Tokyo Institute Of Technology

QNERC
Quantum Nanoelectronics ResearchCenter

Newsletter
December 2004 No. 1

Mission

Quantum Nanoelectronics Research Center

http://www.pe.titech.ac.jp/qnerc

The Quantum Nanoelectronics Research Center (QNERC) was established in April 2004 by Tokyo Institute of Technology (Tokyo Tech) to nurture the ideas and technology developed by its predecessor, the Research Center for Quantum Effect Electronics. The Center conducts research to support the goals of Japan's national strategic 'nanotechnology project' as well as functioning to support Tokyo Tech staff involved in academic, industrial and international collaborative research. This newsletter is produced to communicate the activities of the Center to the international scientific community. This issue gives an overview of our work and aims, with short summaries of research being carried out by the main members affiliated with the Center.

Funding

Major Sources of Research Funding in 2004

21st Century Center of Excellence Program, Shigehisa Arai (Ministry of Education, Culture, Sports, Science and Technology)

"Photonics Nanodevice Integration Engineering " — http://www.coe21-pni.titech.ac.jp/eng/index.htm

Nanotechnology Support Project, QNERC Director, (Ministry of Education, Culture, Sports, Science and Technology) — http://www.nanonet.go.jp/english/

"Neosilicon" , Shinri Oda, (JST-CREST) — http://www.jst.go.jp/EN/

"Functional Optical Devices using Low Dimensional Quantum Structures", Shigehisa Arai, (JST-CREST) — http://www.jst.go.jp/EN/

"Ballistic Electron Devices using Super Hetero-Nano-Structures", Kazuhito Furuya, (JST-CREST) — http://www.jst.go.jp/EN/

Launch

Launch of the Quantum Nanoelectronics Research Center

A special meeting combining light hearted recollections with intense technical discussions was held on 17th June 2004 to formally launch the Quantum Nanoelectronics Research Center.

The invited guests included Professor Hiroyuki Sakaki, of the University of Tokyo, and Dr Yasuharu Suematsu, former president and Professor Emeritus of Tokyo Tech.

Dr Yasuharu Suematsu

Professor Masuo Aizawa

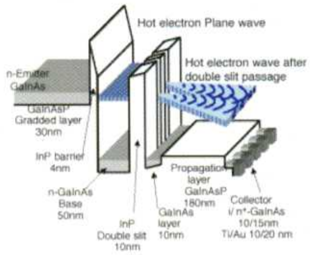
In a speech during the reception, Professor Aizawa, president of Tokyo Tech, stressed the importance of the new Centre in contributing to international efforts in the development of nanotechnology. He also emphasized that Tokyo Tech would support the members of the Center in their efforts to realize their research goals and mission of the Center.

Research Activities

Quantum Effect Electronics

Kazuhito FURUYA http://www.pe.titech.ac.jp/Furuya-MiyamotoLab/e-index.htm

Professor Furuya is investigating the use of hot electrons for ultra high speed functional devices where device operation is governed by the wave properties of electrons. Recently, this group reported on the observation of Young's double slit interference of hot electrons in InP/GaInAsP heterostructures. A magnetic field sweeps these interference fringes over the collector which is seen as a modulation of the collector current. These results are expected to lead to the creation of novel, multifunctional devices.

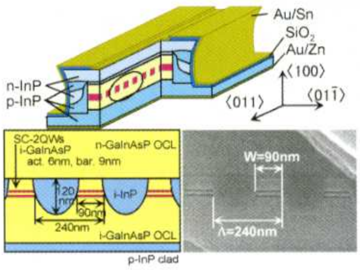


Schematic of double slit interference device.

High-Performance Quantum Effect Photonic Devices

Shigehisa ARAI http://www.pe.titech.ac.jp/AraiLab/index-e.html

Professor Arai's research is focused on the development of quantum effect photonic devices for light wave communications and extremely low damage processes of ultra fine structures for photonic devices utilizing the quantum size effect; and technologies for integration of functional photonic devices. The low damage fabrication process has been used to realize GaInAsP/InP 5-layered quantum-wire lasers with reliable RT-CW operation (>14,000 hrs). A record low threshold current (0.7mA) was also achieved for DFB lasers emitting in the 1.5 to 1.6 micrometer range.

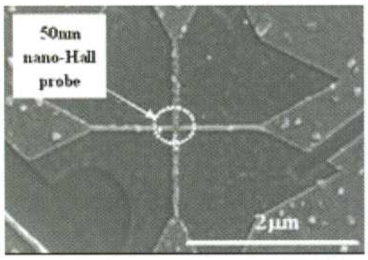


Cross sectional SEM image of DFB lasers with wire like active regions

Scanning Hall Probe Microscopy and Nano-Bio-Magnetics

Adarsh SANDHU http://spirit.pe.titech.ac.jp/index-e.html

A fundamental understanding of the behavior of magnetic domains in external magnetic fields is important for the development of ultra-high density recording media and spintronic devices. Professor Sandhu's group has developed scanning nano-Hall probe microscopy (SHPM) instrumentation for visualization of localized magnetic fields and magnetic domains using GaAs/AlGaAs, InSb and Bi thin film Hall sensors.



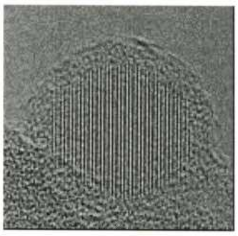
50nm x 50nm Hall probe

Research Activities

Next Generation Silicon VLSI Technology

Shunri ODA http://odalab.pe.titech.ac.jp/en/

The aim of Professor Oda's group is to elucidate successors to today's VLSI technology by investigating quantum effects in silicon semiconductor nanostructures and oxide thin films. Silicon nanostructure devices have been developed using self-organized silicon quantum dots. Single-electron tunneling characteristics and memory effects have been observed in silicon nano devices at various temperatures. Ballistic transport has also been observed as clear quantized conductance in a vertical transistor with a wrap-around gate structure.



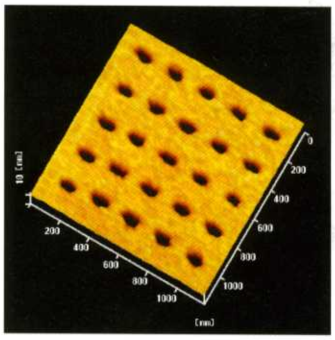
HRTEM image of nano crystalline silicon

Advanced Epitaxial Growth & AFM nano-fabrication

Akira YAMADA http://tkhshi.pe.titech.ac.jp/index_e.html

Professor Yamada's group is using epitaxy for growing strained group-IV semiconductors for ultra high speed Si-based devices and AFM technology for fabricating nanometer sized semiconductor structures.

The theoretical low-field electron mobility of strained $Si_{0.99}C_{0.01}$ is higher than Si thus opening up the possibility of realizing high performance SiC/Si MOSFETs. Transistor operation of the Si_xC_{1-x}/Si_x MOSFET with a strained $Si_{1-x}C_x$channel has been confirmed. In studies on nanofabrication, AFM mechanical lithography has been used to fabricate nano scale. The scale of the nano-holes in the adjacent AFM image is 33nm.



AFM image of p-GaAs surface after fabrication of nano-holes.

Affiliated Researchers

Makoto KONAGAI; semiconductor nanostructure devices. http://solid.pe.titech.ac.jp

Yasuyuki MIYAMOTO; vertical ultra-high speed electron devices and EBL processing. http://www.pe.titech.ac.jp/Furuya-MiyamotoLab/

Hiroshi MIZUTA; silicon based nanoelectronics http://odalab.pe.titech.ac.jp

Masahiro ASADA; metal/insulator/semiconductor heterostructures http://www.pe.titech.ac.jp/AsadaLab/

Masahiro WATANABE; resonant tunneling devices http://www.pe.titech.ac.jp/WatanabeLab/index-j.html

Facilities

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Facts and Figures

Size: Ten floors, with the electron beam lithography clean room below ground. A total area of 3700m^2

- Class five clean room of 132 m^2
- Special gas clean rooms of 409 m^2
- Vibration resistant SEM and AFM rooms of 108 m^2
- Staff rooms of 400 m^2