice. Perhaps the most famous user of this kind of device is Prof. Stephen Hawking, the author of *A Brief History of Time* and an internationally respected physicist.

Current advantages of LCD screens

LCDs, which have been called "green television", are vision-friendly, electricity-efficient and have a significantly longer life-span than current visual devices at 30 years.

A television-sized LCD screen has only one-tenth the thickness and one-third the weight of an ordinary television set, and can be connected to a computer and logged on to the Internet. A joint venture between China and Japan recently launched the world's largest colour LCD screen measuring 28 inches.

Future developments

There is still much more to learn from liquid crystals, since the field has only come into its own in the last few decades. LCDs are now becoming more popular than the older CRT (cathode-ray tube) technology, both for home televisions and computer screens. Other research has led to new applications including windows that change from clear to opaque at the flick of a switch and displays that can run for years without power supplies.

Furthermore, insights into liquid crystals have also helped with understanding biological membranes. The field has opened up. It is no longer the preserve of physicists and chemists, but now also includes biologists and those working in other medical arenas.

Since its accidental discovery, liquid-crystal technology has become a huge industry with a variety of applications, and there is still room for growth. There are still many unsolved problems in this area, plus the need for liquid-crystal applications continues to grow. Research into this technology could yet lead to many discoveries...

There is still much more to learn from liquid crystals.