

21st C applications for heavy ions for fabrication and analysis

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Our civilisation is built on the band-gap of silicon. It is impossible to do anything in the western world without leaving deep digital footprints in the server farms that hold data about our web browsing habits, public transport use, credit card purchases, power consumption, telephone calls and many other everyday activities. Management of these data presents significant challenges, especially if we are to adapt to low emissions technologies required by the mid-21st C and the world becomes more crowded with people adopting power and data intensive lifestyles. All this has been sustained by the extraordinary progress in the ever expanding capabilities of silicon nano-scale complementary metal-oxide-semiconductor field effect transistors. Present generation devices are now so small that the channel length in the transistors (~20 nm) is comparable in size to the Bohr orbit of the donor electrons (~1.22 nm for Si:P). Fabrication of these devices requires many heavy ion implantation steps, but now the devices are sensitive to the distribution of the donor atoms themselves at the atomic level and new deterministic doping techniques have been flagged as a requirement in the International semiconductor roadmap for 2011. This presentation reviews the techniques for deterministic doping with implanted heavy ions developed in Melbourne and the complementary technique for the ion induced injection of charge into the bandgap of silicon for device characterisation and analysis. A specific goal of this work is the development of a solid state quantum computer in which information is encoded in the quantum states of the donor atom electron and nuclear spins which will be the key component of the future quantum internet.