MULTI-FILM VENTURE
(Joint Venture, formerly the American Scaled-Electronics Corporation)

Joining Several Chips Into One Complex Integrated Circuit

In the race to boost the performance and decrease the size of the integrated circuits (ICs) used in computers, one limitation gets a lot of notice: the two-dimensional (2D) nature of ICs. An IC, or chip, is flat. Its operating speed depends greatly on the length of the wires interconnecting its tiny components. Chip designers spend enormous resources to make the longest wire as short as possible and to reduce component size so they can be placed closer together. But as long as chips are 2D devices, wire length constrains how fast they can operate.

COMPOSITE PERFORMANCE SCORE
(Based on a four star rating.)
★ ★ ★

New Capabilities From Interconnected Chips

On a seemingly unrelated front, the need frequently arises for large electronic displays — in hospital operating rooms, military command centers, industrial applications, and even sports bars. Sometimes the display must also be flat. For home use, a display that mounts flat on the wall like a picture is ideal and is much sought after by technology leaders. Large CRT (cathode-ray tube) displays are available. But a 35-inch CRT display may be 30 inches deep and weigh 150 pounds. Flat-panel displays, like those in notebook computers, are also widely available. But they are typically small, since the display usually has just one panel consisting of a single, broad, light-emitting IC.

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Attempts to greatly increase the scale of single-IC fabrication have been accompanied by commercially unacceptable levels of defects. Interconnecting several chips introduces other problems.

One Technology for Two Major Needs

The Multi-Film Venture (MFV) — a partnership between MCC and Kopin Corporation (a small company spun off in 1984 from Lincoln Laboratory at the Massachusetts Institute of Technology) — used ATP funding to speed up by two years the development of technology to address the needs for larger flat-panel displays and for shorter IC component connectors. The new technology can be used to join several broad light-emitting ICs into a single large display with no visible seam. It can also be used to join small ICs, stacked like a deck of cards, so that wire lengths can be shortened. ATP funding made this joint venture possible, and the project's success attracted further research and development funding from outside sources.

The new technology is based on ATP-funded development of advanced methods for positioning IC components with micron-scale alignment and for connecting individual ICs, as well as new adhesive procedures for bonding chips together. It is also based on proven IC fabrication methods and proprietary thin-film transfer technology previously developed by Kopin. MCC contributed its expertise in adhesives, bonding, and positioning.

During the ATP project, MFV researchers proved the feasibility of transferring thin-film, single-crystal silicon ICs to a substrate and interconnecting them to form a functioning multifilm module (MFM). They designed, built, and successfully demonstrated a large-area, flat-panel display to show seamless joining of several panels (single, broad, light-emitting ICs) arranged side by side like floor tiles, to form the display.

Giant Flat Screens and 3D Microprocessors

The earliest commercial use of the new MFM technology is likely to be in military, medical, and industrial flat-panel displays and large high-resolution displays. The tiled displays would replace conventional CRT displays. When cost considerations make it profitable, they would replace

PROJECT HIGHLIGHTS

PROJECT:
To show the feasibility of interconnecting thin-film integrated circuits (ICs), packed side by side or in layers, to form a complex, multifilm module (MFM), and to demonstrate this technology in a large flat-panel display.

Duration: 9/15/1992 — 9/15/1995

ATP Number: 91-01-0262

FUNDING (in thousands):

ATP	$2,776	48%
Company	2,973	52%
Total	$5,749	

ACCOMPLISHMENTS:
MFV developed the MFM technology and demonstrated it in a large, flat-panel display. In actions related to the project, Kopin:

- received two patents for project-related technology:
  "Single Crystal Silicon Tiles for Liquid Crystal Display Panels Including Light Shielding Layers" (No. 5,377,031: filed 8/18/1993, granted 12/27/1994),
  "Method for Forming Three-Dimensional Processor Using Transferred Thin-Film Circuits" (No. 5,656,548: filed 9/19/1995, granted 8/12/1997);
- raised $8.1 million from private sources during the ATP project;
- raised $26.6 million from a second public stock offering in March 1993;
- received (with Northeastern University) $2 million from the Office of Naval Research in June 1996 for R&D work, based directly on the ATP-funded MFM technology, to design and fabricate a 3D microprocessor;
- received (with Northeastern and Polaroid) $5 million from the Defense Advanced Research Projects Agency in June 1996 for R&D work — using the ATP-funded MFM technology — on 3D computational image sensors for compact low-power video cameras;
- raised $31.8 million via private equity investments since the end of the ATP project.

CITATIONS BY OTHERS OF PROJECT'S PATENTS:
See Figure 1.6, Chapter 1, and Figure 4.9.

COMMERCIALIZATION STATUS:
Commercialization is expected within one or two years for products incorporating the 3D microprocessor technology. Large-area flat-panel displays based on the MFM technology are expected to be commercialized when their market develops.

OUTLOOK:
The outlook is very promising. Products based on the ATP-funded technology are being developed by Kopin and are expected to be introduced to the market soon.

Composite Performance Score: ★ ★ ★

COMPANIES:
Multi-Film Venture
(MFV; formerly the American Scaled-Electronics Consortium)
Kopin Corporation (joint venture lead)
695 Myles Standish Blvd.
Taunton, MA 02780

Contact: Ollie Woodard
Phone: (508) 870-5959
Number of employees: 70 at project start, 100 at the end of 1997
Other joint venture participant: MCC, Inc. (formerly Microelectronics & Computer Technology Corporation)

large single-panel displays based on relatively expensive technologies such as liquid crystal display. The new technology also has potential applications in desktop computer displays and — with volume production and lower prices — in wall displays for the home. In addition, the ATP technology should be competitive for very high resolution screens, those with resolutions of 2,000 by 2,000 pixels per inch up to 10,000 by 10,000 pixels.

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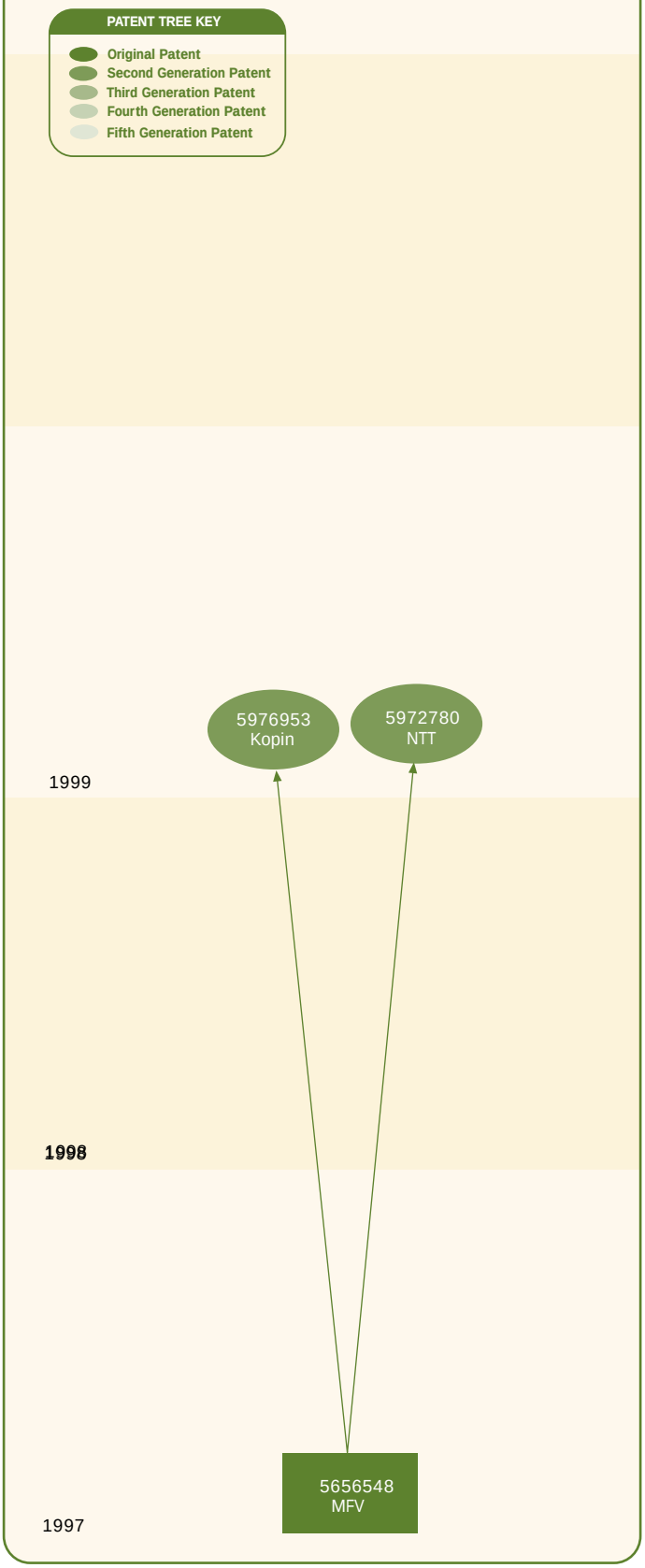
The MFM process is expected to be useful for making devices with directly joined layers of ICs that perform different functions. In one application, Kopin is collaborating with Northeastern University (using $2 million from the Office of Naval Research) to design, fabricate, and demonstrate a three-dimensional (3D) microprocessor.

In a second application, Kopin is working with Northeastern and Polaroid in a five-year project, begun in June 1996, to develop a 3D computational image sensor for compact low-power video cameras. The sensor will be a stack of three chips: a sensor IC, a computation IC, and a read-out IC. The chips will be connected using the ATP-funded MFM technology. This project is supported by $5 million from the Defense Advanced Research Projects Agency.

Kopin Succeeds in Capital Markets

Although products incorporating the ATP-funded technology are not yet on the market, they are likely to arrive

Figure 4.9 Patent Tree for Project Led by Multi-Film Venture: Citations by Others of Multi-Film Venture Patents[1]



. . . potential applications in desktop computer displays and — with volume production and lower prices — in wall displays for the home.

soon. Kopin has shown that it can carry out commercialization plans, as evidenced by its introduction of other products after more than a decade of work on the underlying technology. Also, Kopin's success at raising funds in the private-capital market reflects investor confidence in the company's ability to commercialize its technology. Kopin has raised an additional $31.8 million via private equity investments since the end of the ATP project.

When the new products — flat-panel displays and 3D microprocessors — are introduced, intermediate companies (which purchase components produced by Kopin), final-product manufacturers, and consumers are expected to reap large benefits from the ATP-funded technology.

[1] Also see the patent tree for a different patent from the same project shown in Figure 1.6, Chapter 1.