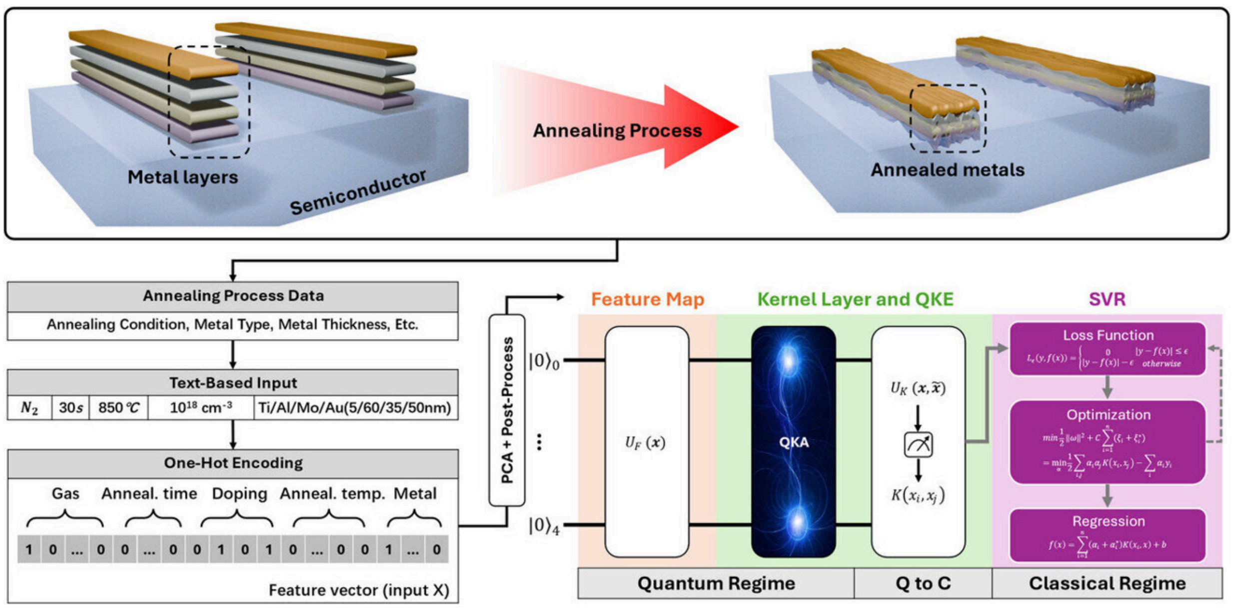
Quantum machine learning improves semiconductor manufacturing for first time

July 3 2025, by Paul Arnold



Schematic representation of the quantum machine learning-based modeling process for the Ohmic contact formation in GaN HEMTs. Credit: *Advanced Science* (2025). DOI: 10.1002/advs.202506213

Semiconductor processing is notoriously challenging. It is one of the most intricate feats of modern engineering due to the extreme precision required and the hundreds of steps involved, such as etching and layering, to make even a single chip.

However, in a world first, researchers at the Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia´s national research agency, have utilized quantum machine learning to fabricate semiconductors. Their research could revolutionize the way chips are made.

The team's study, published in the journal *Advanced Science*, shows for the first time that semiconductor fabrication can be improved by applying quantum methodology to real experimental data.

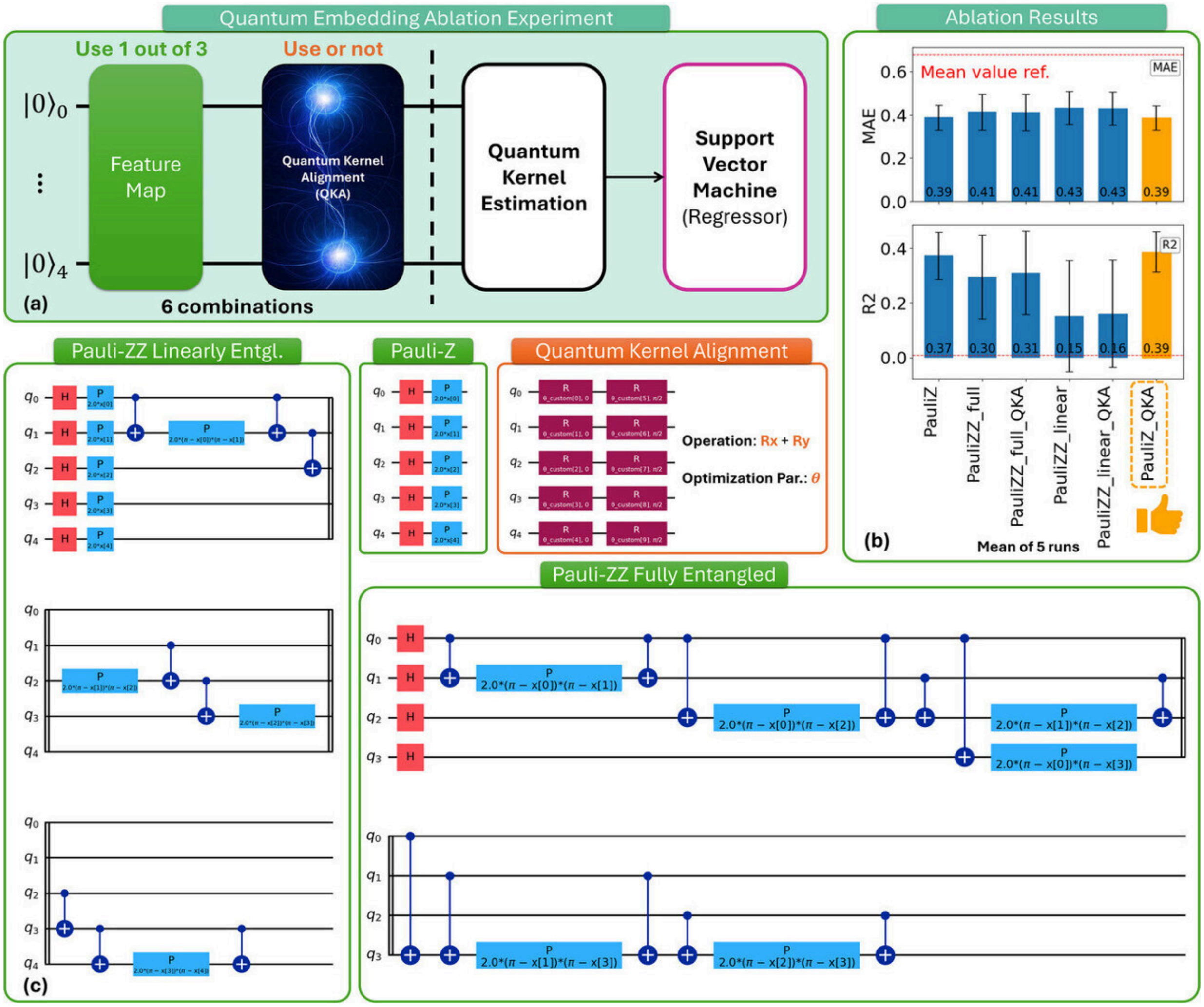
They focused their attention on a critical step in the semiconductor design process—modeling the Ohmic contact resistance of the semiconductor material. This is a measure of the electrical resistance that occurs when a semiconductor comes into contact with metal, which affects how easily current can flow.

Modeling problems

One sticking point until now is that Ohmic contact resistance is very difficult to model. A current approach uses classical machine learning (CML) algorithms, but they require large datasets, and their performance degrades in small-sample, nonlinear settings.

The Australian researchers, led by Muhammad Usman, a professor and head of quantum systems at CSIRO, went a different way.

They employed a quantum machine learning (QML) approach on data from 159 experimental samples of GaN HEMT (gallium nitride high-electron-mobility transistor) semiconductors. This clever method blends classical and quantum techniques.



Quantum ablation study for optimizing the performance of QKAR. Credit: *Advanced Science* (2025). DOI: 10.1002/advs.202506213

First, they narrowed down the many fabrication variables to just those that have a key impact on performance.

Then, they developed a Quantum Kernel-Aligned Regressor (QKAR) architecture to translate classical data into quantum states to begin the machine learning process. Once all the features had been extracted from the data, a classical algorithm retrieved the information, which was then trained to guide the fabrication process.

The QKAR technique outperformed seven different CML algorithms developed for the same problem.

"These findings demonstrate the potential of QML for effectively handling high-dimensional, small-sample regression tasks in semiconductor domains and point to promising avenues for its deployment in future real-world applications as quantum hardware continues to mature," wrote the researchers.

In addition to potentially reducing manufacturing costs and improving device performance in the semiconductor industry, this research may have other far-reaching consequences. As quantum technologies continue to evolve, they may help solve complex problems that are beyond the capabilities of classical computers.

More information: Zeheng Wang et al, Quantum Kernel Learning for Small Dataset Modeling in Semiconductor Fabrication: Application to Ohmic Contact, *Advanced Science* (2025). DOI: 10.1002/advs.202506213