Encouraging quantum dots to emit photons

August 5 2010, By Miranda Marquit

(PhysOrg.com) -- One of the fields of great interest to scientists and researchers is that of using the quantum world to enhance various aspects of our lives. Advances in quantum cryptography make headlines, and scientists continue to look for ways to bring quantum information processing into the mainstream. Anthony Bennett, a scientist at Toshiba Research Europe Limited in Cambridge, in the U.K., works with quantum dots in an effort to look for ways to enhance their applications.

"I work with single quantum dots, manipulating them and doing interesting experiments that will hopefully be useful in the future for quantum information processing," Bennett tells *PhysOrg.com*. "What we've done recently is to show a giant stark effect in semiconductor quantum dots, which will lead to better yields in certain devices and enable entirely new applications."

Bennett worked with a team from Toshiba Research, as well as with scientists at the Cavendish Laboratory at Cambridge University. The results of their recent collaboration are published in *Applied Physics Letters*: "Giant Stark effect in the emission of single semiconductor quantum dots."

"When working with quantum dots," Bennett explains, "there are many circumstances when you want to be able to get dots that are the same. However, quantum dots form naturally with different sizes, shapes and compositions. The idea is to shift them so that they all emit the same energy."

Prior to this work, shifts to quantum dots of this size had not been observed before. “Normally the shift is confined to a very small range,” Bennett says. “We showed that you could shift the transitions in the quantum dots a surprisingly long way with our technique.”

“Previously, people have looked at putting quantum dots in diodes and then changing the voltage. We changed the design so that a fixed electric field is applied across the quantum dot vertically, which leads to a shift an order of magnitude larger than seen before.”

Normally, such experiment uses dots surrounded with either gallium arsenide or aluminum gallium arsenide. Bennett and his colleagues combined these to get the best of both worlds. “With gallium arsenide, the charges confined in the quantum dot as strongly but the quality of the emission is better. So we grew the dot in gallium arsenide, but surrounded that by aluminum gallium arsenide on each side to confine the electric shift.”

After showing the possibility of this large shift to encourage the quantum dots to emit the same energy, the next step is to get two quantum dots with exactly the same energy. “In order to get quantum information processing applications, you need quantum dots with at least two states the same. As a follow up to the work here, we did that.” (More information can be found in Nature Photonics, “Two-photon interference of the emission from electrically tunable remote quantum dots.”)

“Quantum mechanically, both of these experiments represent a significant breakthrough. That we can make quantum dots with the same energy emit identical photons is a great step forward in the field of quantum information processing.”

More information: Anthony J. Bennett, Raj B. Patel, Joanna Skiba-

Szymanska, Christine A. Nicoll, Ian Farrer, David A. Ritchie, and Andrew J. Shields, "Giant Stark effect in the emission of single semiconductor quantum dots," *Applied Physics Letters* (July 2010). Available online: link.aip.org/link/APPLAB/v97/i3/p031104/s1