

## ROBUGS: SMART DUST HAS LEGS

by David Pescovitz

"For fourteen years, I've had this dream of making silicon walk," says UCB EECS professor Kristofer Pister of the Berkeley Sensor & Actuator Center.

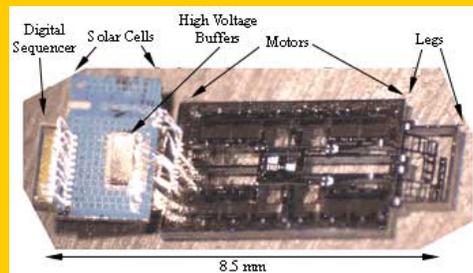
It's a startling idea: Swarms of ant-size robots burrowing through the rubble of a building after an earthquake searching for survivors or crawling onto the hull of a spacecraft to repair damage in-flight. But perhaps the most amazing thing about Pister's dream is that it's not as far off as one might think. Already Pister and his graduate students have built simple solar-powered microrobots just 8.5 mm long and less than 4 mm wide.

"It only has two legs and its tail is too heavy, so it can't quite walk," Pister says. "But it does push-ups."

Still, the solar-powered bug demonstrates that tiny autonomous robots can be fabricated using the same technology used to manufacture integrated circuits. The current microrobot prototypes were built in three separate pieces in UC Berkeley's state-of-the-art Microfabrication Laboratory. The first component is a digital logic chip that controls the walking motion of the two legs. The second includes the near-microscopic solar cells, designed by Pister's former graduate student Seth Hollar. Those 2 components are then combined with the legs, motors and frame of the robot. Eventually, all three steps could be

combined into a single process, enabling the microrobots to be cranked out in bulk at costs of perhaps less than \$1 each.

Key to the microrobot's locomotion is the novel MEMS (micro-electromechanical systems) the researchers developed during the last several years. Aptly-named "inchworm" motors work by repeatedly engaging a shuttle that pulls the leg forward a minuscule amount, releases it, and then engages it again to move it a bit more. Similar to the way a person climbs a ladder, the repetition of small steps will provide the legs with enough force and displacement (distance of travel) to carry the microrobot along.



A full view of the two-legged microrobot.

"Traditionally with MEMS, you get either high force or large displacements," says lead GSR Sarah Bergbreiter. "With the inchworm motors, you have both."

Right now, the microrobot is crippled by a clutch that slips when the leg pushes against the ground. The problem, Bergbreiter says, should be solvable with minor adjustments to the design of the device before the next batch of microrobots is fabricated.

The microrobot research preceded Pister's Smart Dust motes, tiny wireless transceivers outfitted with sensors for myriad applications. A key component in the efforts of the Center for Information Technology Research in the Interest of Society (CITRIS), Smart Dust has a multitude of applications — from diagnosing a building's structural integrity to measuring light and temperature for energy use monitoring. Outfitted with their own TinyOS operating

system, the motes self-organize into ad hoc wireless networks and pass their data from one to another bucket-brigade style until the information reaches a central computer for processing. Now, Pister and Bergbreiter, with private sector collaborator Anita Flynn of MicroPropulsion Corporation are finally able to realize the full potential of the Smart Dust platform.

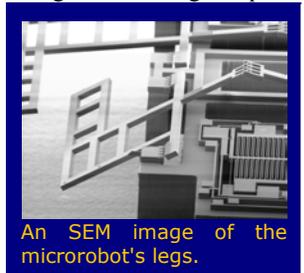
"MEMS technology has shrunk so much that we can start to make microrobots which are essentially smart dust with legs," Bergbreiter says.

The Smart Dust-style sensors and on-board computer processing are what will provide the microrobots with their autonomy, Bergbreiter says. While each robot will control its own activity, the power will come from deploying them in swarms. For instance, much like ants build a nest, a swarm of microrobots dropped on Mars could work collaboratively to construct a satellite antenna so they can transmit their environmental readings to an orbiting spacecraft. Even more amazing, Bergbreiter says, they could says says, they could crawl on top of each other to build a larger silicon structure out of themselves

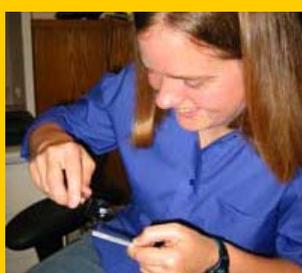
"In my opinion, robotics has always meant big lumbering machines," Bergbreiter says. "I like the idea of making very simple robots, but a lot of them. If one component of a big robot fails, the robot is finished. But if one microrobot dies, the rest of them continue to function and the task can still be completed."



Prof. Pister is currently on industrial leave, working at his start-up company Dust Inc. Peg Skorpinski photo



An SEM image of the microrobot's legs.



Sarah Bergbreiter examines a microrobot using a high-powered magnifying glass.

David Pescovitz photo

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