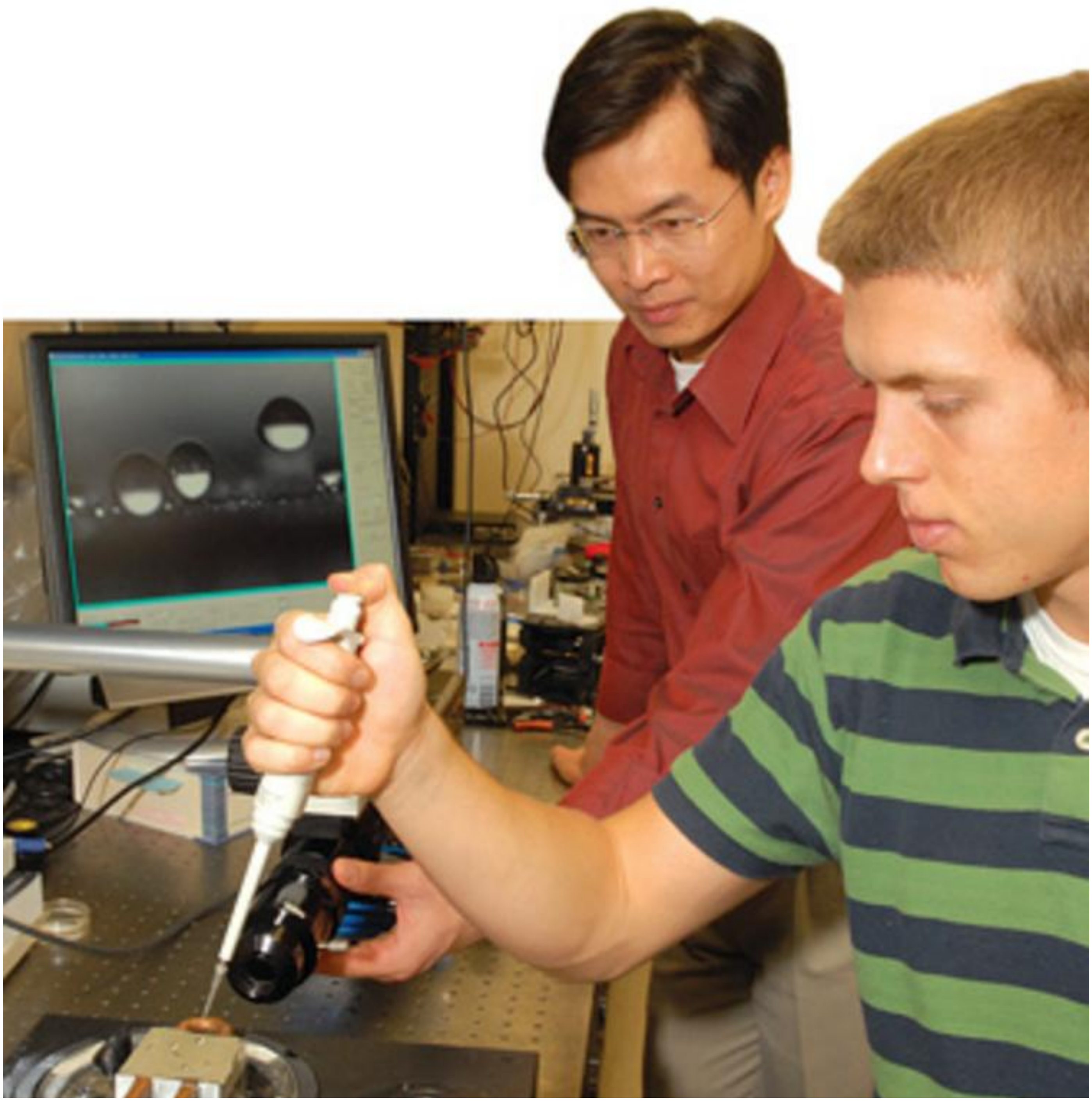
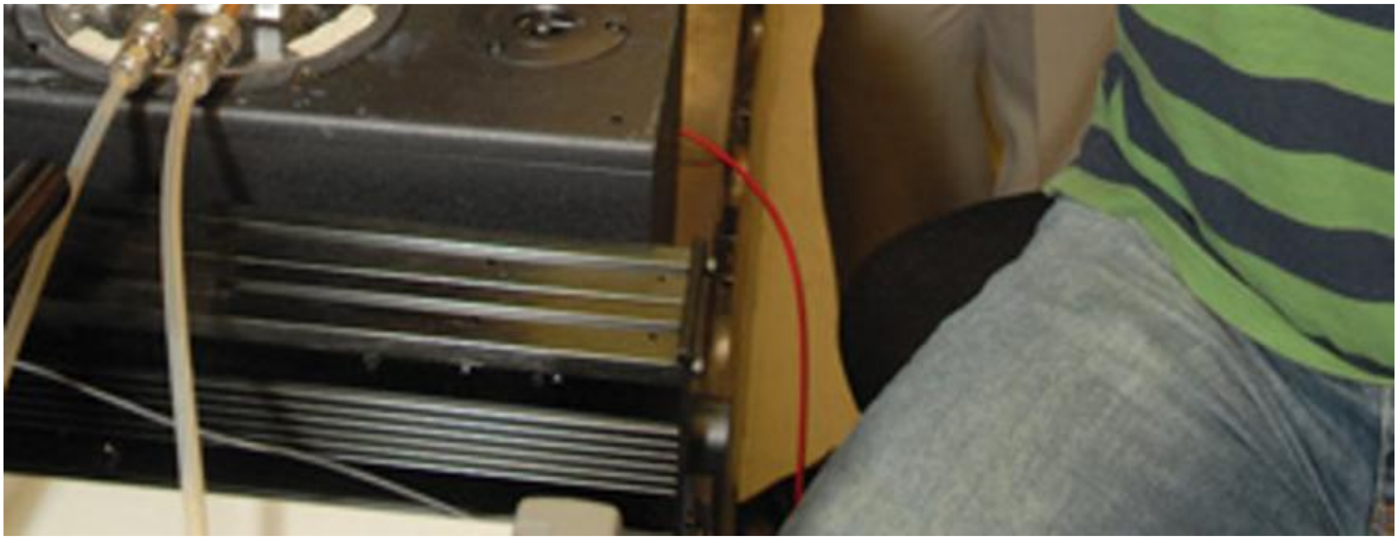
# Researchers see promise in lotus

James Gallagher Oct 29, 2009, 11:05am EDT





Chuan-Hua Chen, left, and Jonathan Boreyko use vibrations to free dew drops from a... more

DURHAM – The surface of the lotus leaf could hold the key to smaller electronics and power plants.

Duke University professor Chuan-Hua Chen and mechanical engineering graduate student Jonathan Boreyko have documented exactly how the leaves stay perfectly dry, and they are working to use that knowledge to create more efficient cooling systems for microchips and power plants.

The two researchers unlocked the key to the leaf's superhydrophobicity – that's the term used to describe surfaces so water repellent that water won't stay on them. Boreyko says the effect is comparable to an air hockey table, where the puck floats across the surface and would float off if not for the walls.

Superhydrophobicity is sort of a hot topic right now among researchers, says Jan Genzer, a chemical engineering professor at North Carolina State University, adding that the work has tremendous possibilities, including improving automobile windshields and creating self-cleaning surfaces.

Researchers have known for about 200 years that the lotus has tiny hairs that keep large drops of water from sticking to the leaf's surface. It's a concept that has been replicated in regular hydrophobic surfaces for many years. By making a surface rough, a layer of air exists between the surface and the droplet, which causes the drop to fall off the surface.

But what they had not yet discovered was how the leaf expelled condensation that formed below the tiny hairs and directly on the leaf's surface. In humid areas, water can condense on the surface of the leaf or inside the crevices of any other hydrophobic surface, and because there is no air between the water and surface, there is nothing to cause the drop to fall off.

Lotus leaves in nature, however, buck that trend. No dew or condensation sticks to lotus leaves.

Using a high-speed camera, Chen and Boreyko were able to film tiny dew drops as they condensed on the leaf's surface and rolled off. What they found was that subtle vibrations, which in nature are caused by the leaf's thin stem but in the lab were created by a speaker, propelled the dew drops off the leaf's surface.

"If you do the vibration in the right way, you can remove this condensation," says Chen.

The discovery could have wide impact on the field of water repellancy, since vibrations naturally occur in many areas. Chen says the system could be applied to the hulls of ships to reduce drag in the water or to optic lenses to keep them from fogging up.

Chen and Boreyko are turning their sights, however, on cooling systems. They have submitted patents for their work and are talking with two large micro-electronics manufacturers about using their research to enhance electronic products. Chen says they are unable to name the companies at this time, due to confidentiality agreements.

Microchips create a lot of heat. And the faster the chips get, the more heat they give off. This isn’t a problem for large desktop computers or servers, which have fans and enough space to dissipate the heat.

But in smaller electronics, fans and air cooling becomes much more difficult – as anyone who has ever worked with a laptop on their lap can attest.

To deal with heat in tighter places, such as computers or nuclear power cells in space crafts, manufacturers have used heat pipes, which are closed liquid cooling systems that use evaporation and condensation to remove heat. Essentially, the heat from the chip causes a liquid to evaporate – much in the way the human body uses sweat to cool down. That evaporated liquid then condenses on a hydrophobic surface and the water falls into a chamber where it can evaporate again.

By incorporating vibrations, like the lotus, the cooling systems can more quickly cycle the condensed liquid back to be evaporated. “If you can figure out a way to remove the condensation drops faster, you create a more efficient system,” says Boreyko.

Chen estimates the technology can make existing systems 10 times more efficient, which would mean they could be 10 times smaller.

Larger heat pipe-like systems also are used in steam-turbine power plants, and Chen says the technology can be used to make the plants significantly smaller as well.

The results of the research will be published on the cover of Physical Review Letters, which is among the top physics journals.