

Intrusion detection system

The present invention relates to an intrusion detection system comprising:

- at least two superimposed mesh layers, each mesh layer comprising a plurality of cells and a plurality of through connecting points, each cell comprising at least one continuous pattern, at least one end of which is connected to a through connecting point, the coverage rate of the set of patterns of each cell being strictly greater than 80 percent, the set of cells of each mesh layer defining a zone protected by the mesh layer,
- a plurality of connections, each connection connecting two cell patterns of different mesh layers to one another via through connecting points to form loops, each loop being a continuous electrical circuit, each loop comprising patterns belonging to at least two different mesh layers,
- a detection module able to detect a modification of an electrical characteristic of each loop.

In the field of computer security, one issue consists of protecting the equipment through which sensitive information passes. Such equipment in particular includes printed circuits or integrated circuits. A printed circuit, also called printed circuit board, is a support making it possible to maintain a set of electronic components and electrically connect them to one another. An integrated circuit, also called electronic chip, is an electronic component reproducing one or several electronic functions and generally integrating several types of basic electronic components in a small space.

The tracks of a printed circuit and the connections of the electronic components connected on such a printed circuit may be subject to physical attacks. Such physical attacks in particular consist of approaching probes or connecting electrodes on the tracks of the printed circuit or on the connections of components connected on the printed circuit so as to capture the signals traveling over the tracks or the connections or to inject signals. The captured signals are next used by the attackers to collect sensitive data. The injected signals are used to disrupt the exchanged signals or to cause a malfunction of the equipment.

Similar attacks may be carried out on integrated circuits.

As a result, protection systems are used to protect the printed circuits and integrated circuits of such equipment from intrusions. The protection systems for example comprise two- or three-dimensional protective meshes that protect the area containing the sensitive data. The meshes are in particular formed by separate electrical loops comprising patterns. The continuity or alteration of such electrical loops is verified by circulating a control signal in the loops and detecting the signal losses or variations, due to a break in the loop, or to a modification of one of the electrical characteristics of the signal

following an alteration of the loop. When an intrusion attempt is detected, reactive actions are triggered by the protection systems for example consisting of erasing the sensitive data from the equipment.

Yet such meshes provide insufficient resistance to attacks and are bypassed by the attacker once the attacker has understood the logic of the mesh.

Indeed, most of the time, the mesh is primarily made up of superimposed parallel straight lines that are offset on different layers so as to conceal the surface to be protected. Such lines for example have straight shapes or are broken lines in the form of chevrons, covering the surface to be protected. The complexity of such a mesh is relatively simple to analyze in order to follow the journey of an electrical loop, and is consequently able to be bypassed by an attacker after a reverse engineering phase. Reverse engineering, also called reverse design, is an activity consisting of studying an object to determine its inner workings or manufacturing method.

After reverse engineering, the attacker knows the positions and properties of the different electrical loops of the mesh. The attacker is then able to shunt some of these electrical loops and therefore section them to free an access space to the equipment to be protected, without the protection system detecting the intrusion. The term "shunt" refers to short-circuiting an electrical circuit.

There is therefore a need for a protection system that better withstands attacks and makes it more difficult for an attacker to short-circuit one or several electrical loops of a mesh after reverse engineering.

To that end, the invention relates to an intrusion detection system of the aforementioned type, in which the through connection points of each mesh layer are distributed over the entire surface of the zone protected by the mesh layer.

According to specific embodiments, the intrusion detection system comprises one or more of the following features, considered alone or according to any technically possible combinations:

- each protected zone is formed by a central part and a peripheral part surrounding the central part, the peripheral part taking up no more than 30 percent of the surface of the protected zone, the connection points traversing each mesh layer being distributed over the central zone and over the peripheral zone of the zone protected by the mesh layer.

- the deviation between the mean density of through connecting points on each connected sub-zone of the protected zone is less than or equal to 10 percent.

- the largest dimension of each cell is at most equal to one third of the largest dimension of the zone protected by the mesh layer of the cell.

- each cell is defined by an enclosure containing the pattern(s) of the cell, at least one pattern of a cell of a mesh layer comprising one end protruding relative to the enclosure of the cell, the protruding end being integral with the or one of the patterns of the cell, the protruding end connecting the pattern to another pattern of the same or another mesh layer.

- at least one cell of a mesh layer comprises at least two interwoven patterns.

- the spacing between the adjacent cells is less than or equal to 100 micrometers, and preferably less than or equal to 50 micrometers.

- the patterns of a same loop and belonging to a same mesh layer and a second mesh layer, adjacent to the first mesh layer, are arranged relative to one another such that the projections along the superposition direction of said patterns of the first mesh layer on the second mesh layer are partially superimposed or not superimposed on said patterns of the second mesh layer.

- the through connecting points connecting the patterns of each loop are arranged across from patterns belonging to at least one other loop.

- the minimum distance separating two cells of a same loop and belonging to two different mesh layers is less than or equal to 100 micrometers.

- the through connecting points are micro-vias.

Other features and advantages of the invention will appear upon reading the following description of embodiments of the invention, provided as an example only and in reference to the drawings, which are:

- figure 1, a diagrammatic cross-sectional view of one example of an intrusion detection system,

- figure 2, an exploded diagrammatic view of two superimposed mesh layers, the cells of the two mesh layers being connected to one another by an interconnection matrix comprising connections,

- figure 3, a diagrammatic top view of an example of a mesh layer comprising cells, each formed by a pattern,

- figure 4, a diagrammatic top view of two patterns interwoven within a same cell,

- figure 5, a diagrammatic top view of a mesh layer comprising triangular cells,

- figure 6, a diagrammatic top view of a mesh layer comprising square cells,

- figure 7, a diagrammatic top view of a mesh layer comprising hexagonal cells,

- figure 8, a diagrammatic top view of a mesh layer comprising cells with a complementary shape,

- figure 9, another diagrammatic view of a mesh layer comprising cells with a complementary shape,

- figure 10, a diagrammatic top view of offset superimposed mesh layers comprising identical square cells,

- figure 11, another diagrammatic top view of offset superimposed mesh layers comprising identical hexagonal cells,

- figure 12, a diagrammatic top view of two offset superimposed mesh layers having cells with different shapes,

- figure 13, a diagrammatic top view of cells having protruding ends in the patterns of other cells, and

- figure 14, a diagrammatic illustration of connections between different mesh layers when the cells are restricted to a matrix of micro-vias.

An intrusion detection system 20 is illustrated in figure 1.

The system 20 is intended to protect a piece of equipment 21 through which sensitive information passes. The equipment 21 for example comprises printed circuits or integrated circuits. The equipment 21 is for example an encryption device or transmission equipment through which sensitive data, such as banking data, passes.

The system 20 is able to detect intrusion attempts coming from outside the system 20. The intrusion attempts are in particular physical attacks consisting of approaching probes or connecting electrodes on a printed circuit of the equipment 21 protected by the system 20.

As illustrated in figure 1, the system 20 comprises a first protection surface 22 for example formed below the equipment 21, and a second protection surface 23, forming a cover, superimposed on the first projection surface 22. The first protection surface 22 and the second protection surface 23 thus form an inner volume 24 protected against intrusions, and in which the equipment 21 to be protected is arranged.

The system 20 further comprises a detection module 26, a primary power source 28 to power the detection module 26, and a secondary power source 30 powering the detection module 26 in emergency situations.

In its volume, the first protection surface 22 comprises several layers superimposed along a superposition direction Z, including at least two mesh layers 40 or at least two mesh layers 40 and at least one interconnection matrix 41.

Each mesh layer 40 comprises a plurality of cells 42.

The set of cells 42 of each mesh layer 40 defines a zone protected by the mesh layer 40. Thus, when the cells 42 occupy the entire mesh layer 40, the protected zone is the entire mesh layer 40.

Preferably, the largest dimension of each cell 42 is at most equal to one third of the largest dimension of the zone protected by the mesh layer 40 of the cell 42.

Each cell 42 comprises at least one geometric pattern 44 covering the entire surface of the cell 42, as illustrated in figure 3 for only one cell 42.

Each pattern 44 is a continuous, non-branching electrical track, for example curved, without intersection and the breaking or alteration of an electrical characteristic of which makes it possible to detect an intrusion attempt in the system 20. The patterns for example have switchbacks. The patterns for example have boustrophedon, spiral or labyrinthine shapes, as illustrated in figure 3.

The term "track" refers to a continuous electrical circuit in which a current is able to circulate and each of the two ends of which is connected either to a connecting point, such as a via, or to a transfer range for components that is for example buried, in the printed circuit, or cabled on the surface in the inner volume 24. A component transfer range is a connection to components situated outside the layers of the first considered protection surface 22.

Preferably, the coverage rate of the set of patterns 44 of each cell 42 is strictly greater than 80 percent, preferably equal to 100%.

The expression "coverage rate" refers to the ratio of the surface occupied by the set of patterns 44 of a cell 42 to the total surface of the cell 42. The surface of a pattern 44 is the area of the track of the pattern 44, completed by the area of the free strip extending on either side of the track over the entire length of the track and necessary to provide the electrical insulation between the track and the other adjacent tracks.

For a track measuring $10\text{ }\mu\text{m}$ wide and having length L , the width of the free strip on either side of the track is for example equal to $4\text{ }\mu\text{m}$. The surface of the pattern is therefore the product of the length of the track by the sum of the width of the track and the free strips on either side of the track, i.e., L multiplied by $18\text{ }\mu\text{m}$.

Advantageously, at least one cell 42 comprises several patterns 44. Thus, in the example shown in figure 4, a cell 42 comprises two interwoven patterns 44. The increase in the number of patterns 44 per cell 42 and the interweaving of the patterns 44 within a same cell 42 makes it more difficult for an attacker to short-circuit a zone of the mesh without being detected.

Each cell 42 has a contour defined by the pattern(s) 44 of the cell 42. In the example illustrated in figure 3, the contour of at least one cell 42 is irregular, such that the cell 42 does not have an axis of symmetry. Indeed, irregular contours for the cells 42 make it more difficult, during a visual analysis, to detect the border between the different cells 42 of a same mesh layer 40, which makes the reverse engineering work that an attacker may conduct more complex.

Each cell 42 has a shape defined as the surface occupied by the pattern(s) 44 of the cell 42.

The shapes of the cells 42 are for example simple geometric shapes, such as triangular shapes illustrated in figure 5, square shapes illustrated in figure 6 or hexagonal shapes illustrated in figure 7.

Alternatively and as illustrated in figure 3, the shapes of certain cells 42 or all of the cells 42 of each mesh layer 40 are more complex, like the shapes used in building puzzles.

Alternatively or additionally, at least two cells 42 of two different mesh layers 40 or of a same mesh layer 40 have different shapes.

Alternatively or additionally, the shapes of the cells 42 of a same mesh layer 40 or adjacent mesh layers 40 are complementary. For example, the interstitial spaces between cells 42 having a first type of shape are complementary to cells 42 having a second type of shape. This makes it possible to minimize the zones of the mesh layers 40 that are not protected by a mesh.

For example, figure 8 illustrates a mesh layer 40 comprising a first type of circular cells 42 and a second type of square cells 42 with convex sides, complementary to the first type of cells 42. Likewise, figure 9 illustrates a mesh layer 40 comprising a first type of hexagonal cells 42 and a second type of triangular cells 42, complementary to the first type of cells 42.

Thus, the shapes of the cells 42 of a same mesh layer 40 are chosen so as to arrange the cells 42 side by side while minimizing the free space, also called interstitial space, between the cells 42.

Advantageously, the interstitial space between the adjacent cells 42 of a same mesh layer 40 is less than or equal to 100 micrometers, preferably less than or equal to 50 micrometers. The interstitial space for example corresponds to the minimum acceptable electrical insulation between two adjacent tracks.

In the embodiments illustrated in figures 10 and 11, the cells 42 of each mesh layer 40 have identical shapes and are arranged opposite interstitial spaces between the cells 42 of at least one other mesh layer 40 adjacent to said mesh layer 40. In particular, the cells 42 of figure 10 have a square shape and the cells 42 of figure 11 have a hexagonal shape. Such an arrangement makes it possible to decrease the zones of the first protection surface 22 not covered by a cell 42 and thus to strengthen the protection against intrusions.

The embodiment of figure 12 is similar to those of figures 10 and 11, with the difference that the cells 42 have different shapes from one mesh layer 40 to another.

The first protective surface 22 further comprises connections 45 providing the connection with the patterns 44 of cells 42 belonging to mesh layers 40 that may or may not be adjacent.

The connections 45 comprise through connecting points 46 and optionally interconnection arms 47. When the two interconnection arms 47 between the patterns 44 of cells 42 belong to a same mesh layer 40, i.e., there are no through connecting points 46 between said two interconnection arms 47, then the patterns are considered to be connected to one another by said two arms 47 forming a pattern 44 of a cell 42 with a particular shape.

Each through connecting point 46 is connected by one of its ends to an end of a pattern 44, and by the other of these ends to one of the elements chosen from among: another pattern 44, another through connecting point 46, an interconnection arm 47 and a component transfer range.

The through connection points 46 of each mesh layer 40 are distributed over the entire surface of the zone protected by the mesh layer 40 and not only on the periphery of the mesh layer 40.

Preferably, each protected zone is formed by a central part and a peripheral part surrounding the central part and taking up no more than 30 percent of the surface of the protected zone. The through connection points 46 of each mesh layer are distributed over the central zone and over the peripheral zone of the protected zone by the mesh layer 40.

Advantageously, the deviation between the mean density of through connecting points 46 on each connected sub-zone of the protected zone is less than or equal to 10 percent. The mean density of through connecting points 46 on each connected sub-zone is defined as the ratio between the surface occupied by the through connecting points 46 on the connected sub-zone and the surface of the connected sub-zone.

In the embodiment illustrated in figure 2, the through connecting points 46 are micro-vias. The term "micro-via" refers to a metal hole traversing the layer in which it is formed to reach the immediately adjacent lower layer. Such a hole is metallized to establish a connection between the layer in which it is formed and the adjacent lower layer. The dimensions of each micro-via are of the order of magnitude of a micrometer, i.e., comprised between 0.1 μm and 100 μm . The dimensions of each micro-via depend on the dielectric thickness present between the conductive layers.

The interconnection arms 47 make it possible to interconnect the patterns 44 of the cells 42 of a same mesh layer 40 or different mesh layers 40, via through connecting points 46.

The interconnection arms 47 connect, in planes perpendicular to the superposition direction Z, through connecting points 46 to one another, ends of patterns 44 to one another, a pattern end 44 with a component transfer range, or a through connecting point 46 with a component transfer range.

5 The interconnection arms 47 are for example wires.

The through connecting points 46 and the interconnection arms 47 connect patterns 44 of cells 42 belonging to separate mesh layers 40 and identical mesh layers 40.

10 In the example illustrated in figure 2, each connection 45 for example comprises, in the following order: a first through connecting point 46 forming one end of a first pattern 44 of the cells 42 of the first mesh layer 40, a first interconnection arm 47 of the interconnection matrix 44 and a second through connecting point 46 forming one end of a second pattern 44 of a cell 42 of a second mesh layer 40.

15 The patterns 44 connected to one another by through connecting points 46 and optionally by interconnection arms 47 form loops, also called equipotential. The term "loop" refers to the combination of tracks, through connecting points 46 and optionally interconnection arms 47, to form a continuous interconnecting electrical circuit between at least two component transfer ranges. The set of loops of a surface forms a mesh.

20 In the examples of figures 2 to 3 and 5 to 13, the cells 42 comprising at least one pattern 44 and belonging to a same loop are represented by a same type of crosshatching, dots or uniform background. The example of figure 2 illustrates only the interconnection arms 47 and the through connecting points 46 connecting the patterns 44 of the cells 42 of a single loop to one another.

25 Advantageously, the interconnection arms 47 and/or the through connecting points 46 connecting the patterns 44 of each loop are arranged across from patterns 44 belonging to at least one other loop.

Each loop formed from connections 45 comprises patterns 44 of cells 42 belonging to at least two mesh layers 40.

30 The connections 45 between the patterns 44 of the cells 42 forming the loops are advantageously configured and chosen in the plant. The connections 45 are preferably not established using a predetermined logic, but are different for each loop. Furthermore, the connections 45 between the patterns 44 of the cells 42 of each loop are not predictable through symmetry or frequency after studying part of the loop. The successive interconnection of the patterns 44 belonging to different layers via interconnection arms 47 and optionally through connecting points 46 is comparable to a knit of different electrical loops to one another.

35

Preferably, the patterns 44 of a same loop and belonging to a same mesh layer 40 and a second mesh layer 40, adjacent to the first mesh layer 40, are arranged relative to one another such that the projections along the superposition direction Z of said patterns 44 of the first mesh layer 40 on the second mesh layer 40 are partially superimposed or not superimposed on said patterns 44 of the second mesh layer 40.

In other words, the patterns 44 belonging to a first loop are not completely superimposed along the superposition direction Z with the patterns 44 of the same loop, but situated on an adjacent mesh layer 40. This makes it possible to make the reverse engineering work by an attacker more complex. Such a feature is in particular illustrated in figures 10, 11 and 12.

Similarly, two patterns 44 of adjacent cells 42 of a same mesh layer 40 preferably belong to separate loops.

An example interconnection matrix 41 is illustrated in figure 2.

In the embodiment of figure 2, the system 20 comprises two mesh layers 40, as well as an interconnection matrix 41.

The mesh layers 40 and the interconnection matrix 41 are superimposed on one another along the superposition direction Z, for example according to the configuration illustrated in figure 2 in which the interconnection matrix 41 is covered on either side by a mesh layer 40.

In this case, the interconnection matrix 41 comprises the interconnection arms 47 able to interconnect the patterns 44 of the cells 42 of the mesh layers 40 to one another.

The interconnection arms 47 are preferably distributed on the entire surface of the interconnection matrix 41.

Alternatively or additionally, each cell 42 is defined by an enclosure containing the pattern(s) 44 of the cell 42. At least one pattern 44 of a cell 42 of a mesh layer 40 comprises an end protruding relative to the enclosure of the cell 42. The protruding end is the extension of the same material of the or one of the patterns 44 of the cell 42. The protruding end makes it possible to connect the pattern 44 to another pattern 44 of the same or another mesh layer 40 in place of an interconnection arm 47 of the interconnection matrix 41.

For example, as illustrated in figure 13, the solid lines 50 show pattern ends 44 of cells 42, connected to the patterns 44 of other cells 42 of the same mesh layer 40.

Such protruding ends make it possible to limit the apparent superimposed surface of the mesh, and thus to make the detection of the loop by an attacker more complex.

The second protection surface 23 is superimposed on the first protection surface 22. In particular, the second protection surface 23 covers all or at least part of the printed circuits and integrated circuits of the equipment 21.

In the example illustrated in figure 1, the second protection surface 23 has a cover shape. In this case, the second protection surface 23 comprises a planar surface 51 with lateral edges 52. The lateral edges 52 of the second protection surface 23 are connected to the first protection surface 22.

The second protection surface 23 advantageously has, in its planar surface 51 and its lateral edges 52, the same structure as the first protection surface 22 illustrated in figure 2, i.e., mesh layers 40 comprising cells 42 and at least one interconnection matrix 41 connecting the cells 42 to one another so as to form a mesh. Thus, the second protection surface 23 comprises a plurality of other loops.

The detection module 26 is positioned inside the inner volume 24.

The detection module 26 is able to detect a modification of an electrical characteristic of each loop, and in particular, a break in continuity or alteration of the signal traveling through the patterns 44 of each loop.

An intrusion being characterized by a break or alteration, the detection module 26 is therefore able to detect intrusions. For example, the detection module 26 is able to detect a power outage by dry loop, transmission-reception of the signal, or latency measurement.

The detection module 26 is configured to apply a security policy following the detection of the modification of an electrical characteristic of the signal traveling a loop, such as a break in continuity. The security policy for example comprises activating an alarm warning an operator that an intrusion attempt has been detected, as well as erasing sensitive data from the equipment 21 protected by the system 20.

Typically, the detection module 26 is configured to emit electrical signals periodically on each electrical loop, then to verify the proper reception thereof. In case of incorrect reception of an electrical signal, the detection module 26 is able to detect a physical alteration of one or several electrical loops. Thus, the detection module 26 continuously monitors the loops to detect variations of their electrical characteristics that would for example indicate an attack attempt by drilling.

The primary power source 28 is situated outside the inner volume 24.

The primary power source 28 is configured to power the detection module 26 via a control, monitoring and power supply interface. The interface makes it possible to connect the output of the inner volume 30 to the primary power source 28 without compromising security.

When the detection module 26 is operating, the primary power source 28 is able to work continuously. When the detection module 26 is operating, the primary power source 28 is able to work continuously.

When the detection module 26 identifies a cut-set of the primary power source 28, the detection module 26 is able to generate an alarm used to make the data to be protected inaccessible or unusable, since surveillance can no longer be ensured.

Secondary power source 30 is situated inside the inner volume 24.

The secondary power source 30 is directly connected to the detection module 26. The secondary power source 30 is able to power the detection module 26 when the detection module 26 detects an outage of the primary power source 28. Thus, due to the secondary power source 30, the detection module 26 is capable of taking actions to make the data to be protected inaccessible or unusable.

An intrusion detection method from the intrusion detection system 20 of figure 1 will now be described.

Initially, the intrusion detection method comprises providing the intrusion detection system 20 as previously described.

The detection module 26 continuously checks the integrity of the loops so as to detect a modification of an electrical characteristic of one of the loops. In this case, the detection module 26 takes protective actions on the equipment protected by the system 20. For example, the detection module 26 erases the sensitive data from the equipment 21.

When the primary power source 28 is cut, the detection module 26 detects such an interruption and is then powered by the secondary power source 30 so as to carry out the protective actions.

Thus, the system 20 makes it possible to protect the inner volume 24 on the periphery through a mesh of several entwined loops, as finely as possible and as difficult as possible to short-circuit at the inputs and outputs of the loops. This requires the attacker to place a multitude of shunts that may generate an alarm on the attacked loop at each step.

Indeed, each cell 42 protects the neighboring and peripheral cells 42, then requiring the placement of many shunts to free a sufficient surface and access the protected volume stage by stage. Furthermore, the ends of each loop are difficult to reach, since they are generally buried in the inner mesh layers 40.

The interweaving of the loops, for example via the interwoven patterns 44 of a same cell 42, make it more difficult to follow a loop from end to end and do not make it possible to short-circuit both ends of the loop easily. Indeed, the formation of different

loops from interwoven patterns increases the risk of short-circuit between these loops during an attack.

Thus, the cellular structure incorporates a high-low knitting of the loops in the mesh layers 40, which requires the attacker to short-circuit at least one cell 42 of nearly all of the loops to access the protective equipment, as well as the same loops several times. However, such short-circuit increase the risk of error by the attacker and therefore increase the likelihood of detection of an intrusion.

Such a cellular structure is made possible by the presence of through connecting points 46 distributed on the entire surface of the mesh layers 40.

Advantageously, the mesh travels over both the second protection surface 23 and the first protection surface 22 so that the mesh is completely continuous and fully protects the detection module 26, as well as the functions to be protected.

Furthermore, in order to have a mesh maximally covering the surface enveloping the volume to be protected, an optimization of the overlap of the empty spaces between the loops is provided by superimposing several layers.

Thus, the system 20 forms a protection system that better withstands attacks and makes it more difficult for an attacker to short-circuit one or several electrical loops of a mesh after reverse engineering.

One skilled in the art will understand that the invention is not limited to the described embodiment, or to the specific examples of the description.

For example, additionally, when the equipment 21 has integrated circuits or printed circuits having sensitive information front and back, the intrusion detection system 20 incorporates a protection surface making it possible to protect the front and back of the integrated circuits and printed circuits of the equipment 21.

Alternatively or additionally, the cells are reduced to connection points and micro-vias. In this case, the minimum distance separating two cells 42 of a same loop and belonging to two different mesh layers 40 is less than or equal to 100 micrometers, preferably less than or equal to 50 micrometers.

For example, figure 14 illustrates three mesh layers 58A, 58B, 58C comprising connecting points 59 and micro-vias 60A, 60B in place of the cells 42. The micro-vias 60A connect the connecting points 59 of a first layer 58A with the connecting points 59 of a second layer 58B, the second layer 58B being immediately adjacent to the first layer 58A. The micro-vias 60B connect the connecting points 59 of the second layer 58B with the connecting points 59 of a third layer 58C, the second layer 58C being immediately adjacent to the second layer 58B and separate from the first layer 58A.

As a result, figure 14 shows two loops formed from micro-vias 60A, 60B: a first loop is shown in thick black lines and a second loop in dotted lines.

14
CLAIMS

1.- Intrusion detection system (20), comprising:

- at least two superimposed mesh layers (40), each mesh layer (40) comprising a plurality of cells (42) and a plurality of through connecting points (46), each cell (42) comprising at least one continuous pattern (44), at least one end of which is connected to a through connecting point (46), the coverage rate of the set of patterns (44) of each cell (42) being strictly greater than 80 percent, the set of cells (42) of each mesh layer (40) defining a zone protected by the mesh layer (40),

- a plurality of connections (45), each connection (45) connecting two cell patterns (44) of different mesh layers (42) to one another via through connecting points (46) to form loops, each loop being a continuous electrical circuit, each loop comprising patterns (44) belonging to at least two different mesh layers (40),

- a detection module (26) able to detect a modification of an electrical characteristic of each loop,

characterized in that the through connection points (46) of each mesh layer (40) are distributed over the entire surface of the zone protected by the mesh layer (40).

2.- System according to claim 1, wherein each protected zone is formed by a central part and a peripheral part surrounding the central part, the peripheral part taking up no more than 30 percent of the surface of the protected zone, the through connecting points (46) of each mesh layer (40) being distributed over the central zone and over the peripheral zone of the zone protected by the mesh layer (40).

3.- System according to claim 1 or 2, wherein the deviation between the mean density of through connecting points (46) on each related sub-zone of the protected zone is less than or equal to 10 percent.

4.- System according to any one of claims 1 to 3, wherein the largest dimension of each cell (42) is at most equal to one third of the largest dimension of the zone protected by the mesh layer (40) of the cell (42).

5.- System (20) according to any one of claims 1 to 4, wherein each cell (42) is defined by an enclosure containing the pattern(s) (44) of the cell (42), at least one pattern (44) of a cell (42) of a mesh layer (40) comprising one end (50) protruding relative to the enclosure of the cell (42), the protruding end (50) being integral with the or one of the

patterns (44) of the cell (42), the protruding end (50) connecting the pattern (44) to another pattern (44) of the same or another mesh layer (40).

5 6.- System (20) according to any one of claims 1 to 5, wherein at least one cell (42) of a mesh layer (40) comprises at least two interwoven patterns (44).

7.- System (20) according to any one of claims 1 to 6, wherein the spacing between the adjacent cells (42) is less than or equal to 100 micrometers, and preferably less than or equal to 50 micrometers.

10 8.- System (20) according to any one of claims 1 to 7, wherein the patterns (44) of a same loop and belonging to a same mesh layer (40) and a second mesh layer (40), adjacent to the first mesh layer (40), are arranged relative to one another such that the projections along the superposition direction (Z) of said patterns (44) of the first mesh
15 layer (40) on the second mesh layer (40) are partially superimposed or not superimposed on said patterns (44) of the second mesh layer (40).

9.- System (20) according to any one of claims 1 to 8, wherein the through connecting points (46) connecting the patterns (44) of each loop are arranged across from
20 patterns (44) belonging to at least one other loop.

10.- System (20) according to any one of claims 1 to 9, wherein the minimum distance separating two cells (42) of a same loop and belonging to two different mesh layers (40) is less than or equal to 100 micrometers.

25 11.- System (20) according to any one of claims 1 to 10, wherein the through connecting points (46) are micro-vias.