Operating quantum memory at room temperature

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Quantum dots, along with quantum wires, have been attracting notice over the past decade as possible building blocks of quantum information processing. Indium arsenide quantum dots (InAs) can be used for memory operations in devices made from gallium arsenide and aluminum gallium arsenide (known as GaAs/AlGaAs devices). The problem is that at room temperature – the experiments are usually done at lower temperatures, the memory operation of these devices suffers, unless there are multiple quantum dot layers.

That is changing now, thanks work done by a team of scientists at Würzburg University in Germany. "Memory operated at room temperature, and with only a single layer quantum dot layer, is important because it can be used in every day life," Lukas Worschech, a member of the team at Würzburg tells *PhysOrg.com*. The work done by the team, which includes Müller, Heinrich, Höfling and Forchel, appears in *Applied Physics Letters*: "Room temperature memory operation of a single InAs quantum dot layer in a GaAs/AlGaAs heterostructure."

For quantum information processing, some sort of memory operation is necessary. One of the ways of realizing a memory device is to use quantum dots coupled to a transport channel. Memory (nonvolatile – such as flash memory) is realized when the charge state of the quantum dots control the system's threshold. A floating gate is used to manage the threshold voltage. In GaAs/AlGaAs devices, the charge storage that is needed can be induced optically as well as electrically, which increases their usefulness and compatibility with different electronic and optoelectronic devices.

“Until now, though,” Worschech explains, “low temperatures were needed with single layer quantum dot. Our idea was to create a system that could work under increased temperatures. Otherwise, you always have to put your samples in cryostats, and use long wirings. This makes it harder to extract all the information you want.” The Würzburg team suggests that with the InAs quantum dot functioning as a floating gate, the memory could be operated at room temperature. “From this structure, field emission is reduced drastically and we are able to observe the memory effect at room temperature.”

One of the more interesting things about this set-up is that the InAs quantum dot is actually self-assembling. “The trick here is that the material does not match directly to the gallium arsenide. You do not have to structure them.” However, it can be difficult to control where these InAs quantum dots end up. “They are randomly distributed,” Worschech says, “you cannot say in a lateral field where they are placed.”

Other scientists, though, have been working on this issue. “Through etching – making small holes at pre-defined sites – it turns out that indium arsenide growth can be controlled laterally,” Worschech points out. “Others have been working on this, and we would like to see our method combined with this lateral positioning that is being studied.”

“This field of quantum dots is being intensely studied right now,” Worschech continues, “for use in quantum computers and sensors. Quantum cryptography is another field that would benefit from this work. It is also interesting for optical electronics. Our work may sever as an inter-connect for different applications.”