ANTENNA WITH DIELECTRIC HAVING GEOMETRIC PATTERNS

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ABSTRACT

An antenna includes a ground plane, a dielectric disposed on the ground plane, and an electrically-conductive radiator disposed on the dielectric. The dielectric includes at least one layer of a first dielectric material and a second dielectric material that collectively define a dielectric geometric pattern, which may comprise a fractal geometry. The radiator defines a radiator geometric pattern, and the dielectric geometric pattern is geometrically identical, or substantially geometrically identical, to the radiator geometric pattern.

20 Claims, 7 Drawing Sheets
FIG. 1

RADIATOR

DIELECTRIC WITH GEOMETRIC PATTERN

GROUND PLANE

FIG. 2

40a

40b
FIG. 12

FIG. 13

DIELECTRIC WITH FRACTAL GEOMETRY LAYER(S)
GROUND PLANE
GEOMETRIC DIELECTRIC RADOME

RADIATOR

GEOMETRIC DIELECTRIC LAYER

GROUND PLANE

FIG. 14
1  ANTENNA WITH DIELECTRIC HAVING
GEOMETRIC PATTERNS

CROSS-REFERENCE TO RELATED PATENT
APPLICATIONS

This patent application is a nonprovisional of and claims
61/324,967, filed Apr. 16, 2010, the contents of which are
hereby incorporated by reference in their entirety.

STATEMENT REGARDING FEDERALLY
SPONSORED RESEARCH OR DEVELOPMENT

The invention was made in part by employees of the United
States Government and may be manufactured and used by or
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ernmental purposes without the payment of any royalties
thereon or therefor.

BACKGROUND OF THE INVENTION

1. Field of the Invention
   This invention relates to antennas such as microstrip anten-
na. More specifically, the invention is an antenna having a
dielectric having a geometric pattern.

2. Description of the Related Art
   Fractal antennas utilize self-similar designed conductors to
maximize antenna length or increase the perimeter of mate-
rial that can receive or transmit electromagnetic signals. Fractal
antennas are compact, are multi-band or wideband, and are
useful in cellular communication applications and microwave
applications. The key aspect of these antennas is their fractal-pat-
ttern repetition of the antenna's conductor over two or more
scale sizes or iterations. Fractal antenna performance can
currently be controlled only via manipulation of the antenna
conductors’ fractal geometry.

3. Summary of the Invention
   Accordingly, it is an object of the present invention to
provide an antenna design offering improved performance,
by having a dielectric layer comprising at least two dielectric
materials arranged in a geometric pattern, including but not
limited to, a fractal pattern.

   Another object of the present invention is to provide a
fractal antenna design having versatile performance manipu-
lation capabilities.

   In yet another embodiment of the present invention, an
antenna comprises a ground plane, a dielectric member, and
an electrically-conductive radiator disposed on the dielectric
member. The antenna may further include a radome disposed
on the radiator, where the radome includes at least one geo-
metric pattern, which may comprise a fractal pattern, and the radia-
tor geometric pattern geometrically matches the dielectric
geometric pattern or (fractal pattern). The radiator also has a
radiator impedance and the dielectric layer has a dielectric
impedance, and the radiator impedance is substantially equal
or equal to the dielectric impedance. The antenna further
comprises a radome disposed on the radiator. The loss quan-
tity does not exceed approximately 0.001.

   In another embodiment, a microstrip antenna comprises a
ground plane, a dielectric layer and an electrically-conductive
radiator disposed on the dielectric layer and adapted to be
exposed to a free space environment. The dielectric layer is
disposed on the ground plane and includes a first layer of a
first dielectric material and a second dielectric material. The
first dielectric material and second dielectric material are
arranged to define a dielectric geometric pattern, which may
comprise a fractal geometry. The first dielectric material is
characterized by a relative permittivity that is at least twice
that of the second dielectric material. The first dielectric material and
the second dielectric material are further characterized by a loss
quantity that yields an antenna efficiency of at least approximately
70 percent. The radiator defines a radiator geometric pattern, which may
comprise a fractal pattern, and the radiator geometrical pattern
matches the dielectric geometric pattern (or fractal pattern). The radiator
also has a radiator impedance and the dielectric layer has a dielectric
impedance, and the radiator impedance is substantially equal
equal to the dielectric impedance. The antenna further
comprises a radome disposed on the radiator. The loss quan-
tity does not exceed approximately 0.001.

   FIG. 1 is a top level schematic view of a antenna that
includes a dielectric having a geometric shape in accordance
with the present invention;

   FIGS. 2-9 are plan views of exemplary dielectrics having
geometric patterns that could be used in the present invention;

   FIG. 10 is a schematic view of a single dielectric layer in
accordance with the present invention;

   FIG. 11 is a schematic view of a multi-layer dielectric with
a geometric dielectric layer and a homogenous dielectric
layer in accordance with another embodiment of the present
invention;
FIG. 12 is a schematic view of another multi-layer dielectric with two geometric dielectric layers sandwiching a homogenous dielectric layer in accordance with another embodiment of the present invention.

FIG. 13 is a schematic view of a microstrip antenna in accordance with an embodiment of the present invention; and FIG. 14 is a top level schematic view of a dielectric antenna that includes a geometric dielectric layer(s) for the antenna’s substrate and radome in accordance with another embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings and more particularly to FIG. 1, an antenna in accordance with the present invention is shown and is referenced generally by numeral 10. The antenna of the present invention may comprise variety of antenna types, including but not limited to, fractal patterns, including but not limited to, a fractal pattern. These concepts are illustrated in exemplary geometries as shown in FIGS. 2-9 where the fractal pattern of radiator 16 could be defined by various fractal geometries (e.g., the Sierpinski Carpet, Koch Curve, Hilbert Curve, Peano Curve, and Cantor Dust) as well as yet-to-be-designed fractal geometries.

For purpose of the present invention, one of the two dielectric materials must have a relative permittivity (i.e., dielectric constant) that is at least twice as great as that of the other dielectric material. The larger relative permittivity material could be used for either the geometric structure or the bounding region(s) (shown as the black regions in FIGS. 2-9) without departing from the scope of the present invention. The two dielectric materials must also characterize a “loss quantity” (i.e., the imaginary portion of permittivity, also referred to in the art by the term “dielectric loss factor” or “loss tangent”) that will allow antenna 10 to achieve an antenna efficiency of at least approximately 70%. To achieve this, both dielectric materials are referred to as low loss dielectrics. The actual loss quantity that the two dielectric materials must satisfy will vary depending on the antenna type and efficiency requirements.

As mentioned above, dielectric 14 includes one or more layers of geometrically arranged dielectrics in accordance with the present invention. Several non-limiting examples of dielectric 14 are illustrated schematically in FIGS. 10-12. A dielectric layer 140 comprised of two dielectric materials. Typically, the geometric pattern will extend fully or completely through the layer’s thickness, and all planar or horizontal cross-sections of the layer may be identical. In FIG. 11, dielectric 14 is realized by a multi-layer construction that includes a geometric dielectric layer 140, and an adjacent homogenous dielectric material layer 142. Layer 142 is simply a contiguous layer of one dielectric material which can be the same as one of the materials in layer 140 or different without departing from the scope of the present invention. FIG. 12 illustrates a three-layer dielectric 14 that has two geometric dielectric layers 140 and 144 sandwiching homogenous dielectric material layer 142. Layers 140 and 144 can have the same or different geometries, including the same or different fractal geometries, and can be made from the same or different dielectric materials.

The choice of particular dielectric materials, layered structures, and/or geometries thereof, can be selected/tailored to modify antenna parameters (e.g., radiation pattern, beamforming characteristics, sidelobe control, polarization, “electromagnetic interference” (EMI) reduction, multiple frequency operation, bandwidth, impedance matching, etc.). The present invention will provide a new level of versatility that can be used to design antennas for space, aircraft, and aerospace applications to include communications, navigation (e.g., GPS, glide slope, Microwave Landing Systems (MLS), Asynchronous Direct Surveillance Broadcast (ADSB), Automatic Direction Finding (ADF), sensing (e.g., icing, weather, proximity, collision avoidance, etc.), radars, missile seeker and tracking heads, Synthetic Aperture Radars (SAR), phased arrays, all dielectric front ends, stealth antennas, radomes, countermeasures, and electronic warfare. Additional applications include cellular phone/video communication antennas, paging, radio, WiFi, GPS, Personal Electronic Devices (PEDs), automotive, security, vehicle and product tracking, smart pass and smart toll, and diversity antennas in signal-cluttered environments (e.g., cities with tall buildings or high density frequency usage areas).

Referring again to FIG. 1, antenna radiator 16 can be configured in a variety of ways without departing from the scope of the present invention. For example, antenna radiator 16 could be impedance matched to dielectric 14. Radiator 16 could also be a fractal pattern of conductive material deposited on dielectric 14. The fractal pattern of radiator 16 could be geometrically matched to dielectric 14 and/or impedance matched to dielectric 14. Radiator 16 could also be a simple conductive strip, wire, conducting run, etc., in the case of a microstrip antenna. Accordingly, FIG. 13 schematically illustrates a microstrip antenna 20 in accordance with the present invention where a simple conductor 18 is disposed on dielec-
A microstrip antenna comprising:

a ground plane;
a dielectric layer disposed on said ground plane and including at least one layer of a first dielectric material and a second dielectric material that collectively define a dielectric geometric pattern, said first dielectric material characterized by a relative permittivity that is at least twice that of said second dielectric material, said first dielectric material and said second dielectric material being further characterized by a loss factor that yields an antenna efficiency of at least 70 percent; and an electrically-conductive radiator disposed on said dielectric member.

The advantages of the present invention are numerous. The geometric dielectric provides a new approach to improving and/or tuning antenna performance. The approach described herein is applicable to a wide variety of antenna types to include microstrip antennas found in many of today’s communication devices.

Although the invention has been described relative to a specific embodiment thereof, there are numerous variations and modifications that will be readily apparent to those skilled in the art in light of the above teachings. For example, the antenna feed structure can be adapted to the particular type of antenna being constructed as would be well understood by one of ordinary skill in the art. Accordingly, antenna feed structures are not limitations of the present invention. It is therefore to be understood that, within the scope of the appended claims, the invention may be practiced other than as specifically described.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. An antenna comprising:
   - a ground plane;
   - a dielectric member disposed on said ground plane and including a first layer of a first dielectric material and a second dielectric material that collectively define a dielectric geometric pattern, said first dielectric material characterized by a relative permittivity that is at least twice that of said second dielectric material, said first dielectric material and said second dielectric material being further characterized by a loss factor that yields an antenna efficiency of at least 70 percent; and
   - an electrically-conductive radiator disposed on said dielectric member.

2. The antenna according to claim 1, wherein said radiator defines a radiator geometric pattern, and wherein said radiator geometric pattern is geometrically matched to said dielectric geometric pattern.

3. The antenna according to claim 2, wherein said radiator geometric pattern and the dielectric geometric pattern comprise a fractal pattern.

4. The antenna according to claim 1, said radiator having a radiator impedance and said dielectric member having a dielectric impedance, wherein said radiator impedance is equal to the dielectric impedance.

5. The antenna according to claim 1, wherein said radiator defines a radiator geometric pattern that is geometrically matched to said dielectric geometric pattern, and wherein said radiator impedance is matched to said dielectric member.

6. The antenna according to claim 1, wherein said dielectric geometric pattern extends fully through said first layer.

7. The antenna according to claim 1, wherein said loss quantity does not exceed 0.001.

8. The antenna according to claim 1, wherein said dielectric member further comprising a second layer having a third dielectric material, wherein said second layer is adjacent to said at least one layer.

9. The antenna according to claim 1, further comprising a radome disposed on said radiator, said radome including dielectric radome having a radome geometric pattern.

10. A dielectric antenna comprising:
    - a ground plane;
    - a dielectric layer disposed on said ground plane and including a first dielectric material and a second dielectric material that collectively define a fractal geometry that extends fully through said dielectric layer, said first dielectric material characterized by a relative permittivity that is at least twice that of said second dielectric material, said first dielectric material and said second dielectric material being further characterized by a loss factor that yields an antenna efficiency of at least 70 percent; and
    - an electrically-conductive radiator disposed on said dielectric layer.

11. The dielectric antenna according to claim 10, wherein said radiator defines a fractal pattern, wherein said fractal pattern geometrically matches said fractal geometry.

12. The dielectric antenna according to claim 11, said radiator having a radiator impedance and said dielectric layer having a dielectric impedance, wherein said radiator impedance is substantially equal to the dielectric impedance.

13. The dielectric antenna according to claim 12, further comprising a radome disposed on said radiator, said radome including at least one fractal geometry dielectric, and wherein said loss quantity does not exceed 0.001.

14. The dielectric antenna according to claim 11, said radiator having a radiator impedance and said dielectric layer having a dielectric impedance, wherein said radiator impedance is equal to the dielectric impedance.

15. The dielectric antenna according to claim 10, wherein said radiator defines a fractal pattern geometrically matched to said fractal geometry of said dielectric layer, and wherein said radiator impedance matched to said dielectric layer.

16. A microstrip antenna comprising:
    - a ground plane;
    - a dielectric layer disposed on said ground plane and including at least one layer of a first dielectric material and a second dielectric material that collectively define a dielectric geometric pattern, said first dielectric material
characterized by a relative permittivity that is at least twice that of said second dielectric material, said first dielectric material and said second dielectric material being further characterized by a loss quantity that yields an antenna efficiency of at least 70 percent; and an electrically conductor disposed on said dielectric layer and adapted to be exposed to a free space environment.

17. The antenna according to claim 16, wherein said conductor is impedance matched to said dielectric layer.

18. The antenna according to claim 16, wherein said fractal geometry extends fully through said at least one layer.

19. The antenna according to claim 16, wherein said loss quantity does not exceed 0.001.

20. The antenna according to claim 16, wherein said dielectric layer further includes a layer of a third dielectric material adjacent to said at least one layer, and wherein said layer of a third dielectric material is homogenous.

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