Epson Using MEMS to Create Advanced Inkjet Heads for POS Printers

By John Boyd

Microelectromechanical Systems, or MEMS, is an emerging technology you will be hearing much about over the next several years. MEMS are tiny three-dimensional devices incorporating moving parts. As an outgrowth of the semiconductor industry, MEMS devices are created from the same materials and similar process techniques employed in fabricating silicon chips. They are already being commercialized in sensors for monitoring pressure, temperature, vibration and light. They are also used in controlling light in optical switches and are found in accelerometers for pacemakers and air bags. According to In-Stat/MDR an IT research firm, MEMS revenues are growing steadily and are forecast to pass $8 billion in 2006.

In recent years, Seiko Epson, using the know-how gained from micromachining precision parts in quartz timepieces, coupled with its long experience in fabricating semiconductor devices, has taken a lead in commercializing MEMS technology. Since 1998 the company has been shipping to the retail market POS (point-of-sale) printers that utilize micromachined high-resolution inkjet printheads.

TM-J7100, Epson's inkjet POS printers

These inkjet heads are driven by on-demand electrostatic force and go by the trademarked name of SEAJet(R), an acronym for static electricity actuator jet. This novel operation enables the POS printer to print at 15 lines a second on rolled paper and three pages per minute on A4-sized paper at a resolution of 360 dots per inch—the industry's fastest. In addition the SEAJet head is small in size and its power consumption is extremely low when compared to printheads in thermal-type printers and the popular piezoelectric-type printers commonly used with personal computers.

The SEAJet printhead is composed of three substrates: a silicon substrate incorporating 128 nozzles; a central silicon cavity substrate incorporating the reservoir for the ink and a pressure plate; and a glass substrate containing an electrode. Each substrate is fabricated using MEMS processes, including deep etching and multiple-step mask patterning. After fabrication the substrates are assembled also using MEMS techniques to directly bond them together to form what is called the head chip.

"At Epson, working with measurements of one micron [one millionth of a meter] is a daily occurrence," says Mitsuro Atobe, general manager of production engineering and development. "But in fabricating the SEAJet, we needed to descend to the nanometer level [one billionth of a meter]."

This is necessary because the SEAJet head fires ink droplets as fine as 20 picoliters (20 trillionths of a liter). Similarly, while substrates that compose ordinary inkjet heads can normally be glued together, in the case of the SEAJet head chip, engineers had to work to an extremely high accuracy of 10 nm, so MEMS technology was also required to directly bond the substrates together.

The method of ink ejection in the SEAJet is simplicity itself. When a DC voltage is switched on and off between the pressure plate and the electrode, the plate moves up and down under the force of electrostatic attraction, and as a result, ink droplets are ejected from the nozzles via the cavity.

Epson first became interested in MEMS in the late 1980s and began researching the possibility of using the technology for sensors and actuators in quartz watches. However, around the same time personal computers had grown into a major industry, creating a huge demand from corporations and consumers alike for high-quality color printers. So Epson researchers began looking into how they could use MEMS techniques to help fabricate printheads.

"We found MEMS could be applied in constructing the cavity portion of the printhead when using silicon as the construction material for the cavity," Atobe explains. "And so we went on to use this process for making the cavity in printheads in Epson's color inkjet printers."

The cavity portion of the head chip acts as an ink pressure chamber, so its dimensions and precision of construction have a direct impact on the size and design of the inkjet nozzle, which in turn impacts the quality of the printing. The improved cavity construction arising from such MEMS fabricating processes as lithography and etching, then, helped to significantly improve the quality of printing in Epson's color inkjet printers, which use a multilayer piezo ink-ejection action and stainless steel nozzle heads. In fact, these printers went on to become leaders in the PC inkjet printer market. As a result Epson become the largest user of silicon wafers in the printer industry, as well as becoming a leader in the application of MEMS technology.

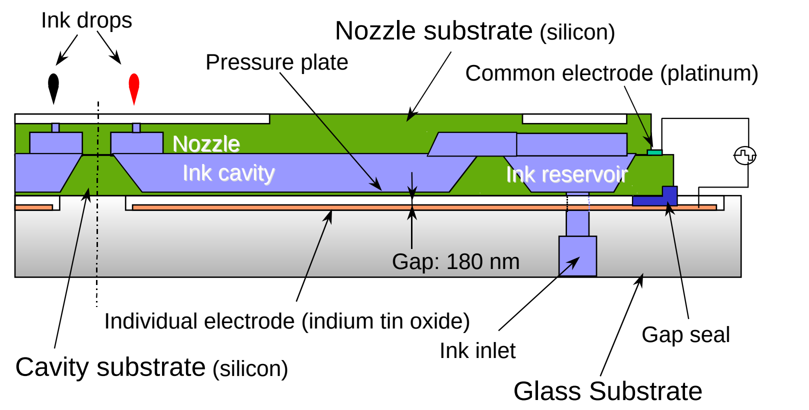
In the case of POS printers for the retail market, including hotels, chain stores and bookshops, different design considerations come into play. These include small size, long life and durability under heavy-duty usage, low power consumption and low noise, as well as high print speed, plain paper printing capability and high printing quality for reproducing bar codes.

With these parameters in mind, Epson researchers came up with the electrostatically driven SEAJet design as described above. This allows multiple nozzles and the nozzle substrate to be fabricated simultaneously, using the deep-etching techniques of MEMS. Similarly, both the cavity substrate and the glass substrate can also be fabricated using micromachining, unlike the piezoelectric-driven heads in Epson's color inkjet printers—which are constructed mechanically, with the exception of the cavity portion, as previously explained.

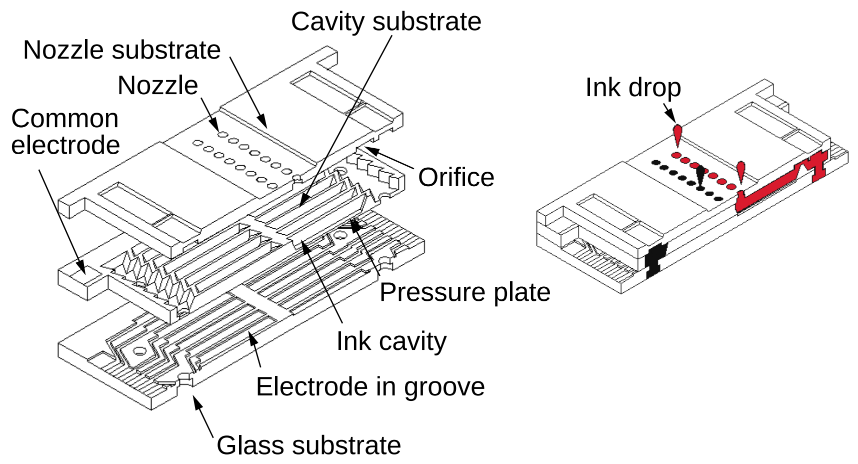
"Because we are using MEMS to fully fabricate the SEAJet, we can take advantage of semiconductor production processes," says Atobe. "This gives us a lot of versatility in design and production." At the same time, because the ink ejection method is driven by electrostatic action, "Power consumption is minuscule," he adds. "It's just one-thousandth of the power used by thermal printheads, and about one-tenth of that used by piezo-type printheads."

With these advantages, Epson sees possibilities for SEAJet technology to be used in future portable battery-driven products, where printing may be required at any given location. "And in the case of the SEAJet printhead itself, we're using only silicon and glass," notes Atobe. "But we can apply the same MEMS processes to different materials, and in place of ink, we could use other substances, like biomaterials and proteins. Similarly, we don't need to be limited to depositing such materials only onto paper, so we see many possible applications for SEAJet technology down the road."

Cross-Sectional View of SEAJet(R) Printhead



Exploded View of SEAJet(R) Printhead



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