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(54) Title: MICROWAVE ENERGY INTERACTIVE STRUCTURE WITH MICROAPERTURES

(57) Abstract: A microwave energy interactive structure comprises a layer of microwave energy interactive material supported on a polymer film. A plurality of microapertures extend through the layer of microwave energy interactive material and the polymer film. The microapertures have a major linear dimension of from about 0.05 mm to about 2 mm.

MICROWAVE ENERGY INTERACTIVE STRUCTURE WITH MICROAPERTURES

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Application No. 61/059,885, filed June 9, 2008, which is incorporated by reference herein in its entirety.

BACKGROUND

Venting apertures often are used in microwave energy interactive packages to allow moisture to be carried away from a food item that is desirably browned and/or crisped. However, such venting apertures generally comprise physical holes that are mechanically punched or cut through the structure. The minimum size of the hole is dictated by the mechanical process used to form the hole. Unfortunately, when such holes extend through a susceptor, the relatively large holes reduce the effective heating area of the susceptor, and therefore, may cause the browning and/or crisping of the food item to be less uniform. Further, the holes also allow free passage of air and contaminants and therefore may reduce the shelf life of the food item.

Thus, there remains a need for a microwave energy interactive structure that includes at least one aperture that allows moisture to be vented away from the food item during heating without substantially diminishing the ability of the structure to convert microwave energy to sensible heat.

SUMMARY

This disclosure is directed generally to a microwave energy interactive structure, package, or other construct for heating, browning, and/or crisping a food item in a microwave oven, and methods of making and using such a structure, package, or other construct. More particularly, the present disclosure is directed generally to a microwave energy interactive structure that includes a plurality of microapertures configured to provide venting of moisture and/or exudates away

from the food item, while not adversely affecting the performance of the microwave energy interactive elements within the structure. As a result, the heating, browning, and/or crisping of the food item may be enhanced significantly.

The microapertures may have any suitable size and arrangement, depending on the need for venting. In some applications, the microapertures generally may have a major linear dimension (e.g., a diameter) of from about 0.05 mm to about 2 mm, for example, from about 0.1 mm to about 0.3 mm. The microapertures may be formed using any suitable process or technique, and in one example, the microapertures are formed using a laser "drilling" process.

The structure may be used to form various wraps, sleeves, pouches, cartons, containers, or other packages (collectively "packages" or "constructs") for containing a food item. If desired, the microapertures may be positioned to provide venting for a particular portion of a package, for example, where the package is divided into compartments and the food item(s) in a particular compartment would benefit from venting. Alternatively or additionally, the microapertures may be positioned to provide venting to a particular portion of a food item, for example, the crust of a dough-based food item. Further still, the microapertures may be used to define a package opening feature that allows the food item to be accessed more readily.

The structure may include one or more microwave energy interactive elements that alter the effect of microwave energy on an adjacent food item. Each microwave interactive element comprises one or more microwave energy interactive materials or segments arranged in a particular configuration to absorb microwave energy, transmit microwave energy, reflect microwave energy, or direct microwave energy, as needed or desired for a particular microwave heating construct and food item. The microwave energy interactive element may be configured to promote browning and/or crisping of a particular area of the food item, to shield a particular area of the food item from microwave energy to prevent overcooking thereof, or to transmit microwave energy towards or away from a particular area of the food item. In one example, the microwave interactive

element comprises a susceptor. However, other microwave energy interactive elements may be used.

Other features, aspects, and embodiments of the invention will be apparent from the following description and accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

The description refers to the accompanying drawings, in which like reference characters refer to like parts throughout the several views, and in which:

FIG. 1 is a schematic cross-sectional view of a microwave energy interactive structure including a plurality of microapertures;

FIG. 2A is a schematic cross-sectional view of yet another microwave energy interactive structure including a plurality of microapertures, before exposure to microwave energy;

FIG. 2B is a schematic cross-sectional view of the microwave energy interactive structure of **FIG. 2A**, during exposure to microwave energy;

FIG. 2C is a schematic cross-sectional view of the microwave energy interactive structure of **FIG. 2B**, after sufficient exposure to microwave energy;

FIG. 3 is a schematic top plan view of an exemplary microwave energy interactive package including a plurality of microapertures; and

FIG. 4 is a schematic top plan view of another exemplary microwave energy interactive package including a plurality of microapertures.

DESCRIPTION

Various aspects of the disclosure may be illustrated by referring to the figures. For purposes of simplicity, like numerals may be used to describe like features. It will be understood that where a plurality of similar features are depicted, not all of such features necessarily are labeled on each figure. Although several different exemplary aspects, implementations, and embodiments are provided, numerous interrelationships between, combinations thereof, and modifications of the various inventions, aspects, implementations, and embodiments are contemplated hereby.

FIG. 1 schematically depicts an exemplary microwave energy interactive structure **100**. The structure **100** includes a substrate **102**, for example, a polymer film, having a first side **104** and a second side **106** opposite one another. The first side **104** of the polymer film **102** may be a food-contacting side of the structure **100** to be positioned adjacent to a food item **F** (shown schematically with dashed lines). A layer of microwave energy interactive material **108** (or "susceptor") is disposed or supported on the second side **106** of the polymer film **102** to collectively define a susceptor film **110**. The susceptor **108** is generally less than about 100 angstroms in thickness, for example, from about 60 to about 100 angstroms in thickness) and tends to absorb at least a portion of impinging microwave energy and convert it to thermal energy (i.e., heat) at the interface with the food item. However, other microwave energy interactive elements may be used, as will be discussed further below.

The structure **100** also may optionally include a support layer **112** joined to the layer of microwave energy interactive material **108** using an adhesive (not shown) or otherwise. The support layer **112** may comprise a material capable of absorbing fluids, for example, a paper-based material (e.g., paper or paperboard), or may be any other suitable material (e.g., a polymer film).

As shown in **FIG. 1**, a plurality of microapertures **114** extend through the thickness of the susceptor **108** and polymer film **102**, such that the first side **104** of the polymer film **102** (i.e., the first side **104** of the structure **100**, and where present, the food item **F**) is in open communication with the support layer **112**. The microapertures **114** may be formed using any suitable process or technique, and in one example, the microapertures are formed using a laser "drilling" process. In such a process, a laser is used to form or cut a bore through all or the portion of the thickness of a structure. Unlike mechanical cutting or punching processes, laser drilling processes typically are capable of forming the bores without producing a "slug" or "chad" of material that requires a costly, inefficient removal step. Further, since there is no strenuous physical manipulation of the structure to remove such chads or slugs, the integrity of the structure is maintained

substantially so the structure can be wound onto rolls more easily without wrinkling.

The microapertures **114** may have any suitable dimensions, for example, a major linear dimension (e.g., a diameter) of from about 0.05 mm to about 2 mm. In each of various independent examples, each microaperture may independently have a major linear dimension of from about 0.08 to about 1.5 mm, from about 0.1 to about 1 mm, from about 0.12 mm to about 0.8 mm, from about 0.15 mm to about 0.5 mm, from about 0.17 to about 0.25 mm. In one particular example, the microapertures have a diameter of from about 0.1 mm to about 0.3 mm, for example, about 0.18 mm.

The structure **100** may be used in the form of a sheet or card to heat, brown, and/or crisp a food item. Alternatively, this and other structures may be used to form all or a portion of a package or wrap for enclosing or enwrapping the food item within an interior space, as will be discussed further below. Any of such structures may have additional layers, as needed for a particular application.

To use the structure, the food item **F** is positioned adjacent to the first side **104** of the polymer film **102**, which may underlie and/or overlie the food item. Upon sufficient exposure to microwave energy **M** (e.g., schematically represented by upwardly pointing arrows in **FIGS. 1-2C**), the susceptor **108** converts at least a portion of the impinging microwave energy into thermal energy, which then can be transferred to the surface of the food item **F** to enhance browning and/or crisping. Any water vapor and/or other exudates **E** (e.g., schematically represented by upwardly pointing arrows in **FIGS. 1-2C**) released from the food item during heating may be carried away from the food item through the microapertures **114** towards the support layer **112** where the fluids can be absorbed, thereby further enhancing browning and/or crisping of the food item **F**. It has been discovered that by using microapertures **114** in the structure **100**, rather than conventional mechanically formed apertures, a greater number of microapertures, and better distribution of microapertures, can be provided to transport the moisture and/or exudate away from the food item more effectively

without significantly adversely affecting the ability of the susceptor **108** to heat, brown, and/or crisp the food item.

Further, it will be noted that in many conventional susceptor structures including a susceptor film joined to a paper layer, venting is achieved by making an aperture through the entire thickness of the structure. If absorbency is needed, a separate absorbent layer may be provided adjacent to the apertured support layer. In sharp contrast, the present inventors have discovered that by using a laser "drilling" process, the microapertures **114** can be formed in the susceptor film **110** only, thereby providing access to the support layer **112**. In this manner, the support layer **112** can also serve as an absorbent layer, notably, without having to jeopardize the integrity of the structure **100** wit h conventional apertures, and without the need for an additional absorbent layer.

If additional bulk heating is needed, one or more microwave energy transparent areas **116** may be provided in the layer of microwave energy interactive material **108** to allow the passage of microwave energy **M** through the structure **100**. In the example illustrated schematically in **FIG. 1**, at least some of the microwave energy transparent areas **116** are at least partially in register with the microapertures **114**, and in some of such instances, the microwave energy transparent area **116** may surround or circumscribe the microaperture **114** extending through the layer of microwave energy interactive material **108**.

Each microwave energy transparent area **116** may have any suitable shape and/or dimensions needed to provide the desired level of microwave energy transmission through the structure **100**, and therefore bulk heating of the food item. In one example, at least one microwave energy transparent area **116** has a major linear dimension greater than the major linear dimension of at least one microaperture **114**, for example, the respectively adjacent microaperture **114** (where applicable). The microwave energy transparent areas **116** may be formed in any suitable manner, for example, by selectively applying the microwave energy interactive material **108** to the substrate **102**, selectively removing the microwave energy interactive material **108**, or by chemically deactivating the microwave energy interactive material **108**, as will be discussed further below.

If additional venting is needed, the support layer **112** optionally may include one or more conventional holes or apertures **118**. If desired, one or more of such apertures **118** may be at least partially in register with the microapertures **114** in the substrate **102** and susceptor layer **108** to facilitate the transport of moisture (i.e., water vapor) and/or other exudates **E** away from the food item **F** and the structure **100**. Each aperture **118** may have any suitable dimension needed to provide the desired level of venting away from the food item **F**, and in one example, at least one aperture **118** has a major linear dimension greater than the major linear dimension of at least one microaperture **114**, for example, the respectively adjacent microaperture **114** (where applicable). However, other suitable dimensions and arrangements of apertures **118** are contemplated. As indicated above, the apertures **118** may be omitted such that the support layer **112** is not perforated.

The structure **100** of **FIG. 1** can be formed in any suitable manner. In one example, the susceptor film **110** is joined to the optionally apertured support layer **112** using an adhesive or otherwise. The first side **104** of the structure **100** then may be exposed to a laser, which is configured to form small holes or microapertures **114** in the susceptor film **110**. In some embodiments, at least some of the microapertures **114** may extend somewhat into the support layer **112**. In other embodiments, at least some of the microapertures **114** may extend through the entire thickness of the support layer **112**.

FIGS. 2A-2C schematically depict another exemplary microwave energy interactive structure **200**. The structure **200** includes features that are similar to the structure **100** shown in **FIG. 1**, except for variations noted and variations that will be understood by those of skill in the art. For simplicity, the reference numerals of similar features are preceded in the figures with a "**2**" instead of a "**1**".

In this example, the microapertures **214** extend through the susceptor **208**, but only partially through the thickness of the substrate **202**, for example, the polymer film, as shown in **FIG. 2A**. Upon sufficient exposure to microwave energy, the susceptor **208** converts microwave energy to sensible heat, which causes the polymer film **202** adjacent to the partial microapertures **214** to soften

and shrink preferentially, thereby forming a plurality of voids **220** in the polymer film **202**, as shown in **FIG. 2B**. Such voids **220** may be characterized as extensions of the microapertures **214**, or may be characterized as voids **220** contiguous with the respective microapertures **214**. In either case, each void **220** and the respectively adjacent microaperture **214** collectively define a venting microaperture or channel **222** that extends through the thickness of the structure **200**, as shown schematically in **FIG. 2C**. Such a structure **200** may be suitable for use, for example, to form a package for containing the food item, where a physical barrier is needed to preserve the shelf life of the food item prior to heating (e.g., by preventing the transmission of moisture and/or oxygen into the package), and venting is needed during heating to attain the desired degree of browning and/or crisping of the resulting food item. Upon sufficient exposure to microwave energy **M**, voids **220** form in the substrate **202** to define the venting apertures **222** capable of carrying moisture and/or other exudates **E** away from the food item **F**, as described above.

As with the structure **100** of **FIG. 1**, if desired, the structure **200** of **FIGS. 2A** and **2B** optionally may include one or more microwave energy transparent areas **216** in the layer of microwave energy interactive material **208** and/or may include one or more apertures **218** in the optional support layer **212**. However, it is contemplated that in the embodiment of **FIG. 1** and the embodiment of **FIGS. 2A** and **2B**, such features may be omitted. For example, the apertures **218** may be omitted such that the support layer **212** is not perforated. The support layer **212** also may be omitted and, if desired, replaced with one or more other layers.

The structure **200** of **FIG. 2A** can be formed in any suitable manner. In one example, the susceptor film **210** is exposed to a laser, which is configured to form small holes or microapertures **214** through the layer of microwave energy interactive material **208** and partially into the polymer film **202**. The layer of microwave energy interactive material **208** then may be joined to the optionally apertured support layer **212** using an adhesive or otherwise. Other methods are contemplated.

As stated above, structures **100**, **200** or numerous others contemplated hereby may be used to form various packages or other constructs. According to another aspect of the disclosure, some or all of the microapertures within the microwave energy interactive structure may serve as a mechanism for opening the package or construct.

For example, **FIG. 3** schematically illustrates a top plan view of a microwave energy interactive package **300** for heating, browning, and/or crisping a food item. The package **300** may include one or more adjoined panels comprising a microwave energy interactive structure (e.g., structures **100**, **200** or numerous others contemplated hereby) that define a cavity or interior space for receiving a food item (not shown). The marginal areas of the sheet(s) or panel(s) may be joined together using edge seals **302** or the like. A first plurality of microapertures defines a line of disruption **304** extending across the package **300** to provide a mechanism for opening the package **300**. Such microapertures may extend through all or a portion of the thickness of the material used to form the package, as needed or desired to facilitate opening of the package **300** to access the food item within the interior space. A second plurality of microapertures **306** arranged in a grid pattern provide venting for a food item heated inside the package, as described in connection with **FIGS. 1-2B**.

In another example shown in **FIG. 4**, the package **400** includes a plurality of microapertures arranged to define a line of disruption **402** that circumscribes a removable panel **404** through which the food item within interior space can be accessed after heating. The microapertures also may provide venting of moisture away from the food item, as described above.

Numerous other packages and constructs having various configurations are contemplated by this disclosure. Furthermore, numerous other microwave energy interactive structures are encompassed by this disclosure. Any of such structures described herein or contemplated hereby may be formed from various materials, provided that the materials are substantially resistant to softening, scorching, combusting, or degrading at typical microwave oven heating temperatures, for

example, at from about 250°F to about 425°F. The particular materials used may include microwave energy interactive materials, for example, those used to form susceptors and other microwave energy interactive elements, and microwave energy transparent or inactive materials, for example, those used to form the substrate, support, and remainder of the structure.

The microwave energy interactive material may be an electroconductive or semiconductive material, for example, a metal or a metal alloy provided as a metal foil; a vacuum deposited metal or metal alloy; or a metallic ink, an organic ink, an inorganic ink, a metallic paste, an organic paste, an inorganic paste, or any combination thereof. Examples of metals and metal alloys that may be suitable include, but are not limited to, aluminum, chromium, copper, inconel alloys (nickel-chromium-molybdenum alloy with niobium), iron, magnesium, nickel, stainless steel, tin, titanium, tungsten, and any combination or alloy thereof.

Alternatively, the microwave energy interactive material may comprise a metal oxide, for example, oxides of aluminum, iron, and tin, optionally used in conjunction with an electrically conductive material. Another metal oxide that may be suitable is indium tin oxide (ITO). ITO has a more uniform crystal structure and, therefore, is clear at most coating thicknesses.

Alternatively still, the microwave energy interactive material may comprise a suitable electroconductive, semiconductive, or non-conductive artificial dielectric or ferroelectric. Artificial dielectrics comprise conductive, subdivided material in a polymeric or other suitable matrix or binder, and may include flakes of an electroconductive metal, for example, aluminum.

While susceptors are illustrated herein, the construct may alternatively or additionally include a foil or high optical density evaporated material having a thickness sufficient to reflect a substantial portion of impinging microwave energy. Such elements are typically formed from a conductive, reflective metal or metal alloy, for example, aluminum, copper, or stainless steel, in the form of a solid "patch" generally having a thickness of from about 0.000285 inches to about 0.05 inches, for example, from about 0.0003 inches to about 0.03 inches. Other

such elements may have a thickness of from about 0.00035 inches to about 0.020 inches, for example, 0.016 inches.

Larger microwave energy reflecting elements may be used where the food item is prone to scorching or drying out during heating. Smaller microwave energy reflecting elements may be used to diffuse or lessen the intensity of microwave energy. A plurality of smaller microwave energy reflecting elements also may be arranged to form a microwave energy directing element to direct microwave energy to specific areas of the food item. If desired, the loops may be of a length that causes microwave energy to resonate, thereby enhancing the distribution effect. Microwave energy distributing elements are described in U.S. Patent Nos. 6,204,492, 6,433,322, 6,552,315, and 6,677,563, each of which is incorporated by reference in its entirety.

If desired, any of the numerous microwave energy interactive elements described herein or contemplated hereby may be substantially continuous, that is, without substantial breaks or interruptions, or may be discontinuous, for example, by including one or more breaks or apertures that transmit microwave energy therethrough. The breaks or apertures may be sized and positioned to heat particular areas of the food item selectively. The breaks or apertures may extend through the entire structure, or only through one or more layers. The number, shape, size, and positioning of such breaks or apertures may vary for a particular application depending on the type of construct being formed, the food item to be heated therein or thereon, the desired degree of shielding, browning, and/or crisping, whether direct exposure to microwave energy is needed or desired to attain uniform heating of the food item, the need for regulating the change in temperature of the food item through direct heating, and whether and to what extent there is a need for venting.

It will be understood that the aperture may be a physical aperture or void (e.g., microapertures **114, 214**), in one or more layers or materials used to form the construct, or may be a non-physical "aperture" (e.g., microwave transparent area **116, 216**). A non-physical aperture is a microwave energy transparent area that allows microwave energy to pass through the structure without an actual void or

hole cut through the structure. Such areas may be formed by simply not applying a microwave energy interactive material to the particular area, or by removing microwave energy interactive material in the particular area, or by chemically and/or mechanically deactivating the microwave energy interactive material in the particular area. It will be noted that chemical deactivation transforms the material in the respective area into a microwave energy transparent (i.e., inactive) substance or material, typically without removing it. While both physical and non-physical apertures allow the food item to be heated directly by the microwave energy, a physical aperture also provides a venting function to allow steam or other vapors to escape from the interior of the construct.

The arrangement of microwave energy interactive and microwave energy transparent areas may be selected to provide various levels of heating, as needed or desired for a particular application. For example, where greater heating is desired, the total inactive (i.e., microwave energy transparent) area may be increased. In doing so, more microwave energy is transmitted to the food item. Alternatively, by decreasing the total inactive area, more microwave energy is absorbed by the microwave energy interactive areas, converted into thermal energy, and transmitted to the surface of the food item to enhance heating, browning, and/or crisping.

In some instances, it may be beneficial to create one or more discontinuities or inactive regions to prevent overheating or charring of the construct. Such areas may be formed by forming these areas of the construct without a microwave energy interactive material, by removing any microwave energy interactive material that has been applied, or by deactivating the microwave energy interactive material in these areas, as discussed above. For example, in the package **300** of **FIG. 3**, the edge seals **302** may be microwave energy transparent or inactive to prevent charring or disjoining of the sealed sheets or panels.

Further still, one or more panels, portions of panels, or portions of the construct may be designed to be microwave energy inactive to ensure that the microwave energy is focused efficiently on the areas to be heated, browned, and/or crisped, rather than being lost to portions of the food item not intended to be

browned and/or crisped or to the heating environment. This may be achieved using any suitable technique, such as those described above.

As stated above, the microwave energy interactive element may be supported on a microwave inactive or transparent substrate **112**, **212**, for example, a polymer film or other suitable polymeric material, for ease of handling and/or to prevent contact between the microwave energy interactive material and the food item. The outermost surface of the polymer film may define at least a portion of the food-contacting surface of the package (e.g., surface **104**, **204** of respective polymer film **102**, **202**). Examples of polymer films that may be suitable include, but are not limited to, polyolefins, polyesters, polyamides, polyimides, polysulfones, polyether ketones, cellophanes, or any combination thereof. In one particular example, the polymer film comprises polyethylene terephthalate. The thickness of the film generally may be from about 35 gauge to about 10 mil. In each of various examples, the thickness of the film may be from about 40 to about 80 gauge, from about 45 to about 50 gauge, about 48 gauge, or any other suitable thickness. Other non-conducting substrate materials such as paper and paper laminates, metal oxides, silicates, cellulosics, or any combination thereof, also may be used.

Where the polymer film is intended to serve as a barrier layer (e.g., prior to heating), the barrier layer may comprise a polymer film having barrier properties and/or a polymer film including a barrier layer or coating. Suitable polymer films may include, but are not limited to, ethylene vinyl alcohol, barrier nylon, polyvinylidene chloride, barrier fluoropolymer, nylon 6, nylon 6,6, coextruded nylon 6/EVOH/nylon 6, silicon oxide coated film, barrier polyethylene terephthalate, or any combination thereof.

One example of a barrier film that may be suitable is CAPRAN® EMBLEM 1200M nylon 6, commercially available from Honeywell International (Pottsville, Pennsylvania). Another example of a barrier film that may be suitable is CAPRAN® OXYSHIELD OBS monoaxially oriented coextruded nylon 6/ethylene vinyl alcohol (EVOH)/nylon 6, also commercially available from Honeywell International. Yet another example of a barrier film that may be

suitable is DARTEK® N-201 nylon 6,6, commercially available from Enhance Packaging Technologies (Webster, New York). Additional examples include BARRIALOX PET, available from Toray Films (Front Royal, VA) and QU50 High Barrier Coated PET, available from Toray Films (Front Royal, VA), referred to above.

Still other barrier films include silicon oxide coated films, such as those available from Sheldahl Films (Northfield, Minnesota). Thus, in one example, a susceptor may have a structure including a film, for example, polyethylene terephthalate, with a layer of silicon oxide coated onto the film, and ITO or other material deposited over the silicon oxide. If needed or desired, additional layers or coatings may be provided to shield the individual layers from damage during processing.

The barrier layer may have an oxygen transmission rate (OTR) of less than about 20 $cc/m^2/day$ as measured using ASTM D3985. In each of various independent examples, the barrier layer may have an OTR of less than about 10 $cc/m^2/day$, less than about 1 $cc/m^2/day$, less than about 0.5 $cc/m^2/day$, or less than about 0.1 $cc/m^2/day$. The barrier layer may have a water vapor transmission rate (WVTR) of less than about 100 $g/m^2/day$ as measured using ASTM F1249. In each of various independent examples, the barrier layer may have a WVTR of less than about 50 $g/m^2/day$, less than about 15 $g/m^2/day$, less than about 1 $g/m^2/day$, less than about 0.1 $g/m^2/day$, or less than about 0.05 $g/m^2/day$.

The microwave energy interactive material may be applied to the substrate in any suitable manner, and in some instances, the microwave energy interactive material is printed on, extruded onto, sputtered onto, evaporated on, or laminated to the substrate. The microwave energy interactive material may be applied to the substrate in any pattern, and using any technique, to achieve the desired heating effect of the food item. For example, the microwave energy interactive material may be provided as a continuous or discontinuous layer or coating including circles, loops, hexagons, islands, squares, rectangles, octagons, and so forth.

Various materials may serve as the support layer (or "support") **112**, **212** for the construct **100**, **200**. For example, the support layer may be formed at least

partially from a polymer or polymeric material. As another example, support layer may be formed from a paper or paperboard material. In one example, the paper has a basis weight of from about 15 to about 60 lbs/ream (lb/3000 sq. ft.), for example, from about 20 to about 40 lbs/ream. In another example, the paper has a basis weight of about 25 lbs/ream. In another example, the paperboard having a basis weight of from about 60 to about 330 lbs/ream, for example, from about 155 to about 265 lbs/ream. In one particular example, the paperboard has a basis weight of about 175 lbs/ream. The paperboard generally may have a thickness of from about 6 to about 30 mils, for example, from about 14 to about 24 mils. In one particular example, the paperboard has a thickness of about 16 mils. Any suitable paperboard may be used, for example, a solid bleached or solid unbleached sulfate board, such as SUS® board, commercially available from Graphic Packaging International.

The package may be formed according to numerous processes known to those in the art, including using adhesive bonding, thermal bonding, ultrasonic bonding, mechanical stitching, or any other suitable process. Any of the various components used to form the package may be provided as a sheet of material, a roll of material, or a die cut material in the shape of the package to be formed (e.g., a blank).

It will be understood that with some combinations of elements and materials, the microwave energy interactive element may have a grey or silver color that is visually distinguishable from the substrate or the support. However, in some instances, it may be desirable to provide a package having a uniform color and/or appearance. Such a package may be more aesthetically pleasing to a consumer, particularly when the consumer is accustomed to packages or containers having certain visual attributes, for example, a solid color, a particular pattern, and so on. Thus, for example, the present disclosure contemplates using a silver or grey toned adhesive to join the microwave energy interactive element to the support, using a silver or grey toned support to mask the presence of the silver or grey toned microwave energy interactive element, using a dark toned substrate, for example, a black toned substrate, to conceal the presence of the silver or grey

toned microwave energy interactive element, overprinting the metallized side of the polymer film with a silver or grey toned ink to obscure the color variation, printing the non-metallized side of the polymer film with a silver or grey ink or other concealing color in a suitable pattern or as a solid color layer to mask or conceal the presence of the microwave energy interactive element, or any other suitable technique or combination of techniques.

The disclosure may be understood further from the following examples, which are not intended to be limiting in any manner.

EXAMPLE 1

A calorimetry test was conducted to demonstrate the conductivity and maximum temperature of various susceptor structures including a plurality of microapertures as compared with a conventional susceptor without microapertures. The samples with microapertures were prepared on an x-y table using a carbon dioxide laser.

For each structure, a sample having a diameter of about 5 in. was positioned between two circular pyrex plates, each having a thickness of about 0.25 in. and a diameter of about 5 in. A 250 g water load in a plastic bowl resting on an about 1 in. thick expanded polystyrene insulating sheet was placed above the plates (so that radiant heat from the water did not affect the plates). The bottom plate was raised about 1 in. above the glass turntable using three substantially triangular ceramic stands. Thermo–optic probes were affixed to the top surface of the top plate to measure the surface temperature of the plate. After heating the sample at full power for about 5 minutes in a 1300 W microwave oven, the average temperature rise in degrees C of the top plate surface was recorded. The conductivity of each sample was measured prior to conducting the calorimetry test, with five data points being collected and averaged. The Gurley porosity (air resistance) was also measured (five repetitions) according to TAPPI T 460 om-02 for some samples prior to heating and after heating. The results are presented in **Table 1**. The samples including the microapertures had a slightly lower, but statistically insignificant, maximum change in temperature.

Table 1.

Sample	Description	Delta T Max (°C)	Conductivity (mmho/sq)	Gurley porosity (s/100 cc)
1	48 gauge metallized polyethylene terephthalate (PET) with no apertures adhesively joined to 12 point (pt) paperboard	146.2	11-12	>1800 before heating 11989 after heating
2	48 gauge metallized PET with about 0.18 mm diameter microapertures spaced about 0.5 in. apart in a grid pattern, adhesively joined to 12 pt paperboard	138.0	11-12	Not tested
3	48 gauge metallized PET with about 0.18 mm diameter microapertures spaced about 0.375 in. apart in a grid pattern, adhesively joined to 12 pt paperboard	145.5	11-12	Not tested
4	48 gauge metallized PET with about 0.18 mm diameter microapertures spaced about 0.25 in. apart in a grid pattern, adhesively joined to 12 pt paperboard	142.6	11-12	Not tested
5	48 gauge metallized PET adhesively joined to 12 pt paperboard, with pin-punched apertures spaced about 0.5 in apart through entire thickness*	145.3	11-12	6543 before heating 3016 after heating
6	48 gauge metallized PET adhesively joined to 12 pt paperboard, with about 4.0 mm diameter punched apertures spaced about 0.5 in. apart through entire thickness*	144.1	11-12	8.2 before heating ~0 after heating

*Samples 5 and 6 were prepared for comparative purposes only and may not be representative of machine-made structures.

The overall pattern of crazing of each sample was also noted. The samples with microapertures (Samples 2-4) exhibited substantially the same pattern of crazing as the control sample (Sample 1), generally indicating that the presence of the microapertures had little or no effect on the behavior of the metallized PET.

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EXAMPLE 2

Various constructs were evaluated to determine their respective ability to heat, brown, and/or crisp a food item. Microwave heating sheets or cards having dimensions of about 3.5 in. by about 7.5 in. were prepared. The samples were 10 used to heat Schwan's flatbread pizzas for about 2 min. in an 1100 W microwave oven. The results are summarized in **Table 2**.

Table 2.

Sample	Description	Results
7	48 gauge metallized polyethylene terephthalate (PET) adhesively joined to 12 pt paperboard with no apertures (control)	Acceptable browning and crisping; minor oil absorption along peripheral edge
8	48 gauge metallized PET adhesively joined to 12 pt paper with about 0.18 mm diameter microapertures spaced about 0.125 in. apart in a grid pattern	Acceptable browning and crisping; substantial oil absorption uniformly across card
9	48 gauge metallized PET adhesively joined to 12 pt paper with about 0.18 mm diameter microapertures spaced about 0.25 in. apart in a grid pattern	Acceptable browning and crisping; some oil absorption scattered across card
10	48 gauge metallized PET adhesively joined to 12 pt paper with about 0.18 mm diameter microapertures spaced about 0.375 in. apart in a grid pattern	Acceptable browning and crisping; some oil absorption scattered across card
11	48 gauge metallized PET adhesively joined to 12 pt paper with about 0.18 mm diameter microapertures spaced about 0.5 in. apart in a grid pattern	Acceptable browning and crisping; some oil absorption scattered across card

Although all of the samples provided a generally acceptable level of browning and/or crisping, Sample 8 provided the greatest degree of moisture and/or exudate absorption.

While the present invention is described herein in detail in relation to specific aspects and embodiments, it is to be understood that this disclosure is only illustrative and exemplary of the present invention and is made merely for purposes of providing a full and enabling disclosure of the present invention and to set forth the best mode of practicing the invention known to the inventors at the time the invention was made. The disclosure set forth herein is illustrative only and is not intended, nor is to be construed, to limit the present invention or otherwise to exclude any such other embodiments, adaptations, variations, modifications, and equivalent arrangements of the present invention. All directional references (e.g., upper, lower, upward, downward, left, right, leftward, rightward, top, bottom, above, below, vertical, horizontal, clockwise, and counterclockwise) are used only for identification purposes to aid the reader's understanding of the various embodiments of the present invention, and do not create limitations, particularly as to the position, orientation, or use of the invention unless specifically set forth in the claims. Joinder references (e.g., joined, attached, coupled, connected, and the like) are to be construed broadly and may include intermediate members between a connection of elements and relative movement between elements. As such, joinder references do not necessarily imply that two elements are connected directly and in fixed relation to each other. Further, various elements discussed with reference to the various embodiments may be interchanged to create entirely new embodiments coming within the scope of the present invention.

What is claimed is:

1. A microwave energy interactive structure comprising:

a layer of microwave energy interactive material supported on a polymer film; and

a plurality of microapertures extending through the layer of microwave energy interactive material and the polymer film, the microapertures having a major linear dimension of from about 0.05 mm to about 2 mm.

2. The structure of claim 1, wherein at least one microaperture in the layer of microwave energy interactive material is circumscribed by a microwave energy transparent area.

3. The structure of claim 1, further comprising a support layer joined to the layer of microwave energy interactive material.

4. The structure of claim 3, wherein

the polymer film includes a first side and a second side opposite one another,

the first side of the polymer film is adapted to face a food item,

the second side of the polymer is adjacent to the layer of microwave energy interactive material, and

the microapertures extend from the first side of the polymer film to the support layer, such that the first side of the polymer film is in open communication with the support layer.

5. The structure of claim 3, wherein the support layer is operative for absorbing at least one of water vapor and exudates from the food item.

6. The structure of claim 3, wherein the support layer comprises paper.

7. The structure of claim 3, wherein the support layer includes a plurality of apertures.

8. The structure of claim 6, wherein at least one aperture in the support layer is in register with one of the microapertures extending through the layer of microwave energy interactive material and the polymer film.

9. The structure of claim 1, comprising at least a portion of a microwave heating construct having an interior space for receiving a food item.

10. The structure of claim 9, wherein the microapertures at least partially define a removable portion of the construct.

11. The structure of claim 10, wherein the removable portion of the construct is operative for accessing the food item within the interior space.

12. A microwave energy interactive structure comprising:

a polymer film having a first side and a second side opposite one another, and a thickness between the first side and the second side;

a layer of microwave energy interactive material disposed on the second side of the polymer film; and

a plurality of microapertures extending through the layer of microwave energy interactive material and only partially through the thickness of the polymer film on the second side of the polymer film, the microapertures having a major linear dimension of from about 0.05 mm to about 2 mm.

13. The structure of claim 12, wherein the polymer film serves as a barrier layer.

14. The structure of claim 12, wherein upon sufficient exposure to microwave energy, a plurality of voids form between the microapertures and the first side of the polymer film.

15. The structure of claim 12, wherein at least one microaperture in the layer of microwave energy interactive material is circumscribed by a microwave energy transparent area.

16. The structure of claim 12, further comprising a support layer joined to the layer of microwave energy interactive material on a side of the layer of microwave energy interactive material opposite the polymer film.

17. The structure of claim 16, wherein the support layer includes a plurality of apertures.

18. The structure of claim 17, wherein at least one aperture in the support layer is in register with one of the microapertures extending through the layer of microwave energy interactive material.

19. The structure of claim 16, wherein the support layer comprises a paper-based material.

20. The structure of claim 12, comprising at least a portion of a microwave heating construct having an interior space for receiving a food item.

21. The structure of claim 20, wherein the microapertures at least partially define a removable portion of the construct.

22. The structure of claim 21, wherein the removable portion of the construct is operative for accessing the food item within the interior space.

23. A method of preparing a food item in a microwave oven, comprising:

providing a food item having a surface that is desirably browned and/or crisped;

providing a microwave heating construct having an interior space dimensioned to receive food item, the microwave heating construct comprising

a polymer film having a first side and a second side opposite one another, the first side of the polymer film facing the interior space, and a thickness between the first side and the second side,

a layer of microwave energy interactive material disposed on the second side of the polymer film, the layer of microwave energy interactive material being operative for converting at least a portion of impinging microwave energy into sensible heat,

a plurality of microapertures extending through the layer of microwave energy interactive material and only partially through the thickness of the polymer film on the second side of the polymer film, and

a support layer joined to the layer of microwave energy interactive material on a side of the layer of microwave energy interactive material opposite the polymer film; and

placing the food item in the interior space of the construct, such that the surface of the food item is adjacent to the first side of the polymer film.

24. The method of claim 23, further comprising exposing the food item in the interior space to microwave energy.

25. The method of claim 24, wherein upon sufficient exposure to microwave energy, the layer of microwave energy interactive material converts at least a portion of the microwave energy into sensible heat.

26. The method of claim 25, wherein the sensible heat at least partially browns and/or crisps the surface of the food item.

27. The method of claim 25, wherein the sensible heat softens the polymer film adjacent to the microapertures, thereby forming a plurality of voids between the microapertures and the first side of the polymer film, such that the first side of the film is in open communication with the support layer.

28. The method of claim 27, wherein the voids and microapertures carry exudates from the food item towards the support layer.

29. The method of claim 23, wherein the microapertures have a major linear dimension of from about 0.05 mm to about 2 mm.

30. A method comprising:

providing a microwave energy interactive structure including

a polymer film having a first side and a second side opposite one another, and a thickness between the first side and the second side,

a layer of microwave energy interactive material disposed on the second side of the polymer film, and

a plurality of microapertures extending through the layer of microwave energy interactive material and only partially through the thickness of the polymer film on the second side of the polymer film; and

exposing the microwave energy interactive structure to microwave energy, thereby forming a plurality of voids between the microapertures and the first side of the polymer film.

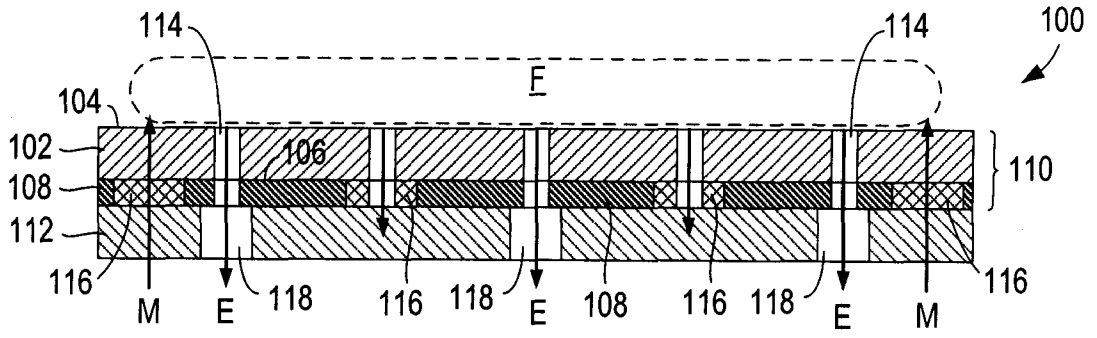


FIG. 1

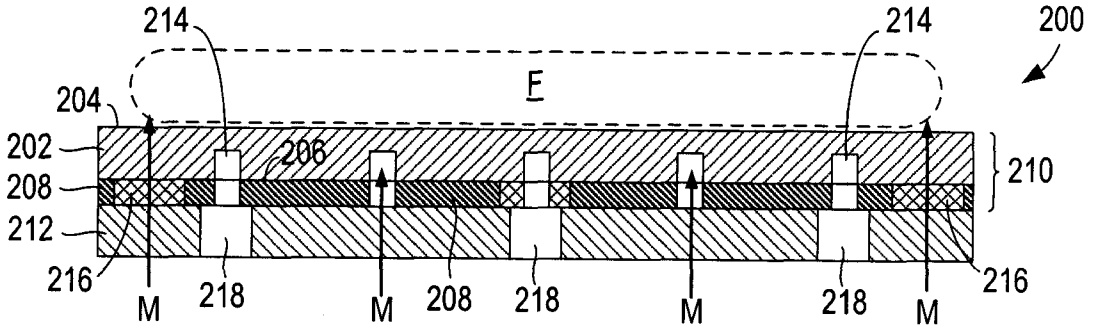


FIG. 2A

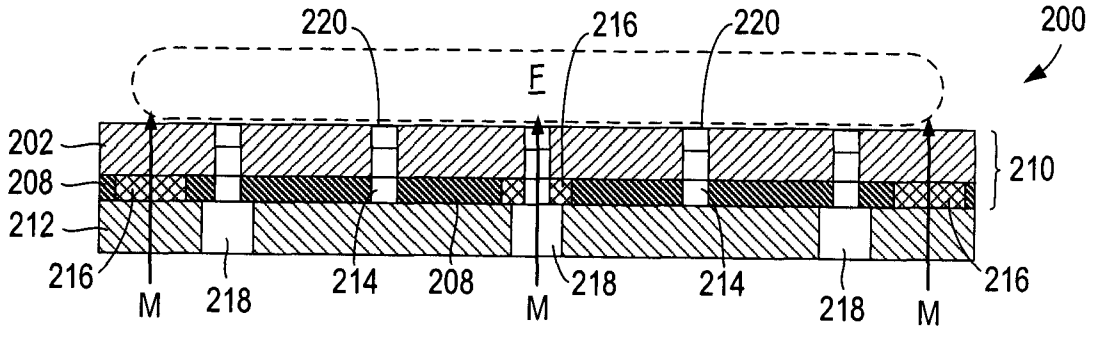


FIG. 2B

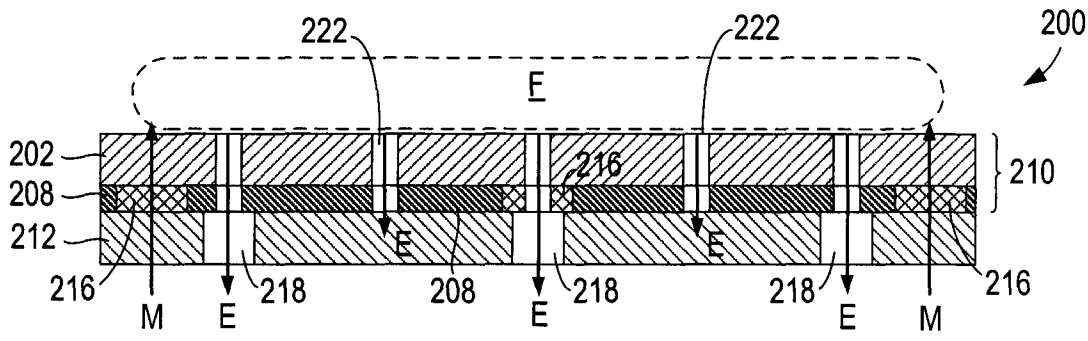


FIG. 2C

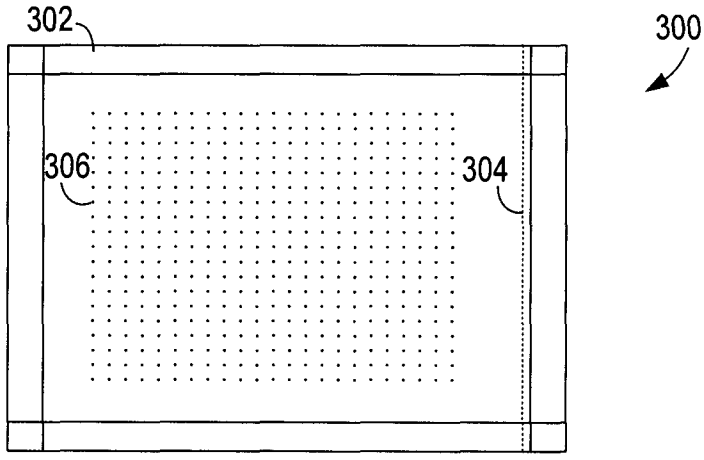


FIG. 3

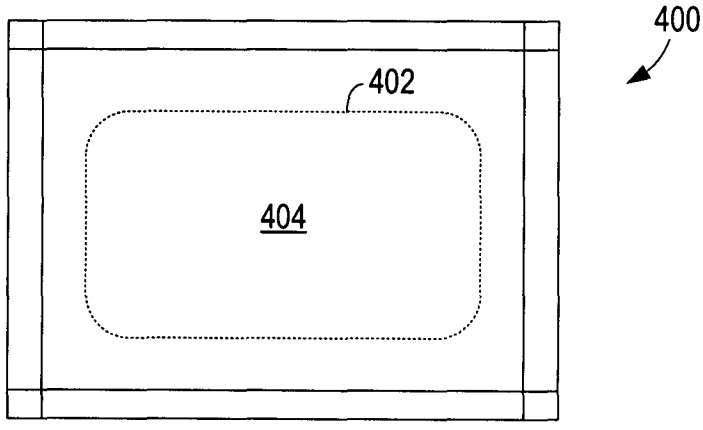


FIG. 4