Dissimilar materials integration – enabling innovation

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One of the most important areas in device engineering today is dissimilar materials integration enabled by new capabilities to both observe and control heterointerfaces at the atomic level. In the solid state, high quality lattice-mismatched systems, relaxed or strained, provide a basis for integrating virtually any combination of material systems. This is attractive for device and systems engineering requiring bulk, nanostructure, ferromagnetics, oxides, *etc*. Several approaches include lateral overgrowth, metamorphic buffers, and interfacial misfit arrays. Formation of nanostructures, both nanowires and quantum dots, are also based on dissimilar materials and the ability to understand atomic energetics. The emerging interest in the extreme lattice-mismatch requires careful studies in material science involving the atomic bonding tendencies, defect energetics, surface adatom chemistry, microscopy.

In this presentation, we review research areas dependent on controlled atomic assembly in highly lattice-mismatched semiconductor material systems, such as nanostructure synthesis and monolithic integration of lattice-mismatched bulk materials. In nanostructure synthesis, dissimilar growth is initiated by either self-assembled or directed approaches. Either a reaction catalyst or complex surface energetics control many aspects such as the structural shape, material content and growth rate. A second area of interest involving atomic assembly produces very high quality bulk material in lattice-mismatched systems including III-Sb on GaAs and Si substrates ($\Delta a_0/a_0$= 8–13%). Atomic assembly controls defect formation, strain balance, and material homogeneity. Relevant technologies include mid-wave to long-wave infrared devices and silicon photonics. General state-of-the-art along with specific research details will be included to provide an accurate vision of current technology and future applications of dissimilar materials integration with applications to device and systems innovation.