layer **975** meets all electrical requirements, allowing for a very flexible EMI shield design that can be easily modified to accommodate different module layouts and devices. Similarly, as discussed above with reference to FIGS. **106**A and **106**B, the vias **971** connecting the wirebond pads **968** (or track **973**) to the ground plane need not be coincident with each pad, or with specific locations on the ground plane, allowing for flexible pad **968** and via **971** placement in the module. The number of wirebond springs required to provide an adequate EMI shield depends on the operating frequency of the devices to be shielded and the level of shielding required. For example, the wire density (i.e., the spacing between immediately adjacent wirebond springs **972** in any given direction) may increase with increasing signal frequency. In one example, a wire spacing of about $\lambda/20$ (where λ is the wavelength of the signal to be shielded) may be used. It is to be appreciated that the wire spacing need not be uniform, provided only that the minimum spacing to achieve desired shielding at a given frequency is maintained. Examples of wirebond spring EMI cages were tested and found to provide approximately a 20 dB shield, which is presently sufficient for most RF handset applications. Thus, the wirebond springs discussed herein can be used to provide a completely integrated EMI shield that is highly flexible and adds minimal cost, weight and/or size to the module. The wirebond springs may be processed using traditional processing techniques which are low cost, robust and do not require the procurement of any additional or specialized assembly equipment.

Having thus described several aspects of the above embodiments in this section, it is to be appreciated that various alterations, modifications, and improvements will readily occur to those skilled in the art. Such alterations, modifications, and improvements are intended to be part of this disclosure and are intended to be within the scope of the invention. Accordingly, the foregoing is by way of example only, and the scope of the invention should be determined from proper construction of the below claims and their equivalents.

XIV. Concluding Remarks and Discussion

While various embodiments and related features, aspects, and characteristics of the present inventions have been described throughout the entirety of this disclosure, it will be apparent to those of ordinary skill in the art that many more embodiments and implementations are possible such as would be within the scope of any respective invention described herein. For example, the inventions hereof are not limited to the materials, process technologies, devices, or systems described above. And further, the inventions hereof may individually or otherwise be combined, integrated, assembled, or joined together in various desired combinations with any other number of relevant, chosen, or suitable aspects of the present inventions as described throughout the entirety of this disclosure to even further improve the performance of integrated circuits, power amplifiers, power amplifier modules, and the wireless devices in which they are employed.

The headings provided in this specification are for convenience only and do not necessarily affect the scope or meaning of the following claims.

Unless the context clearly requires otherwise, throughout the description and the claims, the words "comprise," "comprising," and the like are to be construed in an inclusive sense, as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to." The word "coupled", as generally used herein, refers to two or more elements that may be either directly connected, or connected by way of one or more intermediate elements. Additionally, the words "herein," "above," "below," and words of similar import, when used in this application, shall refer to this application as a whole and not to any particular portions of this application unless the context thereof would indicate that one particular section of the detailed description is thereby intended. Where the context permits, words in the above detailed description that use the singular or plural number may also include the plural or singular number respectively. The word "or" in reference to a list of two or more items, covers all of the following interpretations of the word which include any of the items in the list, all of the items in the list, and any combination of the items in the list.

The above detailed description of embodiments of the invention is not intended to be exhaustive or to limit the invention to the precise form disclosed above. While specific embodiments of, and examples for, the invention are described above for illustrative purposes, various equivalent modifications are possible within the scope of the invention, as those skilled in the relevant art will recognize. For example, while processes, or blocks, or the steps thereof are presented in a given order, alternative embodiments may perform routines having steps, or employ systems having blocks, in a different order, and some processes, blocks, or steps may be deleted, moved, added, subdivided, combined, and/or modified. Each of these processes, blocks, or steps may be implemented in a variety of different ways. Also, while processes, blocks, or steps are at times shown as being performed in series, these may instead be performed in parallel, or may be performed at different times.

The teachings of the invention provided herein can be applied to other systems, not necessarily the systems described above. The elements and acts of the various embodiments described above can be combined to provide further embodiments.

And further while this invention has been described in detail with reference to certain preferred embodiments, it should be appreciated that the present invention is not limited to those precise embodiments. Rather, in view of the present disclosure which describes the current best mode for practicing the invention, many modifications and variations would present themselves to those of skill in the art without departing from the scope and spirit of this invention. The scope of the invention is, therefore, indicated by the following claims rather than by the foregoing description. All changes, modifications, and variations coming within the meaning and range of equivalency of the claims are to be considered within their scope.

What is claimed is:

1. A power amplifier module comprising:

a power amplifier including a gallium arsenide (GaAs) bipolar transistor having a collector, a base abutting the collector, and an emitter, the collector having a doping concentration of at least about 3×10^{16} cm^{-3} at a junction with the base, the collector also having at least a first grading in which doping concentration increases away from the base; and

an RF transmission line driven by the power amplifier, the RF transmission line including a conductive layer and finish plating on the conductive layer, the finish plating including a gold layer, a palladium layer proximate the gold layer, and a diffusion barrier layer proximate the palladium layer, the diffusion barrier layer including nickel and having a thickness that is less than about the skin depth of nickel at 0.9 GHz.

2. The power amplifier module of claim **1** further comprising an output matching network with a first termination circuit configured to match a fundamental frequency of an out-