WHAT IS CLAIMED IS:

1. An antenna apparatus comprising:

a substrate having a cavity in a first outer surface thereof, the substrate having a sidewall defining a portion of the cavity, wherein a first edge contact is formed at the sidewall;

an integrated circuit (IC) chip disposed within the cavity, having a side surface facing the sidewall and a second edge contact formed on the side surface electrically connected to the first edge contact; characterized in that an antenna element is disposed at a second outer surface of the substrate opposite the first outer surface, the antenna element being electrically connected to radio frequency (RF) circuitry within the IC chip through a conductive via extending within the substrate.

2. The antenna apparatus of claim 1, wherein the electrical connection of the antenna element to the RF circuitry within the IC chip is made through the first and second edge contacts, wherein, optionally, the antenna apparatus further comprises a conductive trace on or within the first outer surface and connecting to the first edge contact , and wherein, optionally, the electrical connection of the antenna element to the RF circuitry is made through the conductive via to the conductive trace.

3. The antenna apparatus of claim 1 or 2, wherein:

the cavity has a bottom surface facing a bottom surface of the IC chip; and

the conductive via extends to the bottom surface of the cavity and connects to a connection element at the bottom surface of the IC chip connected to the RF circuitry.

4. The antenna apparatus of claim 3, wherein the connection element comprises a solder bump, and wherein, optionally, the connection element comprises a conductive pillar.

5. The antenna apparatus of any one of claims 1 through 4, further comprising a ground plane within the substrate, wherein, optionally, the cavity has a bottom surface facing a bottom surface of the IC chip, and a portion of the ground plane is formed on the bottom surface of the cavity.

6. The antenna apparatus of any one of claims 1 through 5, wherein the antenna element is a first antenna element, and the antenna apparatus further comprising at least one second antenna element disposed at the second outer surface the at least one second antenna element being electrically connected to the RF circuitry within the IC chip through at least one further conductive via extending within the substrate and connected to the at least one second antenna element, wherein, optionally, the first and second antenna elements are part of an antenna array, and the RF circuitry within the IC chip comprises beamforming components for steering a beam formed by the antenna array.

7. The antenna apparatus of any one of claims 1 through 6, wherein the first and second edge contacts are soldered together.

8. The antenna apparatus of any one of claims 1 through 7, wherein the sidewall and the side surface have respective first and second interlocking features with complementary shapes, the first and second interlocking features being interlocked with one another.

9. The antenna apparatus of any one of claims 1 through 7, wherein the first interlocking feature is a recess in the sidewall or a protrusion from the sidewall, and the second interlocking feature is a complementary protrusion from the side surface or a complementary recess in the side surface, respectively.

10. The antenna apparatus of claim 8, wherein the first and second edge contacts are disposed on respective surfaces of the first and second interlocking features.

11. The antenna apparatus of claim 8, wherein:

the sidewall is a first sidewall, and the cavity having a second sidewall opposite the first sidewall, wherein a third edge contact is formed on the second sidewall; and

the side surface is a first side surface, the IC chip having a second side surface opposite the first side surface and a fourth edge contact on the second side surface connected to the third edge contact.

12. The antenna apparatus of any one of claims 1 through 11, wherein:

the cavity has a dual cavity structure with a first cavity portion directly below a second cavity portion, the first cavity portion having a first perimeter smaller than a second perimeter of the second cavity portion ;

the sidewall is a first sidewall defining a portion of the first cavity portion, the substrate having a second sidewall defining a portion of the second cavity portion, wherein a third edge contact is formed on the second sidewall;

the IC chip is a first IC chip disposed within the first cavity portion; and

the antenna apparatus further comprises a second IC chip disposed within the second cavity portion and having a fourth edge contact electrically connected to the third edge contact.

13. The antenna apparatus of claim 12, wherein the first IC chip and the second IC chip are electrically coupled to one another.

14. The antenna apparatus of claim 13, wherein the first IC chip comprises an amplifier electrically coupled to the antenna element, and the second IC chip comprises beamforming network circuitry coupled to the amplifier.

15. The antenna apparatus of claim 14, wherein the first IC chip comprises a first semiconductor material and the second IC chip comprises a second semiconductor material different from the first semiconductor IC material, and/or wherein a top surface of the first IC chip is separated from a bottom surface of the second IC chip by an air gap or an underfill material.