Extended Abstracts of the 22nd (1990 International) Conference on Solid State Devices and Materials, Sendai, 1990, pp. 757-760 **S-A-11**

Invited

Perspective of Quantum Effect Devices

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As the second stage of exploration in quantum-effct devices, we examine various new possibilities that are brought forth by the introduction of an in-plane potential V(x,y), with characteristic dimension comparable with the de Broglie wavelength of electrons, into otherwise uniform two-dimensional electron systems. This allows, in principle, the formation of various unique quantum states[(1)-(3)] including truly-discrete states confined in quantum box (QB) structures, truly-collimated propagating wave states guided in quantum wire (QWI) structures and various coupled states in coupled QB and QWI arrays, all of which are drastically different from those in more-conventional layered quantum structures[(4)]. In this talk, we examine the significance of these lateral super-structures (LASS) in device physics by clarifying what particular electronic processes should be controlled to create new properties desirable for advanced electronics and opto-electronics. We discuss, in particular, the scattering processes in quantum wire[(5)] and coupled QB arrays[(6)] and their significance both on conventional (non-coherent) transistor action (based on charge modulation)[(5),(7),(8)] and on novel coherent transistor action based on quantum interference (such as gate-controlled Bragg interference and the Aharonov-Bohm effect)[(1)(2)(9)(10)]. We discuss also features of opto-electronic processes particularly in QB structures in connection with laser[(11)(13)] and other opto-electronic device applications[(14)(15)].

We then point out the presence of stringent requirements on the geometrical features of these lateral superstructures for their device applications and emphasize the need to establish material fabrication methods with feature sizes of 200Å or less[(1)-(22)]. The current status of efforts along this line will be reviewed[(16)(22)].

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