The above-mentioned drawbacks impede the performance and/or advancements of PCA THz photomixing emitters. In view of the forgoing, it is highly desirable to develop ways which enhance the emission power of PCA THz photomixing emitters.

SUMMARY

According to a first aspect of the invention, there is provided a THz photomixer emitter comprising: a photoconductive material~~;~~ and ~~an~~ nano-scale antenna structure~~; and an electrode array disposed such that an electric field associated with photocarriers generated in the photoconductive material is coupled to the antenna for emission of a THz wave via the antenna structure; wherein the electrode array is configured such that an electric field resonance pattern of the electrode array is substantially aligned with an emission field pattern of the antenna structure~~. The nano-scale antenna structure comprises a dipole antenna structure having opposing main electrodes for opposite biasing and an electrode array disposed between and connected to the opposing main electrodes for enhancing both an electric field associated with photocarriers generated in the photoconductive material and emission of a THz wave via the nano-scale antenna structure, and wherein the electrode array comprises two sets of electrode elements, each electrode element comprising a trunk portion connected to a respective one of the main electrodes and a set of branch portions extending from the trunk portion, wherein at least a portion of a first set of branch portions are disposed in a tip-to-tip configuration with corresponding ones of a similar at least a portion of a second set of branch portions such that an electric field resonance direction between opposing ones of the at least a portion of the first and second set of branches of the respective sets of the electrode elements is the same as a favored electric field direction of the dipole antenna structure for substantially aligning an electric field resonance direction with an emission field pattern of the nano-scale antenna structure.

~~Preferably, the antenna structure comprises a dipole antenna structure having opposing main electrodes for opposite biasing, and the electrode array is disposed between the main electrodes.~~

Preferably, at least a portion of the first and second sets of branches of the electrode elements~~the electrode array~~ comprises two sets of finger electrodes disposed in the~~a~~ tip-to-tip configuration, each set electrically connected to a respective on of the main electrodes, and such that an electric field resonance direction between opposing fingers of the respective sets is the same as the~~a~~ favored electric field direction of the dipole antenna structure.

The tips of the respective finger electrodes can be tapered for enhancing the electric field associated with the photocarriers generated in the photoconductive material.

~~The electrode array can comprise two sets of electrode elements, each electrode element comprising a trunk portion connected to a respective one of the main electrodes and branch portions extending from the trunk portion, wherein the branch portions are disposed such that an electric field resonance direction between~~

~~opposing branches of the respective sets is the same as the favored electric field direction of the dipole antenna structure.~~

Preferably, the first and second sets of branch portions~~at least some of the electrode elements~~ comprise branch portions extending in different directions from the trunk portion.

The electrode array can comprise two sets of electrode elements, wherein pairs of opposing electrode elements of the respective sets are configured in a circular electrode design.

The electrode array can comprise two sets of electrode elements, wherein pairs of opposing electrode elements of the respective sets are configured in a spiral electrode design. The antenna structure can comprise a broadband antenna. The THz wave can be circularly polarized.

According to a second aspect of the present invention, there is provided a method for emitting a THz wave, the method comprising the steps of: providing a photoconductive material; coupling a nano-scale antenna structure to the photoconductive material, the nano-scale antenna structure being configured to comprise a dipole antenna structure having opposing main electrodes for opposite biasing and the electrode array is disposed between the main electrodes; and generating photocarriers having an associated electric field in the photoconductive material such that the electric field associated with the photocarriers generated in the photoconductive material emits the THz wave via an electrode array of the nano-scale antenna structure, wherein the electrode array is configured to comprise two sets of electrode elements, each electrode element comprising a trunk portion connected to a respective one of the main electrodes and sets of branch portions extending from the trunk portion, wherein finger electrodes of at least a portion of a first set of the branch portions are disposed in a tip-to-tip configuration with corresponding finger electrodes of at least a portion of a second set of the branch portions such that an electric field resonance direction between opposing branch portions of the respective sets of electrode elements is the same as a favored

electric field direction of the dipole antenna structure for emission of the THz waveproviding an antenna structure; and providing an electrode array disposed such that an electric field associated with photocarriers generated in the photoconductive material is coupled to the antenna for emission of the THz wave via the antenna structure; wherein the electrode array is configured such that an electric field resonance pattern of the electrode array is substantially aligned with an emission field pattern of the antenna structure.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example only, and in conjunction with the drawings, in which:

CLAIMS:

1. A THz photomixer emitter comprising:

a photoconductive material; and

a nano-scale antenna structure, the nano-scale antenna structure comprising a dipole antenna structure having opposing main electrodes for opposite biasing and an electrode array disposed between and connected to the opposing main electrodes for enhancing both an electric field associated with photocarriers generated in the photoconductive material and emission of a THz wave via the nano-scale antenna structure, and wherein the electrode array comprises two sets of electrode elements, each electrode element comprising a trunk portion connected to a respective one of the main electrodes and a set of branch portions extending from the trunk portion, wherein at least a portion of a first set of branch portions are disposed in a tip-to-tip configuration with corresponding ones of a similar at least a portion of a second set of branch portions such that an electric field resonance direction between opposing ones of the at least a portion of the first and second set of branches of the respective sets of the electrode elements is the same as a favored electric field direction of the dipole antenna structure for substantially aligning an electric field resonance direction with an emission field pattern of the nano-scale antenna structure.

2. The emitter as claimed in claim 1, wherein the at least a portion of the first and second sets of branches of the electrode elements comprise two sets of finger electrodes disposed in the tip-to-tip configuration, each set electrically connected to a respective one of the main electrodes, and

such that an electric field resonance direction between opposing fingers of the respective sets is the same as the favored electric field direction of the dipole antenna structure.

3. The emitter as claimed in claim 2, wherein the tips of the respective finger electrodes are tapered for enhancing the electric field associated with the photocarriers generated in the photoconductive material.

4. The emitter as claimed in claim 1, wherein the first and second sets of branch portions comprise branch portions extending in different directions from the trunk portion.

5. The emitter as claimed in claim 1, wherein the electrode array comprises two sets of electrode elements, wherein pairs of opposing electrode elements of the respective sets are configured in a circular electrode design.

6. The emitter as claimed in claim 1, wherein the electrode array comprises two sets of electrode elements, wherein pairs of opposing electrode elements of the respective sets are configured in a spiral electrode design.

7. The emitter as claimed in claims 5 or 6, wherein the nano-scale antenna structure comprises a broadband antenna.