Elsicon (formerly Alliant Techsystems, Inc., and Hercules)

Optical Alignment Technique To Improve LCD Quality and Price

Liquid crystal displays (LCDs) are incorporated into myriad technologies ranging from automated teller machines (ATMs) and computers to kitchen appliances and automotive dashboards. Although American businesses and consumers spend billions each year on these types of equipment, LCD brightness and clarity problems persist, and the high costs associated with LCDs remain. For years, the Asian marketplace has dominated LCD manufacturing, while the United States has been eager to establish a stronger position in the industry. Recognizing the potential growth of LCD technology and the need to find better ways to mass-produce LCDs, Hercules, a global manufacturer of chemical specialty products for a variety of markets, conceived of an optical production technique that had the potential to enhance LCD quality and improve the economies of scale in LCD production. At the time, however, Hercules was a small company without a sizeable research budget. The risk involved in developing a generic new technology for LCDs was too high for Hercules to bear alone; therefore, the company applied to the Advanced Technology Program (ATP) for research funds in 1993 and received an award in February 1994. Through this ATP-funded project, the company developed processes and materials that have been applied to several prototype LCDs. Elsicon acquired the optical technology in 1997 and now markets products and services for the optical alignment of LCDs.

COMPOSITE PERFORMANCE SCORE
(based on a four star rating)
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Research and data for Status Report 93-01-0091 were collected during October - December 2001.

Production Technology Is Complicated, Expensive, and Error-Prone

The growth in the demand for liquid crystal displays (LCDs) and monitors in the early 1990s was accompanied by an increasing need to improve manufacturing processes for these products to reduce cost and improve quality. To ensure the clarity and brightness of LCDs, manufacturers must precisely align the crystals within them. Older, less expensive LCDs were often fuzzy and unclear because of improper alignment. Existing LCD technology exhibited high sensitivity to dust, requiring expensive isolation rooms to minimize errors. The industry tried to solve these problems through mechanical buffing, an alignment process that used a polymer film adjoined to the display to align the crystals. Although this process improved the clarity of the LCDs, it produced less-than-perfect results, was expensive, and led to defects in the displays.

Static electricity, for example, caused a problem when the mechanical buffing film touched the liquid crystal medium, thereby creating "dead" crystals. Although LCDs consist of many small crystals, just a few dead crystals can substantially reduce display image quality, forcing the manufacturer to scrap the product. This problem occurred frequently with products that contained a large number of crystals, such as larger laptop monitors, desktop flat-screen displays, and flat-screen televisions. An innovation that could align crystals without making contact with the liquid crystal medium would minimize the risk of damaging the displays. The resultant benefits of this innovation would include reduced scrap waste, tremendous cost savings to the users of LCDs, and greater overall quality of the product.

Before this ATP project, alignment techniques for LCD production relied on a process that created "alignment masters" that had limited reuse capabilities. Attempts to

increase the number of times a master could be reused proved unsuccessful. Consequently, despite large-scale production of LCDs, the production costs remained high. If an alignment process could be created that eliminated the need for these expensive masters, manufacturers could reduce production costs and improve LCD quality.

ATP Funding Crucial to Enabling Generic LCD Technology

Hercules proposed a sound research plan that they would follow to create a new generic LCD manufacturing technology. However, as a small company, it could not take on the risks of this endeavor alone. Therefore, Hercules submitted a proposal to ATP in 1993 and in 1994 was awarded $1.67 million to conduct its proposed research.

New Technology Promises Lower Costs and Higher Quality

The goal of this ATP project was to develop an optical alignment technique to be used in the production of LCDs that would incorporate a noncontact process to eliminate the static electricity problem associated with the existing mechanical buffing process and to improve display quality. The company projected that the use of an optical alignment technique would be less expensive, less prone to display errors, and more suitable for mass production than the existing buffing process. Optical alignment equipment is much smaller and less expensive to transport. Moreover, the use of this noncontact technique would also eliminate the need for expensive isolation rooms. In addition, the optical alignment technique would provide cost savings by eliminating the need for expensive masters, thereby reducing overhead costs.

Researchers Achieve Technical Innovations

During the project, the researchers achieved their technical goals and successfully developed the materials and processes required for the optical alignment of LCDs. Technical accomplishments that resulted from this project included the following:

- Creation of a colorless optical alignment material
- Introduction of an optical alignment material with pre-tilts for both homogeneous and homeotropic alignment configurations
- Development of materials with good dielectric properties measured by voltage-holding ratio and residual DC voltage
- Demonstration of thermal and optical stability
- Development of a process to use an ultraviolet lamp as a light source with acceptable throughput
- Establishment of testing capabilities to characterize electrical, optical, and electro-optical properties of optical alignment materials and liquid crystal test cells
- Fabrication of liquid crystal test cells with nonrubbing optical alignment technology

Hercules conceived of an optical production technique that had the potential to enhance LCD quality and improve the economies of scale in LCD production.

The company continued to search for new applications that could benefit from this technique. Toward the end of the project, they performed research to develop technology solutions for the most important new modes of flat displays with wide viewing angles.

Hercules Evolves from Research to Product Development

In 1995, partway through the ATP project, Alliant Techsystems (a U.S. aerospace and defense company) acquired the aerospace portion of Hercules, including its LCD-related technology. Although the LCD products fell outside the scope of Alliant's strategic focus, the company recognized the business potential of the ATP-funded project and helped to form a separate business unit to focus on the project's goals. As the ATP project came to a close in 1997, the optical technology developed at Hercules and Alliant Techsystems was divested and sold to privately held Elsicon. Elsicon has

continued to develop the ATP-funded technologies, including a pre-tilt analysis system for LCDs, which reduces the risk of defects in the orientation of the liquid crystals, and a research and development tool that enables identification of the process parameters for the optical alignment of LCDs and devices. Elsicon also sells a measurement system for the voltage-holding ratio, a critical electrical parameter for LCDs. Finally, the company offers the materials that support the optical alignment of LCDs. Elsicon sells and markets these products through a Japanese partner, Japan Storage Battery Company, because LCD manufacturers are located predominantly in East Asia. Today, Elsicon generates revenue from contracts, licenses, and consulting assignments that are related to the technology developed during the ATP project.

Project Benefits Elsicon and Creates Economic Spillover

In June 1997, Elsicon received a $1.65 million contract to develop new materials and processes for optical alignment from the U.S. Display Consortium (USDC), a public-private partnership based in San Jose, CA, which aims to establish a U.S. infrastructure to support high-definition display manufacturing.

The USDC, which has 130 corporate members and also receives support from the Defense Advanced Research Projects Agency in the U.S. Department of Defense, paid 50 percent of the $3.3 million cost to develop a scaled-up manufacturing process, with Elsicon funding the other half. According to Dr. Robert Pinnel, the Chief Technical Officer of USDC, Elsicon "...built upon a strong foundation of intellectual property in patents and know-how that were developed under a prior grant in the NIST-ATP program. The research and proof of feasibility developed under the ATP grant will now be supported toward practical realization in fulfillment of the USDC mission."

The alignment process has appeared in several prototype LCDs from various global manufacturers, but none of these manufacturers has brought its prototype into mass production. LCD manufacturers worldwide are evaluating the products commercialized from this project. Although the products have not yet been fully incorporated into manufacturing processes for mass production and large-scale sales, initial results from the products are positive.

Elsicon continues to sell and seek licensing for the products and processes developed during the ATP project, creating a sound foundation for its future. Benefits for Elsicon, however, represent only a fraction of the broader economic benefits that may be provided by optical alignment LCD technology. Current and future benefits include more efficient manufacturing processes, higher quality displays, lower cost to users, and a larger knowledge base for the development of future technologies. In 2000, the LCD market was $20 billion worldwide for laptops, personal digital assistants, and other technologies that rely on flat displays. With the demand for these products increasing rapidly, the high cost of LCD monitors represents a burden on the economy as well as on consumers. As the enhanced production technology spreads in the industry, the cost advantages are expected to translate into lower prices for the displays, benefiting American businesses and consumers.

ATP Award Sustained the Project and Ensured a Short Development Life Cycle

Had the project not received support and funding from ATP, Alliant Techsystems would likely have abandoned the development of the optical alignment technique because of the lack of funding, preventing the important innovations that occurred as a result of the project. The LCD technologies fell outside the scope of Alliant's strategic focus, and the project could not rely on additional internal funding. Thus, external funding was critical in ensuring the timely completion of the project.

Conclusion

Elsicon is in the process of evaluating its optical alignment technology, known as OptiAlign™, in the liquid crystal display (LCD) manufacturing industry. The company has formed strategic partnerships and alliances that provide feedback, allowing researchers to further refine the technology and facilitate its implementation. An evaluation of OptiAlign™ is currently under way by a number of manufacturers in East Asia, Europe, and North America. The results have been very promising and suggest that the technologies may lead to new and improved flat displays.

PROJECT HIGHLIGHTS
Elsicon (formerly Alliant Techsystems, Inc., and Hercules)

Project Title: Optical Alignment Technique To Improve LCD Quality and Price (Optically Controlled Alignment Materials for Liquid Crystal Displays)

Project: To reduce the cost and improve the yield of liquid crystal displays (LCD) manufacturing by developing optically controlled alignment materials and processes to replace the mechanical buffing process, thereby expanding the LCD applications base in optical data storage and signal processing.

Duration: 2/1/1994-1/31/1997
ATP Number: 93-01-0091

Funding (in thousands):

ATP Final Cost	$1,670	55%
Participant Final Cost	1,370	45%
Total	$3,040	

Accomplishments: During the project, the researchers achieved their technical goals and successfully developed the materials and processes required for the optical alignment of LCDs. The project led to the development of successful technologies as well as marketable products.

The U.S. Patent and Trademark Office granted the following patents that stemmed directly from the research conducted during the ATP project. These patents, which Elsicon purchased from Alliant, serve to disseminate the knowledge created by the project.

- "Liquid crystal optical storage medium with gray scale"
  (No. 5,846,452: filed April 6, 1995, granted December 8, 1998)
- "Process and materials for inducing pre-tilt in liquid crystals and liquid crystal displays"
  (No. 5,731,405: filed March 29, 1996, granted March 24, 1998)
- "Process and materials for aligning liquid crystals and liquid crystal optical elements"
  (No. 5,807,498: filed March 29, 1996, granted September 15, 1998)
- "Process and materials for inducing pre-tilt in liquid crystals and liquid crystal displays"
  (No. 5,817,743: filed May 14, 1996, granted October 6, 1998)
- "Process and materials for inducing pre-tilt in liquid crystals and liquid crystal displays"
  (No. 5,856,430: filed March 31, 1997, granted January 5, 1999)
- "Fluorinated amine products"
  (No. 5,929,201: filed May 20, 1997, granted July 27, 1999)
- "Polarizable amines and polyimides for optical alignment of liquid crystals"
  (No. 6,084,057: filed May 20, 1997, granted July 4, 2000)·
- "Materials for aligning liquid crystals"
  (No. 5,965,691: filed July 1, 1997, granted October 12, 1999)
- "Process and materials for inducing pre-tilt in liquid crystals and liquid crystal displays"
  (No. 5,856,431: filed November 7, 1997, granted January 5, 1999)
- "Polarizable amines and polyimides for optical alignment of liquid crystals"
  (No. 6,043,337: filed May 18, 1998, granted March 28, 2000)
- "Process for materials for aligning liquid crystals and liquid crystal optical elements"
  (No. 6,200,655: filed January 25, 1999, granted March 13, 2001)
- "Polymides for optical alignment of liquid crystal displays"
  (No. 6,451,960: filed February 4, 2000, granted September 17, 2002)

Commercialization Status: The ATP project resulted in the development and patenting of several new technologies, which now provide a platform for the commercialization of a series of products and services related to the optical alignment of LCDs at Elsicon.

The alignment process has appeared in several prototype LCDs from various global manufacturers. None of these manufacturers has brought its prototype into mass production, and until that happens, Elsicon will not pursue upfront licensing fees when entering into agreements with manufacturers, opting instead for a percentage of total sales. Elsicon views this as the strategy that will both generate the most revenue and distribute the technology to the largest

number of manufacturers. LCD manufacturers around the globe are evaluating the products commercialized from this project. Although the products have not yet been fully incorporated into manufacturing processes for mass production and large-scale sales, initial results from the products are positive.

Outlook: Elsicon is in the process of implementing its optical alignment technology, known as OptiAlign™, in the LCD manufacturing industry. For the longer term, the company is developing similar technologies related to optical data storage and optical signal processing. Those products include liquid crystal-based storage media, liquid crystal diffractive and holographic elements, phase and polarization devices, document security, and fast optical communication devices. By conducting research in optical signal processing, used in the optical networking industry, the company is working to develop a foundation for additional successful technologies.

Composite Performance Score: * *

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