A modular roofing system includes a lower set of co-adjacent rectangular panels locked together by an upper set of co-adjacent hexagonal tiles made from a light-weight rigid urethane foam material coated with a durable outer layer of non-foam polyurethane plastic. The tiles can carry photovoltaic cells that interconnect at opposite ends to adjacent tiles. The cells can be replaced on the existing installed tiles using an aligned locking structure for aligning electrical contacts and sealing the cells. Length adjustable modular gutter tiles terminate an array of tiles along a lower roof edge.
MODULAR ROOFING SYSTEM

FIELD OF THE INVENTION

[0001] The invention relates generally to modular roofing tiles, and more particularly to roofing tile systems which can provide solar power options.

BACKGROUND

[0002] Roofing systems have likely existed since soon after humans moved out of caves millennia ago. Modernly, preferred systems should be inexpensive, easy to manufacture, install, repair and maintain, and are reasonably effective at keeping the weather out of a dwelling. Other desirable qualities for roofing systems are that they be light-weight, durable, and provide insulation against temperature extremes.

[0003] One relatively recent improvement to roofing systems involves adaptions which generate electricity from solar power and are adapted for use on slanted roofs typically used on single family dwellings. A substantial amount of research and development has been carried out for the purpose of producing practical and economical photovoltaic voltage generating units for roofing systems. Conventional methods of forming photovoltaic modules for installation in roofing systems often involve forming and installing one module at a time to an existing pre-installed roofing system. Such methods can be expensive to manufacture and install. Further, the installation can result in damage or rapid wear of an existing roof, thus reducing its weather protective quality.

[0004] Integrated photovoltaic generating roofing systems are well-known and described, for example, in U.S. Pat. Nos. 4,040,867 and 4,321,416, both of which are incorporated herein by reference. These systems include a plurality of tiles connected to one another in accordance with a predetermined wiring arrangement to form an array to make their generated power available at output terminals of the array. The array of modules may serve as shingles that are secured to the roof or other surfaces of a structure by relatively complicated means including for example fasteners and oversized washers that are positioned and located relative to inactive portions of the photovoltaic modules. Thus, the shingles can be difficult and costly to install and replace.

[0005] There is a need for an improved modular roofing system which can provide a more simple means for being interconnected, both mechanically and electrically; which can be less expensively manufactured, installed, maintained and repaired; which can be light-weight; which can provide improved insulating characteristics; and/or which can provide improved protection against weather extremes in combination with the electricity generating capability.

[0006] The instant invention results from an attempt to address one or more of the above identified disadvantages of prior systems.

SUMMARY

[0007] The principal and secondary objects of the invention are to provide an improved roofing system. These and other objects are achieved by, for example, a modular roofing system having an array of lower panels which interlock and support an array of interlocking upper tiles.

[0008] The content of the original claims is incorporated herein by reference as summarizing features in one or more exemplary embodiments.

[0009] In some embodiments there is provided a roofing system which comprises: a first set of laterally abuttable, uniformly shaped and dimensioned lower support panels; a second set of laterally matable, uniformly shaped and dimensioned roofing tiles; wherein an abutted pair of said panels forms a mutual ridge extending upwardly along their abutting edges; and, wherein a mated pair of said tiles has a common, co-linear bottom channel shaped and dimensioned to intimately nest onto said mutual ridge.

[0010] In some embodiments the roofing system further comprises: said abutted pair of panels having co-planar upper support surfaces astride said ridge; and, said mated pair of tiles having co-planar lower surfaces astride said channel; and, wherein said lower surfaces are bearingly supported by said upper surfaces.

[0011] In some embodiments the roofing system further comprises: said mutual ridge being formed by uniformly shaped and dimensioned prominences extending upwardly along said abutting edge.

[0012] In some embodiments said abutted pair of panels planarly slidingly abut along a pair of substantially planar contact surfaces oriented substantially orthogonally to said upper support surfaces.

[0013] In some embodiments said panels abut in absence of a tongue-in-groove interface.

[0014] In some embodiments the roofing system further comprises: said first set of panels being uniformly shaped and dimensioned; and, said second set of tiles being uniformly shaped and dimensioned.

[0015] In some embodiments said mated pair of tiles mate along tongue-in-groove interface.

[0016] In some embodiments said tiles modularly combine to form a contiguous planar array.

[0017] In some embodiments a first of said tiles interlock with a second adjacent one of said tiles along a first side wall and wherein said first of said tiles interlocks with a third adjacent one of said tiles along a second side wall, and wherein said first and second side walls are non-parallel.

[0018] In some embodiments each of said panels are substantially rectangularly shaped and each of said tiles are substantially hexagonally shaped.

[0019] In some embodiments the roofing system further comprises: a second abutted pair of panels; wherein said first abutted pair of panels abut latitudinally; wherein said second abutted pair of panels abut latitudinally; and wherein said first abutted pair of panels interlocks longitudinally with said second abutted pair of panels.

[0020] In some embodiments each of said tiles comprises a core consisting of a rigid polyurethane foam material and an upper protective coating layer of a non-foam polyurethane material contacting said core; and wherein said rigid polyurethane foam material has a density of no greater than 240 kilograms per cubic meter.

[0021] In some embodiments said tile further comprises a photoelectric module releasably secured to said tile within a recess formed into a substantially planar upper surface of said tile; wherein said module has a substantially planar upper surface which is substantially co-planar with said tile upper surface when the module is secured within said recess.

[0022] In some embodiments said tile further comprises: a first pair of electrical contacts located within said recess and said module comprises a second pair of electrical contacts shaped, dimensioned and located to electrically interconnect with said first pair when said module is secured to said tile;
and, a pair of electrical contact wells formed into said first side wall; and, a pair of dual ended electrical contact pins shaped and dimensioned to intimately and conductively engage said wells and a second pair of wells located on said second one of said tiles.

[0023] In some embodiments the roofing system further comprises: a locking mechanism for securing said module within said recess, where said locking mechanism comprises: alignment tabs extending from a peripheral boundary located to engage commensurately shaped and dimensioned alignment slots formed on a periphery of said recess; and, a sloped track having an endstop located to restrict angular movement of at least one of said tabs.

[0024] In some embodiments said first side wall has a groove which transitions to a second side having a tongue proximate to a vertex; and wherein said groove preferentially extends beyond said vertex of said side to eliminate said tongue; and, wherein said groove extends along three contiguous sides of said tile and said tongue extends along three contiguous side walls of said tile.

[0025] In some embodiments the roofing system further comprises: a gutter tile having an upper surface co-planar with a top surface of said tile array; an aperture passing through said upper surface in communication with a gutter; and, wherein said gutter comprises: a plurality of uniformly shaped and dimensioned U-shaped stacked gutter ribs.

[0026] In some embodiments there is provided a roofing system which comprises: a substantially continuous planar array of uniformly shaped and dimensioned co-adjacent lower panels; a substantially continuous planar array of uniformly shaped and dimensioned co-adjacent upper tiles; and, said lower panels being locked to one another by said tiles.

[0027] In some embodiments each of said panels comprises opposite substantially parallel edges, wherein each of said edges has a raised prominence; and, wherein each of said tiles comprises an undersurface shaped to have a medial channel shaped and dimensioned to intimately engage a laterally adjacent pair of said prominences; and, wherein said panels are substantially rectangular and said tiles are substantially hexagonal.

[0028] In some embodiments there is provided a roofing device which comprises: a plurality of coplanarly interlocking upper tiles; a plurality of coplanarly interlocking lower support panels; wherein each of said panels comprises opposite parallel edges wherein each of said edges has an upwardly extending prominence; wherein each of said tiles comprises a bottom surface shaped and dimensioned to have an upwardly extending channel; and, wherein said channel has a width commensurate an abutted pair of said prominences.

[0029] In some embodiments there is provided a roofing assembly comprises: a plurality of tiles, each having a front edge, a back edge, and left and right lateral side edges, lying contiguously to one another in partially superimposing latitudinal rows; means for forming a right lateral edge of each tile to a left lateral edge of an adjacent tile; each of a group of said tiles comprising: a photoelectric cell; first and second electrical interconnects to said cell; a laterally extending groove supporting said first interconnect; and, a laterally extending tongue supporting said second interconnect.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030] FIG. 1 is a diagrammatic exploded perspective view of a modular roofing system according to an exemplary embodiment of the invention.

[0031] FIG. 2 is a diagrammatic perspective view of a pair of longitudinally interlocking coplanar support panels.

[0032] FIG. 3 is a diagrammatic partial perspective view of a pair of laterally abutting coplanar support panels.

[0033] FIG. 4 is a diagrammatic partial perspective view of a pair of laterally and coplanarly abutting tiles over a pair of laterally abutting coplanar support panels.

[0034] FIG. 5 is a diagrammatic perspective view of a pair of longitudinally and coplanarly abutting tiles over a pair of laterally abutting coplanar support panels.

[0035] FIG. 6 is a diagrammatic partial cross-sectional side view of coplanarly abutting tiles nestling supported by coplanarly abutting panels.

[0036] FIG. 7 is a diagrammatic top view showing the shaping and dimensioning of the tiles and panels.

[0037] FIG. 8 is a diagrammatic top view showing a tile and its tongue and groove structure.

[0038] FIG. 9 is a diagrammatic top and side view showing a tile and its tongue and groove structure.

[0039] FIG. 10 is a diagrammatic top view of partial hex tile roof edge pieces.

[0040] FIG. 11 is a diagrammatic perspective view of a square shaped interlocking and nestable tile.

[0041] FIG. 12 is a diagrammatic partial perspective view of a ridge capping tile nested upon the ridge formed by abutted coplanar panels.

[0042] FIG. 13 is a diagrammatic perspective view of a roof terminating gutter tile structure.

[0043] FIG. 14 is a diagrammatic side view of a gutter rib element.

[0044] FIG. 15 is a diagrammatic exploded perspective view of a hexagonal tile adapted to carry a photocell module.

[0045] FIG. 16 is a diagrammatic partial cross-sectional side view of tile of FIG. 15 having its photocell secured.

[0046] FIG. 17 is a diagrammatic exploded perspective view of a group of coplanarly abutting hexagonal tiles and a replacement tile.

[0047] FIGS. 18-25 show an embodiment of my design for a roofing system interlocking continuous array-forming support panel.

[0048] FIGS. 26-33 show an embodiment of my design for a roofing system interlocking continuous array-forming hexagonally shaped tile.

[0049] FIGS. 34-41 show an embodiment of my design for a roofing system interlocking continuous array-forming square shaped tile.

[0050] FIGS. 42-48 show an embodiment of my design for a roofing system interlocking longitudinally interlocking ridge-capping tile.

[0051] FIGS. 49-56 show an embodiment of my design for a roofing system lower edge gutter-carrying termination tile.

DESCRIPTION OF THE EXEMPLARY EMBODIMENT OF THE INVENTION

[0052] Referring now to the drawing there is shown in FIG. 1 a modular roofing system according to an exemplary embodiment of the invention. The system 1 includes a plurality of modular elements 2 which interlock in a stratified, co-nested manner. In other words, some of the elements include a set of underlying panels 3 which interlock and abut in a laterally co-adjacent, co-planar manner to form a continuous array as a substantially planar first layer 4, while other elements include a set of overlying tiles 5 which interlock in a laterally co-adjacent, co-planar manner to form a continu-
ous array as a substantially planar second layer 6 which is nestingly superimposed over and supported by the first layer.

[0053] As shown in FIGS. 1-3, each of the panel elements 3 has a substantially planar rectangular top surface 14 parallelly spaced apart from a substantially planar bottom surface 15 oriented to bear against the typically planar upper-facing surface 7 of the roof of a structure. Each panel has a front edge 16, a parallelly opposite back edge 17, and two parallelly spaced apart side edges 18, 19. A pair of prominences 22, 23 run linearly along the entire longitudinal length of the opposite side edges. Each prominence can have an oblong quadrangular shape having a height H dimension and a width W dimension. The front edge 16 of each panel can have a groove structure 26 while the back edge 17 has a corresponding tongue structure 27. In this way, longitudinally adjacent panels 10, 11 can mate in a front edge-to-back edge manner in the longitudinal direction 8 to form a longitudinal row 20 of panels where the seam 28 formed between longitudinally adjacent panels is a tongue-in-groove seam which provides additional strength by spreading certain loads to adjacent panels, is more water resistant, and keeps the panel side edges in alignment. This arrangement also prevents one panel from sliding latitudinally with respect to its longitudinally mated adjacent panel. This arrangement provides a non-sliding contact along the seam.

[0054] As shown in FIG. 3, when two panels or rows of panels are brought latitudinally together in a common plane where the prominence of each panel abuts the other, the two adjacent prominences form an upwardly projecting ridge structure 29. Thus rows 20, 21 of longitudinally mated panels can abut against one another in a side edge-to-side edge manner in the longitudinal direction 9 thus forming a substantially continuous planar array of panels as shown in FIG. 1.

[0055] It shall be noted that the side edges 18, 19 can be formed to have substantially planar side surfaces 24, 25. In this way, after a co-planar array of panels has been installed, a panel 34 can be slid longitudinally 32 with respect to its latitudinally abutted panels. Thus some of the panels in the longitudinal row 33 containing the slid panel 34 are also slid. In this way, the panel 34 at an end of the slid panels can be removed from an emplaced array of lower panels. This can save time during installation by allowing for adjustment of panels and can facilitate repair of damaged panels. Further an entire row of panels can be removed without disturbing adjacent rows of panels.

[0056] As shown in FIGS. 1 and 4-6, each of the tile elements 5 can have a substantially planar regular hexagon-shaped top surface 44 parallelly spaced apart from a substantially planar bottom surface 45 oriented to bear against the typically planar upper-facing surfaces 14 of panels 61, 62 when latitudinally abutted. Each tile has six hexagonally oriented side walls including a front wall 46, a parallelly opposite back wall 47, and four angled side walls 48, 49, 50, 51 opposite pairs of which, namely 48, 50 and 49, 51 are parallelly spaced apart. The side walls transition to an adjacent side wall at a vertex.

[0057] A central elongated longitudinal channel 55 is formed upwardly from the bottom surface 45 and extends longitudinally 8 between the front wall 46 and the back wall 47 bisecting the bottom surface 45, thus creating a pair of co-planar lower surfaces 52, 53 astride the channel which are oriented to bear against and be supported by the co-planar upper surfaces 56, 57 of a pair of latitudinally abutted panels astride the mutual ridge 58 formed therebetween.

[0058] Thus the channel 55 can be shaped and dimensioned to have a height H' dimension and a width W' dimension selected to allow the channel to be intimately engaged by the ridge formed between abutted panels. The height H' of the channel can be equal to or slightly larger than the height H of the prominences forming the ridge so that the tile is supported by the co-planar surfaces 56, 57 and possibly the tops of the ridges rather than the tops of the ridges exclusively. The width W' of the channel can be slightly larger than the width of the ridge which is approximately double the width W of a prominence. A ridge having a constant height H and width W will allow a tile or groups of tiles to be slid longitudinally along the ridge while remaining in substantial engagement.

[0059] As shown in FIG. 4, a pair of laterally abuttable, uniformly shaped and dimensioned lower support panels 61, 62 are laterally and co-planarly brought together in a side-to-side manner. And, a pair of laterally matable, uniformly shaped and dimensioned roofing tiles 63, 64 are laterally and co-planarly brought together in a front-to-back manner so that their channels are in substantial alignment thus forming a common, co-linear bottom channel extending longitudinally on the undersurface of the mated tiles.

[0060] As shown in FIGS. 5 and 6, the mated pair of tiles 63, 64 can be lowered downwardly onto the abutting pair of panels so that the channels of the tiles are intimately engaged by the ridge and the tiles are supported by the panels in an interlocked, stratified, and co-nested manner.

[0061] It shall be noted that the abutment of latitudinally adjacent panels can still occur even though a small gap 59 is formed between the mutually facing side surfaces so long as the tiles are longitudinally continuous and the seams between adjacent tiles are designed to be water-tight such as through the use of tongue-in-groove mating.

[0062] Referring now to FIGS. 1 and 6-7, the dimensions of each panel 3 and each tile 5 are selected to allow a contiguous array of tiles to nest upon and be supported by a contiguous array of panels. Thus in the present embodiment the length L of side walls of each tile 3 is selected to be one third the length Lp of the separation of the side surfaces 24, 25 of each panel 5.

[0063] As shown in FIGS. 4, 6 and 8-9, a tongue-in-groove interlock structure 70 can be formed into the side walls 46, 51 of each tile 5. Thus, the front wall 46 and its adjacent side walls 48, 51 can have a groove structure 71 while the back wall 47 and its adjacent side walls 49, 50 can have a corresponding tongue structure 72. The depth G of the groove is at least as large as the width W of the tongue. The groove structure takes precedence over the tongue structure at the transition 78 near the vertex 75 between side walls 48, 49 so that the groove 71 extends beyond the end of its side wall 48 to eliminate the tongue 72 before it reaches the end of its side wall 49. In other words, the tongue structure does not pass over a line 76 perpendicular to the front and back side walls 46, 47 and passing through the vertex 75 between the side walls where a transition from tongue to groove occurs. A similar transition occurs near the opposite vertex 77. The words "substantially universal" are used because some tiles can be made with photocell modules as will be described in greater detail below. However, such tiles can still be used interchangeably for structural purposes.
The tiles should have a common angular orientation so that the front walls of an array of tiles are all parallelly oriented. Longitudinally adjacent tiles can mate laterally in a front wall-to-back wall manner in the longitudinal direction to form a longitudinal row of tiles where the seam formed between longitudinally adjacent tiles is a tongue-in-groove seam which provides additional strength by spreading certain loads to adjacent tiles, and is more water resistant. Adjacent tiles having a latitudinal component to their planar location can also mate in a honeycomb manner where a tongue side wall interlocks with a grooved side wall of an adjacent tile.

As shown in FIG. 10, partial tiles 65-68 having appropriately located side walls 69, can be used to create linear edges to an array of hex tiles.

It shall be noted that the prominences of the panels can have other shapes so long as they come together to form a ridge shaped to intimately engage the channel in the tiles. It can be important that the ridge and channel have uniform height and width along its length so that the tile can move longitudinally along the ridge while remaining fully seated. In this way successive tiles can be added and brought together while seated on a ridge. This can help with tile alignment for easier installation.

The stratified dual interlocking layers enhance strength and leak avoidance so that lighter weight materials such as rigid urethane or polyurethane foam can be used to form the elements. This material can be inexpensively manufactured as uniformly shaped and dimensioned modules. For example, the elements can be made primarily out of injection molded, closed-cell rigid polyurethane foam commercially available from General Plastics Manufacturing Co. of Tacoma, Wash. under the brand name LAST-A-FOAM. The rigid foams can be low density in order to reduce weight on the roof of the structure, and closed cell to be water resistant. Other advantages of this type of material include its mold resistance, termite resistance, and its insulating characteristics. Densities can range from about 25 kilograms per cubic meter (about 1.5 pounds per cubic foot) and about 400 kilograms per cubic meter (about 250 pounds per cubic foot). For many common roofing applications involving a balance of parameters such as strength, durability, material cost and weight, it has been found that the density is preferably between about 80 to 320 kilograms per cubic meter (about 5 to 20 pounds per cubic foot) and more preferably between about 160 to 240 kilograms per cubic meter (about 10 to 15 pounds per cubic foot).

As shown in FIG. 6, the durability and strength of the rigid foam body core can be improved by forming a layer of semirigid non-foam polyurethane or polyvinyl material on the outer surface of each tile. Such polyurethane coating material is commercially available from Scorpion Protective Coatings, Inc. of Cloverdale, Ind. For many common roofing applications involving a balance of parameters such as strength, durability, material cost and weight, it has been found that the thickness is preferably between about 1 millimeter and about 5 millimeter, and more preferably between about 2 millimeters and about 3 millimeters. The thickness can be selected so that the top surface of the coated tile is substantially co-planar with the other tiles in the array. Other durable materials such as metal particle infused polyester can also act as the coating layer.

Other shapes and dimensioning of tiles can be used having upside channels which fit over the ridges formed between two adjacent panels. Some sets of tiles can be uniquely shaped and co-planarly mate together with similar tiles to form a continuous planar array of interconnected tiles similar to the hexagonal tiles described above. One example is a square-shaped tile as shown in FIG. 11.

Other types of tiles as shown in FIG. 12 can mate longitudinally and linearly along and cap only the ridge portion of the underlying latitudinally abutted panels. The seam formed between tiles mated at their front and back walls can be a tongue-in-groove seam. Although the medial upper surface of the panels is exposed the seams between the panels are tongue-in-groove seams as well. In this way, only the more water-resistant tongue-in-groove seams are exposed to the elements. In other words when viewed from above all exposed seams whether are tile-to-tile seams or panel-to-panel seams are tongue-in-groove seams.

Referring now to FIGS. 13 and 14 the lower edge of a peaked roof can terminate in a modular gutter structure formed by a substantially quadrangular upper gutter tile which can be supported and interface with the array of panels. The gutter tile has an aperture 102 extending latitudinally proximate to and along its lower edge 103. The aperture is covered by a durable steel screen to prevent leaves and other debris passing through the aperture and into an underhanging gutter 105 formed by latitudinally stacked gutter ribs 106. Each rib 106, as shown in FIG. 14 is substantially U-shaped where the ends 107 of the upwardly extending arms contact and bond to the underside of the gutter tile straddling the aperture. Each rib can have a tongue-in-groove structure to help seal the seam between adjacent stacked ribs and to help align the stacked ribs to one another. In this way water running down the roof passes through the aperture to collect in the gutter and flow downstream toward a lateral opening leading to an adjacent gutter. The gutter can be capped at an end by a solid capping rib 110. Although the ribs are shown contiguously stacked to one another, those skilled in the art will appreciate that the ribs can be latitudinally spaced apart and cradlingly support an elongated gutter trough.

Referring now to FIGS. 15-16 there is shown a coplanarly matable and nestable hexagonally shaped upper tile element adapted to carry a photocell module thereon. The tile body is shaped and dimensioned similarly to one of the tiles of FIG. 1. The substantially cylindrical photocell module is carried within a substantially cylindrical recess so that when the photocell is fully seated and secured within the recess in an operational orientation the substantially planar top surface of the photocell is co-planar with the substantially planar to surface of the outer protective layer of the tile body. The gap between the recess wall and the peripheral wall of the photocell module is sealed by a resilient washer made from rubber, plastic or other durable, resilient and substantially water-proof material. Alternately, or in addition to the washer, the gap can be sealed with a flexible water-proof caulking such as a silicone sealant.

The photocell module can be locked in place within the recess in a proper angular orientation which aligns the electrical contact bumps with the respective pads by means of a keyed pair of radially extending tabs engaged and tracked along a threaded guideway. Entry of the tabs into the guideway occurs through a pair of slots shaped, sized and spaced apart to allow passage of the tabs therethrough when the module is in angular alignment with the recess. Once engaged the module can be rotated with respect to the
tile body causing the tabs to ride within the threaded track until one of the tabs reaches an endstop 150. The endstop is angularly located to cause rotation to stop when the pads and bumps are in contact.

**[0075]** Electrical interconnection between the photocell module 121 and the tile body 123 occurs through a pair of metal electrical contact bumps 130 extending from a bottom surface 133 of the photocell module. The bumps are located shaped and dimensioned to contact a corresponding pair of metal electrical contact pads 131 set into the upwardly facing bottom surface 132 of the recess when the photocell module is fully seated within the recess.

**[0076]** Electrical interconnection between the photocell carrying tile element 120 and the rest of the system occurs through adjacent tiles either through wires 140 running within an open channel 141 or through pairs of electrical contact pins 142 engaging corresponding wells 143 set into the front and back side walls 144, 145 of the tile body 123. Each pin includes a pair of metal contact prongs 146 extending coaxially from opposite ends of the pin. A medial insulating sleeve 147 provides a finger grasp point to facilitate insertion of the pin into the well. The interconnection of a plurality of interconnect photocell-equipped tiles occurs in a manner similar to that disclosed in Tennent, U.S. Pat. No. 4,321,416 already incorporated herein by reference or through other means well-known in the solar electric energy generating field.

**[0077]** Damaged photocells can be repaired by cutting and removing any sealant, if present, and removing the resilient retaining ring. The photocell module can then be removed by unscrewing it from the recess. A replacement module can then be screwed into place and the retaining ring and an optional new bead of caulk or other sealant applied.

**[0078]** One or more damaged tiles can be removed by first cutting the damaged tiles into pieces and removing them. Care should be taken to avoid damaging underlying panels that are undamaged. Of course, damaged panels can be replaced as previously described once the overlying tiles have been removed. If a plurality of adjacent damaged tiles are removed, it is possible to replace some of the tiles at the periphery of the zone of removed tile with undamaged tiles. However, this may not be possible for those sites in the zone where the tongue-and-groove structure of emplaced tiles interfere with installing an undamaged tile. This scenario occurs when only one tile is to be replaced.

**[0079]** As shown in FIG. 17 the space 160 left by a single removed damaged tile in an existing emplacement 159 can be filled by a partial tile 161 having only the top surface portion 162 and peripheral underlying grooves 163. Three tongue inserts 164 can be placed into the corresponding grooves (indicated by the arrows) of the emplaced tiles to provide a peripheral ledge upon which the replacement partial tile is supported. A bead of sealing adhesive such as silicone caulk can be used to bond the inserts in place and to bond the partial tile to its adjacent tiles. A surrounding bead of sealant can ensure the watertight emplacement of the partial tile. If the damaged tile was a photovoltaic tile, the electrical connector pins can be removed and a pair of jumper wires 165 can be used to bridge the electrical connector wells bordering the space of the damaged tile.

**[0080]** FIGS. 18-25 show an embodiment of my design for a roofing system interlocking continuous array-forming support panel. Specifically, FIG. 18 is back, right, top oblique view thereof. FIG. 19 is front, left, bottom oblique view thereof. FIG. 20 is top plan view thereof. FIG. 21 is bottom plan view thereof. FIG. 22 is back plan view thereof. FIG. 23 is front plan view thereof. FIG. 24 is left plan view thereof. FIG. 25 is right plan view thereof.

**[0081]** FIGS. 26-33 show an embodiment of my design for a roofing system interlocking continuous array-forming hexagonally shaped tile. Specifically, FIG. 26 is front, right, top oblique view thereof. FIG. 27 is back, left, bottom oblique view thereof. FIG. 28 is top plan view thereof. FIG. 29 is bottom plan view thereof. FIG. 30 is front plan view thereof. FIG. 31 is front plan view thereof. FIG. 32 is right plan view thereof. FIG. 33 is left plan view thereof.

**[0082]** FIGS. 34-41 show an embodiment of my design for a roofing system interlocking continuous array-forming square shaped tile. Specifically, FIG. 34 is front, right, top oblique view thereof. FIG. 35 is back, left, bottom oblique view thereof. FIG. 36 is top plan view thereof. FIG. 37 is bottom plan view thereof. FIG. 38 is front plan view thereof. FIG. 39 is back plan view thereof. FIG. 40 is right plan view thereof. FIG. 41 is left plan view thereof.

**[0083]** FIGS. 42-48 show an embodiment of my design for a roofing system interlocking longitudinally interlocking ridge-capping tile. Specifically, FIG. 42 is front, left, top oblique view thereof. FIG. 43 is back, right, bottom oblique view thereof. FIG. 44 is top plan view thereof. FIG. 45 is bottom plan view thereof. FIG. 46 is front plan view thereof. FIG. 47 is back plan view thereof. FIG. 48 is left plan view thereof. FIG. 49 is right side being a mirror image thereof.

**[0084]** FIGS. 49-56 show an embodiment of my design for a roofing system lower edge gutter-carrying termination tile. Specifically, FIG. 49 is front, right, top oblique view thereof. FIG. 50 is back, left, bottom oblique view thereof. FIG. 51 is top plan view thereof. FIG. 52 is bottom plan view thereof. FIG. 53 is front plan view thereof. FIG. 54 is back plan view thereof. FIG. 55 is right plan view thereof. FIG. 56 is left plan view thereof.

**[0085]** While the exemplary embodiments of the invention have been described, it should be understood that modifications can be made and other embodiments may be devised without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. A roofing system which comprises:
   a first set of laterally abuttable, uniformly shaped and dimensioned lower support panels;
   a second set of laterally matable, uniformly shaped and dimensioned roofing tiles;
   wherein an abutted pair of said panels forms a mutual ridge extending upwardly along their abutting edges; and,
   wherein a mated pair of said tiles has a common, co-linear bottom channel shaped and dimensioned to intimately nest onto said mutual ridge.

2. The system of claim 1, which further comprises:
   said abutted pair of panels having co-planar upper support surfaces astride said ridge; and,
   said mated pair of tiles having co-planar lower surfaces astride said channel; and,
   wherein said lower surfaces are bearingly supported by said upper surfaces.

3. The system of claim 2, which further comprises:
   said mutual ridge being formed by uniformly shaped and dimensioned prominences extending upwardly along said abutting edge.
4. The system of claim 3, wherein said abutted pair of panels planarly slidingly abut along a pair of substantially planar contact surfaces oriented substantially orthogonally to said upper support surfaces.

5. The system of claim 4, wherein said panels abut in absence of a tongue-in-groove interface.

6. The system of claim 5, which further comprises:
   said first set of panels being uniformly shaped and dimensioned; and,
   said second set of tiles being uniformly shaped and dimensioned.

7. The system of claim 6, wherein said mated pair of tiles mate along tongue-in-groove interface.

8. The system of claim 7, wherein said tiles modularly combine to form a contiguous planar array.

9. The system of claim 8, wherein a first of said tiles interlock with a second adjacent one of said tiles along a first side wall and wherein said first of said tiles interlocks with a third adjacent one of said tiles along a second side wall, and wherein said first and second side walls are non-parallel.

10. The system of claim 9, wherein each of said panels are substantially rectangularly shaped and each of said tiles are substantially hexagonally shaped.

11. The system of claim 10, which further comprises:
   a second abutted pair of panels;
   wherein said first abutted pair of panels abut latitudinally; wherein said second abutted pair of panels abut latitudinally; and
   wherein said first abutted pair of panels interlocks longitudinally with said second abutted pair of panels.

12. The system of claim 11, wherein each of said tiles comprises a core consisting of a rigid polyurethane foam material and an upper protective coating layer of a non-foam polyurethane material contacting said core; and wherein said rigid polyurethane foam material has a density of no greater than 240 kilograms per cubic meter.

13. The system of claim 12, wherein said tile comprises a photovoltaic module releasably secured to said tile within a recess formed into a substantially planar upper surface of said tile; wherein said module has a substantially planar upper surface which is substantially co-planar with said tile upper surface when the module is secured within said recess.

14. The system of claim 13, wherein said tile comprises:
   a first pair of electrical contacts located within said recess and said module comprises a second pair of electrical contacts shaped, dimensioned and located to electrically interconnect with said first pair when said module is secured to said tile; and,
   a pair of electrical contact wells formed into said first side wall; and,
   a pair of dual ended electrical contact pins shaped and dimensioned to intimately and conducively engage said wells and a second pair of wells located on said second one of said tiles.

15. The system of claim 14, which further comprises:
   a locking mechanism for securing said module within said recess, where said locking mechanism comprises:
   alignment tabs extending from a peripheral boundary located to engage commensurately shaped and dimensioned alignment slots formed on a periphery of said recess; and,
   a sloped track having an endstop located to restrict angular movement of at least one of said tabs.

16. The system of claim 9, wherein said first side wall has a groove which transitions to a second side having a tongue proximate to a vertex; and wherein said groove preferentially extends beyond said vertex of said side to eliminate said tongue; and, wherein said groove extends along three contiguous sides of said tile and said tongue extends along three contiguous side walls of said tile.

17. The system of claim 11, which further comprises:
   a gutter tile having an upper surface co-planar with a top surface of said tile array;
   an aperture passing through said upper surface in communication with a gutter; and,
   wherein said gutter comprises:
   a plurality of uniformly shaped and dimensioned U-shaped stacked gutter ribs.

18. A roofing system comprises:
   a substantially continuous planar array of uniformly shaped and dimensioned co-adjacent lower panels;
   a substantially continuous planar array of uniformly shaped and dimensioned co-adjacent upper tiles; and,
   said lower panels being locked to one another by said tiles.

19. The system of claim 18, wherein each of said panels comprises opposite substantially parallel edges, wherein each of said edges has a raised prominence; and, wherein each of said tiles comprises an undersurface shaped to have a medial channel shaped and dimensioned to intimately engage a laterally adjacent pair of said prominences; and, wherein said panels are substantially rectangular and said tiles are substantially hexagonal.

20. A roofing assembly comprises:
   a plurality of tiles, each having a front edge, a back edge, and left and right lateral side edges, lying contiguously to one another in partially superimposing latitudinal rows;
   means for forming a right lateral edge of each tile to a left lateral edge of an adjacent tile;
   each of a group of said tiles comprising:
   a photovoltaic cell;
   first and second electrical interconnects to said cell;
   a laterally extending groove supporting said first interconnect; and,
   a laterally extending tongue supporting said second interconnect.

21. I claim the design of FIGS. 18-56.