PHOTONIC COMMUNICATION PLATFORM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit under 35 U.S.C. § 119(e) of U.S. Provisional Patent Application Serial No. 62/961,448, entitled "PHOTONICS COMMUNICATIONS PLATFORM WITH SINGLE LITHOGRAPHIC MASK SET," filed on January 15, 2020 under Attorney Docket No. L0858.70013US02, which is hereby incorporated herein by reference in its entirety.

[0002] This application claims the benefit under 35 U.S.C. § 119(e) of U.S. Provisional Patent Application Serial No. 62/923,889, entitled "PHOTONICS COMMUNICATIONS PLATFORM WITH SINGLE LITHOGRAPHIC MASK SET," filed on October 21, 2019 under Attorney Docket No. L0858.70013US01, which is hereby incorporated herein by reference in its entirety.

[0003] This application claims the benefit under 35 U.S.C. § 119(e) of U.S. Provisional Patent Application Serial No. 62/814,444, entitled "PHOTONICS COMMUNICATIONS PLATFORM WITH LITHOGRAPHIC MASK SET," filed on March 6, 2019 under Attorney Docket No. L0858.70013US00, which is hereby incorporated herein by reference in its entirety.

FIELD OF INVENTION

[0004] The present application relates to photonic communication platforms and related methods.

BACKGROUND

[0005] Computer systems include random-access memories (RAM) for storing data and machine code. RAMs are typically volatile memories, such that the stored information is lost when power is removed. In modern implementations, memories take the form of integrated circuits. Each integrated circuit includes several memory cells. To enable access to stored data and machine code, memories are place in electrical communication with processors. Typically, these electrical communications are implemented as metal traces formed on the substrates on which the memories and the processors are disposed.

SUMMARY OF THE DISCLOSURE

[0006] According to a first aspect of the present invention, there is provided a photonic system comprising a photonic substrate patterned with a plurality of photonic modules such that the plurality of photonic modules are embedded in the photonic substrate, the

plurality of photonic modules including at least first and second photonic modules, wherein each photonic module of the plurality of photonic modules is a distinct instance of a photolithography shot performed using at least one common photomask. Each of the first and second photonic modules comprises first and second

boundaries defined by boundaries of the at least one common photomask; a controllable optical distribution network; a first optical waveguide optically coupling the controllable optical distribution network to a first neighboring photonic module of the plurality of photonic modules, the first neighboring photonic module being adjacent to the first boundary; and a second optical waveguide optically coupling the controllable optical distribution network to a second neighboring photonic module of the plurality of photonic modules, the second neighboring photonic module being adjacent to the second boundary. The controllable optical distribution network is configured to selectively couple the first optical waveguide to the second optical waveguide.

[0007] In some embodiments, the first and second boundaries are opposite to one another.

[0008] In some embodiments, the first and second optical waveguides are patterned according to the at least one common photomask.

[0009] In some embodiments, each of the first and second photonic modules further comprises an out-of-plane optical coupler optically coupled to the optical distribution network.

[0010] In some embodiments, the optical distribution network is configured to selectively place the first neighboring photonic module in optical communication with the second neighboring photonic module.

[0011] In some embodiments, each of the first and second photonic modules is patterned according to a common set of photomasks, wherein the at least one common photomask is part of the common set of photomasks.

[0012] In some embodiments, each of the first and second photonic modules further comprises: third and fourth boundaries, wherein the first and second boundaries are opposite to one another and the third and fourth boundaries are opposite to one another; a third optical waveguide optically coupling the optical distribution network to a third neighboring photonic module of the plurality of photonic modules, the third neighboring photonic module being adjacent to the third boundary; and a fourth optical waveguide optically coupling the optical distribution network to a fourth neighboring photonic module of the plurality of photonic modules, the fourth neighboring photonic module being adjacent to the fourth boundary.

[0013] In some embodiments, the optical distribution network is configured to selectively place the first neighboring photonic module in optical communication with the second neighboring photonic module or the third neighboring photonic module.

[0014] In some embodiments, the optical distribution network comprises a plurality of optical switches.

[0015] In some embodiments, the first and second photonic modules are adjacent to one another such that the second photonic module is the first neighboring photonic module for the first photonic module.

module using a second photolithography shot, subsequent to the first photolithography shot, in connection with the at least one common photomask.

[0022] According to a second aspect of the present invention, there is a computing system comprising a photonic substrate patterned with a plurality of photonic modules such that the plurality of photonic modules are embedded in the photonic substrate, the plurality of photonic modules including at least first and second photonic modules, wherein each photonic module of the plurality of photonic modules is a distinct instance of a photolithography shot performed using at least one common photomask, wherein the first photonic module is optically coupled to the second photonic module; a first die in communication with the first photonic module; and a second die in communication with the second photonic module, wherein each of the first and second photonic modules comprises: first and second boundaries defined by boundaries of the at least one common photomask; a controllable optical distribution network; a first optical waveguide optically coupling the controllable optical distribution network to a first neighboring photonic module of the plurality of photonic modules, the first neighboring photonic module being adjacent to the first boundary; and a second optical waveguide optically coupling the controllable optical distribution network to a second neighboring photonic module of the plurality of photonic modules, the second neighboring photonic module being adjacent to the second boundary. The controllable optical distribution network is configured to selectively couple the first optical waveguide to the second optical waveguide.

[0023] In some embodiments, the first die comprises a processor and the second die comprises a memory.

[0024] In some embodiments, the computing system further comprises a laser die coupled to the photonic substrate.

[0025] In some embodiments, each of the first and second photonic modules comprises: first and second boundaries; an optical distribution network; a first optical waveguide optically coupling the optical distribution network to a first neighboring photonic module of the plurality of photonic modules, the first neighboring photonic module being adjacent to the first boundary; and a second optical waveguide optically coupling the optical distribution network to a second neighboring photonic module of the plurality of photonic modules, the second neighboring photonic module being adjacent to the second boundary.

[0026] In some embodiments, the first and second boundaries are opposite to one another.

[0027] In some embodiments, the first and second optical waveguides are patterned according to the at least one common photomask.

[0028] In some embodiments, each of the first and second photonic module comprises an out-of-plane optical coupler, wherein: the first die is optically coupled to the out-of-plane optical coupler of the first photonic module, and the second die is optically coupled to the out-of-plane optical coupler of the second photonic module.

[0029] In some embodiments, the first die is coupled to a first side of the photonic substrate and the second die is coupled to a second side of the photonic substrate opposite the first side.

[0030] In some embodiments, the computing system further comprises a third die stacked on top of the first die.

[0031] In some embodiments, the first and second photonic modules share a boundary such that the first photonic module is adjacent to the second photonic module.

CLAIMS

1. A photonic system comprising:

a photonic substrate patterned with a plurality of photonic modules such that the plurality of photonic modules are embedded in the photonic substrate, the plurality of photonic modules including at least first and second photonic modules, wherein each photonic module of the plurality of photonic modules is a distinct instance of a photolithography shot performed using at least one common photomask, each of the first and second photonic modules comprising:

first and second boundaries defined by boundaries of the at least one common photomask;

a controllable optical distribution network;

a first optical waveguide optically coupling the controllable optical distribution network to a first neighboring photonic module of the plurality of photonic modules, the first neighboring photonic module being adjacent to the first boundary; and

a second optical waveguide optically coupling the controllable optical distribution network to a second neighboring photonic module of the plurality of photonic modules, the second neighboring photonic module being adjacent to the second boundary,

wherein the controllable optical distribution network is configured to selectively couple the first optical waveguide to the second optical waveguide.

2. The photonic system of claim 1, wherein the first and second boundaries are opposite to one another.

3. The photonic system of claim 1, wherein each of the first and second photonic modules further comprises an out-of-plane optical coupler optically coupled to the controllable optical distribution network.

4. The photonic system of claim 1, wherein each of the first and second photonic modules further comprises:

third and fourth boundaries, wherein the first and second boundaries are opposite to one another and the third and fourth boundaries are opposite to one another;

a third optical waveguide optically coupling the controllable optical distribution network to a third neighboring photonic module of the plurality of photonic modules, the third neighboring photonic module being adjacent to the third boundary; and

a fourth optical waveguide optically coupling the controllable optical distribution network to a fourth neighboring photonic module of the plurality of photonic modules, the fourth neighboring photonic module being adjacent to the fourth boundary.

5. The photonic system of claim 4, wherein the controllable optical distribution network is configured to selectively place the first neighboring photonic module in optical communication with the second neighboring photonic module or the third neighboring photonic module.

6. The photonic system of claim 1, wherein the controllable optical distribution network comprises a plurality of optical switches.

7. The photonic system of claim 1, wherein the first and second photonic modules are adjacent to one another such that the second photonic module is the first neighboring photonic module for the first photonic module.

8. A computing system comprising:

a photonic substrate patterned with a plurality of photonic modules such that the plurality of photonic modules are embedded in the photonic substrate, the plurality of photonic modules including at least first and second photonic modules, wherein each photonic module of the plurality of photonic modules is a distinct instance of a photolithography shot performed using at least one common photomask, wherein the first photonic module is optically coupled to the second photonic module;

a first die in communication with the first photonic module; and

a second die in communication with the second photonic module,

wherein each of the first and second photonic modules comprises:

first and second boundaries defined by boundaries of the at least one common photomask;

a controllable optical distribution network;

a first optical waveguide optically coupling the controllable optical distribution network to a first neighboring photonic module of the plurality of photonic modules, the first neighboring photonic module being adjacent to the first boundary; and

a second optical waveguide optically coupling the controllable optical distribution network to a second neighboring photonic module of the plurality of photonic modules, the second neighboring photonic module being adjacent to the second boundary,

wherein the controllable optical distribution network is configured to selectively couple the first optical waveguide to the second optical waveguide.

9. The computing system of claim 8, wherein the first die comprises a processor and the second die comprises a memory.

10. The computing system of claim 8, further comprising a laser die coupled to the photonic substrate.

11. The computing system of claim 8, wherein the first and second boundaries are opposite to one another.

12. The computing system of claim 8, wherein each of the first and second photonic module comprises an out-of-plane optical coupler, wherein:

the first die is optically coupled to the out-of-plane optical coupler of the first photonic module, and

the second die is optically coupled to the out-of-plane optical coupler of the second photonic module.

13. The computing system of claim 8, wherein the first die is coupled to a first side of the photonic substrate and the second die is coupled to a second side of the photonic substrate opposite the first side.

14. The computing system of claim 8, further comprising a third die stacked on top of the first die.

15. The computing system of claim 8, wherein the first and second photonic modules share a boundary such that the first photonic module is adjacent to the second photonic module.

16. The computing system of claim 8, wherein:
the first die is mounted above or below the first photonic module; and
the second die is mounted above or below the second photonic module.

17. The computing system of claim 8, wherein:
the first die is in electronic communication with the first photonic module, and
the second die is in electronic communication with the second photonic module.