Report on Activities of the C8 Semiconductor Commission of IUPAP in 3 year period ending October 2005

During the 3 year period since the last General Assembly, the most important event which occurred under the auspices of the C8 Commission (Semiconductor Physics) was the 27 th International Conference on the Physics of Semiconductors (ICPS), held in Flagstaff, Arizona, USA, July 26-30, 2004.

This is the principal conference in the Physics of Semiconductors, and is held every two years. The Conference in Flagstaff also signalled the return of the conference to the USA after a rather long gap of 20 years (although it was held in North America in Vancouver in 1994).

The C8 commission held its biennial meeting on the Wednesday of the conference, and discussed various matters including the Flagstaff Conference and the sites for the Conference in 2006 and 2008.

C8 considered that the Flagstaff Conference was very successful. It was well attended (~1000 people), and was held in a very beautiful location conducive to a scientific meeting in relaxed surroundings. There were issues regarding the obtaining of visas to enter the US, but due to the efforts of the APS and other US bodies the numbers were greatly reduced at the time of the conference. To the best of our knowledge two visa applications were refused. 15 other people were not able to attend due to visa issues, at least half of whom commenced the visa process late. Overall we regard the visa situation as having been dealt with in the best possible way by the ICPS organisers and APS, with a satisfactory outcome obtained from the point of view of the conference. In the light of the outcome for ICPS, C8 recommended a conference in the USA for support in 2005.

The other main issues discussed by C8 were the location of the ICPS Conferences in 2006 and 2008. A very satisfactory presentation was made by Vienna, the provisional site of the conference in 2006, with the result that Vienna was confirmed as the location of ICPS in 2006.

A recommendation for the site of the Conference in 2008 was also made. This has not yet been announced publicly, since its confirmation, as is the custom awaits a satisfactory presentation at ICPS in 2006.

The other important issues considered by C8 at its biennial meeting were recommendations from the Commission of a short list of candidates for the posts of Chair and Secretary, to take office after the General Assembly, and the choice of conferences for sponsorship in 2005. These are listed below together with a full list of C8 Conferences sponsored over the 3 year period. The full commission then voted by email for its recommended choices for Chair and Secretary to be put forwards to the General assembly. C8 also chose its slate of 10 Commission members, Vice-Chair and Alternate Members by extensive email voting. This slate has been submitted to the General Assembly.

Main Themes at ICPS27, Flagstaff

Semiconductors Physics is a very wide-ranging field, covering the whole spectrum from fundamental physics to devices which permeate everyday life. As such it is not a simple matter to provide a summary of important advances over the three year period. However the ICPS meetings provide a snapshot of the state of field every two years. A brief summary of the state of the field is given, as exemplified mostly by the plenary talks given at the conference is given here.

An over-riding tendency of semiconductor research is towards the study of small scale devices, many of the key advances being achieved in nanoscale structures. Advances in physics thus tend more and more to be achieved side by side with advances in crystal growth techniques and in small scale fabrication methods. The drive towards nanoscale structures was exemplified by the plenary talks, which covered the rapidly advancing fields of carbon nanotubes, quantum dots, semiconductor spintronics and quantum computation.

Carbon nanotubes provide model systems for the study of one dimensional semiconductors, with optical and electrical properties, from metal to semiconductor, being sensitive functions

of diameter and chirality. Recent years have seen rapid advances in control of the synthesis process, which in turn is enabling control of purity, reduced defect density and diameter and chirality. Detailed experimental and theoretical understanding of the electronic properties has now been achieved form a variety of optical spectroscopies.

Self assembled quantum dots were shown to provide model systems with high radiative efficiency, for the study of fundamental optical processes in quasi zero dimensional systems and for telecommunications laser device applications. Again advances have been driven to a large degree by advances in fabrication techniques, but with major future challenges to improve dot uniformity and to achieve nucleation of dots in defined positions, and to integrate the dots with photonic cavities.

One of the emerging applications of quantum dots is in the field of quantum information processing, another important theme of the conference. The atom like properties of zero dimensional quantum dots make them highly promising candidates for one and two qubit systems. Universal quantum logic operations are now being demonstrated including single qubit rotation and two qubit controlled-NOT operations, using ultrafast laser pulses on both self assembled and interface quantum dots. Major challenges here include to achieve increased coherence times and to scale up the number of qubits using for example quantum dot systems.

Few electron quantum dot circuits, fabricated using electrostatic gates were shown to provide very promising systems for scalable quantum bits. The structures now combine the single electron charge degree of freedom, which is easy to manipulate with the spin degree of freedom with its long coherence time (msec range). Readout of just one quantum state has been recently demonstrated. The system based on electrostatic gates has the advantage of potential scalability by increasing the number of gate electrodes. Controlled qubit rotations using high frequency pulses has been demonstrated recently.

The potential of silicon-based systems for quantum computation remains high. The example described at the conference was based on the very long (25sec) nuclear spin decoherence times. Architectures based on the controlled growth of rows of 29Si nuclei on step edges of a Si matrix were described, and prototype two qubit systems based on isotope superlattices were described. This research is complementary to separate research on the controlled implantation of individual donor atoms in a silicon matrix, as a basis for single and multi-qubit systems.

Spintronics is an increasingly important theme in semiconductor physics research, based on the long coherence times already mentioned, and the potential new degrees of freedom in the design of electronic circuits. An important drive is to achieve ferromagnetic semiconductors which exhibits Curie temperatures up to and above a room temperature. At the time of writing the highest fully validated temperatures are in the range of ~200K, with temperatures up to several degrees higher predicted theoretically. In addition to the ferromagnetic semiconductors, the field of spintronics base don optically and electrically controlled spins is highly active, as outlined in the quantum information sections above.

Conferences Supported

2003

- 15 th International Conference on Electronic Properties of Two-Dimensional Systems, Nara, Japan
- 13th International Conference on Nonequilibrium Carrier Dynamics in Semiconductors/ Hot Carriers in Semiconductors, Modena, Italy
- 20th International Conference on Amorphous and Microcrystalline Semiconductors, Rio de Janeiro, Brazil

2004

- Int. Conf. on the Physics and Chemistry of Quantum Dots, Banff, Canada
- 27th International Conference on the Physics of Semiconductors, Flagstaff, USA

2005

- Modulated Semiconductor Structures 12, Albuquerque, USA
- 12th International Conference on II-VI Semiconductors, Warsaw, Poland
- 21st International Conference on Amorphous and Nanocrystalline Semiconductors, Lisbon, Portugal

M S Skolnick
L Vina
1 September 2005