crystal lattice structure that is expanded outwardly fromrelative to the proximal end portion;

an optically active material optically associated with the distal end portion to form a heterojunction therebetween.

Advantageously, the expanded crystal lattice structure of the distal end portion is relaxed in three-dimensional directions with significantly reduced internal lattice strain as compared to the first crystal lattice structure of the proximal end portion. Accordingly, in embodiments which incorporate metal atoms in semiconductor materials (ie such as indium (In) incorporated in GaN), strain can have a large influence on the incorporation of metal atoms in the optically active layer, which affects the wavelength and efficiency of the photonic devices. Thus, strain relaxation is induced in the optically active layer by being connected with the distal end portion of the nano-structure having an expanded lattice structure. This is particularly useful in achieving highly efficient blue- and UV- LEDs.

Furthermore, the expanded lattice structure enables a more uniform incorporation of metal atoms in the semiconductor material, thereby reducing the spectrum of light emitted, or optical losses, from the optically active layer.

In one embodiment, the optically active layer is optically associated with the distal end of the nanostructures in the sense that the optically active layer is in direct contact with the distal end of the nanostructures that is composed of the semiconductor material so that a heterojunction is formed therebetween.

Advantageously, the expanded crystal lattice structure of the distal end portion is energetically unfavourable for dislocation formation (i.e. formation of

a crystallographic defect or irregularity within the crystal structure). Hence, there is a reduction in the dislocation densities of the crystal structure.

Advantageously, the expanded relaxed crystal lattice structure of the distal end portion enables greater incorporation of the optically active material as compared to a non-expanded or non-relaxed crystal lattice structure similar to the first crystal lattice structure of the proximal end portion. This extends the wavelength range of the photonic device to a longer wavelength. This also increases the light emission intensity of the present photonic device relative to devices containing crystal lattice structures that are not expanded and hence not "relaxed". Advantageously, the expanded crystal lattice structure of the distal end portion may be selected ~~to~~ so that it increases the light emission intensity of the photonic device by at least one fold or at least two fold or at least three fold relative to non-expanded crystal lattice structures.

Advantageously in one embodiment, the distal end portion with the expanded crystal lattice structure has a plurality of external facets of different orientations, which not only provides a greater surface area for incorporation or deposition of the optically active material but also enables the optically active material to be applied selectively to a facet of particular orientation, or to a combination of facets that are orientated differently.

According to a second aspect of the present invention, there is provided a method of forming a photonic device comprising a plurality of nanostructures that extend from a substrate, the method comprising the steps of:

(a) providing a template formed of a semiconductor material on the substrate, the template comprising a plurality of primary generally longitudinally shaped nanostructures projecting from the substrate and being formed of semiconductor material having a first crystal lattice structure;

(b) forming a secondary portion on each of the primary nanostructures, said secondary portions being composed of semiconductor material having a second crystal lattice structure that is expanded outwardly from~~relative to~~ the first crystal structure; and

(c) forming an optically active layer of optically active material on the secondary portions of the nanostructures.

In one embodiment, step b) comprises a first stage of growing a portion of the semiconductor material having the first crystal lattice structure by nanoepitaxial growth under selected conditions to form lower sections of the secondary portions of the nanostructures.

Advantageously, nanoepitaxial growth under selected conditions enables the crystal lattice structure of the semiconductor material to undergo expansion in three dimensions to release the compressive strain in the lattice structure and achieve three-dimensional relaxation. This three-dimensional relaxation results in the formation of the secondary end portions of the nanostructures with the expanded, and therefore relaxed, crystal lattice structure.

Advantageously, three-dimensional strain relaxation in the crystal lattice structure as a result of the nanoepitaxial growth may reduce threading dislocation (i.e. defect) densities in the semiconductor material.

Advantageously, three-dimensional strain relaxation in the crystal lattice structure may enable greater incorporation of the optically active material in the secondary portions of the nanostructures.

Advantageously, the conditions used to grow a portion of the semiconductor material having the first crystal lattice structure may be selected to enable nanoepitaxial growth of the semiconductor material only.

Advantageously, the template comprising the primary nanostructures, being in the form of a nano-template, enables the nanometer sized nucleation and growth of the semiconductor material.

Advantageously, the conditions used to grow a portion of the semiconductor material by nanoepitaxial growth may be selected to obtain a particular shape or texture of the secondary portions of the nanostructures having the expanded crystal lattice structure.

According to a third aspect of the present invention, there is provided a light emitting diode device having a semiconductor element comprising:

a plurality of nanostructures that extend from a substrate, each nanostructure comprising:

a generally longitudinal nanostructure body formed of a semiconductor material and having a proximal end portion of a first crystal lattice structure and a distal end portion, opposite the proximal end portion, of a second crystal lattice structure that is expanded outwardly from~~relative to~~ the proximal end portion;

an optically active material optically associated with the distal end portion to form a heterojunction therebetween;

a layer of a semiconductor material disposed over the distal end portions of the nanostructures to form a