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(54) **THERMALLY-ENHANCED AEROSOL FORMING SUBSTRATE**

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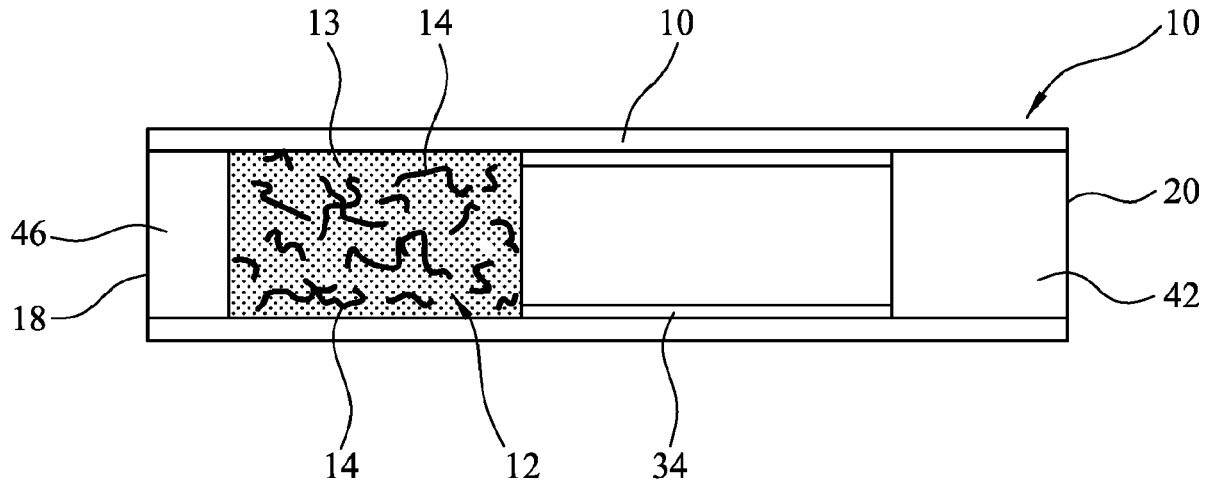
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(57) **ABSTRACT**

An aerosol-forming substrate comprises a first material and a second material, the first material being comprised in the aerosol-forming substrate as a first plurality of discrete elements and the second material being comprised in the aerosol-forming substrate as a second plurality of discrete elements. The first material comprises an aerosol-former and has a first thermal conductivity, and the second material has a second thermal conductivity that is greater than the first thermal conductivity. The presence of the discrete elements of the second material in the aerosol-forming substrate produces a substrate with augmented thermal conductivity resulting in improvements in aerosol generation and delivery.



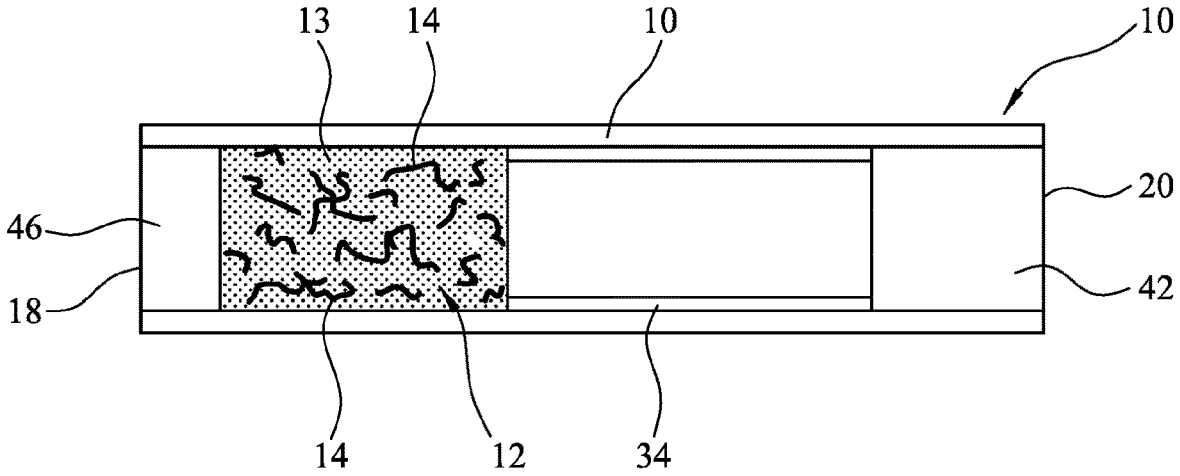


FIGURE 1

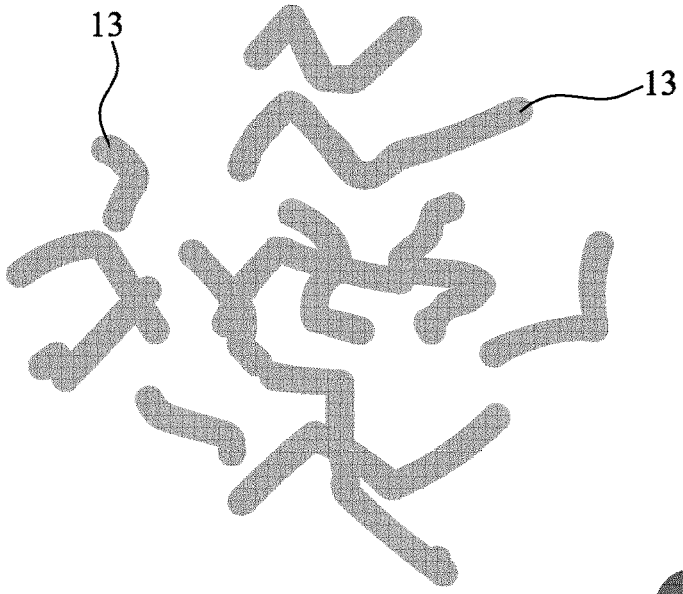


FIGURE 2

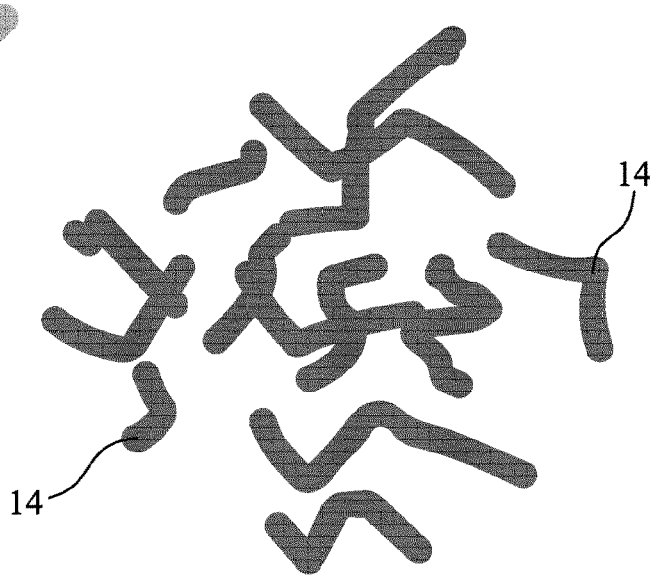


FIGURE 3

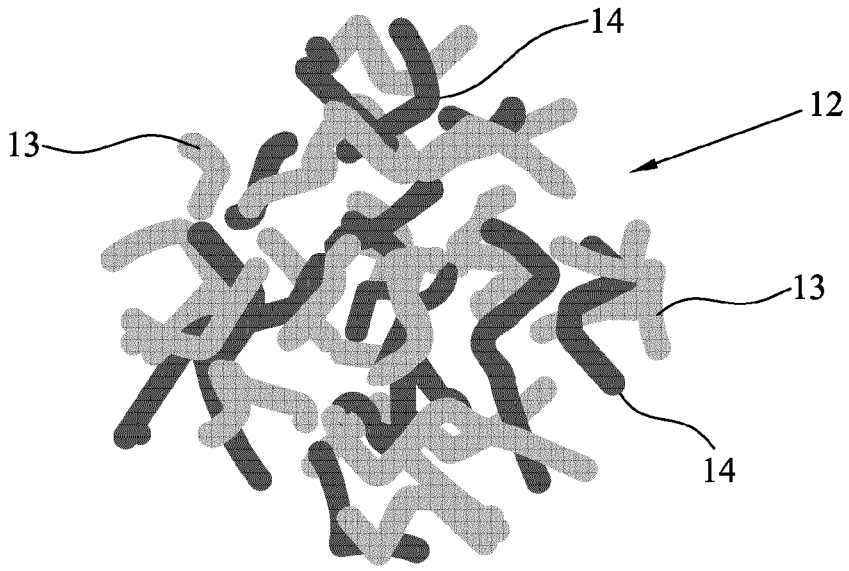


FIGURE 4

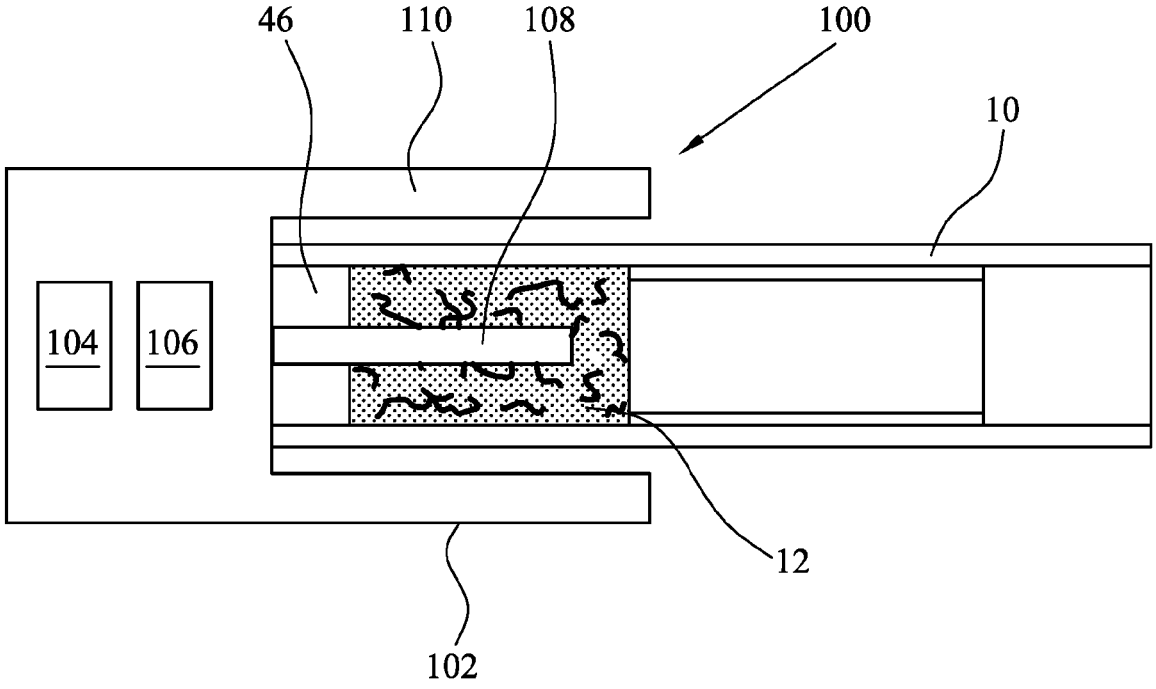


FIGURE 5

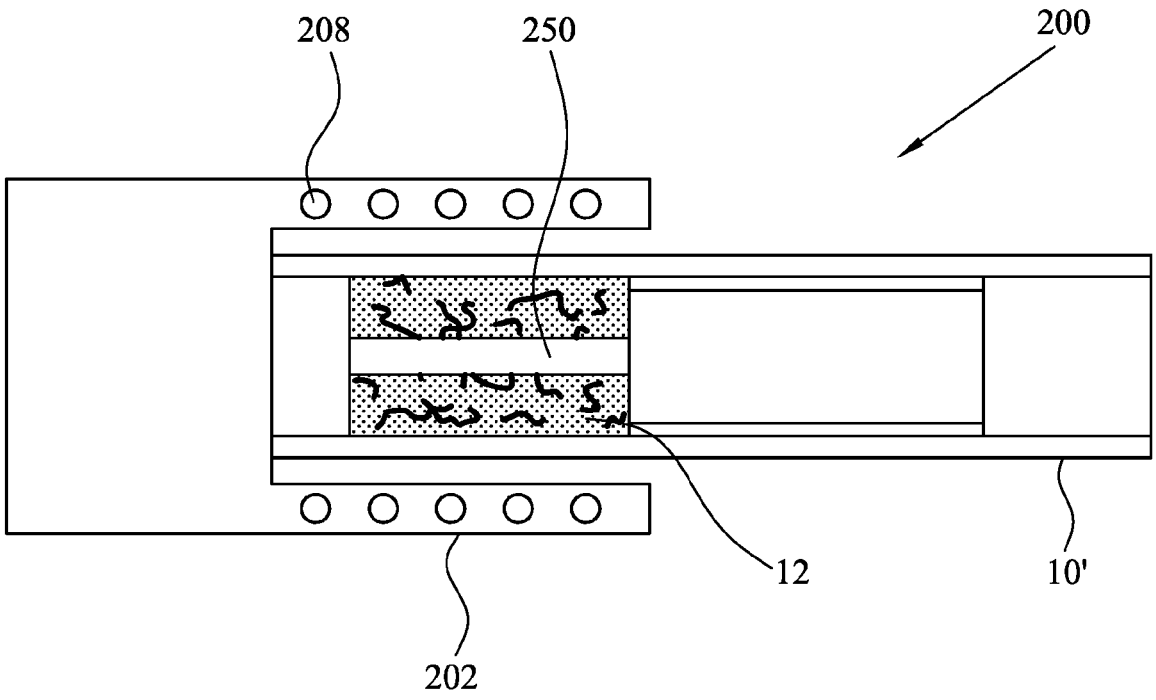


FIGURE 6

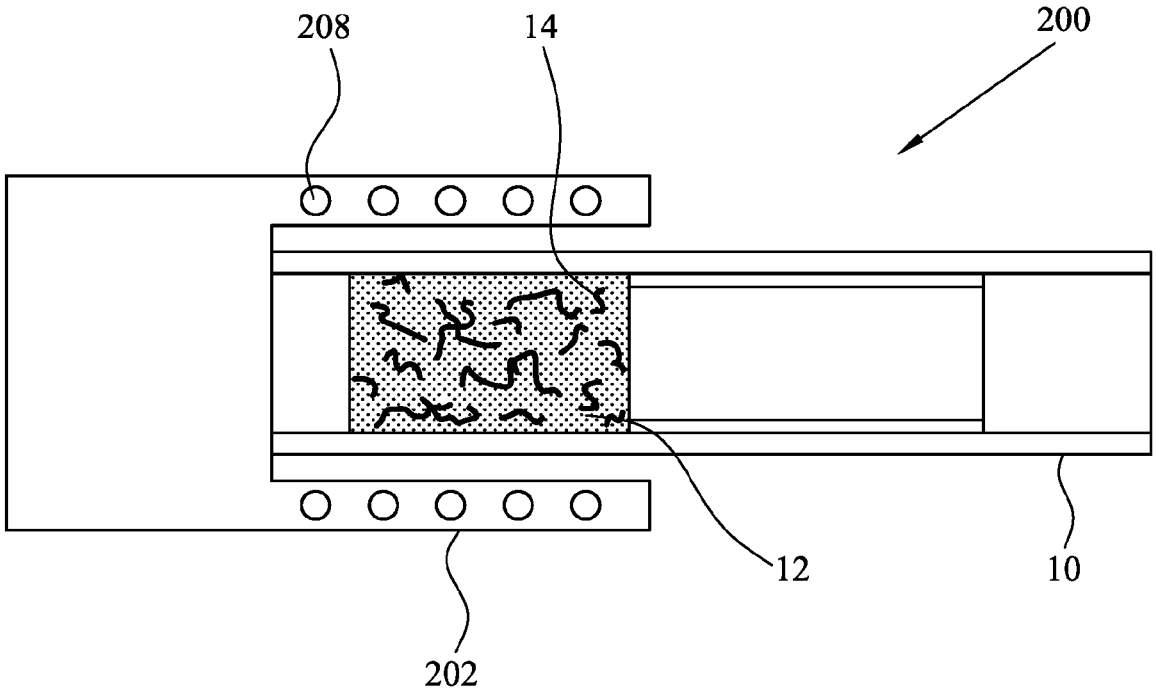


FIGURE 7

THERMALLY-ENHANCED AEROSOL FORMING SUBSTRATE

[0001] The present disclosure relates to an aerosol-forming substrate. The present disclosure also relates to a method of making an aerosol-forming substrate, and an aerosol-generating article comprising the substrate.

[0002] A typical aerosol-generating system comprises an aerosol-generating device and an aerosol-generating article comprising an aerosol-forming substrate. In use, the aerosol-generating device interacts with the aerosol-generating article to heat the aerosol-forming substrate and cause the aerosol-forming substrate to release volatile compounds. These compounds then cool to form an aerosol which is inhaled by a user.

[0003] Known aerosol-forming substrates typically have relatively low thermal conductivities. This may be undesirable. Low thermal conductivity of an aerosol-forming substrate may lead to a relatively large temperature gradient in the aerosol-forming substrate during use. In some systems, the aerosol-forming substrate is heated by a heating element inserted into the aerosol-forming substrate. In some systems, an aerosol-forming substrate is heated by a heater or heat source located externally to the aerosol-forming substrate. If the substrate has low thermal conductivity, portions of the aerosol-forming substrate which are located furthest from the heater or heat source do not reach a high temperature and so do not release as many volatile compounds as they would if the aerosol-forming substrate had a higher thermal conductivity. Thus, the low thermal conductivity of the aerosol-forming substrate may undesirably result in a low usage efficiency of the aerosol-forming substrate. Problems of poor thermal conductivity may be exacerbated where the aerosol-forming substrate is in the form of a plurality of discrete elements, for example where the substrate is in the form of cut filler. Individual elements of the cut filler have few points of contact with other elements of cut filler within the substrate, which can result in poor aerosol delivery when cut filler is used as a substrate in a heated aerosol-generating system.

[0004] Attempts have been made to increase the thermal conductivity of aerosol-forming substrates. However, to date, these attempts have been inadequate in one or more respects.

[0005] It is an aim of the present invention to provide an improved aerosol-forming substrate, for example an aerosol-forming substrate having an increased or augmented thermal conductivity.

[0006] According to the present disclosure there may be provided an aerosol-forming substrate comprising a first plurality of discrete elements of a first material and a second plurality of discrete elements of a second material. At least the first material is configured to generate an aerosol on heating. The second material has a greater thermal conductivity than the first material.

[0007] For example, there may be provided an aerosol-forming substrate comprising a mixture of a first plurality of discrete elements of a first material, and a second plurality of discrete elements of a second material, in which both the first plurality of discrete elements and the second plurality of discrete elements are in the form of strips having a length dimension greater than a width dimension and a thickness dimension.

[0008] For example, there may be provided an aerosol-forming substrate comprising a first plurality of discrete elements of a first material, each element of the first plurality of discrete elements of the first material comprising aerosol forming material and having a first thermal conductivity, and a second plurality of discrete elements of a second material, each element of the second plurality of discrete elements of the second material having a second thermal conductivity that is at least 10% greater than the first thermal conductivity.

[0009] For example, there may be provided an aerosol-forming substrate comprising a first material and a second material, the first material being comprised in the aerosol-forming substrate as a first plurality of discrete elements and the second material being comprised in the aerosol-forming substrate as a second plurality of discrete elements, in which the first material comprises an aerosol-former and has a first thermal conductivity, and in which the second material has a second thermal conductivity that is greater than the first thermal conductivity.

[0010] Advantageously, the presence of discrete elements of the second material, which has greater thermal conductivity than the first material, may increase the overall thermal conductivity of the aerosol-forming substrate. The increased thermal conductivity of the substrate may provide a more even temperature distribution throughout the substrate during use. The discrete elements of the second material have an increased thermal conductivity compared with the first material and may act to transport heat through the aerosol forming substrate to heat discrete elements of the first material. This may result in a greater proportion of the aerosol-forming substrate reaching a sufficiently high temperature to release volatile compounds, and thus a higher usage efficiency of the aerosol-forming substrate. Further, the increased thermal conductivity of the substrate may allow a heater, for example a heating blade configured to heat the substrate or an external heater, to operate at a lower temperature and thus require less power. Further still, the increased overall thermal conductivity of the substrate may allow a heater to heat the substrate to a temperature in which volatile compounds are released in less time. Thus, the increased thermal conductivity may reduce the time required to form an inhalable aerosol for a user or reduce the preheating time needed to prepare the aerosol-forming substrate for aerosol delivery.

[0011] Preferably, the second thermal conductivity is at least 5% greater than the first thermal conductivity. For example the second thermal conductivity may be at least 7% greater, or at least 10% greater, or at least 12% greater, or at least 15% greater than the first thermal conductivity. Where the aerosol-forming substrate comprises a substantially homogeneous mixture of first discrete elements of the first material and second discrete elements of the second material, a small increase in the thermal conductivity of the second material may result in a significant improvement in aerosol quality and delivery.

[0012] In some examples, the thermal conductivity of the second material is at least 10% greater than the thermal conductivity of the first material, for example at least 12% greater, or at least 15% greater, or at least 20% greater.

[0013] The first plurality of discrete elements may be elongated elements, each having a length dimension that is greater than a width dimension and a thickness dimension. The second plurality of discrete elements may be elongated elements, each having a length dimension that is greater than a width dimension and a thickness dimension. Advanta-

geously, both the first and second plurality of discrete elements, may be elongated elements, each having a length dimension that is greater than a width dimension and a thickness dimension. The elongated elements may be, for example, in the form of strips, shreds, threads, or ribbons.

[0014] The first plurality of discrete elements, or the second plurality of discrete elements, or both the first and second plurality of discrete elements, may be formed by a casting process or a paper making process. For example discrete elements may be formed by a casting process or a paper making process followed by a cutting process.

[0015] The first plurality of discrete elements, or the second plurality of discrete elements, or both the first and second plurality of discrete elements, may be formed by an extrusion process. For example, a slurry or dough may be formed and extruded to form elongate spaghetti-like elements.

[0016] Advantageously, at least a portion of the first plurality of discrete elements, or at least a portion of the second plurality of discrete elements, or at least a portion of both the first and second plurality of discrete elements, may be crimped elements. Each crimped element may have one or more kinks or directional changes defined in a length dimension of the crimped element. By providing at least a portion of the aerosol forming substrate in the form of crimped elements, the volume of the aerosol forming substrate and the air flow through the substrate may be controlled.

[0017] In some embodiments the first material is comprised in the aerosol-forming substrate in the form of cut filler. In some embodiments the second material is comprised in the aerosol-forming substrate in the form of cut filler. Advantageously, both the first material and the second material may be in the form of cut-filler.

[0018] In some embodiments, the discrete elements of the first plurality of discrete elements, or the second plurality of discrete elements, or both the first and second plurality of discrete elements have an average thickness of between 5 microns and 2000 microns, for example between 50 microns and 500 microns, for example between 150 microns and 300 microns.

[0019] In some embodiments, the discrete elements of the first plurality of discrete elements, or the second plurality of discrete elements, or both the first and second plurality of discrete elements have an average width of between 100 microns and 2000 microns, for example between 500 microns and 1500 microns, for example between 600 microns and 1000 microns.

[0020] In some embodiments, the discrete elements of the first plurality of discrete elements, or the second plurality of discrete elements, or both the first and second plurality of discrete elements have an average length of between 100 microns and 60 millimetres, for example between 500 microns and 30 millimetres, for example between 1000 microns and 10 millimetres, or 2000 microns and 6 millimetres.

[0021] The second material may comprise thermally conductive particles. For example, the second material may be formed from a carrier matrix an conductive particles located by the carrier matrix. The carrier matrix may be an aerosol forming matrix. The carrier matrix may comprise an aerosol former. The carrier matrix may be tobacco-free. The carrier matrix may comprise tobacco.

[0022] In some embodiments, the second material may comprise between 1% and 95% of thermally conductive particles on a dry weight basis. For example, the second material may comprise between 2% and 90% of thermally conductive particles on a dry weight basis, for example between 3% and 80%, or 4% and 70%, or 5% and 60%.

[0023] The second material may comprise thermally conductive particles formed from a thermally conductive material selected from the list consisting of carbon, graphite, expanded graphite, graphene, and metal. In advantageous embodiments, the thermally conductive particles may be carbon based particles, for example particles selected from the list consisting of carbon, graphite, expanded graphite, graphene, diamond, and carbon nanoparticles such as carbon nanotubes.

[0024] Where the term "thermally conductive particles" is used to refer to particles comprising carbon, for example particles comprising or consisting of one or more of graphite, expanded graphite, graphene, carbon nanotubes, charcoal, and diamond, the thermally conductive particles may be referred to as carbon particles or carbon-containing particles.

[0025] Optionally, some or all of the thermally conductive particles comprise carbon, for example at least 10, 30, 50, 70, 90, 95, 98, or 99 wt % carbon.

[0026] Optionally, some or all of the thermally conductive particles are graphite particles. Optionally, some or all of the thermally conductive particles are expanded graphite particles. Optionally, some or all of the thermally conductive particles are graphene particles. Optionally, some or all of the thermally conductive particles are carbon nanotubes or carbon nanotube particles. Optionally, some or all of the thermally conductive particles are charcoal particles. Optionally, some or all of the thermally conductive particles are diamond particles, for example artificial diamond particles. Advantageously, such materials may have relatively high thermal conductivities.

[0027] Expanded graphite may have a density less than 2, 1.8, 1.5, 1.2, 1, 0.8, or 0.5, 0.2, 0.1, 0.05, 0.02 grams per centimetre cubed (g/cm3). Expanded graphite may have a density greater than 0.01, 0.02, 0.05, 0.1, 0.2, 0.5, 0.8, 1, 1.2, 1.5 or 1.8 grams per centimetre cubed (g/cm3). Expanded graphite may have a density between 0.01 and 3, 0.01 and 2, 0.01 and 1.8, 0.01 and 1.5, 0.01 and 1.2, 0.01 and 1, 0.01 and 0.8, 0.01 and 0.5, 0.02 and 3, 0.02 and 2, 0.02 and 1.8, 0.02 and 1.5, 0.02 and 1.2, 0.02 and 1, 0.02 and 0.8, 0.02 and 0.5, 0.01 and 3, 0.05 and 2, 0.05 and 1.8, 0.05 and 1.5, 0.05 and 1.2, 0.05 and 1, 0.05 and 0.8, 0.05 and 0.5 g/cm3, 0.1 and 3, 0.1 and 2, 0.1 and 1.8, 0.1 and 1.5, 0.1 and 1.2, 0.1 and 1, 0.1 and 0.8, 0.1 and 0.5, 0.2 and 3, 0.2 and 2, 0.2 and 1.8, 0.2 and 1.5, 0.2 and 1.2, 0.2 and 1, 0.2 and 0.8, 0.2 and 0.5, 0.5 and 3, 0.5 and 2, 0.5 and 1.8, 0.5 and 1.5, 0.5 and 1.2, 0.5 and 1, 0.5 and 0.8, 0.8 and 3, 0.8 and 2, 0.8 and 1.8, 0.8 and 1.5, 0.8 and 1.2, 0.8 and 1 grams per centimetre cubed (g/cm3).

[0028] Optionally, according to aspects where each of the thermally conductive particles does not necessarily consist of one or more carbon particles, some or all of the thermally conductive particles comprise a metal. Alternatively, or in addition, some or all of the thermally conductive particles comprise an alloy. Alternatively, or in addition, some or all of the thermally conductive particles comprise an intermetallic. Advantageously, such materials may have relatively high thermal conductivities.

[0029] Optionally, some or all of the thermally conductive particles comprise one or more of silicon carbide, silver, copper, gold, aluminium nitride, aluminium, tungsten, and boron nitride. Optionally, some or all of the thermally conductive particles are silicon carbide particles. Optionally, some or all of the thermally conductive particles are silver particles. Optionally, some or all of the thermally conductive particles are copper particles. Optionally, some or all of the thermally conductive particles are gold particles. Optionally, some or all of the thermally conductive particles are aluminium nitride particles. Optionally, some or all of the thermally conductive particles are aluminium particles. Optionally, some or all of the thermally conductive particles are tungsten particles. Optionally, some or all of the thermally conductive particles are boron nitride particles. Advantageously, such materials may have relatively high thermal conductivities.

[0030] The thermally conductive particles may each have a "particle size". The meaning of the term "particle size" and a method of measuring particle size is set out later.

[0031] The thermally conductive particles may be characterised by a particle size distribution. The particle size distribution may have number D10, D50 and D90 particle sizes. The number D10 particle size is defined such that 10% of the particles have a particles size less than or equal to the number D10 particle size. Similarly, the number D50 particle size is defined such that 50% of the particles have a particles size less than or equal to the number D50 particle size. Thus, the number D50 particle size may be referred to as a median particle size. The number D90 particle size is defined such that 90% of the particles have a particles size less than or equal to the number D90 particle size. Thus, if there were 1,000 particles in the distribution and the particles were order by ascending particle size, one would expect the number D10 particle size to be roughly equal to the particle size of the 100^{th} particle, the number D50 particle size to be roughly equal to the particle size of the 500^{th} particle, and the number D90 particle size to be roughly equal to the particle size of the 900^{th} particle.

[0032] The particle size distribution may have volume D10, D50 and D90 particle sizes. The volume D10 particle size is defined such that 10% of the sum of the volumes of all of the particles is accounted for by the sum of the volumes of the particles having a particles size less than or equal to the volume D10 particle size. Similarly, the volume D50 particle size is defined such that 50% of the sum of the volumes of all of the particles is accounted for by the sum of the volumes of the particles having a particles size less than or equal to the volume D50 particle size. And the volume D90 particle size is defined such that 90% of the sum of the volumes of all of the particles is accounted for by the sum of the volumes of the particles having a particles size less than or equal to the volume D90 particle size.

[0033] Optionally, the thermally conductive particles have a particle size distribution having a number D10 particle size, wherein the number D10 particle size is at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns.

[0034] Optionally, the thermally conductive particles have a particle size distribution having a number D10 particle size, wherein the number D10 particle size is no more than 1,000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns.

[0035] A compromise has to be made when deciding the sizes of the particle. Larger thermally conductive particles may advantageously increase the thermal conductivity of the second material more than smaller thermally conductive particles. However, larger thermal conductive particles may reduce the space available for aerosol-forming material and may increase the required thickness of discrete elements made from the second material.

[0036] Optionally, the thermally conductive particles have a particle size distribution having a number D50 particle size, wherein the number D50 particle size is at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns.

[0037] Optionally, the thermally conductive particles have a particle size distribution having a number D50 particle size, wherein the number D50 particle size is no more than 1,000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns.

[0038] Optionally, the thermally conductive particles have a particle size distribution having a number D90 particle size, wherein the number D90 particle size is at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns.

[0039] Optionally, the thermally conductive particles have a particle size distribution having a number D90 particle size, wherein the number D90 particle size is no more than 1,000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns.

[0040] It may be particularly preferably for the thermally conductive particles have a particle size distribution having a number D10 particle size between 1 and 20 microns. Alternatively, or in addition, it may be particularly preferably for the thermally conductive particles have a particle size distribution having a number D90 particle size between 50 and 300 microns, or between 50 and 200 microns.

[0041] Optionally, the thermally conductive particles have a particle size distribution having a number D10 particle size and a number D90 particle size, wherein the number D90 particle size is no more than 50, 40, 30, 20, 10, or 5 times the number D10 particle size.

[0042] Optionally, the thermally conductive particles have a particle size distribution having a number D10 particle size and a number D90 particle size, wherein the number D90 particle size is at least 1.5, 2, 3, 5, 10, or 20 times the number D10 particle size.

[0043] A compromise must be made in relation to the particle size distribution. A tighter particle size distribution, for example characterised by a smaller ratio between the D90 and D10 particle sizes, may advantageously provide a more uniform thermal conductivity throughout the material, for example the second material. This is because there will be less variation in particle size in different locations in the material. This may advantageously allow for more efficient usage of the aerosol-forming component throughout the material. However, a tighter particle size distribution may disadvantageously be more difficult and expensive to achieve. The inventors have found that the particle size distributions described above may provide an optimal compromise between these two factors.

[0044] The particle size may be more conveniently defined in relation to a volume size rather than a number size. Optionally, the thermally conductive particles have a particle size distribution having a volume D10 particle size, wherein the volume D10 particle size is at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns.

[0045] Optionally, the thermally conductive particles have a particle size distribution having a volume D10 particle size, wherein the volume D10 particle size is no more than 1,000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns

[0046] Optionally, the thermally conductive particles have a particle size distribution having a volume D50 particle

size, wherein the volume D50 particle size is at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns.

[0047] Optionally, the thermally conductive particles have a particle size distribution having a volume D50 particle size, wherein the volume D50 particle size is no more than 1,000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns.

[0048] Optionally, the thermally conductive particles have a particle size distribution having a volume D90 particle size, wherein the volume D90 particle size is at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns.

[0049] Optionally, the thermally conductive particles have a particle size distribution having a volume D90 particle size, wherein the volume D90 particle size is no more than 1,000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns.

[0050] It may be particularly preferably for the thermally conductive particles have a particle size distribution having a volume D10 particle size between 1 and 20 microns. Alternatively, or in addition, it may be particularly preferably for the thermally conductive particles have a particle size distribution having a volume D90 particle size between 50 and 300 microns, or between 50 and 200 microns.

[0051] Optionally, the thermally conductive particles have a particle size distribution having a volume D10 particle size and a volume D90 particle size, wherein the volume D90 particle size is no more than 50, 40, 30, 20, 10, or 5 times the volume D10 particle size.

[0052] Optionally, the thermally conductive particles have a particle size distribution having a volume D10 particle size and a volume D90 particle size, wherein the volume D90 particle size is at least 1.5, 2, 3, 5, 10, or 20 times the volume D10 particle size.

[0053] As explained above, a compromise must be made in relation to the particle size distribution, and the inventors have found that the particle size distributions above may provide an optimal compromise.

[0054] Optionally, each of the thermally conductive particles has a particle size of at least 0.1, 0.2, 0.5, 1, 2, 5, 10, 20, 50, 100, 200, or 500 microns. Optionally, each of the thermally conductive particles has a particle size of no more than 1,000, 500, 300, 200, 100, 50, 20, 10, 5, 2, 1, 0.5, or 0.2 microns. It may be particularly preferable for each of the thermally conductive particles to have a particle size of at least 1 micron. Alternatively, or in addition, it may be particularly preferable for each of the thermally conductive particles to have a particle size of no more than 300 microns. Particles smaller than 1 micron may be difficult to handle during manufacturing. Particles greater than 300 microns may take up a rather large amount of space in the substrate which could be used for aerosol-forming material. Thus, it may be particularly advantageous for each of the thermally conductive particles to have a particle size of at least 1 micron, or a particle size of no more than 300 microns, or both.

[0055] Optionally, each of the thermally conductive particles may have three mutually perpendicular dimensions, a largest dimension of the three dimensions being no more than 10, 8, 5, 3, or 2 times larger than a smallest dimension of the three dimensions. Optionally, each of the thermally conductive particles has three mutually perpendicular dimension, a largest dimension of the three dimensions being no more than 10, 8, 5, 3, or 2 times larger than a second largest dimension of the three dimensions. Optionally, each of the thermally conductive particles is substantially spherical. Advantageously, the orientation of substantially spherical particles may not affect the thermal conductivity of the substrate as much as the orientation of non-spherical particles. Thus, the use of more spherical particles may result in less variability between different substrates where the orientations of the particles is not controlled. In addition, substantially spherical particles may be more easy to characterise.

[0056] Optionally, each discrete element of the second material comprises at least 10, 20, 50, 100, 200, 500, or 1000 thermally conductive particles. Advantageously, a greater number of particles in the each discrete element may allow the thermal conductivity of the substrate to be more uniform.

[0057] Optionally, the second material comprises, on a dry weight basis, at least 20, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80 or 85 wt % of the thermally conductive particles. Optionally, the substrate comprises, on a dry weight basis, no more than 85, 80, 75, 70, 65, 60, 55, 50, 45, 40, 35, 30, 25, 20, or 15 wt % of the thermally conductive particles. Optionally, the substrate comprises, on a dry weight basis, between 10 and 90, 20 and 90, 30 and 90, 40 and 90, 50 and 90, 60 and 90, 70 and 90, 80 and 90, 10 and 80, 20 and 80, 30 and 80, 40 and 80, 50 and 80, 60 and 80, 70 and 80, 10 and 70, 20 and 70, 30 and 70, 40 and 70, 50 and 70, 60 and 70, 10 and 60, 20 and 60, 30 and 60, 40 and 60, 50 and 60, 10 and 50, 20 and 50, 30 and 50, 40 and 50, 10 and 40, 20 and 40, 30 and 40, 10 and 30, 20 and 30, or 10 and 20 wt % of the thermally conductive particles. It may be particularly preferable for the substrate to comprise, on a dry weight basis, between 50 and 90, or more preferably between 60 and 90, or even more preferably between 65 and 85, wt % of the thermally conductive particles.

[0058] A comprise must be made in relation to the weight percent of thermally conductive particles in the substrate. Increasing the weight percent of particles in the aerosol-forming substrate may advantageously increase the thermal conductivity of the substrate. However, increasing the weight percent of particles in the aerosol-forming substrate may also reduce the available space for one or more of the aerosol former, binder, and fibres, so could result in a substrate which forms less aerosol, or which has less tensile strength.

[0059] The second material may be a material with augmented thermal conductivity. The second material may comprise thermally conductive particles and a carrier matrix, the carrier matrix comprising an aerosol-former, for example glycerine or propylene glycol, fibres, and a binder. The carrier matrix may be a homogenised tobacco material. Thus, the second material may be a homogenised tobacco material having augmented thermal conductivity bestowed by a proportion of thermally conductive particles.

[0060] In some embodiments, the second material may be a thermally conductive material selected from the list consisting of carbon, graphite, expanded graphite, graphene, and metal. For example, each discrete element of the second material may be a strip of metal foil or carbon foil, for example a strip of copper foil, or aluminium foil, or stainless steel foil, or graphite foil.

[0061] The first material may be a tobacco material, for example tobacco leaf or homogenised tobacco. Standard homogenised tobacco typically has a thermal conductivity of between 0.1 W/mK to 0.2 W/mK. Thus, in some embodiments the first material may have a thermal conductivity of less than 0.2 W/mK, for example when measured at 25° C., and the second material may have a thermal conductivity of

greater than 0.22 W/mK, for example when measured at 25° C. The second material may have a thermal conductivity as high as 1700 W/mK, for example as found in commercial graphite foil along its planar direction.

[0062] Thus, the first material may have a thermal conductivity of less than 0.2 W/mK and the second material may have a thermal conductivity of at least 0.22 W/mK in at least one direction at 25° C. These thermal conductivities may be measured when a moisture content of the materials is between 0 and 20, or 5 and 15, for example around 10%. This thermal conductivity may be measured when the material comprises between 0 and 20, or 5 and 15, for example around 10 wt % water. The moisture or water content of the material may be measured using a titration method. The moisture or water content of the material may be measured using the Karl Fisher method.

[0063] The first material is preferably configured to generate an aerosol on heating, for example on heating to a temperature of between 120 degrees Centigrade and 395 degrees Centigrade. In some embodiments the second material is not configured to generate an aerosol on heating, for example on heating to a temperature of between 120 degrees Centigrade and 350 degrees Centigrade. Thus, in these embodiments, the first material is an aerosol generating material and the second material is not an aerosol generating material. The role of the discrete elements of the second material in such embodiments is to facilitate the transfer of heat to allow aerosol generation from the first material to be optimised.

[0064] In some embodiments, both the first material and the second material are configured to generate an aerosol on heating, for example on heating to a temperature of between 120 degrees Centigrade and 395 degrees Centigrade. In such embodiments, the second material contributes to the delivery of aerosol as well as improving thermal conductivity of the overall substrate.

[0065] The first material may comprise tobacco. For example, the first material may be formed from homogenised tobacco. Preferably, the first material comprises tobacco and an aerosol-former. Preferably, the first material is configured to generate an aerosol when heated to a temperature of between 120 degrees Centigrade and 395 degrees Centigrade. The first material may be a homogenised tobacco material comprising an aerosol former such as glycerine or propylene glycol. The first material may further comprises fibres and a binder to improve the structure of the first material.

[0066] The presence of fibres and a binder may increase a tensile strength of the first material. The increased tensile strength may allow the production of a sheet of the first material which does not easily tear.

[0067] Optionally, the first material and/or the second material comprises, on a dry weight basis, at least 10, 15, 20, 25, 30, 35, 40, 45, 50, or 55 wt % of an aerosol former. Optionally, the material comprises, on a dry weight basis, no more than 55, 50, 45, 40, 35, 30, 25, 20, or 15 wt % of the aerosol former. Optionally, the material comprises, on a dry weight basis, between 7 and 60, 10 and 60, 20 and 60, 30 and 60, 40 and 60, 50 and 60, 7 and 50, 10 and 50, 20 and 50, 30 and 50, 40 and 50, 7 and 40, 10 and 40, 20 and 40, 30 and 40, 7 and 30, 10 and 30, 20 and 30, 7 and 20, 10 and 20, or 7 and 10 wt % of the aerosol former. It may be particularly preferable for the first material and/or the second material to comprise, on a dry weight basis, between 15 and 25 wt % of the aerosol former.

[0068] Optionally, the aerosol-former comprises or consists of one or more of: polyhydric alcohols, such as propylene glycol, polyethylene glycol, triethylene glycol, 1, 3-butanediol and glycerine; esters of polyhydric alcohols, such as glycerol mono-, di- or tri-acetate; and aliphatic esters of mono-, di- or poly-carboxylic acids, such as dimethyl dodecanedioate and dimethyl tetradecanedioate. Optionally, the first material and/or the second material comprises one or both of glycerine and glycerol.

[0069] In some embodiments the second material comprises an aerosol-former and conductive particles, for example conductive particles constituting between 3 wt % and 90 wt % of the second material on a dry weight basis. Thus, the second material may be configured to generate an aerosol when heated to a temperature of between 120 degrees Centigrade and 395 degrees Centigrade.

[0070] The second material may comprise tobacco and an aerosol-former and conductive particles constituting between 3 wt % and 90 wt % of the second material on a dry weight basis, the second material thereby being configured to generate an aerosol when heated to a temperature of between 120 degrees Centigrade and 395 degrees Centigrade. The second material may be a thermally conductive homogenised tobacco material comprising an aerosol-former such as glycerine or propylene glycol. The second material may further comprise fibres and a binder.

[0071] Optionally, the first material and/or the second material comprises, on a dry weight basis, at least 2, 4, 6, 8, 10, 12, 14, 16 or 18 wt % of the fibres. Optionally, the material comprises, on a dry weight basis, no more than 20, 18, 16, 14, 12, 10, 8, 6, or 4 wt % of the fibres. Optionally, the material comprises, on a dry weight basis, between 4 and 20, 6 and 20, 8 and 20, 10 and 20, 12 and 20, 14 and 20, 16 and 20, 18 and 20, 2 and 18, 4 and 18, 6 and 18, 8 and 18, 10 and 18, 12 and 18, 14 and 18, 16 and 18, 2 and 16, 4 and 16, 6 and 16, 8 and 16, 10 and 16, 12 and 16, 14 and 16, 2 and 14, 4 and 14, 6 and 14, 8 and 14, 10 and 14, 12 and 14, 2 and 12, 4 and 12, 6 and 12, 8 and 12, 10 and 12, 2 and 10, 4 and 10, 6 and 10, 8 and 10, 2 and 8, 4 and 8, 6 and 8, 2 and 6, 4 and 6, or 2 and 4 wt % of the fibres. It may be particularly preferable for the substrate to comprise, on a dry weight basis, between 2 and 10 wt % of the fibres.

[0072] Optionally, the fibres are cellulose fibres. Advantageously, cellulose fibres are not overly costly and can increase the tensile strength of the material.

[0073] Optionally, each of the fibres has three mutually perpendicular dimensions, a largest dimension of the three dimensions being at least 1.5, 2, 3, 5, 10, or 20 times larger than a smallest dimension of the three dimensions. Optionally, each of the fibres has three mutually perpendicular dimensions, a largest dimension of the three dimensions being at least 1.5, 2, 3, 5, 10, or 20 times larger than a second largest dimension of the three dimensions. In some embodiments the second material does not comprise tobacco. For example, the second material may be a thermally conductive tobacco-free material. The thermally conductive tobacco free material may comprise thermally conductive particles held in a tobacco-free carrier matrix. The thermally conductive tobacco-free material may comprise an aerosol-former such as glycerine or propylene glycol, and may further comprise fibres and a binder. In preferred embodiments of a

tobacco-free second material, the thermally conductive particles are carbon based particles.

[0074] Optionally, the first material and/or the second material comprises, on a dry weight basis, at least 4, 6, or 8 wt % of the binder. Optionally, the material comprises, on a dry weight basis, no more than 8, 6, or 4 wt % of the binder. Optionally, the material comprises, on a dry weight basis, between 4 and 10, 6 and 10, 8 and 10, 2 and 8, 4 and 8, 6 and 8, 2 and 6, 4 and 6, 2 and 4 wt % of the binder. It may be particularly preferable for the first material and/or the second material to comprise, on a dry weight basis, between 2 and 10 wt % of the binder.

[0075] Suitable binders are well-known in the art and include, but are not limited to, natural pectins, such as fruit, citrus or tobacco pectins; guar gums, such as hydroxyethyl guar and hydroxypropyl guar; locust bean gums, such as hydroxyethyl and hydroxypropyl locust bean gum; alginate; starches, such as modified or derivatized starches; celluloses, such as methyl, ethyl, ethylhydroxymethyl and carboxymethyl cellulose; tamarind gum; dextran; pullalon; konjac flour; xanthan gum and the like. It may be particularly preferable for the binder to be or comprise guar. It may be particularly preferable for the binder to comprise or consist of one or more of carboxymethyl cellulose or hydroxypropyl cellulose or a gum such as guar gum.

[0076] The discrete elements of the first material and the discrete elements of the second material may be formed separately and mixed together in a predetermined ratio to form the aerosol-forming material. The precise ratio may be selected to control delivery of aerosol from the aerosol forming substrate.

[0077] Optionally, the thermally conductive particles are substantially homogeneously distributed throughout the second material. Optionally, the aerosol former is substantially homogeneously distributed throughout the second material. Optionally, the fibres are substantially homogeneously distributed throughout the second material. Optionally, the binder is substantially homogeneously distributed throughout the second material. Advantageously, a homogenous distribution of components of the second material may result in the material have more spatially uniform properties. For example, substantially homogeneously distributed thermally conductive particles may result in the material having a substantially uniform thermal conductivity. As another example, substantially homogeneously distributed binder or fibres may result in the material having a substantially uniform tensile strength.

[0078] Optionally, the first material and/or the second material may comprise nicotine. Optionally, the first and/or second material comprises, on a dry weight basis, at least 0.01, 1, 2, 3, or 4 wt % nicotine. Optionally, the material comprises, on a dry weight basis, no more than 5, 4, 3, 2, or 1 wt % nicotine. Optionally, the material comprises, on a dry weight basis, between 0.01 and 5, 1 and 5, 2 and 5, 3 and 5, 4 and 5, 0.01 and 4, 1 and 4, 2 and 4, 3 and 4, 0.01 and 3, 1 and 3, 2 and 3, 0.01 and 2, 1 and 2, 0.01 and 1 wt % nicotine. It may be particularly preferable for the first material and/or second material to comprise, on a dry weight basis, between 0.5 and 4 wt % nicotine.

[0079] Optionally, the nicotine is substantially homogeneously distributed throughout the material.

[0080] Optionally, the first material and/or second material additionally comprises an acid. Optionally, the material comprises, on a dry weight basis, at least 0.01, 1, 2, 3, or 4 wt % of the acid. Optionally, the material comprises, on a dry weight basis, no more than 5, 4, 3, 2 or 1 wt % of the acid. Optionally, the material comprises, on a dry weight basis, between 0.01 and 5, 1 and 5, 2 and 5, 3 and 5, 4 and 5, 0.01 and 4, 1 and 4, 2 and 4, 3 and 4, 0.01 and 3, 1 and 3, 2 and 3, 0.01 and 2, 1 and 2, 0.01 and 1 wt % of the acid. It may be particularly preferable for the first material and/or the second material to comprise, on a dry weight basis, between 0.5 and 5 wt % of acid.

[0081] Optionally, the acid comprises or consists of one or more of fumaric acid, lactic acid, benzoic acid, and levulinic acid.

[0082] Optionally, the acid is substantially homogeneously distributed throughout the material.

[0083] Optionally, the first material and/or the second material comprises at least one botanical. Optionally, the material comprises, on a dry weight basis, at least 0.01, 1, 2, 5, 10, or 15 wt % of the at least one botanical. Optionally, the material comprises, on a dry weight basis, no more than 20, 15, 10, 5, 2 or 1 wt % of the at least one botanical.

[0084] Optionally, the material comprises, on a dry weight basis, between 0.01 and 20, 1 and 20, 2 and 20, 5 and 20, 10 and 20, 15 and 20, 0.01 and 15, 1 and 15, 2 and 15, 5 and 15, 10 and 15, 0.01 and 10, 1 and 10, 2 and 10, 5 and 10, 0.01 and 5, 1 and 5, 2 and 5, 0.01 and 2, 1 and 2, 0.01 and 1 wt % of the at least one botanical. It may be particularly preferable for the material to comprise, on a dry weight basis, between 1 and 15 wt % of the at least one botanical.

[0085] Optionally, the at least one botanical comprises or consists of one or both of clove and rosmarinus.

[0086] Optionally, the at least one botanical is substantially homogeneously distributed throughout the material.

[0087] Optionally, the first material and/or the second material comprises at least one flavourant. Optionally, the material comprises, on a dry weight basis, at least 0.1, 1, 2, or 5 wt % of the at least one flavourant. Optionally, the substrate comprises, on a dry weight basis, no more than 10, 5, 2 or 1 wt % of the at least one flavourant. Optionally, the substrate comprises, on a dry weight basis, between 0.1 and 10, 1 and 10, 2 and 10, 5 and 10, 0.1 and 5, 1 and 5, 2 and 5, 0.1 and 2, 1 and 2, 0.1 and 1 wt % of the at least one flavourant. It may be particularly preferable for the substrate to comprise, on a dry weight basis, between 0.1 and 5 wt % of the at least one flavourant.

[0088] Optionally, the at least one flavourant is present as a coating, for example a coating on one or more discrete elements of the aerosol-forming substrate. Alternatively, or in addition, the at least one flavourant is substantially homogeneously distributed throughout the material.

[0089] In some embodiments, the ratio of the first material to second material in the aerosol-forming substrate may be between 1:10 and 10:1, for example between 1:5 and 8:1, for example between 1:1 and 5:1.

[0090] In some embodiments, the second material may comprise, on a dry weight basis: between 20 and 90 wt % of particulate carbon material, for example between 40 and 80 wt %; between 10 and 40 wt % of an aerosol former; between 4 and 20 wt % of fibres; and between 2 and 10 wt % of a binder. The particulate carbon material preferably consists of one or more of graphite, expanded graphite, graphene, carbon nanoparticles such as carbon nanotubes, and charcoal.

[0091] While the first material has a lower thermal conductivity than the second material, it is envisaged that the

first material may be a material with augmented thermal conductivity. The first material may comprise any particles as described above in relation to the second material. For example, the first material may comprise, on a dry weight basis: between 40 and 80 wt % of particulate carbon material, between 10 and 40 wt % of an aerosol former, between 4 and 20 wt % of fibres, and between 2 and 10 wt % of a binder. The particulate carbon material preferably consists of one or more of graphite, expanded graphite, graphene, carbon nanoparticles such as carbon nanotubes, and charcoal.

[0092] Advantageously, the second material and the first material are homogeneously distributed within the aerosol-forming substrate.

[0093] In a second aspect, the disclosure may provide a method of forming an aerosol-forming substrate comprising steps of providing a first plurality of discrete elements formed from a first material, providing a second plurality of discrete elements formed from a second material, and combining the first plurality of discrete elements with the second plurality of discrete elements to form the aerosol-forming substrate. The second material has a greater thermal conductivity than the first material. Preferably, the first material is an aerosol forming material comprising an aerosol-former such as glycerine or propylene glycol. The first material may be any first material as described above in relation to the first aspect of the invention. The second material may be any second material as described above in relation to the first aspect of the invention.

[0094] The method of forming the aerosol-forming substrate may comprise steps of forming the first plurality of discrete elements from the first material, and/or steps of forming the second plurality of discrete elements from the second material, and then combining the first plurality of discrete elements with the second plurality of discrete elements to form the aerosol-forming substrate.

[0095] The first plurality of discrete elements may be formed by cutting a sheet of the first material into strips. The second plurality of discrete elements may be formed by cutting a sheet of the second material into strips. Advantageously, the first plurality of discrete elements and the second plurality of discrete elements may be cut to be substantially the same size. This may facilitate the combination of the two sets of discrete elements to for the aerosol-forming substrate.

[0096] A step of forming at least one of the first plurality of discrete elements and the second plurality of discrete elements may involve a step of crimping. For example, the first plurality of discrete elements, the second plurality of discrete elements, or both the first and second plurality of discrete elements may be crimped elements. Crimping may be performed on a sheet of the first material or the second material before the sheet is cut into discrete elements. Thus a sheet of the first material or the second material may be crimped and then cut. Alternatively, the discrete elements may be formed and then subsequently crimped. Crimping introduces bends and kinks to the discrete particles which may give volume to an aerosol forming substrate formed from a plurality of such discrete elements.

[0097] In some embodiments, the first material is a tobacco material such as cut leaf or cut filler produced by slicing a homogenised tobacco sheet. Methods of making homogenised tobacco and cut-filler suitable as the first plurality of elements are well known to the skilled person.

[0098] In some embodiments the second material comprises thermally conductive particles within a carrier matrix. In some embodiments the first material also comprises thermally conductive particles. A material suitable as the second material, and in some cases the first material, may be formed by the following method.

[0099] A method for forming a conductively augmented material, for example the second material, may comprise steps of forming a slurry comprising a plurality of thermally conductive particles, an aerosol former, reinforcement fibres, and a binder; and casting and drying the slurry to form the material. The material and its components may be as described above.

[0100] The slurry may comprise water. Optionally, the slurry comprises between 20 and 90, 30 and 90, 40 and 90, 40 and 85, 50 and 80, 60 and 80, or 60 and 75 wt % water.

[0101] Optionally, the slurry comprises an acid. Optionally, the acid comprises or consists of one or more of fumaric acid, lactic acid, benzoic acid, and levulinic acid.

[0102] Optionally, the slurry comprises nicotine.

[0103] Optionally, forming the slurry comprises forming a first mixture. The first mixture may comprise the aerosol former. The first mixture may comprise the fibres, for example cellulose fibres. The first mixture may comprise water. The first mixture may comprise the acid. The first mixture may comprise the nicotine. Forming the slurring may comprise forming a second mixture. The second mixture may comprise the thermally conductive particles. The second mixture may comprise the binder. Forming the slurry may comprise adding the second mixture to the first mixture to form a combined mixture.

[0104] Thus, forming the slurry may comprise: forming a first mixture comprising the aerosol former, the fibres, water, optionally, the acid, and optionally, the nicotine; forming a second mixture comprising the thermally conductive particles and the binder; and adding the second mixture to the first mixture to form a combined mixture.

[0105] The combined mixture may subsequently be formed into the slurry, for example by mixing.

[0106] Optionally, forming the first mixture comprises providing the aerosol former or a solution comprising the aerosol former and the nicotine.

[0107] Optionally, forming the first mixture comprises adding the acid to the aerosol former or the solution comprising the aerosol former and the nicotine to form a first pre-mixture.

[0108] Optionally, forming the first mixture comprises adding the water to the aerosol former or the solution comprising the aerosol former and the nicotine, or to the first pre-mixture, to form a second pre-mixture.

[0109] Optionally, forming the first mixture comprises adding the fibres to the second pre-mixture.

[0110] Optionally, forming the second mixture comprises mixing the thermally conductive particles and the binder.

[0111] Optionally, the method, for example the step of forming the slurry, comprises a first mixing of the combined mixture. Optionally, the first mixing occurs under a first pressure of no more than 500, 400, 300, 250, or 200 mbar. Optionally, the first mixing occurs for between 1 and 10, 2 and 8, or 3 and 6 minutes, for example for around 4 minutes.

[0112] Optionally, the method, for example the step of forming the slurry, comprises, after the first mixing, a second mixing. Optionally, the second mixing occurs under a second pressure which is less than the first pressure. Optionally,

the second pressure is no more than 500, 400, 300, 200, 150, or 100 mbar. Optionally, the second mixing occurs for between 5 and 120, 5 and 80, 5 and 40, or 10 and 30 seconds, for example around 20 seconds.

[0113] Casting the slurry may comprise casting the slurry onto a flat support, for example a steel flat support.

[0114] Optionally, after casting the slurry and before drying the slurry, the method may comprise setting a thickness of the slurry, for example setting a thickness of the slurry to between 100 and 1200, 200 and 1000, 300 and 900, 500 and 700 microns, for example around 600 microns.

[0115] Optionally, drying the slurry comprises providing a flow of a gas such as air over or past the slurry. Optionally, the flow of gas is heated. Optionally, the flow of gas is heated to a temperature of between 100 and 160, or 120 and 140 degrees Celsius. Optionally, the flow of gas is provided for between 1 and 10 or 2 and 5 minutes. Optionally, drying the slurry comprises drying the slurry until the slurry has a moisture content of between 1 and 20, 2 and 15, 2 and 10, or 3 and 7 wt %.

[0116] Optionally, drying the slurry forms the precursor for forming into a sheet of aerosol-forming material. The sheet may be a sheet of the second material as used in some embodiments described above. The sheet may be a sheet of the first material as used in some embodiments described above. Optionally, the method comprises cutting the sheet of aerosol-forming material to form discrete elements of the aerosol-forming material.

[0117] In a third aspect, the present disclosure may provide an aerosol generating comprising an aerosol-forming substrate as described above in relation to the first aspect of the invention or manufactured by any method described above in relation to the second aspect of the invention.

[0118] Such an article may be, for example, in the form of a rod comprising a plurality of components, including the aerosol-forming substrate, assembled within a wrapper or casing. The aerosol-generating article may have a length of between 30 mm and 120 mm, for example between 40 mm and 80 mm, for example about 45 mm. The aerosol generating article may have a diameter of between 3.5 mm and 10 mm, for example between 4 mm and 8.5 mm, for example between 4.5 mm and 7.5 mm.

[0119] Optionally, the aerosol-generating article comprises a front plug. Optionally, the aerosol-generating article comprises a first hollow tube, for example a first hollow acetate tube. Optionally, the aerosol-generating article comprises a second hollow tube, for example a second hollow acetate tube. Optionally, the second hollow tube comprises one or more ventilation holes. Optionally, the aerosol-generating article comprises a mouth plug filter. Optionally, the aerosol-generating article comprises wrapper, for example a paper wrapper.

[0120] Optionally, the front plug is arranged a most upstream end of the article. Optionally, the aerosol-forming substrate is arranged downstream of the front plug. Optionally, the first hollow tube is arranged downstream of the aerosol-forming substrate. Optionally, the second hollow tube is arranged downstream of the first hollow tube. Optionally, the mouth plug filter is arranged downstream of one or both of the first hollow tube and the second hollow tube. Optionally, the mouth plug filter is arranged at a most downstream end of the article. Optionally, the most downstream end of the article, which may be referred to as a mouth end of the article, may be configured for insertion into a mouth of a user. A user may be able to inhale on, for example directly on, the mouth end of the article.

[0121] Optionally, the front plug, the aerosol-forming substrate, one or both of the first hollow tube and the second hollow tube, and the mouth plug filter are circumscribed by a wrapper, for example a paper wrapper.

[0122] Optionally, the front plug has a length of between 2 and 10, 3 and 8, or 4 and 6 mm, for example around 5 mm. Optionally, the aerosol-forming substrate within the article has a length of between 5 and 20, 8 and 15, or 10 and 15 mm, for example around 12 mm. Optionally, the first hollow tube has a length of between 2 and 20, 5 and 15, or 5 and 10 mm, for example around 8 mm. Optionally, the second hollow tube has a length of between 2 and 20, 5 and 15, or 5 and 10 mm, for example around 8 mm. Optionally, the mouth plug filter has a length of between 5 and 20, 8 and 15, or 10 and 15 mm, for example around 12 mm. The lengths of one or more of the front plug, the aerosol-forming substrate, the first hollow tube, the second hollow tube, and the mouth plug filter may extend in a longitudinal direction.

[0123] One or more of the front plug, the aerosol-forming substrate, the first hollow tube, the second hollow tube, and the mouth plug filter may be substantially cylindrical, for example right cylindrical, in shape.

[0124] According to a fourth aspect of the present disclosure, there is provided an aerosol-generating system.

[0125] The system may comprise an aerosol-generating article and an electrical aerosol-generating device. The article may be an article as described above, for example an article according to the third aspect.

[0126] Optionally, the electrical aerosol-generating device is configured to resistively heat the aerosol-generating article in use.

[0127] Optionally, the electrical aerosol-generating device is configured to inductively heat the aerosol-generating article, for example the aerosol forming substrate of the aerosol-generating article, in use.

[0128] As would be understood by the skilled person having read this disclosure, the features described herein in relation to one aspect may be applicable to any other aspect. For example, features described in relation to the combined aerosol-forming substrate of the second aspect, or in relation to the first second material of the combined aerosol-forming substrate of the second aspect, may be applicable to the aerosol-forming substrate of the first aspect, and vice versa.

[0129] As used herein, the term "aerosol-forming substrate" may refer to a substrate capable of releasing an aerosol or volatile compounds that can form an aerosol. Such volatile compounds may be released by heating the aerosol-forming substrate. An aerosol-forming substrate may comprise an aerosol-forming material. An aerosol-forming substrate may be adsorbed, coated, impregnated or otherwise loaded onto a carrier or support. An aerosol-forming substrate may conveniently be part of an aerosol-generating article or smoking article.

[0130] As used herein, the term "thermally conductive particles" may refer to particles having a thermal conductivity greater than 1 W/(MK) in at least one direction at 25 degrees Celsius, for example in all directions at 25 degrees Celsius. The particles may exhibit anisotropic or isotropic thermal conductivity.

[0131] As used herein, the term "expanded graphite" may refer to a graphite-based material, or a material having a graphite-like structure. Expanded graphite may have carbon

layers (similar to graphite, for example) with spacing between the carbon layers greater than the spacing found between carbon layers in regular graphite. Expanded graphite may have carbon layers with elements or compounds intercalated into spaces between the carbon layers.

[0132] As used herein, the term "particle size" may refer to a single dimension and may be used to characterise the size of a given particle. The dimension may be the diameter of a spherical particle occupying the same volume as the given particle. All particle sizes and particle size distributions herein can be obtained using a standard laser diffraction technique. Particle sizes and particle size distributions as stated herein may be obtained using a commercially available sensor, for example a Sympatec HELOS laser diffraction sensor.

[0133] As used herein, where not otherwise specified, the term "density" may be used to refer to true density. Thus, where not otherwise specified, the density of a powder or plurality of particles may refer to the true density of the powder or plurality of particles (rather than the bulk density of the powder or plurality of particles, which can vary greatly depending on how the powder or plurality of particles are handled). The measurement of true density can be done using a number of standard methods, these methods often being based on Archimedes' principle. The most widely used method, when used to measure the true density of a powder, entails the powder being placed inside a container (a pycnometer) of known volume, and weighed. The pycnometer is then filled with a fluid of known density, in which the powder is not soluble. The volume of the powder is determined by the difference between the volume as shown by the pycnometer, and the volume of liquid added (i.e. the volume of air displaced).

[0134] As used herein, the term "aerosol-generating article" may refer to an article able to generate, or release, an aerosol, for example when heated.

[0135] As used herein, the term "longitudinal" may refer to a direction extending between a downstream or proximal end and an upstream or distal end of a component such as an aerosol-forming substrate or aerosol-generating article.

[0136] As used herein, the term "transverse" may refer to a direction perpendicular to the longitudinal direction.

[0137] As used herein, the term "aerosol-generating device" may refer to a device for use with an aerosol-generating article to enable the generation, or release, of an aerosol.

[0138] As used herein, the term "sheet" may refer to a generally planar, laminar element having a width and a length which are substantially greater than, for example at least 2, 3, 5, 10, 20 or 50 times, its thickness.

[0139] As used herein, the term "strip" may refer to a generally planar, laminar element having a width and a length which are substantially greater than its thickness. The width of a strip may be greater than its thickness, for example at least 2, 3, 5 or 10 times its thickness. The length of a strip may be greater than its width, for example at least 2, 3, 5 or 10 times its width.

[0140] As used herein, the term "aerosol former" may refer to any suitable known compound or mixture of compounds that, in use, facilitates formation of an aerosol. The aerosol may be a dense and stable aerosol. The aerosol may be substantially resistant to thermal degradation at the operating temperature of the aerosol-forming substrate or aerosol-generating article.

[0141] As used herein, the term "rod" may refer to a generally cylindrical, for example right cylindrical, element of substantially circular, oval or elliptical cross-section.

[0142] As used herein, the term "crimped" may refer to a sheet or discrete element having one or more ridges or corrugations. The ridges or corrugations may be substantially parallel.

[0143] When present in a component of an aerosol-generating article, the ridges or corrugations may extend in a longitudinal direction with respect to the aerosol-generating article.

[0144] The invention is defined in the claims. However, below there is provided a non-exhaustive list of non-limiting examples. Any one or more of the features of these examples may be combined with any one or more features of another example, embodiment, or aspect described herein.

[0145] Exi. An aerosol-forming substrate comprising:

[0146] a first plurality of discrete elements of a first material and a second plurality of discrete elements of a second material, in which at least the first material is configured to generate an aerosol on heating, and in which the second material has a greater thermal conductivity than the first material.

[0147] Exii. An aerosol-forming substrate comprising:

[0148] a mixture of a first plurality of discrete elements of a first material and a second plurality of discrete elements of a second material, in which both the first plurality of discrete elements and the second plurality of discrete elements are in the form of strips having a length dimension greater than a width dimension and a thickness dimension, in which at least the first material is configured to generate an aerosol on heating, and in which the second material has a greater thermal conductivity than the first material.

[0149] Exiii. An aerosol-forming substrate comprising:

[0150] a first plurality of discrete elements of a first material, each element of the first plurality of discrete elements of the first material comprising aerosol forming material and having a first thermal conductivity, and

[0151] a second plurality of discrete elements of a second material, each element of the second plurality of discrete elements of the second material having a second thermal conductivity that is at least 10% greater than the first thermal conductivity.

[0152] Ex1. An aerosol-forming substrate comprising a first material and a second material, the first material being comprised in the aerosol-forming substrate as a first plurality of discrete elements and the second material being comprised in the aerosol-forming substrate as a second plurality of discrete elements, in which the first material comprises an aerosol-former and has a first thermal conductivity, and in which the second material has a second thermal conductivity that is greater than the first thermal conductivity.

[0153] Ex2. An aerosol-forming substrate according to Ex1 in which the second thermal conductivity is at least 5% greater than the first thermal conductivity, for example at least 7% greater, or at least 10% greater, or at least 12% greater, or at least 15% greater.

[0154] Ex3. An aerosol-forming substrate according to any preceding example in which the thermal conductivity of the second material is at least 10% greater than the thermal conductivity of the first material, for example at least 12% greater, or at least 15% greater, or at least 20% greater.

[0155] Ex4. An aerosol-forming substrate according to any preceding example in which the first plurality of discrete elements, or the second plurality of discrete elements, or both the first and second plurality of discrete elements, are elongated elements, each having a length dimension that is greater than a width dimension and a thickness dimension.

[0156] Ex5. An aerosol-forming substrate according to example Ex4 in which the elongated elements are in the form of strips, shreds, threads, or ribbons.

[0157] Ex6. An aerosol-forming substrate according to any preceding example in which the first plurality of discrete elements, or the second plurality of discrete elements, or both the first and second plurality of discrete elements, are formed by a casting process, for example by a casting process followed by a cutting process.

[0158] Ex7. An aerosol-forming substrate according to any preceding example in which the first plurality of discrete elements, or the second plurality of discrete elements, or both the first and second plurality of discrete elements, are formed by an extrusion process.

[0159] Ex8. An aerosol-forming substrate according to any preceding example in which at least a portion of the first plurality of discrete elements, or at least a portion of the second plurality of discrete elements, or at least a portion of both the first and second plurality of discrete elements, are crimped elements, for example in which each crimped element has one or more kinks or directional changes defined in a length dimension of the crimped element.

[0160] Ex9. An aerosol-forming substrate according to any preceding example in which the first material is comprised in the aerosol-forming substrate in the form of cut filler.

[0161] Ex10. An aerosol-forming substrate according to any preceding example in which the second material is comprised in the aerosol-forming substrate in the form of cut filler.

[0162] Ex11. An aerosol-forming substrate according to any preceding example in which the discrete elements of the first plurality of discrete elements, or the second plurality of discrete elements, or both the first and second plurality of discrete elements have an average thickness of between 5 microns and 2000 microns, for example between 50 microns and 500 microns, for example between 150 microns and 300 microns.

[0163] Ex12. An aerosol-forming substrate according to any preceding example in which the discrete elements of the first plurality of discrete elements, or the second plurality of discrete elements, or both the first and second plurality of discrete elements have an average width of between 100 microns and 2000 microns, for example between 500 microns and 1500 microns, for example between 600 microns and 1000 microns.

[0164] Ex13. An aerosol-forming substrate according to any preceding example in which the discrete elements of the first plurality of discrete elements, or the second plurality of discrete elements, or both the first and second plurality of discrete elements have an average length of between 100 microns and 60 millimetres, for example between 300 microns and 45 millimetres microns, for example between 500 microns and 30 millimetres microns, for example between 800 microns and 20 millimetres microns, for example between 1000 microns and 10 millimetres microns, for example between 1500 microns and 6000 microns.

[0165] Ex14. An aerosol-forming substrate according to any preceding example in which the second material comprises thermally conductive particles.

[0166] Ex15. An aerosol-forming substrate according to any preceding example in which the second material comprises between 1% and 95% thermally conductive particles on a dry weight basis, for example between 2% and 90% thermally conductive particles on a dry weight basis, for example between 3% and 80% thermally conductive particles on a dry weight basis, for example between 4% and 50% thermally conductive particles on a dry weight basis.

[0167] Ex16. An aerosol-forming substrate according to any preceding example in which the second material comprises thermally conductive particles formed from a thermally conductive material selected from the list consisting of carbon, graphite, expanded graphite, graphene, carbon nanoparticles, carbon nanotubes, charcoal, diamond, and metal.

[0168] Ex17. An aerosol-forming substrate according to any preceding example in which the second material is a thermally conductive material selected from the list consisting of carbon, graphite, expanded graphite, graphene, and metal, for example in which each discrete element of the second material is a strip of metal foil or carbon foil, for example copper foil, or aluminium foil, or stainless steel foil, or graphite foil.

[0169] Ex18. An aerosol-forming substrate according to any preceding example in which the first material has a thermal conductivity of less than 0.2 W/mK, for example at 25° C. and the second material has a thermal conductivity of greater than 0.22 W/mK, for example at 25° C., for example between 0.22 W/mK and 1700 W/mK.

[0170] Ex19. An aerosol-forming substrate according to any preceding example in which the first material is configured to generate an aerosol on heating, for example on heating to a temperature of between 120 degrees Centigrade and 395 degrees Centigrade, and the second material is not configured to generate an aerosol on heating, for example on heating to a temperature of between 120 degrees Centigrade and 350 degrees Centigrade.

[0171] Ex20. An aerosol-forming substrate according to any of examples Exi to Ex18 in which both the first material and the second material are configured to generate an aerosol on heating, for example on heating to a temperature of between 120 degrees Centigrade and 395 degrees Centigrade.

[0172] Ex21. An aerosol-forming substrate according to any preceding example in which the first material comprises tobacco, for example in which the first material is formed from homogenised tobacco.

[0173] Ex22. An aerosol-forming substrate according to any preceding example in which the first material comprises tobacco and an aerosol-former, and is configured to generate an aerosol when heated to a temperature of between 120 degrees Centigrade and 395 degrees Centigrade.

[0174] Ex23. An aerosol-forming substrate according to example Ex22 in which the first material is a homogenised tobacco material, and further comprises fibres and a binder.

[0175] Ex24. An aerosol-forming substrate according to any preceding example in which the second material comprises an aerosol-former and conductive particles constituting between 3 wt % and 90 wt % of the second material on a dry weight basis, the second material being configured to

generate an aerosol when heated to a temperature of between 120 degrees Centigrade and 395 degrees Centigrade.

[0176] Ex25. An aerosol-forming substrate according to any preceding example in which the second material comprises tobacco and an aerosol-former and conductive particles constituting between 3 wt % and 90 wt % of the second material on a dry weight basis, the second material being configured to generate an aerosol when heated to a temperature of between 120 degrees Centigrade and 395 degrees Centigrade.

[0177] Ex26. An aerosol-forming substrate according to example Ex25 in which the second material is a thermally conductive homogenised tobacco material, and further comprises fibres and a binder.

[0178] Ex27. An aerosol-forming substrate according to example Ex24 in which the second material does not comprise tobacco, for example in which the second material is a thermally conductive tobacco-free material, and further comprises fibres and a binder.

[0179] Ex28. An aerosol-forming substrate according to any preceding example in which the discrete elements of the first material and the discrete elements of the second material are formed separately and mixed together in a predetermined ratio to form the aerosol-forming material.

[0180] Ex29. An aerosol-forming substrate according to any preceding example in which the ratio of the first material to second material in the aerosol-forming substrate is between 1:10 and 10:1, for example between 1:5 and 8:1, for example between 1:1 and 5:1.

[0181] Ex30. An aerosol-forming substrate according to any preceding example in which the second material comprises, on a dry weight basis: between 20 and 90 wt %, for example between 40 and 80 wt %, of particulate carbon material; between 10 and 40 wt % of an aerosol former; between 4 and 20 wt % of fibres; and between 2 and 10 wt % of a binder, wherein the particulate carbon material consists of one or more of graphite, expanded graphite, graphene, carbon nanotubes, and charcoal.

[0182] Ex31. An aerosol-forming substrate according to any preceding example in which the first material comprises, on a dry weight basis: between 40 and 80 wt % of particulate carbon material; between 10 and 40 wt % of an aerosol former; between 4 and 20 wt % of fibres; and between 2 and 10 wt % of a binder, wherein the particulate carbon material consists of one or more of graphite, expanded graphite, graphene, carbon nanotubes, and charcoal, the first material having a lower thermal conductivity than the second material.

[0183] Ex32. An aerosol-forming substrate according to any preceding example in which the second material and the first material are homogeneously distributed within the aerosol-forming substrate.

[0184] Ex33. A method of forming an aerosol-forming substrate comprising steps of forming a first plurality of discrete elements from a first material; forming a second plurality of discrete elements from a second material, and combining the first plurality of discrete elements with the second plurality of discrete elements to form the aerosol-forming substrate, in which the second material has a greater thermal conductivity than the first material.

[0185] Ex34. A method of forming an aerosol-forming substrate comprising steps of providing a first plurality of discrete elements from a first material; providing a second plurality of discrete elements from a second material, and combining the first plurality of discrete elements with the second plurality of discrete elements to form the aerosol-forming substrate, in which the second material has a greater thermal conductivity than the first material.

[0186] Ex35. A method according to Ex33 or Ex34 in which the first plurality of discrete elements are formed by cutting a sheet of the first material into strips, and in which the second plurality of discrete elements are formed by cutting a sheet of the second material into strips.

[0187] Ex36. A method according to Ex35 in which the first plurality of discrete elements and the second plurality of discrete elements are cut to be substantially the same size.

[0188] Ex37. A method according to any of Ex33 to Ex36 in which the step of forming at least one of the first plurality of discrete elements and the second plurality of discrete elements involves a step of crimping, for example such that the first plurality of discrete elements, the second plurality of discrete elements, or both the first and second plurality of discrete elements are crimped elements.

[0189] Ex38. A method according to any of Ex33 to Ex37, further comprising the steps of forming the first material, forming the second material, or forming both the first and the second material.

[0190] Ex39. A method according to any of Ex33 to Ex38 in which the aerosol-forming substrate is a substrate as described in relation to any of examples Exi to Ex32.

[0191] Ex40. An aerosol-generating article comprising an aerosol-forming substrate as defined in any of examples Exi to Ex32 or manufactured by any method defined in examples Ex33 to Ex38.

[0192] Ex41. An aerosol-generating article according to Ex40 in which the article is in the form of a rod and comprises a plurality of components, including the aerosol-forming substrate, assembled within a wrapper or casing.

[0193] Examples will now be further described with reference to the figures in which:

[0194] FIG. **1** shows a schematic cross-sectional view of a first embodiment of an aerosol-generating article;

[0195] FIG. **2** shows a plurality of discrete elements of a first material;

[0196] FIG. **3** shows a plurality of discrete elements of a second material;

[0197] FIG. **4** shows an aerosol-forming substrate formed by combining the first material of FIG. **2** and the second material of FIG. **3**;

[0198] FIG. **5** shows a schematic cross-sectional view of an embodiment of an aerosol-generating system;

[0199] FIG. **6** shows a schematic cross-sectional view of a further embodiment of an aerosol-generating system; and

[0200] FIG. **7** shows a schematic cross-sectional view of a further embodiment of an aerosol-generating system.

[0201] FIG. **1** shows a schematic cross-sectional view of an exemplary aerosol-generating article **10** according to an embodiment of the invention. The aerosol-generating article **10** extends from an upstream or distal end **18** to a downstream or proximal or mouth end **20** and has an overall length of about 45 millimetres and a diameter of about 7.2 mm.

[0202] The aerosol-generating article **10** comprises a plurality of elements arranged coaxially and assembled within a wrapper **70**. The plurality of elements forming the article are, from distal end to proximal end, a front plug **46**, a rod of thermally enhanced aerosol-forming substrate **12**, a card-

board tube free flow filter **34**, and a mouthpiece filter **42**. The wrapper **70** is a cigarette paper.

[0203] The front plug **46**, also referred to as an upstream element, is located immediately upstream of the rod **12** of thermally enhanced aerosol-forming substrate. The front plug **46** is provided in the form of a cylindrical plug of cellulose acetate. The front plug **46** has a diameter of about 7.2 mm and a length of about 5 millimetres. The RTD of the front plug **46** is about 30 millimetres H_2O.

[0204] The rod of thermally enhanced aerosol-forming substrate **12** has a diameter of about 7.2 millimetres and a length of about 12 millimetres. The rod comprises the thermally-enhanced aerosol forming substrate **12** encircled by a wrapper to facilitate easy handling. The aerosol-forming substrate **12** comprises a plurality of discrete elements of a first material **13** combined with a plurality of elements of a second material **14**. (note that for reasons of clarity individual discrete elements of the second material **14** only are shown in FIG. **1**; the discrete elements of the first material **13** are represented by the shaded portion of the aerosol-forming substrate **12**). The discrete elements **13**, **14** are in the form of strips of crimped cut filler. The first material is configured to form an aerosol when heated to a temperature of between 150 degrees Centigrade and 350 degrees Centigrade. The second material may or may not be configured to generate an aerosol. The second material has a thermal conductivity of at least 10% greater than the conductivity of the first material. The first material may be, for example, homogenised tobacco and the second material may be, for example, graphite foil. Some specific examples of suitable aerosol-forming substrates **12** are provided below.

[0205] The cardboard tube **34** has a length of 16 mm and provides a free space within the article **10** within which volatile components generated by heating of the aerosol-forming substrate can cool and form an aerosol.

[0206] The mouthpiece element **42** is provided in the form of a cylindrical plug of low-density cellulose acetate. The mouthpiece element **42** has a length of about 12 millimetres and an external diameter of about 7.2 mm. The RTD of the mouthpiece element **42** is about 12 millimetres H_2O.

[0207] It should be clear that the configuration of the aerosol-generating article **10** of FIG. **1** is intended to serve as an example only. The thermally enhanced aerosol-forming substrate could, for example, be employed in an aerosol generating article that is longer, for example 80 mm long, and thinner, for example 4.5 mm in diameter.

[0208] The general principle of the thermally-enhanced aerosol-forming substrate is illustrated in relation to FIGS. **2**, **3**, and **4**.

[0209] FIG. **2** illustrates a plurality of discrete elements of a first material **13**. Each of the discrete elements **13** of the first material is in the form of a strip of crimped cut filler. Each strip of cut filler has a length of between 5 mm and 15 mm, a width of between 1 mm and 2 mm, and a thickness of between 150 microns and 250 microns. The first material may be, for example a homogenised tobacco material, and the plurality of discrete elements may be formed by crimping and cutting a sheet of that material.

[0210] FIG. **3** illustrates a plurality of discrete elements of a second material **14**. Each of the discrete elements **14** of the second material is in the form of a strip of crimped cut filler. Each strip of cut filler has a length of between 5 mm and 15 mm, a width of between 1 mm and 2 mm, and a thickness of between 150 microns and 250 microns. The second material may be, for example a homogenised tobacco material with augmented thermal conductivity, and the plurality of discrete elements may be formed by crimping and cutting a sheet of that material.

[0211] The thermally enhanced aerosol-forming substrate **12** is formed by combining a plurality of discrete elements of the first material, as illustrated in FIG. **2**, with a plurality of discrete elements of the second material, as illustrated in FIG. **3**. The resultant thermally enhanced aerosol-forming substrate is illustrated in FIG. **4**. The thermally-enhanced aerosol-forming substrate **12** includes discrete elements of the first material **13** and discrete elements of the second material **14**. Each discrete element of the second material **14** may contact many discrete elements of the first material and can therefore act as a thermal pathway through the substrate. The proportions of first material and second material may be varied depending on the specific properties of the first material and the second material and on the desired properties of the aerosol-forming substrate **12**.

[0212] Some specific thermally-enhanced aerosol forming substrates will now be identified as examples. The examples use combinations of three specific materials identified below; Material A, Material B, and Material C.

Material A

[0213] Material A is a standard homogenised tobacco material. Material A comprises tobacco powder, about 4 wt % cellulose fibres, about 3 wt % of guar as a binder, and about 15 wt % glycerine as an aerosol-former.

[0214] Material A is formed by a process including the following steps:

[0215] pre-mixing the binder, guar gum, with the aerosol-former, glycerine, to form a first pre-mixture;

[0216] pre-mixing the tobacco powder and water to form a second pre-mixture;

[0217] mixing the first and second pre-mixtures to form a slurry;

[0218] homogenising the slurry using a high-shear mixer;

[0219] casting the slurry onto a conveyor belt;

[0220] controlling a thickness of the slurry and drying the slurry to form a large sheet of reconstituted, substantially homogeneous, tobacco-containing, aerosol-forming material; and

[0221] crimping and shredding the large sheet of reconstituted and substantially homogeneous aerosol-forming material to form cut-filler.

[0222] Material A has a thermal conductivity of 0.15 W/mK.

Material B

[0223] Material B is a homogenised tobacco material with augmented thermal conductivity. Material B comprises tobacco powder, about 5 wt % expanded graphite particles, about 4 wt % cellulose fibres, about 3 wt % of guar as a binder, and about 15 wt % glycerine as an aerosol-former.

[0224] The expanded graphite particles have a particle size distribution with a D10 particle size of 6.6 microns, a D50 particle size of 20 microns, and a D90 particle size of 56 microns. Each of the expanded graphite particles has a particle size greater than 2 microns and less than 100 microns. The expanded graphite particles have a volume

mean particle size of around 35 microns. Each of the expanded graphite particles is substantially spherical in shape. The expanded graphite particles have a density of less than 1000 kilograms per metre cubed.

[0225] Material B is formed by a process including the following steps:

[0226] pre-mixing the binder, guar gum, with the aerosol-former, glycerine, to form a first pre-mixture;

[0227] pre-mixing the tobacco powder, expanded graphite particles, and water to form a second pre-mixture;

[0228] mixing the first and second pre-mixtures to form a slurry;

[0229] homogenising the slurry using a high-shear mixer;

[0230] casting the slurry onto a conveyor belt;

[0231] controlling a thickness of the slurry and drying the slurry to form a large sheet of reconstituted, substantially homogeneous, tobacco-containing, aerosol-forming material; and

[0232] crimping and shredding the large sheet of reconstituted and substantially homogeneous aerosol-forming material to form cut-filler.

[0233] Material B has a thermal conductivity of 0.25 W/mK. The replacement of 5 wt % of the tobacco powder with expanded graphite particles reduces the overall tobacco content, and therefore nicotine content, slightly. The thermal conductivity of the material is increased, however. In experiments, adding between 4.5 wt % and 10 wt % of graphite particles to a homogenized tobacco material increased thermal conductivity by between 20% and 50%.

Material C

[0234] Material C is a non-tobacco aerosol-forming material with high thermal conductivity. Material C comprises, on a dry weight basis, around 76.1 wt % graphite particles, specifically FP 99.5 (>99.5% purity) graphite particles from Graphit Kropfmül GmbH, AMG Graphite GK, though other particles or mixtures of particles could be used.

[0235] Material C further comprises around 17.7 wt % of an aerosol former. In this embodiment, the aerosol former is glycerol, specifically ICOF Europe food grade (>99.5% purity) glycerol.

[0236] Material C further comprises, on a dry weight basis, around 3.9 wt % of fibres. In this embodiment, the fibres are cellulose fibres, specifically Birch cellulose fibers from Stora Enso OYJ.

[0237] Material C further comprises, on a dry weight basis, around 2.3 wt % of a binder. In this embodiment, the binder is a guar gum, specifically guar gum from Gumix International Inc.

[0238] Material C may further comprise one or more of nicotine, an acid such as fumaric acid, a botanical such as clove or rosmarinus, water, and a flavourant.

[0239] Material C is formed by the process set out below.

[0240] A slurry is formed using a lab disperser capable of mixing viscous liquids, dispersing powders through liquids, and removing gas from a mixture (for example by applying a vacuum or other suitably low pressure). In this embodiment, a commercially available lab disperser from PC Laborsystem was used.

[0241] To form the slurry, a first mixture is formed by adding to the lap disperser around 7.11 grams of the aerosol former, then around 157.5 grams of water, then around 1.57 grams of the fibres. Then, these first ingredients are mixed at 25 degrees Celsius for 5 minutes at 600-700 rpm to ensure a homogeneous mixture and to hydrate the fibers. Then, a second mixture is formed by manually mixing around 32.95 grams of the thermally conductive particles and around 0.92 grams of the binder. This mixing of the second mixture avoids the formation of lumps in the lab dispersion. Then, the second mixture is added to the first mixture to form a combined mixture. Then, the combined mixture is mixed at 5000 rpm for 4 minutes at 25 degrees Celsius and a first reduced pressure of around 200 mbar. The reduced pressure may help to ensure that the thermally conductive particles are homogeneously dispersed in the mixture and that there is little trapped air and few lumps in the combined mixture. Then, the combined mixture is mixed at 5000 rpm for 20 second minutes at 25 degrees Celsius and a second reduced pressure of around 100 mbar. This second reduced pressure may help to remove any remaining air bubbles. This forms a slurry for casting.

[0242] The slurry is then cast and dried using a suitable apparatus. In this embodiment, a commercially available Labcoater Mathis apparatus is used. This apparatus includes a stainless steel, flat support, and a coma blade for adjusting a thickness of slurry cast onto the flat support.

[0243] The slurry is cast onto the flat support and a gap between the coma blade and the flat support is set at 0.6 millimetres. This ensures that a thickness of the slurry is no more than 0.6 millimetres at any given point.

[0244] The slurry is then dried with hot air between 120 and 140 degrees Celsius for between 2 and 5 minutes. After this drying, a sheet of the aerosol-forming substrate is formed. This sheet has a thickness of around 159 microns, a grammage of around 125.7 grams per metre squared, and a density of around 0.79 kilograms per metre cubed.

[0245] The sheet is then crimped and cut to form Material C. The thermal conductivity of Material C is 6 W/mK.

[0246] It can be seen that a wide range of different aerosol-forming substrates may be produced simply by combining Material A, B, and C in different proportions.

[0247] Thus, a first exemplary aerosol-forming substrate **12** may comprise a mixture of 60 wt % of discrete elements of Material A and 40 wt % of discrete elements of Material B. Both Material A and Material B are homogenized tobacco material, but Material B has augmented thermal conductivity by virtue of the presence of expanded graphite particles. The presence of Material B in the first exemplary aerosol-forming substrate provides discrete elements that have increased thermal conductivity and, as a result, aerosol delivery and nicotine delivery are improved.

[0248] A second exemplary aerosol-forming substrate **12** may comprise a mixture of 70 wt % of discrete elements of Material A and 30 wt % of discrete elements of Material C. The presence of Material C in the second exemplary aerosol-forming substrate reduced the overall amount of tobacco in the substrate, but significantly improved the thermal conductivity. Material C also contribute to the generation of aerosol.

[0249] A third exemplary aerosol-forming substrate **12** may comprise a mixture of 80 wt % of discrete elements of Material B and 20 wt % of discrete elements of Material C. In this example, the first material is Material B, a homogenized tobacco material with augmented thermal conductivity and the second material is Material C.

[0250] Any of these three exemplary aerosol-forming substrates may be used as the substrate in the aerosol-generating article **10** of FIG. **1**.

[0251] Aerosol-generating articles will typically be used as part of an aerosol-generating system including a device for heating the article. FIG. **5** shows a schematic cross-sectional view of an embodiment of such an aerosol-generating system **100**. The system **100** comprises an aerosol-generating device **102** and the aerosol-generating article **10** of FIG. **1**.

[0252] The aerosol-generating device **102** comprises a battery **104**, a controller **106**, a heating blade **108** coupled to the battery, and a puff-detection mechanism (not shown). The controller **106** is coupled to the battery **104**, the heating blade **108** and the puff-detection mechanism.

[0253] The aerosol-generating device **102** further comprises a housing **110** defining a substantially cylindrical cavity for receiving a portion of the article **10**. The heating blade **108** is positioned centrally within the cavity and extends longitudinally from a base of the cavity.

[0254] In this embodiment, the heating blade **108** comprises a substrate and an electrically resistive track located on the substrate. The battery **104** is coupled to the heating blade **108** so as to be able to pass a current through the electrically resistive track and heat the electrically resistive track and heating blade **108** to an operational temperature.

[0255] In use, a user inserts the article **10** into the cavity, causing the heating blade **108** to penetrate the upstream element **46** and rod of aerosol-forming substrate **12** of the article **10**. FIG. **3** shows the article **10** inserted into the cavity of the device **102**.

[0256] To use, the user puffs on the downstream end of the article **10**. This causes air to flow through an air inlet (not shown) of the device **102**, then through the article **10** and into the mouth of the user.

[0257] The user puffing on the article **10** causes air to flow through the air inlet of the device. The puff-detection mechanism detects that the air flow rate through the air inlet has increased to greater than a non-zero threshold flow rate. The puff-detection mechanism sends a signal to the controller **106** accordingly. The controller **106** then controls the battery **104** so as to pass a current through the electrically resistive track and heat up the heating blade **108**. This heats up the rod of aerosol-forming substrate **12**, which is in contact with the heating blade **108**.

[0258] Heating of the aerosol-forming substrate cause the aerosol-forming substrate **12** to release volatile compounds. These compounds are entrained by the air flowing through the article **10**. The compounds cool and condense to form an aerosol, which then passes through the mouthpiece and into the mouth of the user.

[0259] When the user stops inhaling on the article **10**, the air flow rate through the air inlet of the device decreases to less than the non-zero threshold flow rate. This is detected by the puff-detection mechanism. The puff-detection mechanism sends a signal to the controller **106** accordingly. The controller **106** then controls the battery **104** so as to reduce the current being passed through the electrically resistive track to zero.

[0260] After a number of puffs on the article **10**, the user may choose to replace the article **10** with a fresh article.

[0261] FIG. **6** shows a schematic cross-sectional view of a second embodiment of an aerosol-generating system **200**. The system **200** comprises an aerosol-generating device **202** and an aerosol-generating article **10'**. The aerosol-generating article **10'** is substantially the same as the article **10** of FIG. **1**, with the difference that a strip of stainless steel susceptor material **250** is located in a radially central position within the aerosol-forming substrate **12**.

[0262] The aerosol-generating device **202** is similar to the device described in relation to FIG. **5**, except the heater of the device is not a resistance heater, but rather an inductor coil **208**. The inductor coil **208** spirals around the cavity and can be controlled to generate a fluctuating electromagnetic field, which interacts with the susceptor **250** causing the susceptor to heat up. Heat from the susceptor heats the aerosol-forming substrate to generate an aerosol.

[0263] FIG. **7** illustrates a variation to the system of FIG. **6**. In this case the aerosol-generating article **10** is as described in FIG. **1**, with the specific selection of a second material **14** capable of acting as a susceptor material within a fluctuating electromagnetic field. Thus, the second material may be, for example, a graphite foil or a material with high graphite content such as Material C described above. In the system of FIG. **7**, the second material **14** of the aerosol-forming substrate acts as a susceptor to heat the substrate.

[0264] For the purpose of the present description and of the appended claims, except where otherwise indicated, all numbers expressing amounts, quantities, percentages, and so forth, are to be understood as being modified in all instances by the term "about". Also, all ranges include the maximum and minimum points disclosed and include any intermediate ranges therein, which may or may not be specifically enumerated herein. In this context, therefore, a number A is understood as A±10% of A. Within this context, a number A may be considered to include numerical values that are within general standard error for the measurement of the property that the number A modifies. The number A, in some instances as used in the appended claims, may deviate by the percentages enumerated above provided that the amount by which A deviates does not materially affect the basic and novel characteristic(s) of the claimed invention. Also, all ranges include the maximum and minimum points disclosed and include any intermediate ranges therein, which may or may not be specifically enumerated herein.

1. An aerosol-forming substrate comprising a first material and a second material, the first material being comprised in the aerosol-forming substrate as a first plurality of discrete elements and the second material being comprised in the aerosol-forming substrate as a second plurality of discrete elements, in which the first material comprises an aerosol-former and has a first thermal conductivity, and in which the second material has a second thermal conductivity that is greater than the first thermal conductivity, in which the second material comprises thermally conductive particles, the thermally conductive particles being substantially homogeneously distributed throughout the second material.

2. An aerosol-forming substrate according to claim **1** in which the thermal conductivity of the second material is at least 10% greater than the thermal conductivity of the first material, for example at least 12% greater, or at least 15% greater, or at least 20% greater.

3. An aerosol-forming substrate according to claim **1** in which both the first and second plurality of discrete elements are elongated elements, each having a length dimension that is greater than a width dimension and a thickness dimension, and in which the second material comprises an aerosol former.

4. An aerosol-forming substrate according to claim **1** in which the discrete elements of the first plurality of discrete elements, or the second plurality of discrete elements, or both the first and second plurality of discrete elements have an average thickness of between 5 microns and 2000 microns, for example between 50 microns and 500 microns, for example between 150 microns and 300 microns.

5. An aerosol-forming substrate according to claim **1** in which both the first and second plurality of discrete elements are elongated elements, each having a length dimension that is greater than a width dimension and a thickness dimension.

6. An aerosol-forming substrate according to claim **1** in which the discrete elements of the first plurality of discrete elements, or the second plurality of discrete elements, or both the first and second plurality of discrete elements have an average length of between 100 microns and 60 millimetres, for example between 300 microns and 45 millimetres microns, for example between 500 microns and 30 millimetres microns, for example between 800 microns and 20 millimetres microns, for example between 1000 microns and 10 millimetres microns, for example between 1500 microns and 6000 microns.

7. An aerosol-forming substrate according to claim **1** in which the second material comprises between 1% and 95% thermally conductive particles on a dry weight basis, for example between 2% and 90% thermally conductive particles on a dry weight basis, for example between 3% and 80% thermally conductive particles on a dry weight basis, for example between 4% and 50% thermally conductive particles on a dry weight basis.

8. An aerosol-forming substrate according to claim **1** in which:

the second material comprises thermally conductive particles formed from a thermally conductive material selected from the list consisting of carbon, graphite, expanded graphite, graphene, carbon nanoparticles, carbon nanotubes, charcoal, diamond.

9. An aerosol-forming substrate according to claim **1** in which the first material has a thermal conductivity of less than 0.2 W/mK, for example at 25° C., and the second material has a thermal conductivity of greater than 0.22 W/mK, for example at 25° C., for example between 0.22 W/mK and 1700 W/mK.

10. An aerosol-forming substrate according to claim **1** in which the first material comprises tobacco, for example in which the first material is formed from homogenised tobacco.

11. An aerosol-forming substrate according to claim **1** in which the second material comprises an aerosol-former and conductive particles constituting between 3 wt % and 90 wt % of the second material on a dry weight basis, the second material being configured to generate an aerosol when heated to a temperature of between 120 degrees Centigrade and 395 degrees Centigrade.

12. An aerosol-forming substrate according to claim **1** in which the second material comprises tobacco and an aerosol-former and conductive particles constituting between 3 wt % and 90 wt % of the second material on a dry weight basis, the second material being configured to generate an aerosol when heated to a temperature of between 120 degrees Centigrade and 395 degrees Centigrade.

13. An aerosol-forming substrate according to claim **11** in which the second material does not comprise tobacco, for example in which the second material is a thermally conductive tobacco-free material, and further comprises fibres and a binder.

14. An aerosol-forming substrate according to claim **1** in which the second material comprises, on a dry weight basis: between 10 and 90 wt %, for example between 20 and 85 wt % or between 40 and 80 wt %, of particulate carbon material; between 10 and 40 wt % of an aerosol former; between 4 and 20 wt % of fibres; and between 2 and 10 wt % of a binder, wherein the particulate carbon material consists of one or more of graphite, expanded graphite, graphene, carbon nanotubes, and charcoal.

15. An aerosol-generating article comprising an aerosol-forming substrate according to claim **1**, wherein the aerosol-generating article further comprises a mouth plug filter arranged at a most downstream end of the article.

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