FLUID EJECTION TECHNOLOGY COULD HAVE BIOMEDICAL, MANY OTHER APPLICATIONS

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Ink jet printers may soon produce better quality images, all because a few guys weren't afraid to work with bubbles.

Working on a fluid ejection project, University of California, Los Angeles professor Chang-Jin "C.J." Kim and his team used an extra bubble to regulate the flow of ink coming into and out of every nozzle in the ink cartridge. This was done in addition to the usual bubble that ejects ink droplets.

"We found we had the speed advantage and the two bubbles allowed you to control the droplets very well," Kim said. "Our system is completely free of satellite droplets. The clean ejection of the droplet was most important and attractive to commercial companies."

A computer company recently licensed the technology and is working on a product, which Kim said might be ready for a market debut in 2004.

"This technology can be applied to hundreds of applications," said Fan-Gang Tseng, assistant professor at National Tsing Hua University in Taiwan who as a doctoral student was part of the UCLA research team with Kim and Chih-Ming Ho. Tseng's list of potential uses for the technology includes integrated circuit cooling, lithography direct writing and virtual reality systems.

The fluid ejection technology is a byproduct of research Kim conducted for the U.S. Navy to develop a fuel injector for incinerators on submarines. Because the device can tolerate corrosive fluids such as blood, it also has applications in the biomedical field. Two biomedical companies are reviewing non-exclusive contracts, he said.

"The device can be used when people need to put a lot of droplets on a glass slide and analyze them," said Kim. "Our ejection technology allows excellent control of size and speed."

"Our droplet ejector is immune to the chemical nature of the drops," Kim said. "It can handle a wide range of liquids, which includes biological samples and chemical substances."

Kim's research with microfluids took off when he faced a physics foe: surface tension. Surface tension is the force that makes an ant struggle to get out of a droplet of water. When things are sized about one millimeter or smaller, the laws of physics are tweaked and moisture creates a very strong force.

"In our scale, you can move water with muscle force, but when you go into the (micro) scale surface tension dominates everything," said Kim. Unwanted moisture in a MEMS device, for example, can make the gears lock on the tiny machines.

But Kim and his lab group made surface tension work for them when they used bubbles as a stop valve for ink coming into and out of an ink ejector. The process that eliminated tiny satellite droplets of ink has resulted in technology that is six times faster than traditional ink ejectors.

In continuing his work with surface tension, Kim progressed from regulating the flow of liquid, to outright moving liquids. In the normal-sized world, a pump and valve could do the job just fine. But in the micro world, forget it. Pumps that might be in MEMS devices would require billions of times higher pressure to move liquid.

So Kim and another team in his group created a miniature electric motor that contains a circular channel filled with a liquid metal and an electrolyte. When a small amount of electrical voltage is applied to manipulate the surface tension of the drops, the liquid circulates around the channel.

In the future, pico satellites, which are about the size of a deck of cards, may contain the microfluidic technology developed by Kim and his crew. In space, the moving liquid would create a change in direction for the satellite.

During the next few years, Kim will be working on another bit of MEMS technology that can cut a column of liquid into smaller droplets that are 100 micrometers. The droplets can be moved into the system to be analyzed or mixed with other droplets to create a new chemical product.

"Each device can be programmed to move liquids according to needs," said Kim. "Somebody can connect the device to a computer and design the path for each droplet. Then it becomes a programmable microfluid device."

Funded by the Defense Advanced Research Project Agency, the project could likely produce technology that would have many applications in the biomedical field. But, Kim said, it would take another two years before he and his team could fully realize the full biomedical usages.

New developments with microfluidics in MEMS devices will lower research costs by reducing the amount of expensive material needed and by speeding the research process, said Thomas J. Dietz, managing director of Pacific Growth Equities in San Francisco, an investment firm specializing in biotechnology.

"The benefit is, the higher the throughput, the higher the chances of success in the drug discovery effort," Dietz said.

Like his MEMS colleagues, Kim faces packaging problems, but he said he is a little ahead of the game because liquids must be encapsulated in the device before it is packaged.

"But now," he laughed, "there is a new problem of connecting the device for liquid input and output."

C.J. Kim profile:
UCLA'S C.J. KIM STARTED WITH A DREAM, HAS BECOME A MEMS PIONEER AND MENTOR