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Quantum Wires and Quantum Dots: Fabrication Technology and Physics

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There is increasing interest in the potential application of quantum dots and quantum wires to various solid state devices. Applications include enhancing the performance of existing devices (e.g., semiconductor lasers based on quantum dot active layers), the creation of materials with exotic optical nonlinearities, the development of novel processor architectures based on cellular automata, as well as new concepts concerning the generation of synthetic dopants. In the quantum well hierarchy that has emerged over the last decade (i.e., quantum wells, wires and dots), quantum dots are the extreme quasi zero-dimensional case. They are, in a sense, large man-made atoms (50 to 200 Angstroms in diameter). An ideal quantum wire, on the other hand, is the electrical analog of single mode optical fiber. In this paper, we will first review the basic features of their electronic state space and bandstructure, including important band mixing effects which do not occur in the conventional quantum well system. We will then review work directed towards fabrication of quantum wire and dot structures. This will include discussion of a novel approach based on selective epitaxial growth of GaAs and also recent results on fabrication of single crystal GaAs clusters in the 40 to 100 Angstrom size range. Cluster absorption spectra will also be presented showing evidence for quantum confinement.