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Periodical negative differential conductivity phenomenon expands to natural quantum dot systems

25 January 2007

The periodical negative differential conductivity (NDC) is a beautiful physical phenomenon originating from the electric field domain and domain-related current oscillations in low-dimensional semiconductor systems. So far, it has been mostly observed in the man-made III-V semiconductor superlattices for its strict requirements on layer uniformity and thickness.

In a recent article published in *Nanotechnology* **18**, 015203, J Chen, J J Lu, W Pan, K Zhang, X Y Chen, and W Z Shen of the Laboratory of Condensed Matter Spectroscopy & Optoelectronic Physics, Shanghai Jiao Tong University, China, report on the observation of periodical NDC in a natural quantum dot system of hydrogenated nanocrystalline silicon/crystalline silicon diode heterostructures, which can be easily integrated with the mainstream silicon-based technology.

Group photo

The NDC-related series of spike-like current peaks were found to result from the accumulation and depletion of electrons tunnelling through the nanodot layers in the neutral region. A wide range of experimental results, including the spike-like current profile, onset-voltage blueshift and peak number variation with the increase of temperature, as well as the inter-Landau-level tunnelling under an external magnetic field, were all consistent with their theoretical analysis and assignment. The strict physical conditions were weakened by the *p-n* junction, which compensated for the non-uniformity of the nanodot size distribution.

These exciting findings, breaking the limitation that periodical NDC could only be demonstrated in artificial semiconductor superlattices, indicate a significant step towards the investigation and application of the periodical NDC effect in natural nanodot systems.

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Observation of periodical negative differential conductivity in nanocrystalline silicon/crystalline silicon heterostructures

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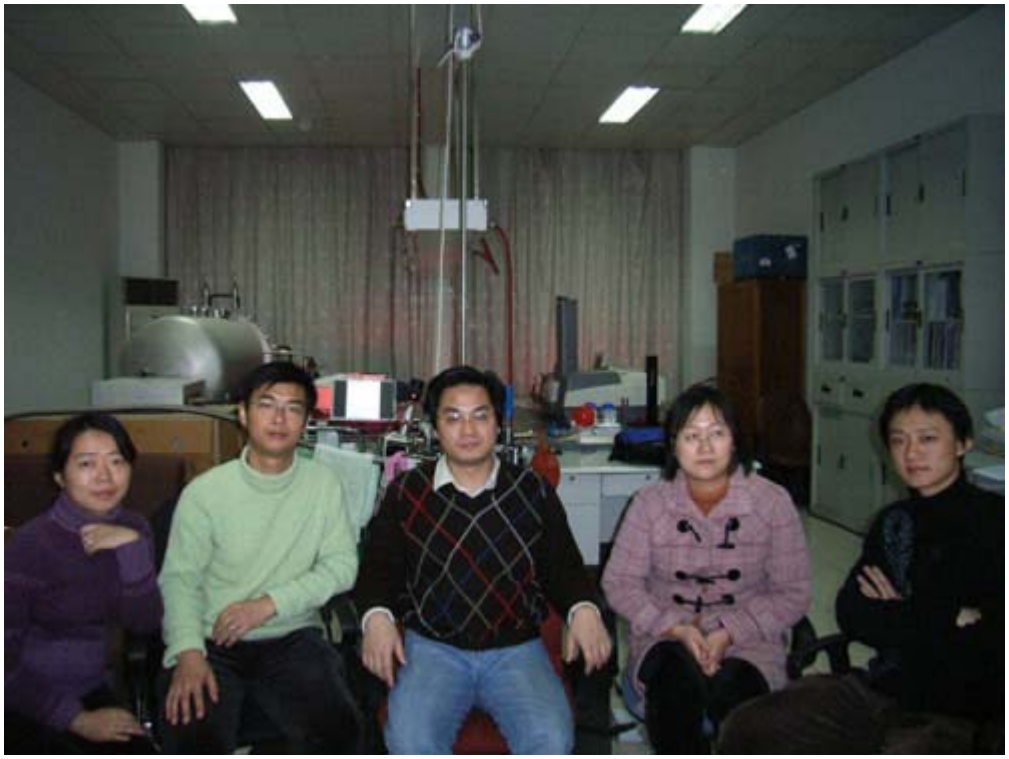

Dr. W Z Shen is National Cheung Kong professor of condensed matter physics at Shanghai Jiao Tong University, China, and winner of National Science Fund for Distinguished Young Scholars. Prof. Shen directs the Condensed Matter Spectroscopy & Optoelectronic Physics Laboratory performing research in the fields of optical and electrical properties of novel semiconductors, as well as semiconductor quantum electronic devices.

Prof. W Z Shen (middle) and his research team, from the left, J Chen, J J Lu, W Pan, and K Zhang, have been working on the optical and electrical properties of nanocrystalline silicon since 2003. Their work is supported by the National Science Foundation of China, National Minister of Education and Shanghai Municipal Commission of Science and Technology.

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