

thereby causing each of the pockets to not overlap into the adjacent layer, resulting in a distortion that results in a smaller change in the lattice constant.

[0058] FIGS. 11 and 12 are diagrams of X-ray intensities for each of the distortion types, similar to the structure shown in FIGs. 8 and 10 respectively, according to embodiments described herein. In the diagram shown in FIG. 11, the intensity for the distortion resulting from intermixed (IM) layer having a distortion type A is illustrated. In the diagram shown in FIG. 12, the intensity for the distortion resulting from superlattices (SL) layer having a distortion type C is illustrated.

[0059] FIG. 13 is an example of a layered structure that illustrates nanocomposites of different species in the distortion layer 110, according to an embodiment described herein. In some embodiments, the amount of distortion created in distortion layer 110 may be controlled by inserting different species of nanocomposites. For example, group V species can be used—a single rare earth (RE) species may form either rare earth-arsenide (RE-As) or rare earth-phosphide (RE-P) nanocomposites. As shown in FIG. 7, nanocomposites of a first species 704 (e.g., RE-As) and a second species 702 (e.g., RE-P) are inserted in distortion layer 110 to introduce lattice distortion. In some embodiments, phosphorus (P) is introduced to produce the second species 702 (e.g., rare earth-P) in which there is no incorporation into the III-V alloy of the distortion layer 110.

[0060] FIG. 14 is an example diagram illustrating aspects of the distortion produced by a stack of multiple combinations of the stabilization layer and the distortion layer, according to an embodiment described herein. Layered structure 800 of FIG. 14 depicts two

thereby reducing the number of intermediate layers between the binary III-V semiconductors, resulting in the more efficient and cost-effective layered structures.

[0064] FIG. 17 shows an example layered structure including a combination of various dislocation filters, according to an embodiment described herein. The layered structure 1100 includes a GaAs substrate with a first III-V semiconductor 1104 formed over the GaAs substrate. Further, a first dislocation filter 1106 (e.g., a distortion layer using RE nanocomposites pockets to filter dislocation) over the first III-V semiconductor 1104 and a second III-V semiconductor 1108 grown over the first dislocation filter 1106. The first III-V semiconductor can be the same or different as the second III-V semiconductor. Further, a second dislocation filter 1110 is grown over the second III-V semiconductors layer. Such a configuration is employed to block the dislocations that permeated from the substrate because of the lattice mismatch. Accordingly, the layered structure is able to be formed with fewer dislocations.

[0065] In some embodiments, the order of the various layers may be different based on the need of lattice stability and the need to block dislocation in the III-V semiconductor. For example, first dislocation filter 1106, and second dislocation filter 1110 may act as lattice distortion layers that may introduce distortion to increase or decrease the lattice constant of the layered structure 1100 and may further block dislocations from traveling up the layered structure. A III-V semiconductor (e.g., InP), may be epitaxially grown over first dislocation filter 1106.

The sequencing, number, specific lattice constant, and density or number of pockets of nanocomposites in the distortion layers may be varied to achieve a target lattice constant at the upper

(Er)), grown over the first distortion layer, and a III-V stabilization layer grown over the second distortion layers. According to such a configuration, the distortion is tuned to bridge lattice mismatch between
5 binary III-V semiconductors.

[0070] The image in FIG. 21 (TEM) shows the layered structure similar to the structure shown in FIG. 20 with the first distortion layer having a distortion type C and the second distortion having a distortion type B.

10 **[0071]** FIG. 22 shows a diagram of sheet resistivity of a layered structure having various distortion layers, according to an embodiment described herein. In the diagram shown in FIG. 22, the sheet resistivity for the variety of distorted layers is shown. Specifically,
15 electric behavior of the layer stack may be determined by the choice of nanocomposite and/or distortion design.

[0072] FIG. 23 shows an example of an individual nanocomposite with a different lattice construction to the surrounding crystal lattice. At the boundary of the
20 individual nanocomposite as shown are 2 different lattice constants allowing for the distortion required to change the overall crystal lattice spacing or filter dislocation as described herein. In the pocket, the rare earth may be any selected type of rare earth. In some embodiments,
25 the rare earth is selected from a group consisting of Er, Gd and Lu. An example of the group V element is As.

[0073] As described herein, a layer means a substantially-uniform thickness of a material covering a surface. A layer can be either continuous or
30 discontinuous (i.e., having gaps between regions of the material). For example, a layer can completely or partially cover a surface, or be segmented into discrete regions, which collectively define the layer (i.e., regions formed using selective-area epitaxy).

What is Claimed is:

1. A layered structure comprising:
a substrate;
5 a distortion layer having a first lattice constant and being epitaxially grown over the substrate, wherein the distortion layer comprises a plurality of nanocomposites that modify the first lattice constant of the distortion layer; and
10 a stabilization layer having a second lattice constant and being epitaxially grown over the distortion layer, wherein a second lattice constant of the stabilization layer is lattice matched to the first lattice constant modified by the plurality of
15 nanocomposites of the distortion layer.
2. The layered structure of claim 1, wherein:
the plurality of nanocomposites form a plurality of pockets in the distortion layer, and
20 each pocket of the plurality of pockets modify the first lattice constant in a respective local region of the distortion layer.
3. The layered structure of claim 1, wherein the
25 plurality of nanocomposites comprises a first species of nanocomposites and a second species of nanocomposites different from the first species of nanocomposites.
4. The layered structure of claim 1, wherein the
30 plurality of nanocomposites comprises RE pnictide.
5. The layered structure of claim 1, wherein the stabilization layer has a homogenous crystal structure.

6. The layered structure of claim 1, wherein the stabilization layer comprises III-V semiconductors.
7. The layered structure of claim 6, wherein the III-V semiconductors in the stabilization layer comprise III-V alloy and wherein the III-V alloy is a $\text{In}_x\text{Ga}_y\text{Al}_z\text{As}_n\text{P}_m$ alloy.
8. The layered structure of claim 1, further comprising a semiconductor layer epitaxially grown over the stabilization layer.
9. The layered structure of claim 8, wherein the semiconductor layer comprises a Group III element and a Group V element.
10. The layered structure of claim 1, wherein the substrate comprises GaAs.
11. The layered structure of claim 1, wherein the distortion layer comprises a shared element with the substrate.
12. The layered structure of claim 1, further comprising a stack, wherein the stack comprises up to 40 units of the distortion layer and the stabilization layer.
13. The layered structure of claim 14, wherein the stack comprises nanocomposites of varying elements, sizes, and densities.

14. The layered structure of claim 1, wherein the distortion layer comprises Group III elements and a Group V element.
- 5 15. The layered structure of claim 1, further comprising a dislocation filter over the stabilization layer.
16. The layered structure of claim 1, wherein the distortion layer has a sheet resistivity of greater than
10 25,000 ohm-cm.
17. A layered structure comprising:
a substrate;
a first semiconductor layer epitaxially grown over
15 the substrate;
a dislocation filter epitaxially grown over the first semiconductor layer; and
a second semiconductor layer epitaxially grown over the dislocation filter,
20 wherein the dislocation filter comprises a plurality of nanocomposites.
18. The layered structure of claim 1, further comprising
25 a second distortion layer, wherein the second distortion layer comprises a plurality of nanocomposites that modify the lattice constant of the second distortion layer.
19. The layered structure of claim 20, wherein the distortion layer or the second distortion layer includes
30 multiple sublayers, and wherein some of the sublayers have pockets of nanocomposites.

20. The layered structure of claim 21, wherein a distribution, density or size of the nanocomposites is different across different sublayers.