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Continuous Laterally Varying II-VI Alloys and Applications

Bandgap engineering in semiconductors can be used to produce optoelectronic devices, such as photovoltaic devices and lasers for operation in different wavelengths. A new bandgap (or wavelength) can be achieved by alloying together two (or more) semiconductor materials of different bandgaps. However, existing methods of growing planar epitaxial heterostructures of semiconductors on crystalline substrates invariably require limited lattice constant mismatch (or a method to relieve the strain developed by lattice mismatch). Consequently, this requirement has provided the primary obstacle to manufacturing semiconductor-based optoelectronic devices with controllable and widely variable (tunable) operating wavelengths. Recent methods employing nanowire-based technology have made great strides in overcoming this obstacle, greatly relaxing this restriction to allow for the growth of materials with mismatch as high as 8%, or even removing this restriction altogether. Notwithstanding these successes, there remains an important challenge of achieving a full-range of alloy composition variation within a single substrate in a single run of growth.

Researchers at Arizona State University have developed II-VI semiconductor structures with laterally varying bandgaps across a substrate, allowing broad wavelength operation ranges from UV to IR for optoelectronic devices. The entire spatial extension of nanomaterials (on a given substrate) can be subdivided into multiple regions laterally that are electronically separated from each other, so that separate electrical contacts can be fashioned for each region (or band). This can allow extraction (or injection) of electrons and holes separately from other regions (bands). This unprecedented bandgap range on a single substrate could enable a wide variety of applications.

Potential Applications

- Lateral multi-junction solar cells
- Wavelength tunable laser arrays
- Broadband light sources for solid state lighting and displays
- Multicolor detectors

Benefits and Advantages

- Allows Wavelength Selective Absorption over the Entire Solar Spectrum on a single substrate, potentially reaching the theoretical limit of solar cell efficiency.
- Allows Extraction of Charged Carriers within the Same Energy Range in which the Charged Carriers are Created ? eliminates or largely reduces heat generation; provides for greatly increased device efficiency potential by minimizing loss

- Provides Straightforward Preparation with Single Step Growth
- Offers Benefits of Nanowire-Based Technology ? functions with extremely wide bandgap tuning, provides channels for electronic conduction and waveguiding, and acts as gain/absorbing material