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IMPACT

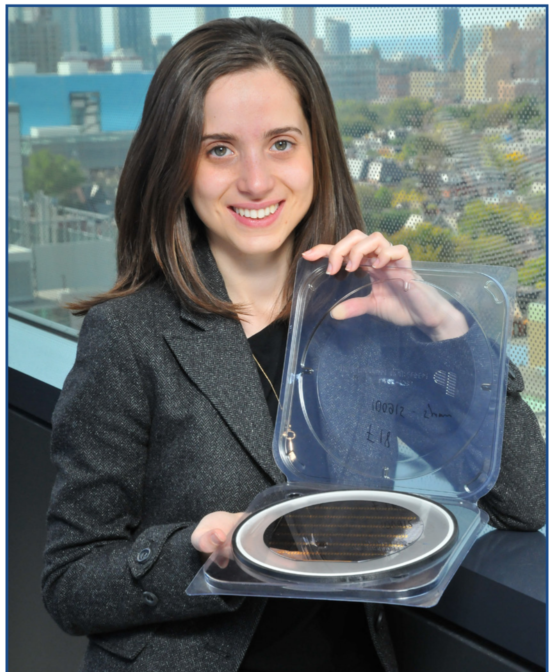
The most sensitive nanostructured biosensing chip of its kind – advancing disease determination and solutions to global challenges

A breakthrough at a Toronto university has led to the most sensitive biosensor of its kind in the world, paving the way to improved diagnostic tools for rapid disease detection in almost any environment. The novel biosensor, which monitors the nucleic acids associated with, among other things, viral and bacterial diseases, integrates new and advanced materials with biomolecular probes on standard semiconductor technology.

"We've combined findings in biochemistry, materials engineering and electrical engineering to create an integrated circuit for improving the quality of healthcare. This would not have been possible without collaborations with researchers from different fields," explains Dr. Leyla Soleymani, Assistant Professor in electrical and computer engineering at Ryerson University. Soleymani was a major contributor to this research while working towards her PhD at the University of Toronto.

Silicon serves as the enabling technology for this fully-integrated chip-based platform: robust, reproducible and low-cost, it places these diagnostic tools within easy reach of hospitals and clinics around the world. And by assembling their advanced materials and technologies on microelectronics, the team achieved better sensitivity for high-speed, ultra-sensitive and specific molecular sensing. The chip's biomolecular probes were designed for utmost precision in identifying the specific biomarkers that indicate a particular disease exists within the body. In addition, due to its highly optimized, nanostructured electrodes, the device detects enough molecules for a diagnosis in only half an hour. In fact, the device is so sensitive that it eliminates amplification and labeling—time-consuming processing steps associated with more traditional laboratory methods—further contributing to more rapid results. Soleymani explains: "The 10 aM sensitivity we reported had never before been achieved on a chip-based platform using single-step readout."

Soleymani's passion for improving health care and quality of life for all people was inspired by Dr. Ted Sargent, Professor in electrical and computer engineering at the University of Toronto. She completed her PhD as part of his research group, which combines expertise in chemistry, physics, electrical engineering, materials science and medicine. Other major contributors to this work include Dr. Shana Kelley, Professor (who was the principal investigator for this project) and Dr. Zhichao Fang, post-doctoral fellow, both in the Faculty of Pharmacy at the University of Toronto, as well as Dr. Sargent.



Dr. Leyla Soleymani's research contributed to a novel biosensor, integrating new and advanced materials with biomolecular probes on standard semiconductor technology, that improves the detection of viruses and bacteria.

Supported by seven publications and a patent, the research is receiving recognition from around the world. An article in Nature Nanotechnology, co-authored by Soleymani, describes how the team demonstrated that their proposed methods and devices can be used in sensitive and specific disease state determination. Related proof-of-concept fabrication services were provided through CMC in partnership with the Canadian Photonics Fabrication Center (CPFC) and allowed the team to perform a series of experiments on real biological samples. The research also received financial support from agencies including Canada Foundation for Innovation, Canadian Institutes of Health Research, Genome Canada, Natural Sciences and Engineering Research Council of Canada, Ontario Centres of Excellence, Ontario Genomics Institute, Ontario Institute for Cancer Research, and Ontario Ministry of Research and Innovation.

Soleymani explains that advancements in diagnostic technologies have the potential to save many lives in developing countries, where viruses and bacteria for diseases such as lower respiratory infections, HIV, and tuberculosis often spread before field specimens can be analyzed and identified. "I hope to develop technologies that are compatible with the limited infrastructure and resources available in the developing world," she says. "Some of the technologies I envision are battery-operated diagnostic devices that send results automatically via text messages to physicians abroad, and lateral flow strip biosensors that generate visible signals and operate without any readout instrumentations."*cmc*

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