Cold Plasma Ignites Hot Applications

BY JAMES SCHULTZ

If somehow it were possible to scratch the surface of the sun without incinerating, Old Dominion research assistant professor of electrical and computer engineering Mounir Laroussi might give it a go. For now, Laroussi has settled for a quick and literal touch of a bluish, pilot-light-like ionized gas in his laboratory — otherwise known as plasma, and often described as a fourth state of matter.

Fortunately, when Laroussi pokes a finger inside, no skin chars; no damage is done. He's also tested paper, plastics, glass, rubber, even a small hair brush, with no ill effect. Unlike solar plasmas, which can reach many millions of degrees Fahrenheit, this discharge remains at room temperature. Still, Laroussi's cool tabletop plasma has much in common with the sun's fusion reactions that produce the heat and light that bathe Earth and make it habitable.

"If you put a finger inside a cold-plasma plume it gives you a little tinge. It's nothing much," Laroussi asserts. "But you wouldn't want to leave it there unless you wanted to sterilize your skin."

Sterilization of food, medical equipment, and contaminated civilian and military gear is just one potential major application of so-called "cold" plasmas. These ambient-air-temperature ionized gases could also be used as a Star Trek-like protective shield around sensitive electronics-bearing devices, such as satellites; as cloaking technology for military aircraft, as a means of absorbing radar waves in order to remain hidden on enemy screens; and as components of a new generation of miniature lasers and in advanced, low-energy-consumption flourescent light tubes.

"It's easy to make plasmas at low pressures, like the near-vacuum of space. It's much harder to initiate and maintain them at low temperature and at atmospheric pressure," Laroussi says. "What my co-workers and I have managed to do is to figure out a cost-effective way to make plasma, keep it cold and generate it in volume. We probably produce more total cold plasma than anyone else in the world, and at a relatively low level of input power.

"The beauty of this is that it's relatively inexpensive. The device we're using costs less than $1,000. Compare that to a fusion reactor, which costs millions, or other, smaller devices that start at tens or hundreds of thousands of dollars. Ours is very practical."

COOKING THE COSMIC SOUP

Interest in plasma physics initially developed because of radio communications and the effect of Earth's ionosphere on radio-wave transmission. Because the ionosphere is essentially a plasma, ranging from approximately 50 to 600 miles above the planet's surface, radio waves are partly absorbed by ionized air and in part refracted, or bent downward. The bending effect makes possible reception at distances much greater than for signals sent in a straight line, ones that could not follow the curvature of the globe.

Plasmas, a kind of cosmic soup comprised of molecules, atoms, electrons and ions, comprise 99 percent of the known universe. The three other known states of matter — solids, liquids and gases — make up a mere 1 percent. Plasmas are most commonly found in interstellar space, where residual hydrogen is ionized by radiation, and in stars whose energy-generating efficiencies earthbound scientists have long desired to emulate.

In stars, for hydrogen nuclei to fuse into heavier nuclei, they must be fast enough to overcome a mutual electric repulsion when the hydrogen ionizes into a plasma. Very hot plasmas overcome these limitations when their constituent particles collide with one another, acquiring sufficient energy to fuse, releasing enormous energy. Such reactions are at the literal heart of the sun's core and, for the next four or so billion years, a ready and abundant source of solar heat.

If the same kind of forces that have kept the sun's nuclear furnace burning thus far could somehow be efficiently replicated terrestrially, power would be abundant and inexpensive, even in the world's remotest regions. Unlike nuclear fission, fusion poses little significant environmental threat. However, despite researchers' best efforts, technical problems have so far derailed efforts to produce practical fusion-based power.

AN EXPLOSION OF INTEREST

Laroussi is not seeking to build a miniature fusion generator in his laboratory at the Applied Research Center in Newport News. Although his cold-plasma approach involves the excitation of helium gas inside a plexiglass cube (inside a star, hydrogen is converted into helium), the key is the way in which electric current flows in and through the gas via specially calibrated electrodes. The formula, specified in pending patent applications, is scalable; cold-plasma containers of virtually any size are feasible.

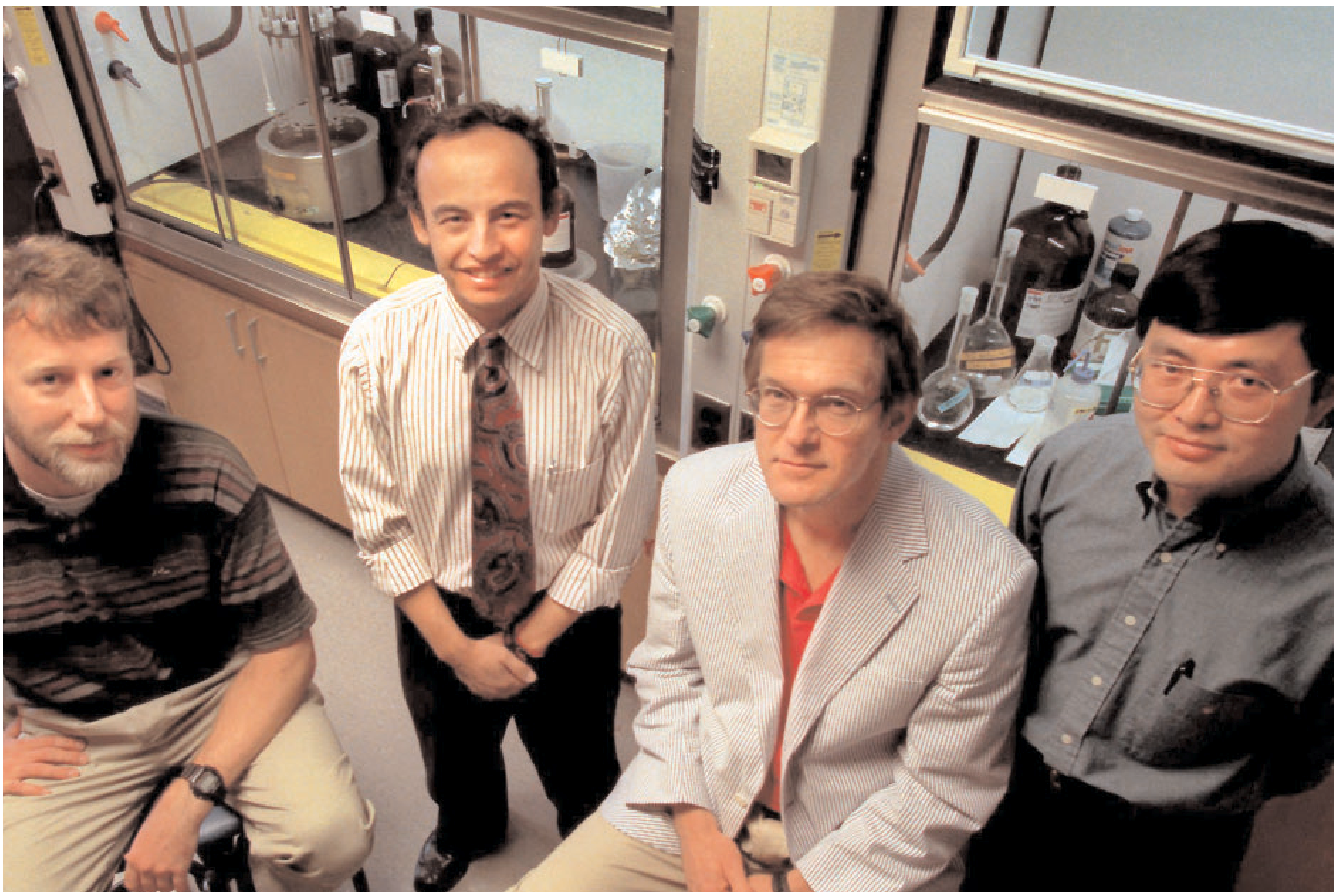
That's especially good news when it comes to rapid decontamination of clothing, equipment or personal gear. In disrupting the integrity of cell membranes, cold plasmas appear to offer a rapid, simple and inexpensive means of destroying even the hardiest bacterial spores. Time required for sterilization would nosedive, from many hours to mere minutes. Should this application pan out, it could offer to hospitals and armies alike a safe and reliable way to counteract potential health hazards, either those posed by disease or in combat.

To elucidate the agents and molecular sites of plasma-induced cell damage, Laroussi has teamed with Fred Dobbs, an associate professor in Old Dominion's Department of Ocean, Earth and Atmospheric Sciences. Laroussi remains cautious in assessing cold plasma's decontamination potential. "We have our work cut out for us," he says. "I'll be more gratified when we really understand the biochemical and biophysical details of the phenomenon that are occurring."

Other defense-related, cold-plasma applications, such as electronics shielding and radar-absorbing cloaking, have so intrigued the Air Force Office of Scientific Research that it has underwritten Laroussi's work to the tune of $300,000 over the last five years, with a separate, additional grant of $167,000 awarded just this year. Given Laroussi's technological achievement and clear progress, further funding from private and public sources may be forthcoming. More patents are pending, as are additional uses.

In recognition of his achievements in plasma science, this spring Laroussi was slated to receive the Millennium Graduate of the Last Decade (GOLD) Award from the Institute of Electrical and Electronics Engineers, one of the largest professional societies in the world. "There is interest everywhere now in plasma science," he says. "The military is interested. The scientific community is interested. The general public is interested.

"This is a field that will only grow. We at Old Dominion will be on the forefront. We'll be one of the leaders."



As with many research projects, teamwork can be the difference between success and failure. Old Dominion faculty members, Mounir Laroussi (second from left), research assistant professor, and Fred C. Dobbs (second from right), associate professor of ocean, earth and atmospheric sciences, consistently tap into one another's strengths to reach a promising conclusion. They also are aided by graduate student J. Paul Richardson (far left) who runs experiments on the biological applications of atmospheric pressure plasmas, and Zibiao Wei (far right), a post-doctoral researcher who assists Laroussi with all projects run at the Applied Plasma Technology Laboratory.