Autonomous energy-scavenging micro devices will test water quality, monitor bridges, more

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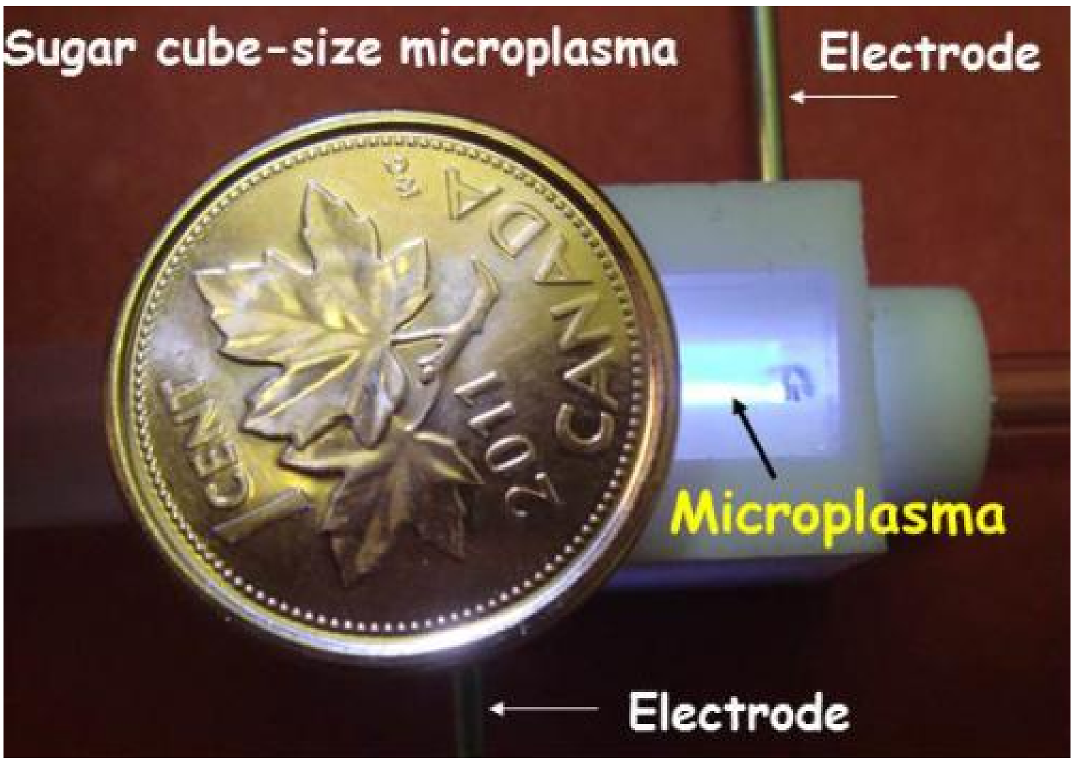

Battery-operated sugar-cube-size microplasma: The microplasma fits inside the letter "A" of a one-cent coin (shown for scale); the sample is introduced into the chamber to the right. Credit: Vassili Karanassios, University of Waterloo

Out in the wilds or anywhere off the grid, sophisticated instruments small enough to fit in a shirt pocket will one day scavenge power from sunlight, body heat, or other sources to monitor water quality or bridge safety, enabling analysis in the field rather than bringing samples and data back to the lab.

Researchers at the University of Waterloo in Ontario are using optics and photonics in their quest to "bring the lab to the sample," said lead researcher Vassili Karanassios of the Department of Chemistry and of the university's Institute for Nanotechnology (WIN). A major aspect of his team's solution, reported in a conference and publication by SPIE, the international society for optics and photonics, is scavenging energy from various sources to power instruments at the sample site.

While energy harvesting utilizes sources such as wind power, energy scavenging involves re-using discarded energy, such as the electric light that runs a calculator, Karanassios said.

The team is incorporating wake-up systems in the devices to support energy autonomy, the ability to be powered as needed without an external source, without losing selectivity, the ability to gather and accurately analyze relevant data.

An important feature of his lab's approach is the integration of several features of full-scale laboratory instruments.

"People have experimented with sensors and with lab-on-a-chip devices for a long time," Karanassios said. "But taking an entire instrument to the field in a hand-held device is new. Not many research groups have the expertise to integrate it all, to go from the sensor level to the micro-instrument level."

The team is also working to reduce the power required for miniature instruments that perform optical emission spectrometry — using light to generate the spectral patterns that are intrinsically unique to materials —

with very small samples. The resulting spectral "signature" is used to identify what is in the sample, for example, in on-site monitoring of water quality.

Among power source optics, sunlight is one obvious answer, Karanassios said, but limited by clouds and brief daylight in some regions. Additional possible sources and applications for energy scavenging are:

- Plugging in to human body heat, unobtrusively scavenging energy in the form of otherwise-wasted heat generated by a person while walking, to power instruments for testing water quality or wearable biomedical monitors.
- Harnessing animal body heat, to recharge implanted tracking devices. "When tagging and tracking animals in the wild, you do not want to have to catch the same animal one more time just to replace the battery that powers its sensors," Karanassios noted.
- Charging up a bridge sensor using mechanical energy generated in a spring-loaded device in the road, activated by vehicles crossing the bridge.

Because smaller sensors and instruments require less power, Karanassios' lab is working toward "shirt-pocket size" micro-instruments that eventually will deliver performance comparable to full-size lab versions.

They have experimented with a device the size of sugar cube that can be used along with a portable spectrometer for rapid screening of environmental contaminants, using spectral lines generated by wavelengths in the visible light and ultraviolet regions.

More information: A paper detailing the work by Karanassios and

Waterloo colleagues Donghyun Lee and Gurjit Dulai was published 28 May in the SPIE Digital Library, and presented in a conference on Energy Harvesting and Storage at SPIE Defense, Security, and Sensing 2013 last month in Baltimore. Titled "Survey of energy harvesting and energy scavenging approaches for on-site powering of wireless sensor- and microinstrument-networks," the paper is available via open access through 31 August 2013.

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