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Scientists at Nanyang Technological University (NTU Singapore) have developed an artificial intelligence (AI)-powered biochip capable of detecting tiny genetic markers linked to disease in just 20 minutes, marking a significant advance in rapid molecular diagnostics.

Detailed in the journal *Advanced Materials*, the biosensing platform combines a specially designed nanophotonic chip with AI-driven image analysis to identify extremely small quantities of microRNAs.

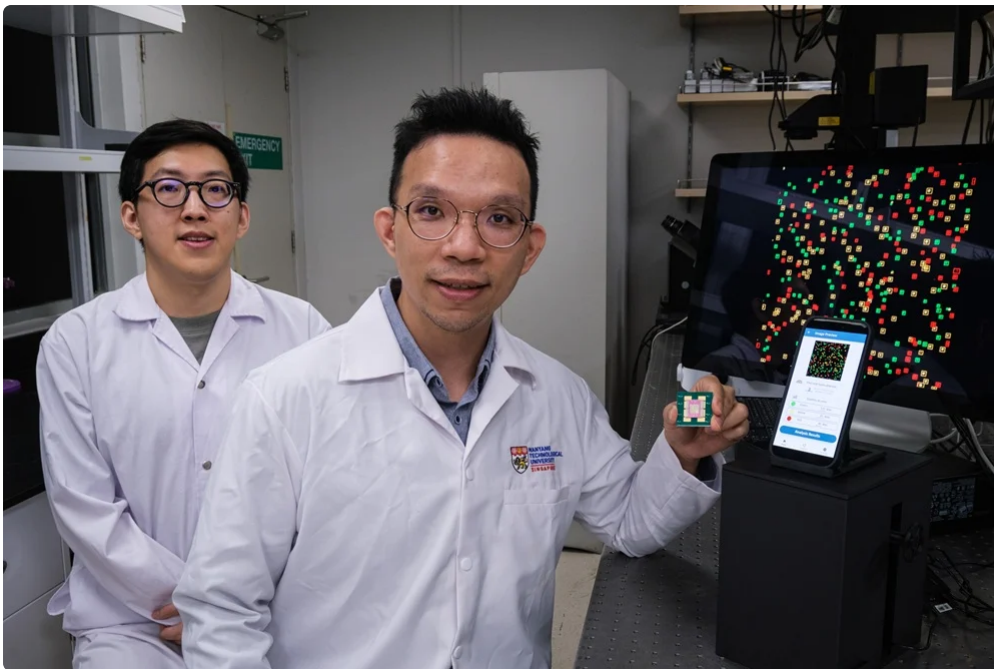


Image credits: Nanyang Technological University

These short RNA molecules play a key role in regulating gene activity and have been widely studied as biomarkers for diseases including cardiovascular conditions, cancer, neurodegenerative disorders and metabolic illnesses.

Using only a small drop of blood, the device can detect and measure multiple microRNAs simultaneously. Its integrated imaging system captures thousands of signals in a single snapshot, which are then

analysed by AI algorithms to deliver rapid and accurate results.

Compared with conventional methods such as polymerase chain reaction (PCR), which require hours to amplify genetic material before detection, the new platform reduces turnaround time dramatically while maintaining high sensitivity.

The research was led by Associate Professor Chen Yu-Cheng from NTU's School of Electrical and Electronic Engineering. He explained that the team aims to build a system capable of quickly and accurately measuring multiple microRNAs, with the flexibility to adapt to a wide range of diseases.

Early experiments using lung cancer cell extracts demonstrated that the platform can detect specific microRNAs associated with non-small cell lung cancer, suggesting strong potential for oncology applications as well as broader clinical use.

At the core of the innovation is a nanocavity structure engineered to enhance detection sensitivity. This structure, hundreds of times smaller than the width of a human hair, acts like a light-trapping chamber that amplifies fluorescent signals emitted when target microRNAs bind to their corresponding probes.

By boosting these signals, the system can detect even single molecules of microRNA, overcoming a long-standing challenge in molecular diagnostics for faster, more accurate clinical testing applications, offering better outcomes.

The platform also incorporates a deep-learning model to automate the analysis of microscopic images. Once the signals are captured, the AI system identifies and classifies different microRNA types, removing the need for manual counting and significantly reducing the risk of human error. This automated process enables high-throughput analysis, allowing thousands of nanocavities to be processed within minutes.

To support real-world application, the team has developed a compact prototype that integrates a colour camera with a mobile phone application. The app processes captured images using AI algorithms and provides near-instant results, pointing to the possibility of portable diagnostic tools that can be used in clinical or even remote settings.

The platform has also demonstrated strong performance in more complex biological environments. Tests involving synthetic microRNAs added to biological extracts showed reliable detection, indicating that the system can function effectively under realistic conditions. It achieved accuracy rates exceeding 99% across different test channels while detecting microRNAs at extremely low concentrations.

Researchers believe the technology could play a key role in advancing personalised medicine by enabling large-scale screening of multiple biomarkers from minimally invasive samples such as blood, saliva or urine.

In addition to clinical diagnostics, the system may support pharmaceutical research, particularly in the development and testing of therapies targeting microRNAs.

The work was supported by national research funding and innovation initiatives, reflecting broader efforts to strengthen interdisciplinary collaboration and translate scientific discoveries into practical healthcare solutions with meaningful societal impact.

The team is now seeking collaborations with clinicians and industry partners to further validate and scale the technology, with the aim of expanding its application across a broader range of diseases and moving closer to practical deployment in healthcare settings.

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