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Self-assembled nanostructures in mixed III-V and III-nitride layers

The group III arsenides and phosphides crystallize in the zinc-blende (ZB) structure, whereas the III group nitrides have the wurtzitic (WZ) structure. The ZB structure consists of two interpenetrating FCC sub-lattices that are displaced from each other by $a/4 \langle III \rangle$, where "a" is the lattice parameter of the layer; the WZ structure also consists of two interpenetrating HCP sub-lattices that are also displaced from each other. In both structures, the group III species occupy one-sub-lattice, whereas the group V atoms reside on the second sub-lattice.

The binary arsenides, phosphides and nitrides have discrete band gaps. The binaries are mixed to produce ternary and quaternary layers that have band gaps in between those of the binaries. The question is: are the atomic species distributed at random on their respective sub-lattices? We will show experimentally that they are not. Two types of deviations from randomness are observed in the two material systems: phase separation and atomic ordering. Phase separation is observed in mixed layers that contain atomic species differing in their covalent tetrahedral radii. In arsenides and phosphides, atomic ordering is caused by (2x4) surface reconstruction that biases the occupation of sub-surface sites by atoms differing in their tetrahedral radii. At present, the occurrence of ordering in the nitrides is not well understood.

Phase separation and ordering affects electronic and optical properties of the layers.



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Dr. S. Mahajan is a Distinguished Professor and was Special Advisor to the Chancellor at the University of California, Davis, from 2011 - 2016. Prior to assuming his current position in 2011, he was associated with the University of Denver; Atomic Energy Research Establishment, Harwell, England; Bell Telephone Laboratories, Murray Hill; Carnegie Mellon University; and Arizona State University.

Mahajan's research interests are in structure-property relations in functional materials and deformation behavior of solids. He received numerous awards for excellence in research and teaching of electronic materials. He is a Fellow of TMS, MRS, and ASM; a Member of NAE and a Foreign Fellow of the Indian National Academy of Engineering.



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