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(54) **METHOD AND SYSTEM FOR COMMUNICATING VIA LEAKY WAVE ANTENNAS WITHIN A FLIP-CHIP BONDED STRUCTURE**

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Publication Classification

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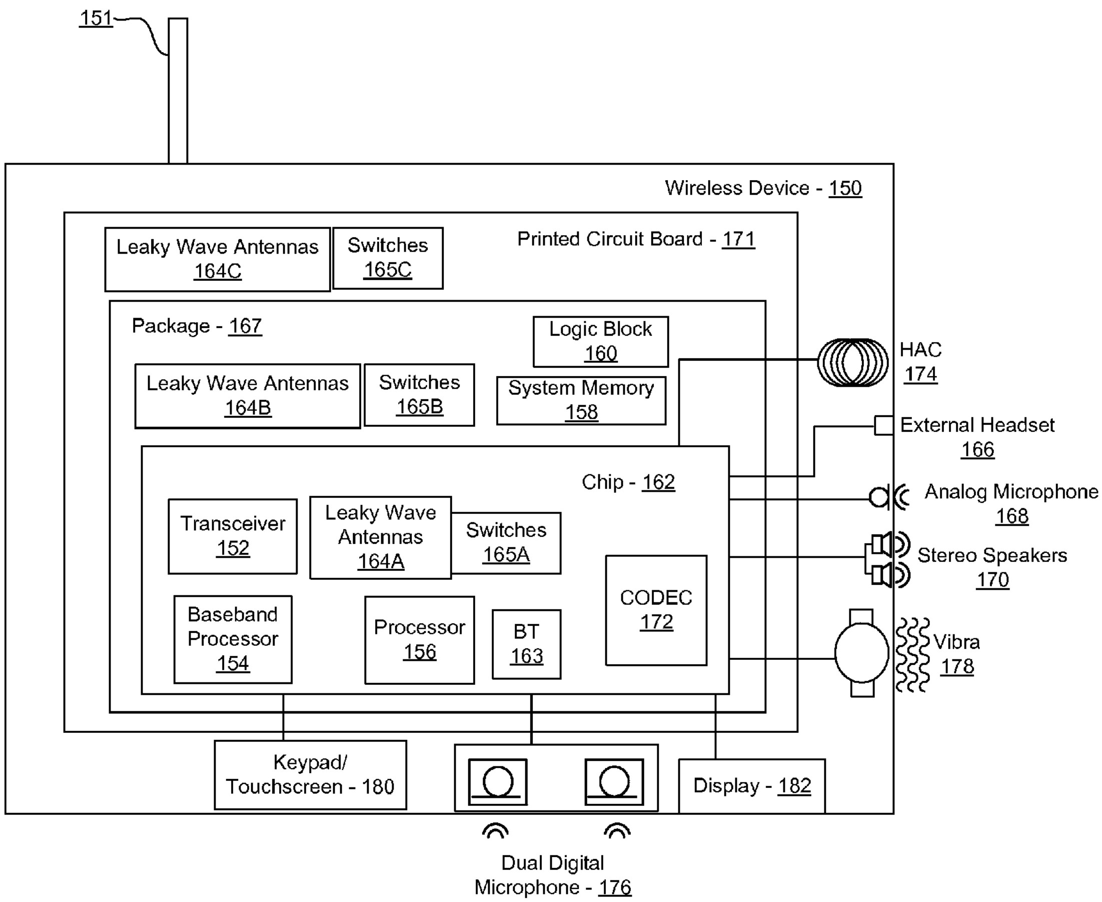
H04B 1/04 (2006.01)

(52) **U.S. Cl.** **455/129**

(57) **ABSTRACT**

Methods and systems for communicating via leaky wave antennas (LWAs) within a flip-chip bonded structure are disclosed and may include communicating RF signals in a wireless device including one or more LWAs between a plurality of support structures, the structures being coupled via flip-chip bonding. Low-frequency signals may be communicated via flip-chip bonding contacts. The RF signals may be communicated perpendicular to a surface and/or at a desired angle from the surface of the structures, which may include at least one of: an integrated circuit, an integrated circuit package, and a printed circuit board. The LWAs may include microstrip and/or coplanar waveguides where a cavity height of the LWAs may be configured by controlling spacing between conductive lines in the waveguides. The low-frequency signals may include DC bias voltages. The RF signals may be communicated from a single LWA to a plurality of LWAs.



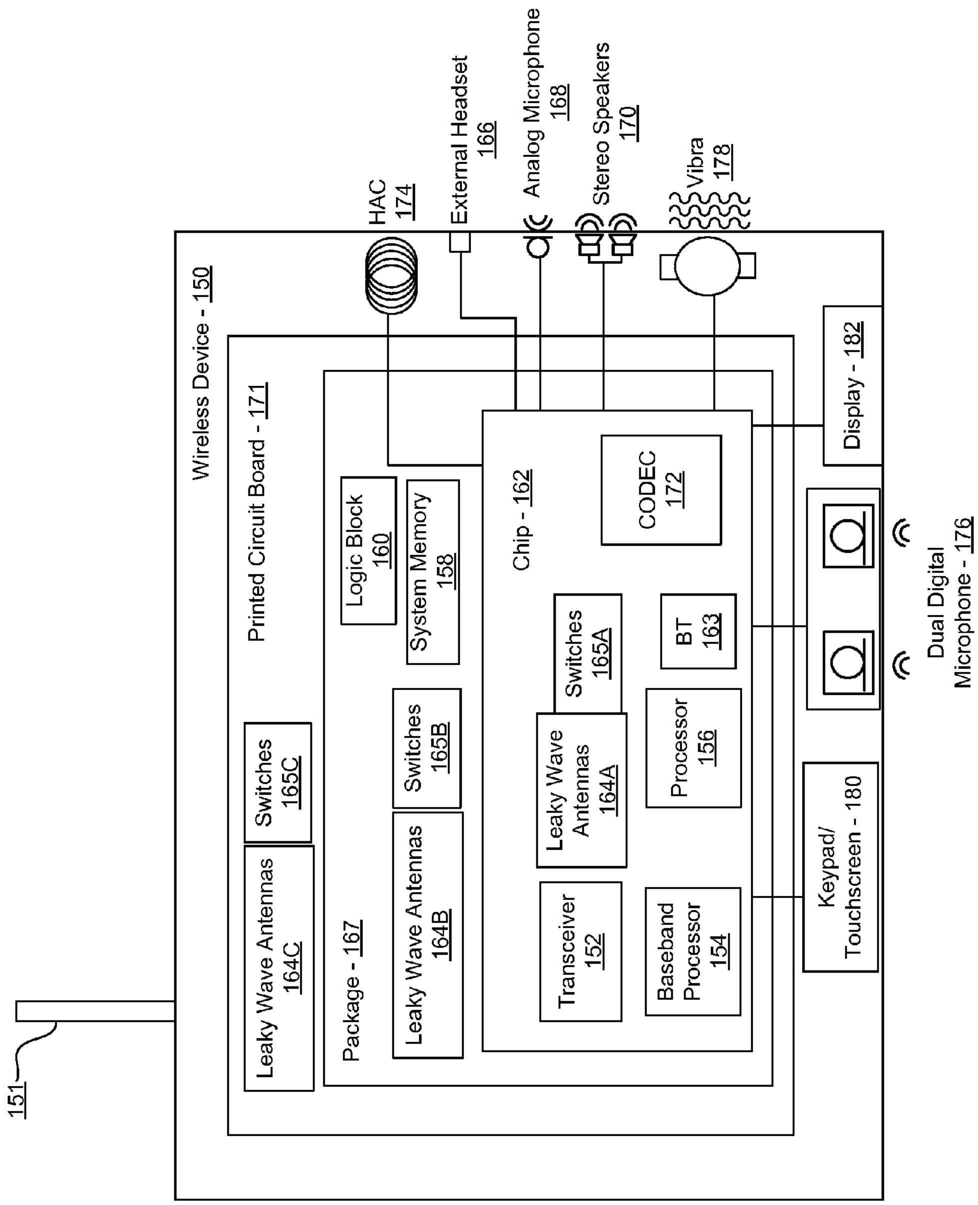

Wireless Device - 150
Printed Circuit Board - 171
Package - 167
Chip - 162
Leaky Wave Antennas 164C
Switches 165C
Leaky Wave Antennas 164B
Switches 165B
Logic Block 160
System Memory 158
Leaky Wave Antennas 164A
Switches 165A
Transceiver 152
Baseband Processor 154
Processor 156
BT 163
CODEC 172
HAC 174
External Headset 166
Analog Microphone 168
Stereo Speakers 170
Vibra 178
Display - 182
Dual Digital Microphone - 176
Keypad/ Touchscreen - 180
151

FIG. 1

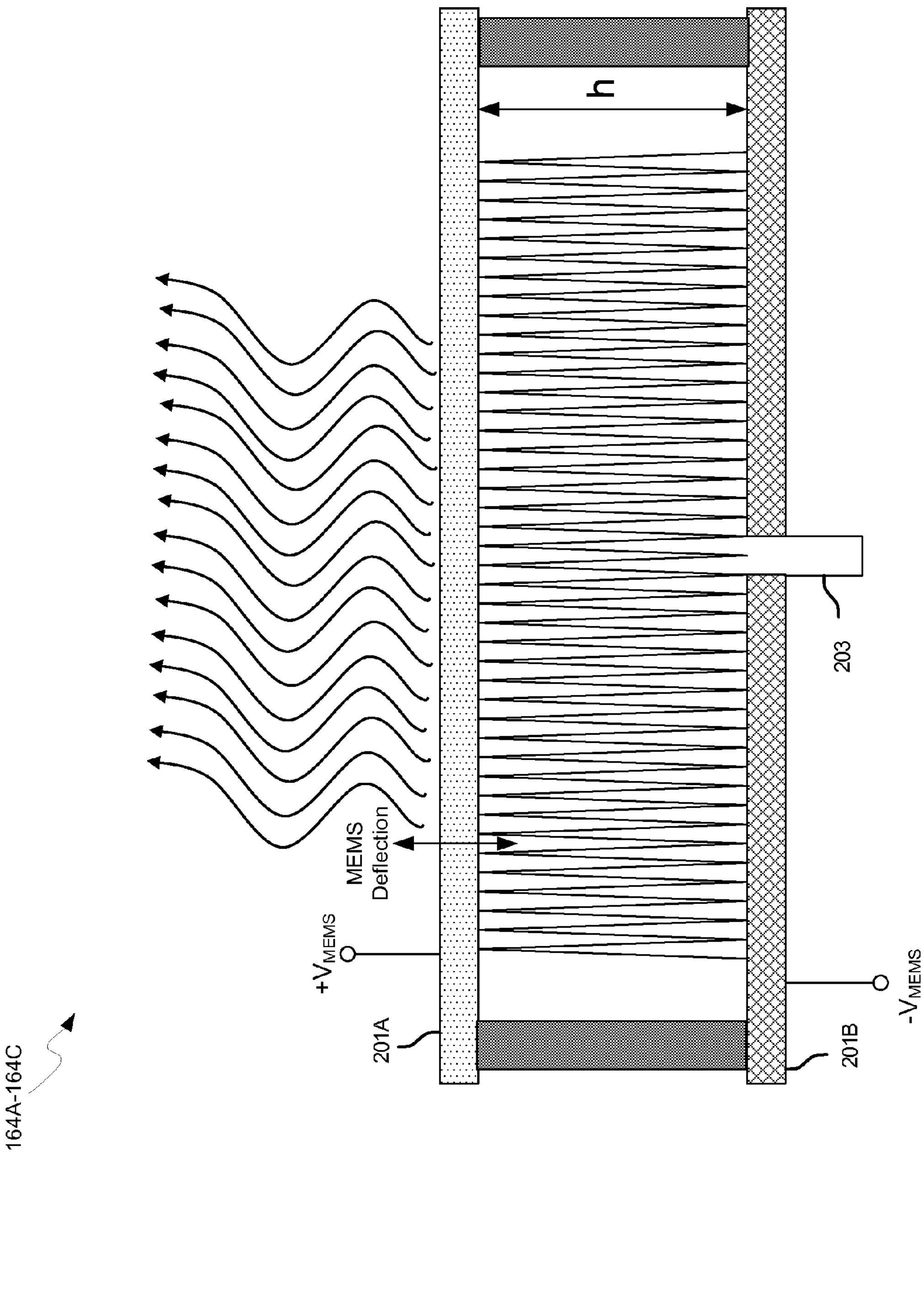

h
203
MEMS
Deflection
+V_{MEMS}
-V_{MEMS}
201A
201B
164A-164C

FIG. 2

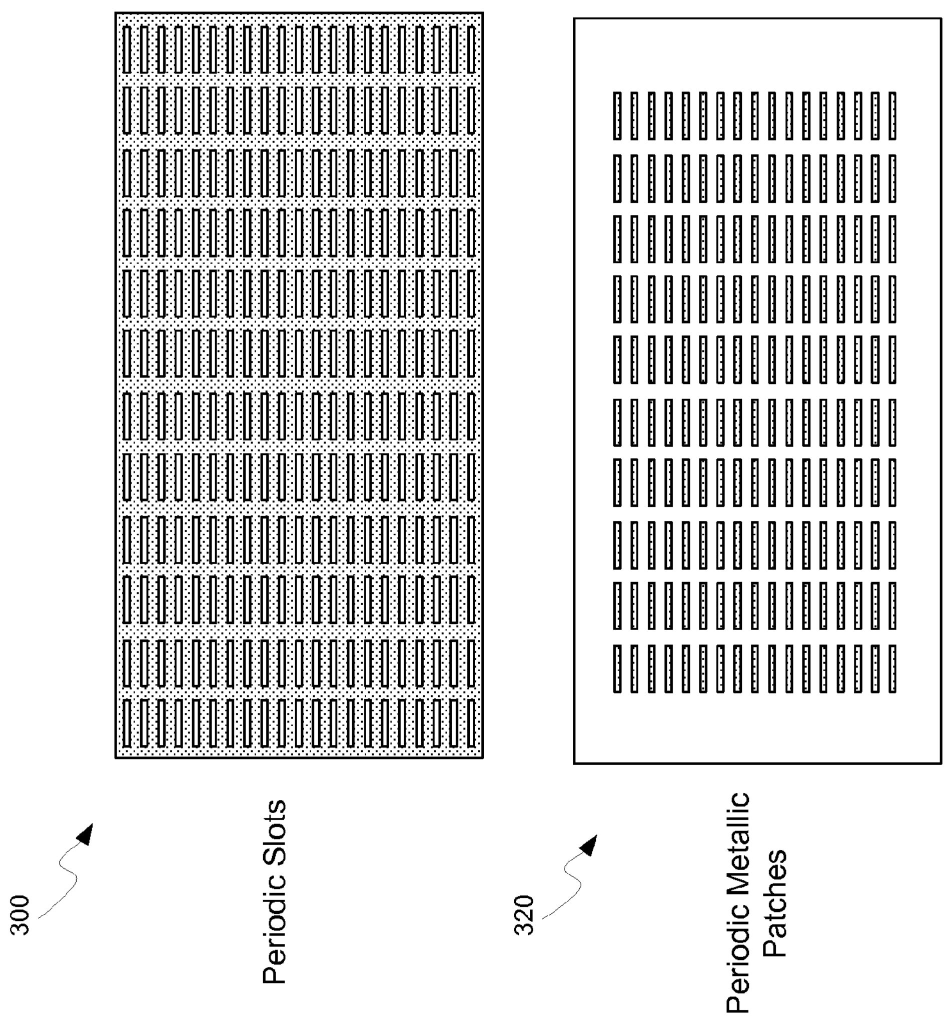


FIG. 3

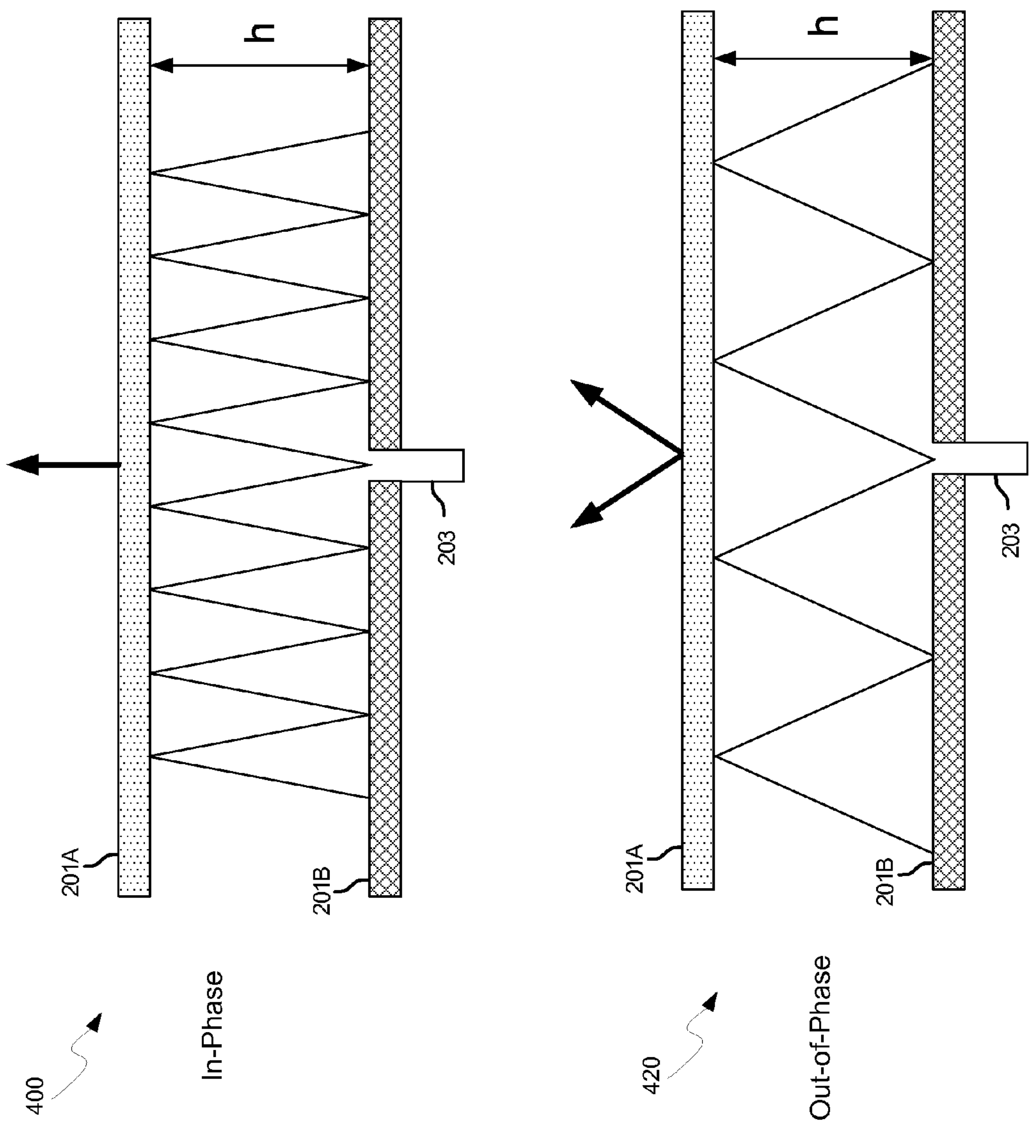


FIG. 4

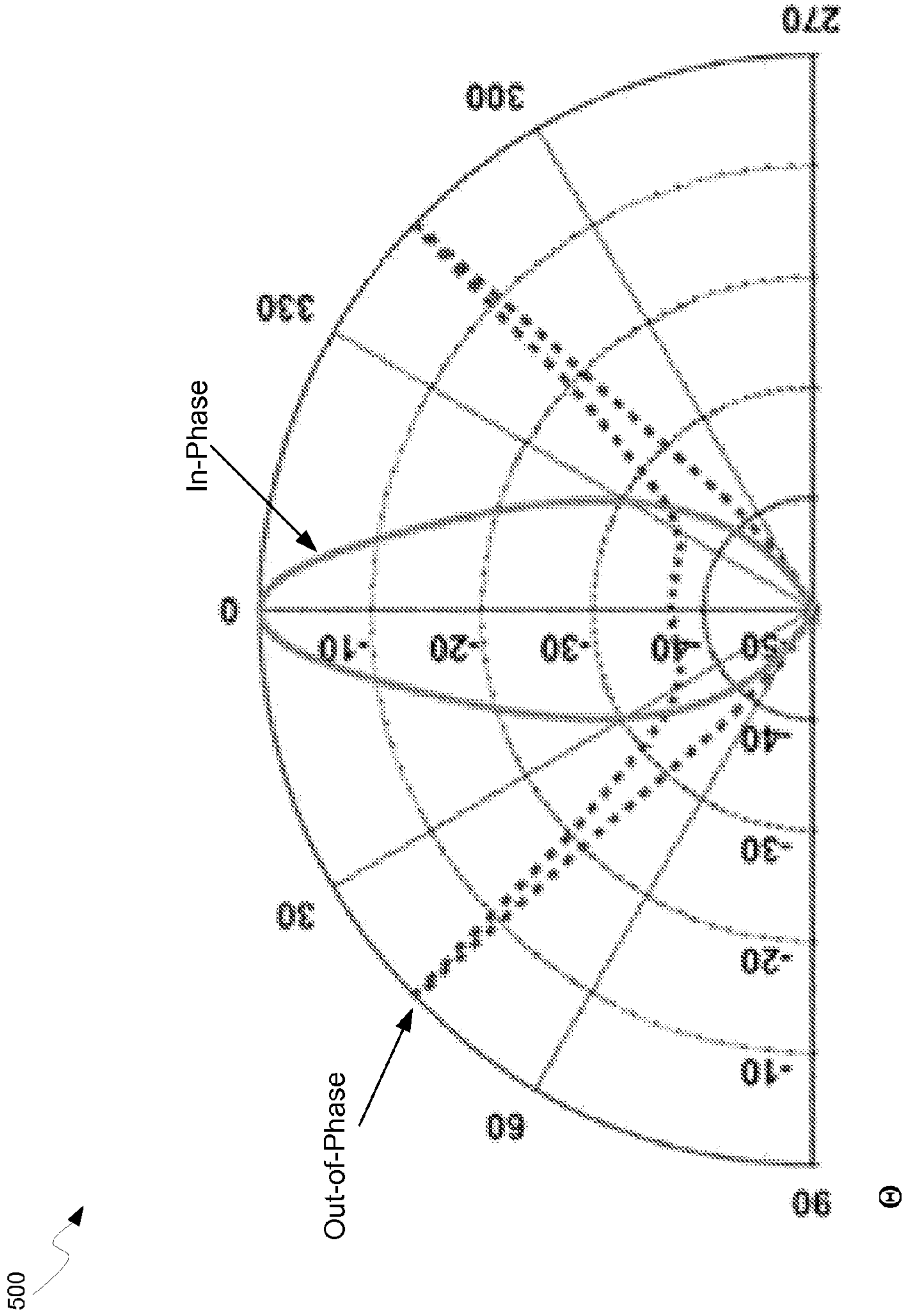


FIG. 5

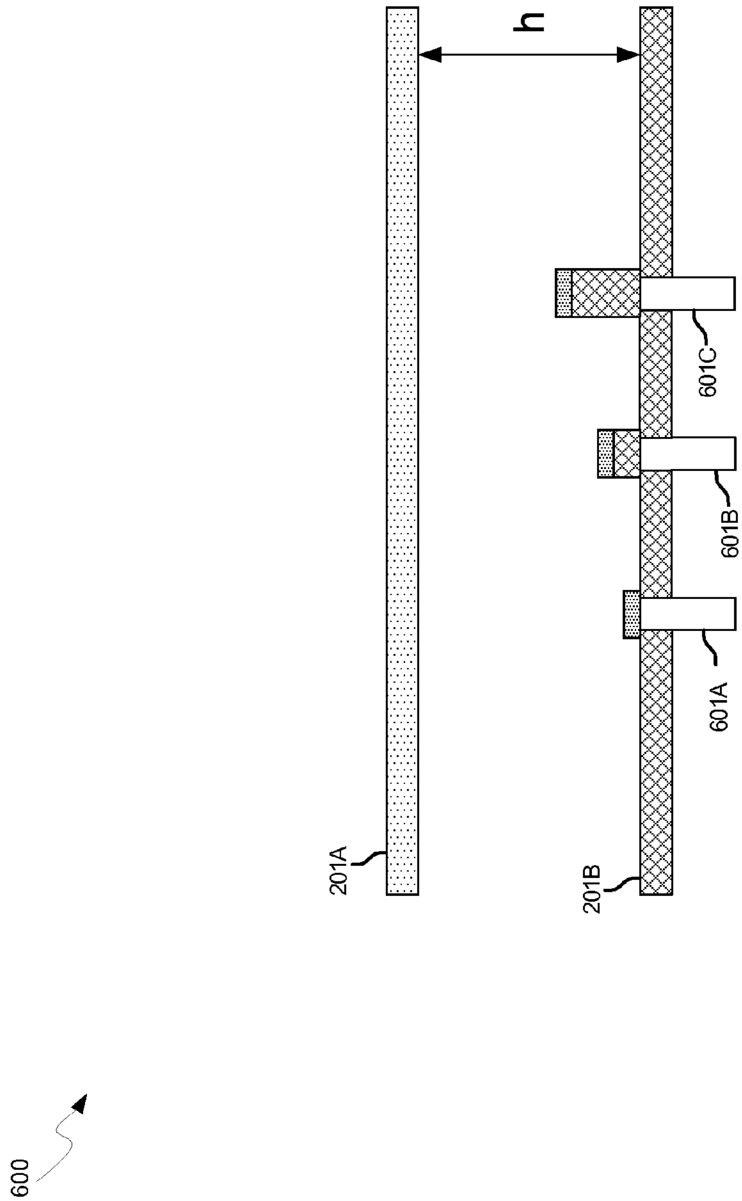


FIG. 6

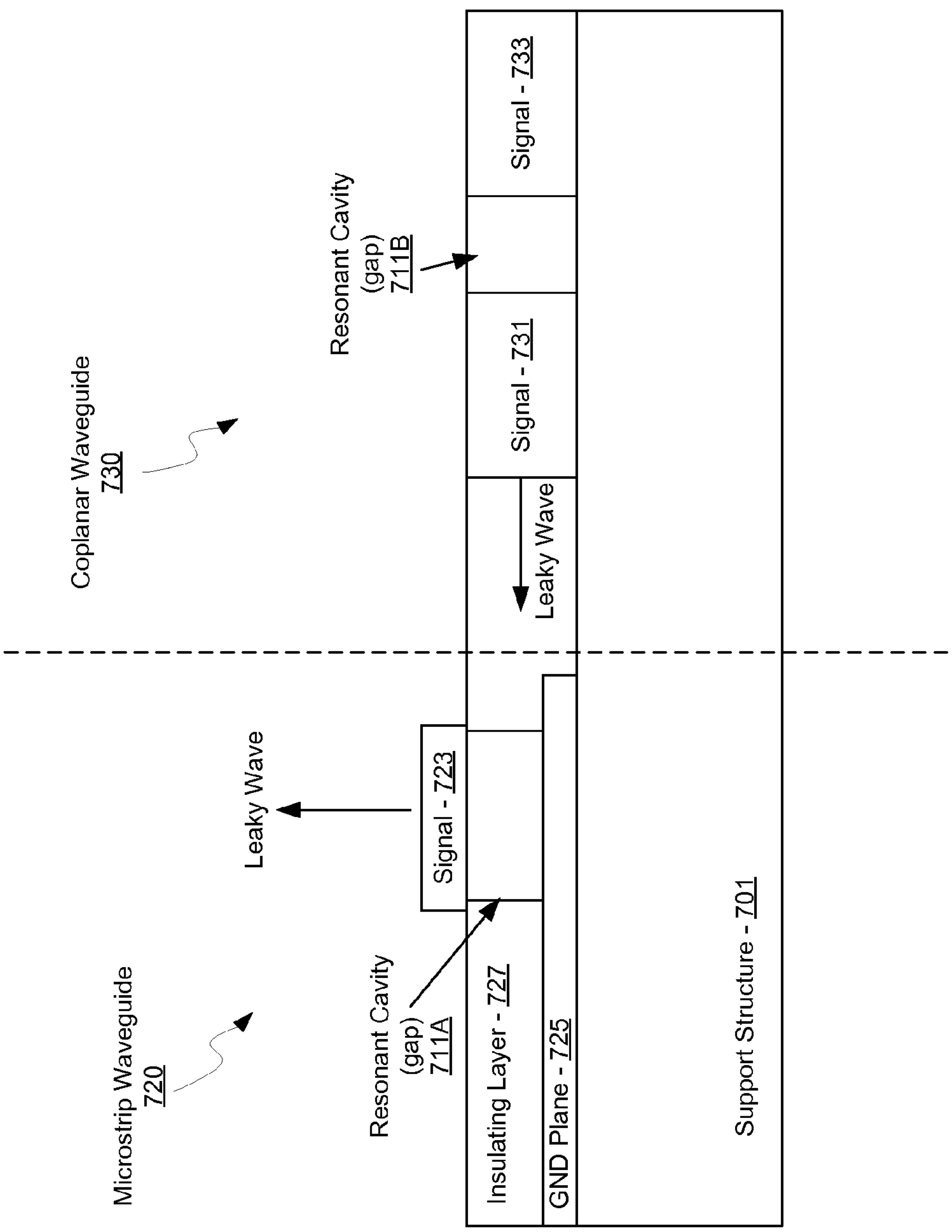

Coplanar Waveguide
730
Resonant Cavity
(gap)
711B
Signal - 733
Signal - 731
Leaky Wave
Microstrip Waveguide
720
Leaky Wave
Signal - 723
Resonant Cavity
(gap)
711A
Insulating Layer - 727
GND Plane - 725
Support Structure - 701

FIG. 7

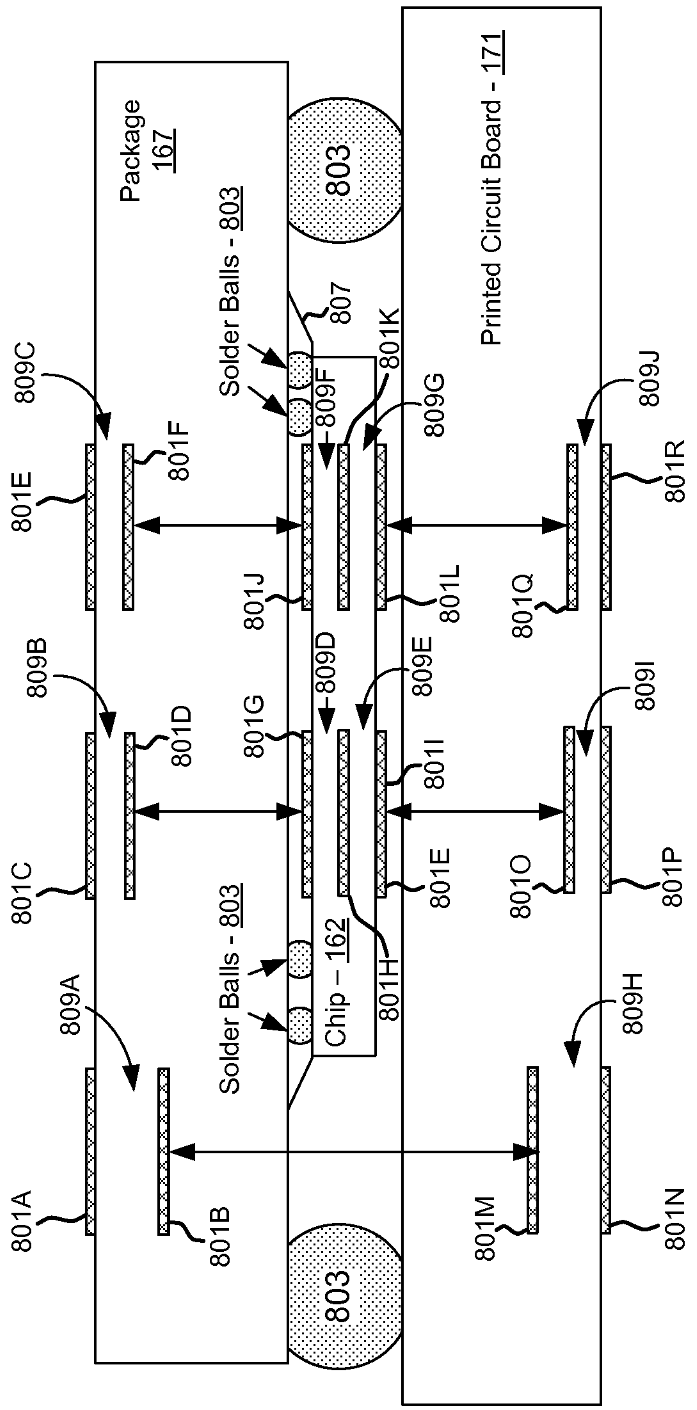

Package
167
Solder Balls - 803
803
807
Printed Circuit Board - 171
Chip – 162
809A
809B
809C
809D
809E
809F
809G
809H
809I
809J
801A
801B
801C
801D
801E
801F
801G
801H
801I
801J
801K
801L
801M
801N
801O
801P
801Q
801R

FIG. 8

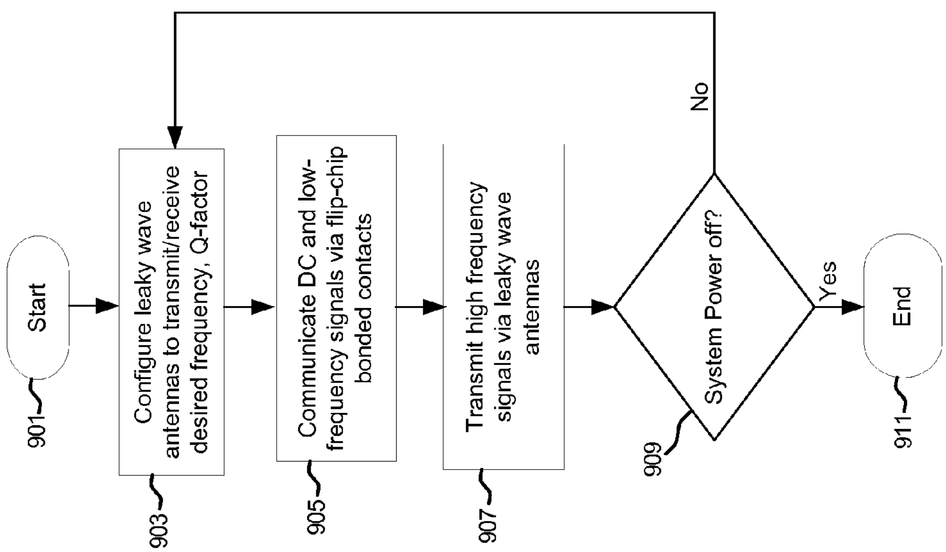

Start
901
Configure leaky wave antennas to transmit/receive desired frequency, Q-factor
903
Communicate DC and low-frequency signals via flip-chip bonded contacts
905
Transmit high frequency signals via leaky wave antennas
907
System Power off?
909
No
Yes
End
911

FIG. 9

METHOD AND SYSTEM FOR COMMUNICATING VIA LEAKY WAVE ANTENNAS WITHIN A FLIP-CHIP BONDED STRUCTURE

CROSS-REFERENCE TO RELATED APPLICATIONS/INCORPORATION BY REFERENCE

[0001] This application makes reference to, claims the benefit from, and claims priority to U.S. Provisional Application Ser. No. 61/246,618 filed on Sep. 29, 2009, and U.S. Provisional Application Ser. No. 61/185,245 filed on Jun. 9, 2009.

[0002] This application also makes reference to:

[0003] U.S. patent application Ser. No. 12/650,212 filed on Dec. 30, 2009;

[0004] U.S. patent application Ser. No. 12/650,295 filed on Dec. 30, 2009;

[0005] U.S. patent application Ser. No. 12/650,277 filed on Dec. 30, 2009;

[0006] U.S. patent application Ser. No. 12/650,192 filed on Dec. 30, 2009;

[0007] U.S. patent application Ser. No. 12/650,224 filed on Dec. 30, 2009;

[0008] U.S. patent application Ser. No. 12/650,176 filed on Dec. 30, 2009;

[0009] U.S. patent application Ser. No. 12/650,246 filed on Dec. 30, 2009;

[0010] U.S. patent application Ser. No. 12/650,292 filed on Dec. 30, 2009;

[0011] U.S. patent application Ser. No. 12/650,324 filed on Dec. 30, 2009;

[0012] U.S. patent application Ser. No. 12/708,366 filed on Feb. 18, 2010;

[0013] U.S. patent application Ser. No. ______ (Attorney Docket No. 21202US02) filed on even date herewith;

[0014] U.S. patent application Ser. No. ______ (Attorney Docket No. 21203US02) filed on even date herewith;

[0015] U.S. patent application Ser. No. ______ (Attorney Docket No. 21206US02) filed on even date herewith;

[0016] U.S. patent application Ser. No. ______ (Attorney Docket No. 21208US02) filed on even date herewith;

[0017] U.S. patent application Ser. No. ______ (Attorney Docket No. 21209US02) filed on even date herewith;

[0018] U.S. patent application Ser. No. ______ (Attorney Docket No. 21213US02) filed on even date herewith;

[0019] U.S. patent application Ser. No. ______ (Attorney Docket No. 21218US02) filed on even date herewith; and

[0020] U.S. patent application Ser. No. ______ (Attorney Docket No. 21220US02) filed on even date herewith.

[0021] Each of the above stated applications is hereby incorporated herein by reference in its entirety.

FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0022] [Not Applicable]

MICROFICHE/COPYRIGHT REFERENCE

[0023] [Not Applicable]

FIELD OF THE INVENTION

[0024] Certain embodiments of the invention relate to wireless communication. More specifically, certain embodiments of the invention relate to a method and system for communicating via leaky wave antennas within a flip-chip bonded structure.

BACKGROUND OF THE INVENTION

[0025] Mobile communications have changed the way people communicate and mobile phones have been transformed from a luxury item to an essential part of every day life. The use of mobile phones is today dictated by social situations, rather than hampered by location or technology. While voice connections fulfill the basic need to communicate, and mobile voice connections continue to filter even further into the fabric of every day life, the mobile Internet is the next step in the mobile communication revolution. The mobile Internet is poised to become a common source of everyday information, and easy, versatile mobile access to this data will be taken for granted.

[0026] As the number of electronic devices enabled for wireline and/or mobile communications continues to increase, significant efforts exist with regard to making such devices more power efficient. For example, a large percentage of communications devices are mobile wireless devices and thus often operate on battery power. Additionally, transmit and/or receive circuitry within such mobile wireless devices often account for a significant portion of the power consumed within these devices. Moreover, in some conventional communication systems, transmitters and/or receivers are often power inefficient in comparison to other blocks of the portable communication devices. Accordingly, these transmitters and/or receivers have a significant impact on battery life for these mobile wireless devices.

[0027] Further limitations and disadvantages of conventional and traditional approaches will become apparent to one of skill in the art, through comparison of such systems with the present invention as set forth in the remainder of the present application with reference to the drawings.

BRIEF SUMMARY OF THE INVENTION

[0028] A system and/or method for communicating via leaky wave antennas within a flip-chip bonded structure as shown in and/or described in connection with at least one of the figures, as set forth more completely in the claims.

[0029] Various advantages, aspects and novel features of the present invention, as well as details of an illustrated embodiment thereof, will be more fully understood from the following description and drawings.

BRIEF DESCRIPTION OF SEVERAL VIEWS OF THE DRAWINGS

[0030] FIG. **1** is a block diagram of an exemplary wireless system with flip-chip bonded leaky wave antennas, which may be utilized in accordance with an embodiment of the invention.

[0031] FIG. **2** is a block diagram illustrating an exemplary leaky wave antenna, in accordance with an embodiment of the invention.

[0032] FIG. **3** is a block diagram illustrating a plan view of exemplary partially reflective surfaces for a leaky wave antenna, in accordance with an embodiment of the invention.

[0033] FIG. **4** is a block diagram illustrating an exemplary phase dependence of a leaky wave antenna, in accordance with an embodiment of the invention.

[0034] FIG. **5** is a block diagram illustrating exemplary in-phase and out-of-phase beam shapes for a leaky wave antenna, in accordance with an embodiment of the invention.

[0035] FIG. **6** is a block diagram illustrating a leaky wave antenna with variable input impedance feed points, in accordance with an embodiment of the invention.

[0036] FIG. **7** is a block diagram illustrating a cross-sectional view of coplanar and microstrip waveguides, in accordance with an embodiment of the invention.

[0037] FIG. **8** is a diagram illustrating a cross-sectional view of flip-chip bonded structures with integrated leaky wave antennas, in accordance with an embodiment of the invention.

[0038] FIG. **9** is a block diagram illustrating exemplary steps for communicating signals via flip-chip bonded structures with integrated leaky wave antennas, in accordance with an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0039] Certain aspects of the invention may be found in a method and system for communicating via leaky wave antennas within a flip-chip bonded structure. Exemplary aspects of the invention may comprise communicating RF signals in a wireless device between a plurality of support structures with one or more integrated leaky wave antennas integrated within and/or on the support structures. The support structures may be coupled via flip-chip-bonding. Low-frequency signals may be communicated via contacts defined via the flip-chip bonding. The RF signals may be communicated between the support structures perpendicular to a surface of the structures. The leaky wave antennas may be configured to transmit the wireless signals at a desired angle from the surface of the support structures, which may comprise at least one of: an integrated circuit, an integrated circuit package, and a printed circuit board. The leaky wave antennas may comprise microstrip waveguides where a cavity height of the leaky wave antennas may be configured by controlling spacing between conductive lines in the microstrip waveguides. The leaky wave antennas may comprise coplanar waveguides where a cavity height of the leaky wave antennas may be configured by controlling spacing between conductive lines in the coplanar waveguides. The low-frequency signals may comprise DC bias voltages. The RF signals may be communicated from a single leaky wave antenna to a plurality of leaky wave antennas.

[0040] FIG. **1** is a block diagram of an exemplary wireless system with flip-chip bonded leaky wave antennas, which may be utilized in accordance with an embodiment of the invention. Referring to FIG. **1**, the wireless device **150** may comprise an antenna **151**, a transceiver **152**, a baseband processor **154**, a processor **156**, a system memory **158**, a logic block **160**, a chip **162**, leaky wave antennas **164**A-**164**C, switches **165**A-**165**C, an external headset port **166**, and a package **167**. The wireless device **150** may also comprise an analog microphone **168**, integrated hands-free (IHF) stereo speakers **170**, a printed circuit board **171**, a hearing aid compatible (HAC) coil **174**, a dual digital microphone **176**, a vibration transducer **178**, a keypad and/or touchscreen **180**, and a display **182**.

[0041] The transceiver **152** may comprise suitable logic, circuitry, interface(s), and/or code that may be enabled to modulate and upconvert baseband signals to RF signals for transmission by one or more antennas, which may be represented generically by the antenna **151**. The transceiver **152** may also be enabled to downconvert and demodulate received RF signals to baseband signals. The RF signals may be received by one or more antennas, which may be represented generically by the antenna **151**, or the leaky wave antennas **164**A-**164**C. Different wireless systems may use different antennas for transmission and reception. The transceiver **152** may be enabled to execute other functions, for example, filtering the baseband and/or RF signals, and/or amplifying the baseband and/or RF signals. Although a single transceiver **152** is shown, the invention is not so limited. Accordingly, the transceiver **152** may be implemented as a separate transmitter and a separate receiver. In addition, there may be a plurality of transceivers, transmitters and/or receivers. In this regard, the plurality of transceivers, transmitters and/or receivers may enable the wireless device **150** to handle a plurality of wireless protocols and/or standards including cellular, WLAN and PAN. Wireless technologies handled by the wireless device **150** may comprise GSM, CDMA, CDMA2000, WCDMA, GMS, GPRS, EDGE, WIMAX, WLAN, 3GPP, UMTS, BLUETOOTH, and ZigBee, for example.

[0042] The baseband processor **154** may comprise suitable logic, circuitry, interface(s), and/or code that may be enabled to process baseband signals for transmission via the transceiver **152** and/or the baseband signals received from the transceiver **152**. The processor **156** may be any suitable processor or controller such as a CPU, DSP, ARM, or any type of integrated circuit processor. The processor **156** may comprise suitable logic, circuitry, and/or code that may be enabled to control the operations of the transceiver **152** and/or the baseband processor **154**. For example, the processor **156** may be utilized to update and/or modify programmable parameters and/or values in a plurality of components, devices, and/or processing elements in the transceiver **152** and/or the baseband processor **154**. At least a portion of the programmable parameters may be stored in the system memory **158**.

[0043] Control and/or data information, which may comprise the programmable parameters, may be transferred from other portions of the wireless device **150**, not shown in FIG. **1**, to the processor **156**. Similarly, the processor **156** may be enabled to transfer control and/or data information, which may include the programmable parameters, to other portions of the wireless device **150**, not shown in FIG. **1**, which may be part of the wireless device **150**.

[0044] The processor **156** may utilize the received control and/or data information, which may comprise the programmable parameters, to determine an operating mode of the transceiver **152**. For example, the processor **156** may be utilized to select a specific frequency for a local oscillator, a specific gain for a variable gain amplifier, configure the local oscillator and/or configure the variable gain amplifier for operation in accordance with various embodiments of the invention. Moreover, the specific frequency selected and/or parameters needed to calculate the specific frequency, and/or the specific gain value and/or the parameters, which may be utilized to calculate the specific gain, may be stored in the system memory **158** via the processor **156**, for example. The information stored in system memory **158** may be transferred to the transceiver **152** from the system memory **158** via the processor **156**.

[0045] The system memory **158** may comprise suitable logic, circuitry, interface(s), and/or code that may be enabled to store a plurality of control and/or data information, including parameters needed to calculate frequencies and/or gain, and/or the frequency value and/or gain value. The system memory **158** may store at least a portion of the programmable parameters that may be manipulated by the processor **156**.

[0046] The logic block **160** may comprise suitable logic, circuitry, interface(s), and/or code that may enable controlling of various functionalities of the wireless device **150**. For example, the logic block **160** may comprise one or more state machines that may generate signals to control the transceiver **152** and/or the baseband processor **154**. The logic block **160** may also comprise registers that may hold data for controlling, for example, the transceiver **152** and/or the baseband processor **154**. The logic block **160** may also generate and/or store status information that may be read by, for example, the processor **156**. Amplifier gains and/or filtering characteristics, for example, may be controlled by the logic block **160**.

[0047] The BT radio/processor **163** may comprise suitable circuitry, logic, interface(s), and/or code that may enable transmission and reception of Bluetooth signals. The BT radio/processor **163** may enable processing and/or handling of BT baseband signals. In this regard, the BT radio/processor **163** may process or handle BT signals received and/or BT signals transmitted via a wireless communication medium. The BT radio/processor **163** may also provide control and/or feedback information to/from the baseband processor **154** and/or the processor **156**, based on information from the processed BT signals. The BT radio/processor **163** may communicate information and/or data from the processed BT signals to the processor **156** and/or to the system memory **158**. Moreover, the BT radio/processor **163** may receive information from the processor **156** and/or the system memory **158**, which may be processed and transmitted via the wireless communication medium a Bluetooth headset, for example

[0048] The CODEC **172** may comprise suitable circuitry, logic, interface(s), and/or code that may process audio signals received from and/or communicated to input/output devices. The input devices may be within or communicatively coupled to the wireless device **150**, and may comprise the analog microphone **168**, the stereo speakers **170**, the hearing aid compatible (HAC) coil **174**, the dual digital microphone **176**, and the vibration transducer **178**, for example. The CODEC **172** may be operable to up-convert and/or down-convert signal frequencies to desired frequencies for processing and/or transmission via an output device. The CODEC **172** may enable utilizing a plurality of digital audio inputs, such as 16 or 18-bit inputs, for example. The CODEC **172** may also enable utilizing a plurality of data sampling rate inputs. For example, the CODEC **172** may accept digital audio signals at sampling rates such as 8 kHz, 11.025 kHz, 12 kHz, 16 kHz, 22.05 kHz, 24 kHz, 32 kHz, 44.1 kHz, and/or 48 kHz. The CODEC **172** may also support mixing of a plurality of audio sources. For example, the CODEC **172** may support audio sources such as general audio, polyphonic ringer, I^2S FM audio, vibration driving signals, and voice. In this regard, the general audio and polyphonic ringer sources may support the plurality of sampling rates that the audio CODEC **172** is enabled to accept, while the voice source may support a portion of the plurality of sampling rates, such as 8 kHz and 16 kHz, for example.

[0049] The chip **162** may comprise an integrated circuit with multiple functional blocks integrated within, such as the transceiver **152**, the processor **156**, the baseband processor **154**, the BT radio/processor **163**, and the CODEC **172**. The number of functional blocks integrated in the chip **162** is not limited to the number shown in FIG. **1**. Accordingly, any number of blocks may be integrated on the chip **162** depending on chip space and wireless device **150** requirements, for example. The chip **162** may be flip-chip bonded, for example, to the package **167**, as described further with respect to FIG. **8**.

[0050] The leaky wave antennas **164**A-**164**C may comprise a resonant cavity with a highly reflective surface and a lower reflectivity surface, and may be integrated in and/or on the chip **162**, the package **167**, and/or the printed circuit board **171**. The lower reflectivity surface may allow the resonant mode to "leak" out of the cavity. The lower reflectivity surface of the leaky wave antennas **164**A-**164**C may be configured with slots in a metal surface, or a pattern of metal patches, as described further in FIGS. **2** and **3**. The physical dimensions of the leaky wave antennas **164**A-**164**C may be configured to optimize bandwidth of transmission and/or the beam pattern radiated. By integrating the leaky wave antennas **164**A on the chip **162**, the package **167**, and/or the printed circuit board **171** and flip-chip bonding the chip **162** to the package **167** and the package **167** to the printed circuit board **171**, wireless signals may be communicated between devices in the chip **162**, the package **167**, and the printed circuit board **171**.

[0051] In an exemplary embodiment of the invention, the leaky wave antennas **164**A-**164**C may comprise a plurality of leaky wave antennas integrated in and/or on the chip **162**, the package **167**, and/or printed circuit board **171**. The leaky wave antennas **164**A-**164**C may be operable to transmit and/or receive wireless signals at or near 60 GHz, for example, due to the cavity length of the devices being on the order of millimeters. The leaky wave antennas **164**A may be configured to transmit in different directions, including in the lateral direction parallel to the surface of the chip **162**, the package **167**, and the printed circuit board **171**, thereby enabling communication between regions of the chip **162**, the package **167**, and the printed circuit board **171**.

[0052] The switches **165**A-**165**C may comprise switches such as CMOS or MEMS switches that may be operable to switch different antennas of the leaky wave antennas **164**A-**164**C to the transceiver **152** and/or switch elements in and/or out of the leaky wave antennas **164**A-**164**C, such as the patches and slots described in FIG. **3**. In another embodiment of the invention, the switches **165**A-**165**C may comprise MEMS devices that enable MEMS actuation of reflective surfaces in the leaky wave antennas **164**A-**164**C. Accordingly, the resonant frequency and/or the angle of transmission/reception may be configured for the leaky wave antennas **164**A-**164**C.

[0053] The external headset port **166** may comprise a physical connection for an external headset to be communicatively coupled to the wireless device **150**. The analog microphone **168** may comprise suitable circuitry, logic, interface(s), and/or code that may detect sound waves and convert them to electrical signals via a piezoelectric effect, for example. The electrical signals generated by the analog microphone **168** may comprise analog signals that may require analog to digital conversion before processing.

[0054] The package **167** may comprise a ceramic package, a circuit board, or other support structure for the chip **162** and other components of the wireless device **150**. In this regard, the chip **162** may be bonded to the package **167**. The package **167** may comprise insulating and conductive material, for example, and may provide isolation between electrical components mounted on the package **167**.

[0055] The printed circuit board **171** may comprise an essentially electrically insulating material with conductive traces integrated within and/or on the surface for the interconnection of devices affixed to the printed circuit board **171**. For example, the package **167** may be affixed to the printed circuit board **171** utilizing flip-chip bonding. In addition, the leaky wave antennas **164**C and the switches **165**C may be integrated in and/or on the printed circuit board **171** to enable communication of RF signals between the printed circuit board **171** and devices in the chip **162** and the package **167**. The number of devices on the printed circuit board **171** is not limited to the number shown in FIG. **1**. Accordingly, any number of chips, packages, and other devices may be integrated, depending on space requirements and desired functionality.

[0056] The stereo speakers **170** may comprise a pair of speakers that may be operable to generate audio signals from electrical signals received from the CODEC **172**. The HAC coil **174** may comprise suitable circuitry, logic, and/or code that may enable communication between the wireless device **150** and a T-coil in a hearing aid, for example. In this manner, electrical audio signals may be communicated to a user that utilizes a hearing aid, without the need for generating sound signals via a speaker, such as the stereo speakers **170**, and converting the generated sound signals back to electrical signals in a hearing aid, and subsequently back into amplified sound signals in the user's ear, for example.

[0057] The dual digital microphone **176** may comprise suitable circuitry, logic, interface(s), and/or code that may be operable to detect sound waves and convert them to electrical signals. The electrical signals generated by the dual digital microphone **176** may comprise digital signals, and thus may not require analog to digital conversion prior to digital processing in the CODEC **172**. The dual digital microphone **176** may enable beamforming capabilities, for example.

[0058] The vibration transducer **178** may comprise suitable circuitry, logic, interface(s), and/or code that may enable notification of an incoming call, alerts and/or message to the wireless device **150** without the use of sound. The vibration transducer may generate vibrations that may be in synch with, for example, audio signals such as speech or music.

[0059] In operation, control and/or data information, which may comprise the programmable parameters, may be transferred from other portions of the wireless device **150**, not shown in FIG. **1**, to the processor **156**. Similarly, the processor **156** may be enabled to transfer control and/or data information, which may include the programmable parameters, to other portions of the wireless device **150**, not shown in FIG. **1**, which may be part of the wireless device **150**.

[0060] The processor **156** may utilize the received control and/or data information, which may comprise the programmable parameters, to determine an operating mode of the transceiver **152**. For example, the processor **156** may be utilized to select a specific frequency for a local oscillator, a specific gain for a variable gain amplifier, configure the local oscillator and/or configure the variable gain amplifier for operation in accordance with various embodiments of the invention. Moreover, the specific frequency selected and/or parameters needed to calculate the specific frequency, and/or the specific gain value and/or the parameters, which may be utilized to calculate the specific gain, may be stored in the system memory **158** via the processor **156**, for example. The information stored in system memory **158** may be transferred to the transceiver **152** from the system memory **158** via the processor **156**.

[0061] The CODEC **172** in the wireless device **150** may communicate with the processor **156** in order to transfer audio data and control signals. Control registers for the CODEC **172** may reside within the processor **156**. The processor **156** may exchange audio signals and control information via the system memory **158**. The CODEC **172** may up-convert and/or down-convert the frequencies of multiple audio sources for processing at a desired sampling rate.

[0062] The leaky wave antennas **164**A-**164**C may be operable to transmit and/or receive wireless signals between the chip **162**, the package **167**, and the printed circuit board **171**. Resonant cavities may be configured between reflective surfaces in and/or on the chip **162**, the package **167**, and/or the printed circuit board **171** so that signals may be transmitted and/or received from any location without requiring large areas needed for conventional antennas and associated circuitry. Coplanar waveguide structures may be utilized to enable the communication of signals in the horizontal direction within the chip **162**, the package **167**, and/or the printed circuit board **171**.

[0063] The cavity height of the leaky wave antennas **164**A-**164**C may be configured to control the frequency of the signals that may be transmitted and/or received. Accordingly, the reflective surfaces may be controlled to provide different heights in the chip **162**, the package **167**, and/or the printed circuit board **171**, thereby configuring leaky wave antennas with different resonant frequencies.

[0064] The leaky wave antennas **164**A may be operable to transmit and/or receive signals to and from the chip **162**. In this manner, high frequency traces to an external antenna, such as the antenna **151**, may be reduced and/or eliminated for higher frequency signals.

[0065] Different frequency signals may be transmitted and/or received by the leaky wave antennas **164**A-**164**C by selectively coupling the transceiver **152** to leaky wave antennas with different cavity heights. For example, a leaky wave antenna with reflective surfaces on the top and the bottom of the printed circuit board **171** may have the largest cavity height, and thus provide the lowest resonant frequency. Conversely, a leaky wave antenna with both reflective surfaces in the same plane of the chip **162**, as in a coplanar waveguide configuration, for example, may provide a higher resonant frequency.

[0066] FIG. **2** is a block diagram illustrating an exemplary leaky wave antenna, in accordance with an embodiment of the invention. Referring to FIG. **2**, there is shown the leaky wave antennas **164**A-**164**C comprising a partially reflective surface **201**A, a reflective surface **201**B, and a feed point **203**. The space between the partially reflective surface **201**A and the reflective surface **201**B may be filled with dielectric material, for example, and the height, h, between the partially reflective surface **201**A and the reflective surface **201**B may be utilized to configure the frequency of transmission of the leaky wave antennas **164**A-**164**C. In another embodiment of the invention, an air gap may be integrated in the space between the partially reflective surface **201**A and the reflective surface **201**B to enable MEMS actuation. There is also shown (microelectromechanical systems) MEMS bias voltages, $+V_{MEMS}$ and $-V_{MEMS}$.

[0067] The feed point **203** may comprise an input terminal for applying an input voltage to the leaky wave antennas

164A-164C. The invention is not limited to a single feed point 203, as there may be any amount of feed points for different phases of signal or a plurality of signal sources, for example, to be applied to the leaky wave antennas 164A-164C.

[0068] In an embodiment of the invention, the height, h, may be one-half the wavelength of the desired transmitted mode from the leaky wave antennas 164A-164C. In this manner, the phase of an electromagnetic mode that traverses the cavity twice may be coherent with the input signal at the feed point 203, thereby configuring a resonant cavity known as a Fabry-Perot cavity. The magnitude of the resonant mode may decay exponentially in the lateral direction from the feed point 203, thereby reducing or eliminating the need for confinement structures to the sides of the leaky wave antennas 164. The input impedance of the leaky wave antennas 164A-164C may be configured by the vertical placement of the feed point 203, as described further in FIG. 6.

[0069] In operation, a signal to be transmitted via a power amplifier in the transceiver 152 may be communicated to the feed point 203 of the leaky wave antennas 164A-164C with a frequency f. The cavity height, h, may be configured to correlate to one half the wavelength of a harmonic of the signal of frequency f. The signal may traverse the height of the cavity and may be reflected by the partially reflective surface 201A, and then traverse the height back to the reflective surface 201 B. Since the wave will have travelled a distance corresponding to a full wavelength, constructive interference may result and a resonant mode may thereby be established.

[0070] Leaky wave antennas may enable the configuration of high gain antennas without the need for a large array of antennas which require a complex feed network and suffer from loss due to feed lines. The leaky wave antennas 164A-164C may be operable to transmit and/or receive wireless signals via conductive layers in and/or on chip 162, the package 167, and the printed circuit board 171. In this manner, the resonant frequency of the cavity may cover a wider range due to the larger size of the printed circuit board 171, compared to the package 167, and similarly compared to the chip 162, without requiring large areas needed for conventional antennas and associated circuitry. Accordingly, RF signals may be communicated between the chip 162, the package 167, and the printed circuit board 171.

[0071] In an exemplary embodiment of the invention, the frequency of transmission and/or reception of the leaky wave antennas 164A-164C may be configured by selecting one of the leaky wave antennas 164A-164C with the appropriate cavity height for the desired frequency and with an appropriate direction of transmission and/or reception to enable communication between desired locations. Leaky wave antennas integrated on the chip 162, the package 167, and the printed circuit board 171 may comprise coplanar waveguide structures, either on a surface and/or integrated within the chip 162, the package 167, and the printed circuit board 171, such that wireless signals may be communicated in a horizontal direction, enabling wireless communication between regions of the structure. Additionally, leaky wave antennas may be integrated with the direction of the leaked signal coming out of the surface of the chip 162, thereby enabling communication between the chip 162 and external devices on the package 167, the printed circuit board 171, and/or other external devices.

[0072] In another embodiment of the invention, the cavity height, h, may be configured by MEMS actuation. For example, the bias voltages $+V_{MEMS}$ and $-V_{MEMS}$ may deflect one or both of the reflective surfaces 201A and 201 B compared to zero bias, thereby configuring the resonant frequency of the cavity.

[0073] FIG. 3 is a block diagram illustrating a plan view of exemplary partially reflective surfaces for a leaky wave antenna, in accordance with an embodiment of the invention. Referring to FIG. 3, there is shown a partially reflective surface 300 comprising periodic slots in a metal surface, and a partially reflective surface 320 comprising periodic metal patches. The partially reflective surfaces 300/320 may comprise different embodiments of the partially reflective surface 201A described with respect to FIG. 2.

[0074] The spacing, dimensions, shape, and orientation of the slots and/or patches in the partially reflective surfaces 300/320 may be utilized to configure the bandwidth, and thus Q-factor, of the resonant cavity defined by the partially reflective surfaces 300/320 and a reflective surface, such as the reflective surface 201B, described with respect to FIG. 2. The partially reflective surfaces 300/320 may thus comprise frequency selective surfaces due to the narrow bandwidth of signals that may leak out of the structure as configured by the slots and/or patches.

[0075] The spacing between the patches and/or slots may be related to wavelength of the signal transmitted and/or received, which may be somewhat similar to beamforming with multiple antennas. The length of the slots and/or patches may be several times larger than the wavelength of the transmitted and/or received signal or less, for example, since the leakage from the slots and/or regions surround the patches may add up, similar to beamforming with multiple antennas.

[0076] In an embodiment of the invention, the slots/patches may be configured via CMOS and/or micro-electromechanical system (MEMS) switches, such as the switches 165A-165C described with respect to FIG. 1, to tune the Q of the resonant cavity. The slots and/or patches may be configured in conductive layers in and/or on the chip 162, the package 167, and the printed circuit 171, and may be shorted together or switched open utilizing the switches 165A-165C. In this manner, RF signals, such as 60 GHz signals, for example, may be transmitted from various locations in the chip 162, the package 167, and the printed circuit board 171 without the need for additional circuitry and conventional antennas with their associated circuitry that require valuable space.

[0077] In another embodiment of the invention, the slots or patches may be configured in conductive layers in a vertical plane of the chip 162, the package 167, and/or the printed circuit board 171, thereby enabling the communication of wireless signals in a horizontal direction in the structure.

[0078] FIG. 4 is a block diagram illustrating an exemplary phase dependence of a leaky wave antenna, in accordance with an embodiment of the invention. Referring to FIG. 4, there is shown a leaky wave antenna comprising the partially reflective surface 201A, the reflective surface 201B, and the feed point 203. In-phase condition 400 illustrates the relative beam shape transmitted by the leaky wave antennas 164A-164C when the frequency of the signal communicated to the feed point 203 matches that of the resonant cavity as defined by the cavity height, h, and the dielectric constant of the material between the reflective surfaces.

[0079] Similarly, out-of-phase condition 420 illustrates the relative beam shape transmitted by the leaky wave antenna 164A-164C when the frequency of the signal communicated to the feed point 203 does not match that of the resonant cavity. The resulting beam shape may be conical, as opposed to a single main vertical node. These are illustrated further with respect to FIG. **5**. The leaky wave antennas **164**A-**164**C may be integrated at various heights in the chip **162**, the package **167**, and the printed circuit board **171**, thereby providing a plurality of transmission and reception sites in the structure with varying resonant frequency. In addition, a coplanar structure may be utilized to configure leaky wave antennas in the chip **162**, the package **167**, and/or the printed circuit board **171**, thereby enabling communication of wireless signals in the horizontal plane of the structure.

[0080] By configuring the leaky wave antennas **164**A-**164**C for in-phase and out-of-phase conditions, signals possessing different characteristics may be directed out of the chip **162**, the package **167**, and/or printed circuit board **171** in desired directions. In an exemplary embodiment of the invention, the angle at which signals may be transmitted by a leaky wave antenna may be dynamically controlled so that signal may be directed to desired receiving leaky wave antennas. In another embodiment of the invention, the leaky wave antennas **164**A-**164**C may be operable to receive RF signals, such as 60 GHz signals, for example. The direction in which the signals are received may be configured by the in-phase and out-of-phase conditions.

[0081] FIG. **5** is a block diagram illustrating exemplary in-phase and out-of-phase beam shapes for a leaky wave antenna, in accordance with an embodiment of the invention. Referring to FIG. **5**, there is shown a plot **500** of transmitted signal beam shape versus angle, Θ, for the in-phase and out-of-phase conditions for a leaky wave antenna.

[0082] The In-phase curve in the plot **500** may correlate to the case where the frequency of the signal communicated to a leaky wave antenna matches the resonant frequency of the cavity. In this manner, a single vertical main node may result. In instances where the frequency of the signal at the feed point is not at the resonant frequency, a double, or conical-shaped node may be generated as shown by the Out-of-phase curve in the plot **500**. By configuring the leaky wave antennas for in-phase and out-of-phase conditions, signals may be directed out of the chip **162**, the package **167**, and/or the printed circuit board **171** in desired directions.

[0083] In another embodiment of the invention, the leaky wave antennas **164**A-**164**C may be operable to receive wireless signals, and may be configured to receive from a desired direction via the in-phase and out-of-phase configurations.

[0084] FIG. **6** is a block diagram illustrating a leaky wave antenna with variable input impedance feed points, in accordance with an embodiment of the invention. Referring to FIG. **6**, there is shown a leaky wave antenna **600** comprising the partially reflective surface **201**A and the reflective surface **201**B. There is also shown feed points **601**A-**601**C. The feed points **601**A-**601**C may be located at different positions along the height, h, of the cavity thereby configuring different impedance points for the leaky wave antenna.

[0085] In this manner, a leaky wave antenna may be utilized to couple to a plurality of power amplifiers, low-noise amplifiers, and/or other circuitry with varying output or input impedances. Similarly, by integrating leaky wave antennas in conductive layers in the chip **162**, or integrating antennas in the printed circuit board **171** and/or the package **167** and flip-chip bonding to the chip **162**, the impedance of the leaky wave antenna may be matched to the power amplifier or low-noise amplifier without impedance variations that may result with conventional antennas and their proximity or distance to associated driver electronics. Similarly, by integrating reflective and partially reflective surfaces with varying cavity heights and varying feed points, leaky wave antennas with different impedances and resonant frequencies may be enabled.

[0086] FIG. **7** is a block diagram illustrating a cross-sectional view of coplanar and microstrip waveguides, in accordance with an embodiment of the invention. Referring to FIG. **7**, there is shown a microstrip waveguide **720**, a coplanar waveguide **730**, and a support structure **701**. The microstrip waveguide **720** may comprise signal conductive lines **723**, a ground plane **725**, a gap **711**A, an insulating layer **727** and a substrate **729**. The coplanar waveguide **730** may comprise signal conductive lines **731** and **733**, a gap **711**B, and the insulating layer **727**. The support structure **701** may comprise the chip **162**, the package **167**, or the printed circuit board **171**.

[0087] The signal conductive lines **723**, **731**, and **733** may comprise metal traces or layers deposited in and/or on the insulating layer **727**. In another embodiment of the invention, the signal conductive lines **723**, **731**, and **733** may comprise poly-silicon or other conductive material. The separation and the voltage potential between the signal conductive line **723** and the ground plane **725** may determine the electric field generated therein. In addition, the dielectric constant of the insulating layer **727** may also determine the electric field between the signal conductive line **723** and the ground plane **725**.

[0088] The insulating layer **727** may comprise SiO_2 or other insulating material that may provide a high resistance layer between the signal conductive line **723** and the ground plane **725**, and the signal conductive lines **731** and **733**. In addition, the electric field between the signal conductive line **723** and the ground plane **725** may be dependent on the dielectric constant of the insulating layer **727**.

[0089] The thickness and the dielectric constant of the insulating layer **727** and/or the gaps **711**A and **711**B may determine the electric field strength generated by the applied signal. The resonant cavity thickness of a leaky wave antenna may be dependent on the spacing between the signal conductive line **723** and the ground plane **725**, or the signal conductive lines **731** and **733**, for example. In an exemplary embodiment of the invention, the insulating layer **727** may be removed in localized regions in the microstrip waveguide **720** and the coplanar waveguide **730** to configure the gaps **711**A and **711**B, thereby allowing for MEMS deflection of the conductive layers and configuring of the height of the resonant cavity. The gaps **711**A and **711**B may extend completely between the signal conductive layer **723** and the ground plane **725** or the signal conductive lines **731** and **733**, or may extend only a portion of the distance.

[0090] The signal conductive lines **731** and **733**, and the signal conductive line **723** and the ground plane **725** may define resonant cavities for leaky wave antennas. Each layer may comprise a reflective surface or a partially reflective surface depending on the pattern of conductive material. For example, a partially reflective surface may be configured by alternating conductive and insulating material in a 1-dimensional or 2-dimensional pattern. In this manner, signals may be directed out of, or received into, a surface of the support structure **701**, as illustrated with the microstrip waveguide **720**. In another embodiment of the invention, signals may be communicated in the horizontal plane of the support structure **701** utilizing the coplanar waveguide **730**.

[0091] The support structure **701** may provide mechanical support for the microstrip waveguide **720**, the coplanar waveguide **730**, and other devices that may be integrated within. In an embodiment of the invention, the support structure **701** may comprise Si, GaAs, sapphire, InP, GaO, ZnO, CdTe, CdZnTe, ceramics, polytetrafluoroethylene, and/or Al_2O_3, for example, or any other substrate material that may be suitable for integrating microstrip structures.

[0092] In operation, a bias and/or a signal voltage may be applied across the signal conductive line **723** and the ground plane **725**, and/or the signal conductive lines **731** and **733**. The thickness of a leaky wave antenna resonant cavity may be dependent on the distance between the conductive lines in the microstrip waveguide **720** and/or the coplanar transmission waveguide **730**.

[0093] By alternating patches of conductive material with insulating material, or slots of conductive material in dielectric material, a partially reflective surface may result, which may allow a signal to "leak out" in that direction, as shown by the Leaky Wave arrows in FIG. **7**. In this manner, wireless signals may be directed out of the surface plane of the support structure **701**, or parallel to the surface of the support structure **701**.

[0094] FIG. **8** is a diagram illustrating a cross-sectional view of flip-chip bonded structures with integrated leaky wave antennas, in accordance with an embodiment of the invention. Referring to FIG. **8**, there is shown metal layers **801**A-**801**R, solder balls **803**, thermal epoxy **807**, and leaky wave antennas **809**A-**809**J. The chip **162**, the package **167**, and the printed circuit board **171** may be as described previously.

[0095] The chip **162**, or integrated circuit, may comprise one or more components and/or systems within the wireless system **150**. The chip **162** may be bump-bonded or flip-chip bonded to the package **167** utilizing the solder balls **803**. In this manner, wire bonds connecting the chip **162** to the package **167** may be eliminated, thereby reducing and/or eliminating uncontrollable stray inductances due to wire bonds, for example. In addition, the thermal conductance out of the chip **162** may be greatly improved utilizing the solder balls **803** and the thermal epoxy **807**. The thermal epoxy **807** may be electrically insulating but thermally conductive to allow for thermal energy to be conducted out of the chip **162** to the much larger thermal mass of the package **167**.

[0096] The metal layers **801**A-**801** R may comprise deposited metal layers utilized to delineate leaky wave antennas in and/or on the chip **162**, the package **167**, and the printed circuit board **171**. The metal layers **801**A-**801**R may be utilized to communicate signals between devices in the chip **162**, the package **167**, and/or the printed circuit board **172**, and/or to external devices via leaky wave antennas. In addition, the leaky wave antennas **809**A-**809**J may comprise conductive and insulating layers integrated in and/or on the chip **162**, the package **167**, and/or the printed circuit board **172** to enable communication of signals horizontally in the plane of the structure, as illustrated by the coplanar waveguide **730** described with respect to FIG. **7**.

[0097] In an embodiment of the invention, the spacing between pairs of metal layers, for example **801**A and **801**B, **801**C and **801**D, **801**E and **801**F, **801**G and **801**H, **801**H and **801**I, **801**J and **801**K, **801**K and **801**L, **801**M and **801**N, **801**O and **801**P, and **801**Q and **801**R, may define vertical resonant cavities of the leaky wave antennas **809**A-**809**J, respectively. At least one of the metal layers in a leaky wave antenna may comprise a partially reflective surface, as shown in FIGS. **2** and **3**, for example, and may enable the resonant electromagnetic mode in the cavity to leak out from that surface. In this manner, leaky wave antennas may be operable to communicate wireless signals between leaky wave antennas in and/or on the chip **162**, the package **167**, and/or the printed circuit board **171**, and/or to external devices.

[0098] The metal layers **801**H and **801**K may be shared by two leaky wave antennas, such as the leaky wave antennas **809**D and **809**E, and **809**F and **809**G. In another embodiment of the invention, the metal layers **801**H and **801**K may be eliminated, thereby making the leaky wave antennas the entire thickness of the chip **162**.

[0099] The metal layers **801**A-**801**R may comprise microstrip structures as described with respect to FIG. **7**. The region between the metal layers **801**A-**801**R may comprise a resistive material that may provide electrical isolation between the metal layers **801**A-**801**R thereby creating a resonant cavity.

[0100] The number of metal layers is not limited to the number of metal layers **801**A-**801**F shown in FIG. **8**. Accordingly, there may be any number of layers embedded within and/or on the chip **162**, the package **167**, and/or the printed circuit board **171**, depending on the number of leaky wave antennas, traces, waveguides and other devices fabricated.

[0101] The solder balls **803** may comprise spherical balls of metal to provide electrical, thermal and physical contact between the chip **162**, the package **167**, and/or the printed circuit board **171**. In making the contact with the solder balls **803**, the chip **162** and/or the package **167** may be pressed with enough force to squash the metal spheres somewhat, and may be performed at an elevated temperature to provide suitable electrical resistance and physical bond strength. The thermal epoxy **807** may fill the volume between the solder balls **803** and may provide a high thermal conductance path for heat transfer out of the chip **162**.

[0102] In operation, the chip **162** may comprise an RF front end, such as the RF transceiver **152**, described with respect to FIG. **1**, and may be utilized to transmit and/or receive RF signals, at 60 GHz, for example. The chip **162** may be electrically coupled to the package **167**, and the package **167** may be electrically coupled to the printed circuit board **171** via flip-chip bonding. In instances where high frequency signals, 60 GHz or greater, for example, may be communicated between the chip **162**, the package **167**, the printed circuit board **171**, and/or external devices, leaky wave antennas may be utilized. Accordingly, the leaky wave antennas **809**A-**809**J integrated on or within the chip **162**, the package **167**, and/or the printed circuit board **171** may be enabled to communicate signals from regions or sections within the chip **162**, the package **167**, and/or the printed circuit board **171** to other leaky wave antennas in the chip **162**, the package **167**, and/or the printed circuit board **171**.

[0103] In another embodiment of the invention, leaky wave antennas may comprise coplanar waveguide structures, for example, and may be operable to communicate wireless signals in the horizontal plane, parallel to the surface of the chip **162**, the package **167**, and/or the integrated circuit board **171**. In this manner, signals may be communicated between disparate regions of the chip **162**, the package **167**, and/or the integrated circuit board **171** without the need to run lossy electrical signal lines. The leaky wave antennas **809**A-**809**J may comprise microstrip waveguide structures, for example, that may be operable to wirelessly communicate signals perpendicular to the plane of the supporting structure, such as the chip **162**, the package **167**, and the printed circuit board **171**. In this manner, wireless signals may be communicated between the chip **162**, the package **167**, and the printed circuit board **171**.

[0104] The integration of leaky wave antennas in the chip **162**, the package **167**, and the printed circuit board **171** and electrical coupling via flip-chip bonding may result in the reduction of stray impedances when compared to wire-bonded connections between structures as in conventional systems, particularly for higher frequencies, such as 60 GHz. By flip-chip bonding structures with integrated leaky wave antennas, high frequency signals may be communicated between via the leaky wave antennas **809**A-**809**J, while DC and low frequency signals may be communicated via bump-bonds such as the solder balls **803**. In this manner, volume requirements may be reduced and performance may be improved due to lower losses and accurate control of impedances via switches in the chip **162** or on the package **167**, for example.

[0105] In an embodiment of the invention, leaky wave antennas may be integrated in different structures, such as the chip **162**, the package **167**, and the printed circuit board **171**, with matching resonant frequency leaky wave antennas, such that only sections of circuits that are desired to receive signals may be configured to receive them. For example, the leaky wave antennas **809**A and **809**H may have the same cavity height and thus resonant frequency, as compared to the other leaky wave antennas, thereby enabling an exclusive communication link between these antennas.

[0106] In another embodiment of the invention, the leaky wave antennas **809**A-**809**J may be configured to communicate RF signal at an angle from the vertical by adjusting the frequency of the feed signal, as described with respect to FIGS. **4** and **5**. In this manner, the leaky wave antennas **809**A-**809**J may be operable to communicate with a plurality of antennas.

[0107] FIG. **9** is a block diagram illustrating exemplary steps for communicating signals via flip-chip bonded structures with integrated leaky wave antennas, in accordance with an embodiment of the invention. Referring to FIG. **9**, in step **903** after start step **901**, one or more leaky wave antennas integrated may be configured to communicate wireless signals by coupling to RF power amplifiers or low noise amplifiers, for example. In step **905**, DC and/or low frequency signals may be communicated between structures via bump-bonded interconnects. In step **907**, high frequency signals may be communicated between the chip, the package, and/or the printed circuit board via leaky wave antennas. In step **909**, in instances where the wireless device **150** is to be powered down, the exemplary steps may proceed to end step **911**. In step **909**, in instances where the wireless device **150** is not to be powered down, the exemplary steps may proceed to step **903** to configure the leaky wave antenna at a desired frequency.

[0108] In an embodiment of the invention, a method and system are disclosed for communicating RF signals in a wireless device **150** between a plurality of support structures **162**, **167**, and **171** with one or more integrated leaky wave antennas **164**A-**164**C, **400**, **420**, **600**, and **809**A-**809**J integrated in the support structures **162**, **167**, and **171**. The support structures **162**, **167**, and **171** may be coupled via flip-chip-bonding. Low-frequency signals may be communicated via contacts **803** defined via the flip-chip bonding. The RF signals may be communicated between the support structures **162**, **167**, and **171** perpendicular to a surface of the structures **162**, **167**, and **171**. The leaky wave antennas **164**A-**164**C, **400**, **420**, **600**, and **809**A-**809**J may be configured to transmit the wireless signals at a desired angle from the surface of the support structures **162**, **167**, and **171**, which may comprise at least one of: an integrated circuit **162**, an integrated circuit package **167**, and a printed circuit board **171**.

[0109] The leaky wave antennas **164**A-**164**C, **400**, **420**, **600**, and **809**A-**809**J may comprise microstrip waveguides **720** where a cavity height of the leaky wave antennas **164**A-**164**C, **400**, **420**, **600**, and **809**A-**809**J may be configured by controlling spacing between conductive lines **723** and **725** in the microstrip waveguides **720**. The leaky wave antennas **164**A-**164**C, **400**, **420**, **600**, and **809**A-**809**J may comprise coplanar waveguides **730** where a cavity height of the leaky wave antennas **164**A-**164**C, **400**, **420**, **600**, and **809**A-**809**J may be configured by controlling spacing between conductive lines **731** and **733** in the coplanar waveguides **730**. The low-frequency signals may comprise DC bias voltages. The RF signals may be communicated from a single leaky wave antenna to a plurality of leaky wave antennas.

[0110] Other embodiments of the invention may provide a non-transitory computer readable medium and/or storage medium, and/or a non-transitory machine readable medium and/or storage medium, having stored thereon, a machine code and/or a computer program having at least one code section executable by a machine and/or a computer, thereby causing the machine and/or computer to perform the steps as described herein for communicating via leaky wave antennas within a flip-chip bonded structure.

[0111] Accordingly, aspects of the invention may be realized in hardware, software, firmware or a combination thereof. The invention may be realized in a centralized fashion in at least one computer system or in a distributed fashion where different elements are spread across several interconnected computer systems. Any kind of computer system or other apparatus adapted for carrying out the methods described herein is suited. A typical combination of hardware, software and firmware may be a general-purpose computer system with a computer program that, when being loaded and executed, controls the computer system such that it carries out the methods described herein.

[0112] One embodiment of the present invention may be implemented as a board level product, as a single chip, application specific integrated circuit (ASIC), or with varying levels integrated on a single chip with other portions of the system as separate components. The degree of integration of the system will primarily be determined by speed and cost considerations. Because of the sophisticated nature of modern processors, it is possible to utilize a commercially available processor, which may be implemented external to an ASIC implementation of the present system. Alternatively, if the processor is available as an ASIC core or logic block, then the commercially available processor may be implemented as part of an ASIC device with various functions implemented as firmware.

[0113] The present invention may also be embedded in a computer program product, which comprises all the features enabling the implementation of the methods described herein, and which when loaded in a computer system is able to carry out these methods. Computer program in the present context may mean, for example, any expression, in any language, code or notation, of a set of instructions intended to cause a system having an information processing capability to perform a particular function either directly or after either or both of the following: a) conversion to another language, code or notation; b) reproduction in a different material form. However, other meanings of computer program within the understanding of those skilled in the art are also contemplated by the present invention.

[0114] While the invention has been described with reference to certain embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the present invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present invention without departing from its scope. Therefore, it is intended that the present invention not be limited to the particular embodiments disclosed, but that the present invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. A method for communication, the method comprising:
in a wireless device comprising one or more leaky wave antennas integrated within and/or on a plurality of support structures, said support structures being coupled via flip-chip-bonding:
communicating RF signals between said support structures via said one or more integrated leaky wave antennas; and
communicating low-frequency signals via contacts defined via said flip-chip bonding.

2. The method according to claim **1**, comprising communicating said RF signals between said support structures perpendicular to a surface of said support structures.

3. The method according to claim **1**, comprising configuring said leaky wave antennas to transmit said RF signals at a desired angle from said surface of said support structures.

4. The method according to claim **1**, wherein said support structures comprise at least one of: an integrated circuit, an integrated circuit package, and a printed circuit board.

5. The method according to claim **1**, wherein said leaky wave antennas comprise microstrip waveguides.

6. The method according to claim **5**, comprising configuring a cavity height of said leaky wave antennas by controlling spacing between conductive lines in said microstrip waveguides.

7. The method according to claim **1**, wherein said leaky wave antennas comprise coplanar waveguides.

8. The method according to claim **7**, comprising configuring a cavity height of said leaky wave antennas by controlling spacing between conductive lines in said coplanar waveguides.

9. The method according to claim **1**, wherein said low-frequency signals comprise DC bias voltages.

10. The method according to claim **1**, comprising communicating said RF signals from a single leaky wave antenna to a plurality of leaky wave antennas.

11. A system for enabling communication, the system comprising:
one or more circuits for use in a wireless device comprising one or more leaky wave antennas integrated within and/or on a plurality of support structures, said support structures being coupled via flip-chip-bonding, wherein said one or more circuits are operable to:
communicate RF signals between said support structures via said one or more integrated leaky wave antennas; and
communicate low-frequency signals via contacts defined via said flip-chip bonding.

12. The system according to claim **11**, wherein said one or more circuits are operable to communicate said RF signals between said support structures perpendicular to a surface of said support structures.

13. The system according to claim **11**, wherein said one or more circuits are operable to configure said leaky wave antennas to transmit said RF signals at a desired angle from said surface of said support structures.

14. The system according to claim **11**, wherein said support structures comprise at least one of: an integrated circuit, an integrated circuit package, and a printed circuit board.

15. The system according to claim **11**, wherein said leaky wave antennas comprise microstrip waveguides.

16. The system according to claim **15**, wherein said one or more circuits are operable to configure a cavity height of said leaky wave antennas by controlling spacing between conductive lines in said microstrip waveguides.

17. The system according to claim **11**, wherein said leaky wave antennas comprise coplanar waveguides.

18. The system according to claim **17**, wherein said one or more circuits are operable to configure a cavity height of said leaky wave antennas by controlling spacing between conductive lines in said coplanar waveguides.

19. The system according to claim **11**, wherein said low-frequency signals comprise DC bias voltages.

20. The system according to claim **11**, wherein said one or more circuits are operable to communicate said RF signals from a single leaky wave antenna to a plurality of leaky wave antennas.

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