THE UNIVERSITY OF MELBOURNE

FIGURE 1

The School of Physics (David Caro) Building.

FIGURE 2

Crossed beam SEM/FIB, which was designed and built in an international collaboration between JEOL (Japan) and Orsay Physics (France), is centrally located in the CQCT Cleanroom Complex.

The Melbourne Node of the Centre is situated in the David Caro and Nuclear Physics Buildings of the University of Melbourne (Figure 1). It is co-located with the Microanalytical Research Centre (MARC), Quantum Communications Victoria (QCV) and the Melbourne Materials Institute. The Centre is one of the largest research groups in the School of Physics and is home to: the Pelletron accelerator, the Centre Cleanroom Complex, Advanced Materials Laboratory, Scanning Probe Microscopy resources (SPM) and the Quantum Device Theory Program Group. Laboratory based research staff and students are based in offices located on the levels 2, 4, 6 and 7 of the building with the combined office space totalling ~380 m^2. The MARC office, which is home to the Node Administrator, provides centralised resources for the group.

Ion Accelerator Facilities

The Melbourne Node is home to three particle accelerators. The largest of these, the NEC 5U Pelletron, operates in the basement of the Nuclear Building and is home to the CSIRO microprobe which was relocated from the North Ryde facility. Originally commissioned in 1975 the Pelletron is a high brightness source of light ions operating at charging potentials from 0.5 to 5MeV. It is routinely used to perform Ion Implantation, Rutherford Backscattering (RBS), Proton Induced X-ray emission (PIXE), Ion Beam Induced Charge (IBIC) and Channelling Contrast Microscopy (CCM) measurements on a variety of materials. The Pelletron laboratory comprises ~400m^2 of floor space spanning 3 levels.

The second accelerator is an Orsay Physics Focussed Ion Beam (FIB) with crossed beam SEM (Figure 2). It is fitted with gas injection and eutectic sources and the system is able to process (i.e. machine and implant) materials with sub 100nm resolution. This instrument was originally assessed for operation as a precision, multi-source, ion implanter for quantum device development. Results using a nickel source to produce luminescent centres in diamond have been successful with further work planned for 2010.

The third accelerator located at this node is a Colutron low energy ion implanter (0.01-15keV) predominantly used for phosphorus implantation of quantum devices (Figure 3). It was originally commissioned in 2001 and is equipped with a: G2 ion gun, beam imaging system, computer controlled ion selection, beam scanning for large area implantation, beam on demand and single ion detection capabilities.

Materials Fabrication Facilities

Micro- and nano-fabrication facilities at the Melbourne Node are located in the CQCT cleanroom and consist of an electron beam (EBL) and photolithographic processing facility. A UV front side mask aligner (Neutronix Quintel Q4000-6 UV), located in the CQCT Cleanroom Complex (Figure 4), is equipped with the following functionality a flexible size vacuum chuck system for handling wafers (6") and smaller sample pieces, sub-micron feature resolution, contact/non-contact/vacuum/proximity exposure modes and the ability to process both thin and thick photoresists. The EBL facility is associated with the SEM/FIB which includes a Wraith pattern generator. A custom Thermionics physical vapour deposition system with both electron beam and resistive filament sources and a quartz crystal monitor for thickness control is also located in the CQCT Cleanroom Complex.

Fabrication and deposition facilities are distributed throughout the Advanced Materials, Pelletron and Cleanroom laboratories. General facilities in the Pelletron and Advanced Materials Laboratories include: wet chemical processing, inert gas furnace annealing, sample polishing, time-resolved reflectivity and optical microscopy. A replacement microwave CVD system customised for diamond growth was commissioned in 2009 in the Pulsed Laser Deposition laboratory. Manufactured by IPLAS, it will be used to fabricate novel doped diamond structures.

The Pulsed Laser Deposition (PLD) laboratory (70m^2), located on the fourth level of the building, is equipped with a Class 350 Cleanroom (10m^2), Class 35 laminar flow cabinet, turbulently ventilated fumecupboard and a Type II deionised water purification system. The Pulsed Laser Deposition system was relocated this year to the Engineering Faculty at the University of Melbourne where it will become part of the fabrication infrastructure under the new Melbourne Materials Institute.

FIGURE 3

Colutron low energy ion implanter which is used for precision (single) ion implantation of Si:P quantum devices.

Centre for Quantum Computer Technology Cleanroom (CQCTC)

Completed in October 2002, the Centre's Cleanrooms span more than 200m^2 and comprise the following functional areas: a dual Class (350/3500) changeroom (23m^2), services (32m^2), wet chemical processing (40m^2), Scanning Electron Microscopy (SEM)/Focused Ion Beam (FIB) (19m^2), general measurement (41m^2), Advanced Spectroscopy (27m^2) and Scanning Probe Microscopy (23m^2). The cleanroom is equipped with two turbulently ventilated (HEPA) fumecupboards, chemical storage and decontamination station. It is serviced by filtered (HEPA) and conditioned air, chilled water, gas exhaust, high purity gas supplies, instrument grade air and vacuum. Many of these services are configured for remote operation. The following equipment is located within the Cleanroom environment: a Colutron low energy ion implanter, a JEOL/Orsay Physics Focussed Ion Beam (FIB) column integrated (crossed beam) with a Scanning Electron Microscope (SEM) and Elphy Quantum Lithography control system, a Speedline Coating Systems P6708 Spin Coater, Modulapro Rapid Thermal Annealer, JEOL JAFM 4500XT UHV Atomic Force Microscope with STAIB Surface Spectroscopy facility and a Renishaw confocal micro-Raman spectrometer with operating laser wavelengths of 244 nm, 325 nm and 514.5 nm.

The adjacent Transmission Electron Microscope (TEM) laboratory (40m^2) has been redeveloped during 2009 to house the new low temperature dilution fridge facility. Building works are expected to be completed by February 2010.

Device Measurement Facilities

Electrical characterisation takes place in the Pelletron and undergraduate teaching laboratories where new probe stations have been setup. Low noise DC SQUID (Star Cryo-electronics) and Deep Level Transient Spectroscopy (SULA) instruments operate in the undergraduate teaching laboratories. The new milli-Kelvin, adiabatic magnetisation refrigerator (Figure 5) was ordered in 2008 (to be delivered in 2010) using funding from an ARC LEIF grant. The successful vender (Leiden Cryogenics) will supply the cryogen free measurement platform which uses pulse tube refrigeration technology combined with a traditional dilution unit enabling the fridge to reach a base temperature of $<$15mK, with a cooling power of 450μW at 120mK. It will be supplied with a superconducting 3D vector magnet allowing the application of fields up to 9T in one direction, and 1T in each of the remaining orthogonal directions. Optical access is facilitated through the use of cryostat windows along with optical fibre feedthroughs. This system will be a fundamental tool for the electrical-optical characterisation of Si:P related samples in a low temperature, high magnetic field environment.

FIGURE 4

Neutronix Quintel Q4000-6 UV front side mask aligner, which was commissioned in 2007, is located in the CQCT Cleanroom Complex.

Advanced Spectroscopy Facilities

The Melbourne Node is home to three commercial micro-Raman Spectrometers for conducting Ultra-Violet, Visible and Near Infra-Red Raman and Luminescence studies. The systems are located in the Pelletron Laboratory (Dilor XY), the CQCT Cleanroom (Renishaw RM 1000) and the Bio21 Molecular Science and Biotechnology Institute (Renishaw Invia Reflex). The Dilor system is a triple grating, high resolution spectrometer with a diode pumped, frequency doubled solid state excitation source. The Renishaw RM1000 system is a single grating, extended wavelength Raman/ luminescence spectrometer (244 - 1000nm) with Coherent I90 FRED, Kimmon HeCd and Stellar Pro Modulaser excitation sources. The Renishaw Invia Reflex system is configured with both visible and near infrared excitation sources.

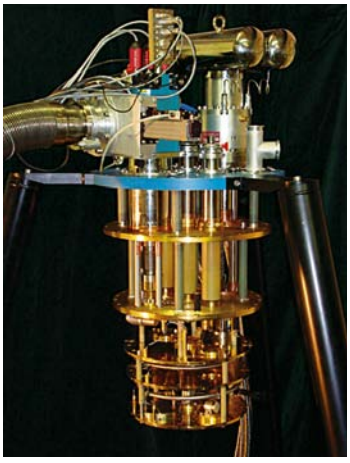

FIGURE 5

Photograph of the new Leiden Cryogenics milli-Kelvin cryostat insert. This system is scheduled to be commissioned at the Melbourne Node in 2010.

Atomic Imaging Facilities

This Node is also home to a range of scanning probe instruments (AFM) which include a JEOL JAFM 4500XT UHV AFM which is capable of CITS, lateral force, scanning Kelvin and modulation imaging modes with atomic resolution. It also features: an argon ion gun, e-beam evaporator, in vacuum cleaver and atomic hydrogen source. A Staib Surface Spectroscopy facility was added to this system in 2002 and includes: a micro-focus electron gun with scintillation detector for SEM imaging, cylindrical mirror analyser (CMA) with integral electron gun for Auger spectroscopy and SAM and an X-ray source for XPS analysis.

A second JEOL AFM (JSTM 4200A) is located in close proximity to the CQCT cleanroom facility and is equipped with many of the same features as the 4500 XT. The two JEOL systems are complimented by a Nanonics NSOM/AFM and an NT-MDT SMENA portable AFM (located in the undergraduate teaching laboratories). The Nanonics system provides 50 nm lateral imaging resolution and has been successfully interfaced to the Renishaw micro-Raman spectrometer. The NT-MDT SMENA AFM is located in the School's undergraduate teaching laboratories where it caters for both undergraduate teaching and research activities.