Could silicon be ideal in quantum computing?

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(PhysOrg.com) -- "Quantum computing could provide a way to significantly speed up the way we process certain algorithms," Malcolm Carroll tells *PhysOrg.com*. "The primary issue, though, is that you need a well controlled two-level system." He also points out that problems exist in terms of noise in quantum computing. One of the essentials in some models of quantum computing is utilizing the "spin" of certain electrons. Controlling the spins in GaAs quantum dots has advanced to a fairly sophisticated point, but there is still the issue of noise.

One way to reduce the noise in a quantum system is to use silicon. "Silicon spins have long coherence times. The noise is reduced with silicon, and that is an advantage for this type of quantum computing, since you want to maintain coherence for as long as possible. However, it's been a challenge to isolate and manipulate silicon spins," Carroll explains.

In order to find a way to isolate and control silicon spins, Carroll, a scientist at Sandia National Laboratories in Albuquerque, New Mexico, has been working with a team. One member of the team, Tzu-Ming Lu, has been helping with the idea of controlling the number of spins with a gate, rather than using doping methods. The work on this project is published in *Applied Physices Letters*: "Enhancement-mode buried strained silicon channel quantum dot with tunable lateral geometry."

"Increasing the distance between the spins and defects is part of the benefit of this process," Lu explains. "One of the ways to get spins is to use doping to provide electrons. However, the defects are closer. Instead, we use a gate in an alternative enhancement mode approach."

Lu's alternative enhancement mode technique was demonstrated during his time as a graduate student at Princeton; it set a world record in mobility. However, the set up was too big to be used effectively for quantum computing. "What we've done is taken the large scale field effect transistor structure, and make it into a few-electron quantum dot," Carroll says. "We squeeze it down for better control of single electrons in this system."

The structure, rather than being a single quantum dot, is actually a double quantum dot. "The dots are placed next to each other, and this gate structure makes it easier to control the spins in the device," Carroll explains.

But why the focus on silicon? Well, as Carroll mentions earlier, the coherence time is longer. There is less noise at low temperature when silicon is used. Caroll and Lu also point out that there is already a solid silicon infrastructure. "We already have silicon foundries that can build the device," Lu says. "People are used to working with silicon, and so you have very clean environment for the electrons, further reducing unintended noise sources."

Now that some control over these silicon quantum dots has been demonstrated in a few-electron device, the team at Sandia is ready to move on to the next steps. "We aren't sure that our device is small enough yet," Carroll says. "Additionally, there was an instability in this particular device. We've worked through a new design, and we want to check to make sure that the stability issue is gone."

"Progress is being made in this area, and we're not the only ones," Carroll continues. "Silicon is a promising approach to quantum computing because of the long coherence times. This materials approach to isolating and controlling spins is very promising and it could allow even more people to realize the benefits of using silicon in quantum computing."

More information: T.M. Lu, N.C. Bishop, T. Pluym, J. Means, P.G. Kotula, J. Cedarberg, L.A.

Tracy, J. Dominguez, M.P. Lilly and M.S. Carroll, "Enhancement-mode buried strained silicon quantum channel quantum dot with tunable lateral geometry," *Applied Physics Letters* (2011). Available online: link.aip.org/link/doi/10.1063/1.3615288

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