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III-V semiconductors: plate form for photonic and optoelectronic devices and beyond

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Abstract

Part 1: Amongst all the “quantum enabled” technologies being explored, photon-based quantum communication is of key-societal relevance since it facilitates long-distance quantum cryptography along with safe and fast information processing between communicating parties. An essential element are single photon emitting devices. Compatibility of single photon sources (SPS) with existing telecommunication networks is one of the utmost importance along with high operating rate and photon purity. Therefore, it is desired for new devices to emit at 1.55 µm, which fits lowest attenuation (C-band telecom) window of optical fibers. InP based structures are attractive candidates, but the low refractive index contrast of layers lattice matched to the (001) InP substrate complicates the generation of efficient photonic out coupling. For this purpose, it would be desirable/ideal to obtain device fabrication on some other semiconductors, which can suitably provide an alternate, like e.g. GaAs [1, 2, 3].

Part 2: Light matter interaction in semiconductors is the core of our technology-driven world. Possibility to create optical and electronic systems in which photons and excited-state electrons (excitons) are mixed together in an optical microcavity and energy is exchanged between them coherently, forming entirely new particles called “polaritons”. When a sufficient number of polaritons is generated in a cavity, they form a coherent state called a polariton condensate [4]. Such condensates are a form of ‘liquid light’ and display quantum properties, even though the condensate can be quite large (tens of microns in diameter). These exotic objects can be used as the basis for an entirely new type of electronics, called ‘polaritonics’.

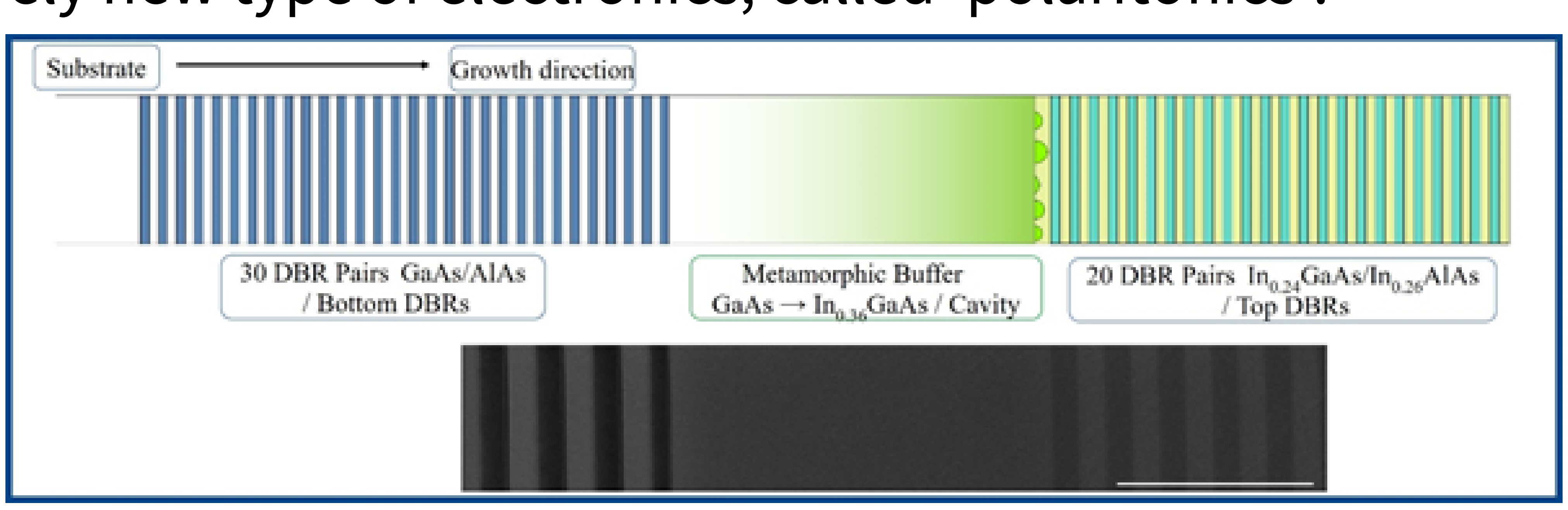

Fig. Microcavity layout comprising Distributed Bragg Reflectors (DBRs), top and bottom, metamorphic buffer layer with QDs embedded between $In_{0.36}Ga_{0.64}As$ and $In_{0.24}Ga_{0.76}As$ at maxima of 5 λ/2 cavity. SEM micrograph showing the metamorphic buffer layer with few top and bottom DBRs. Scale bar is 1µm.

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