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(54) **AEROSOL-FORMING SUBSTRATE WITH IMPROVED THERMAL CONDUCTIVITY**

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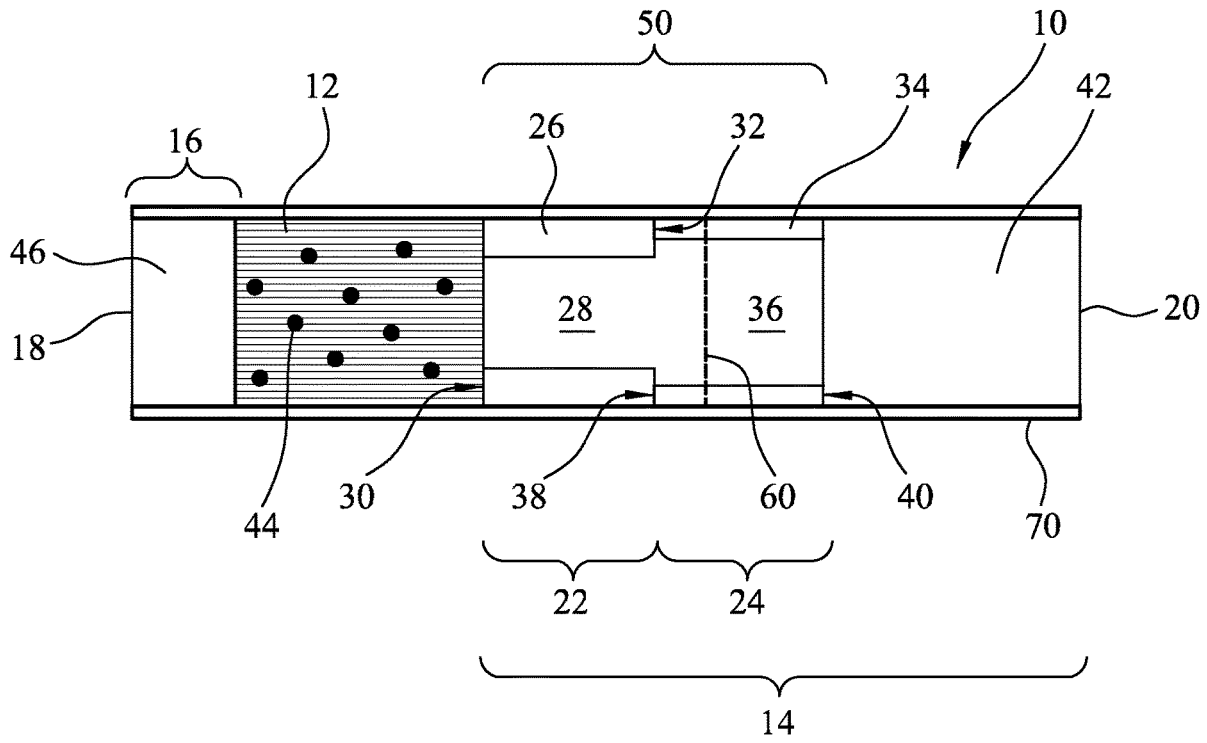
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(57) **ABSTRACT**

An aerosol-forming substrate for a heatable aerosol-generating article is provided, the aerosol-forming substrate including an aerosol-forming material and between 0.1 and 15 weight percent carbon particles, the carbon particles having a volume mean particle size of greater than 10 microns, the carbon particles having a particle size distribution having a D10 particle size and a D90 particle size, and the D90 particle size being less than 20 times the D10 particle size. A method of forming the aerosol-forming substrate, and an aerosol-generating article including the aerosol-forming substrate, are also provided.



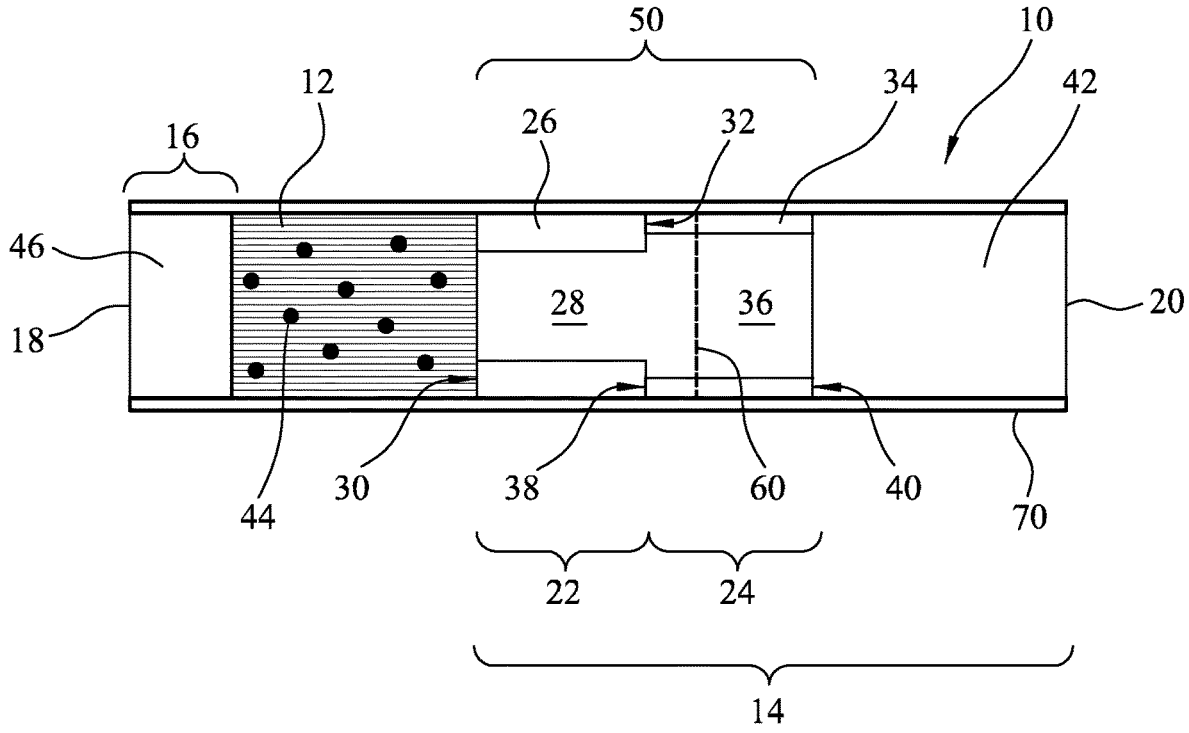


Figure 1

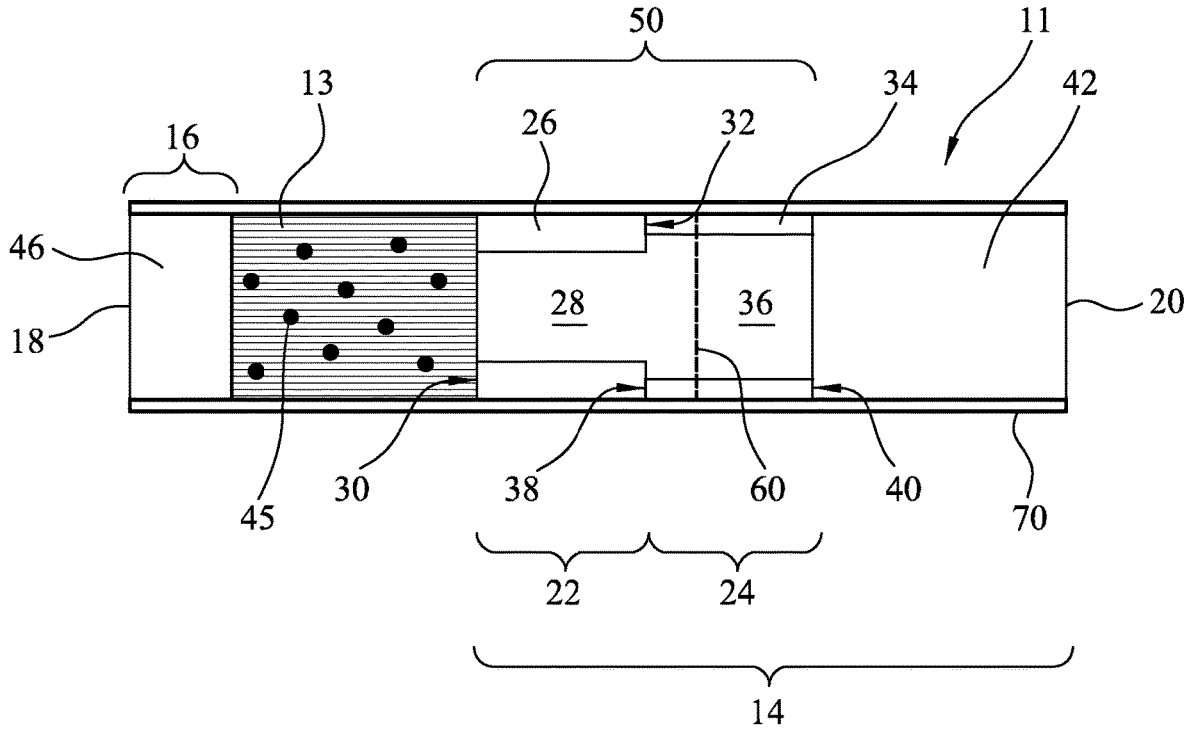


Figure 2

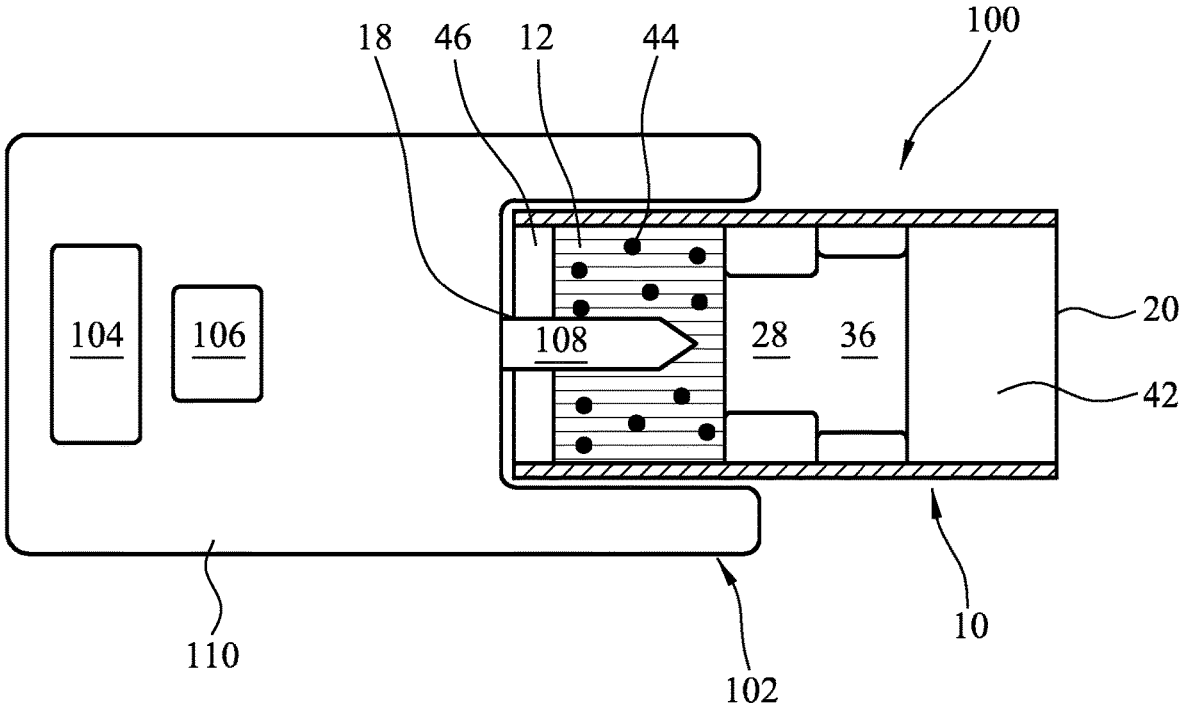


Figure 3

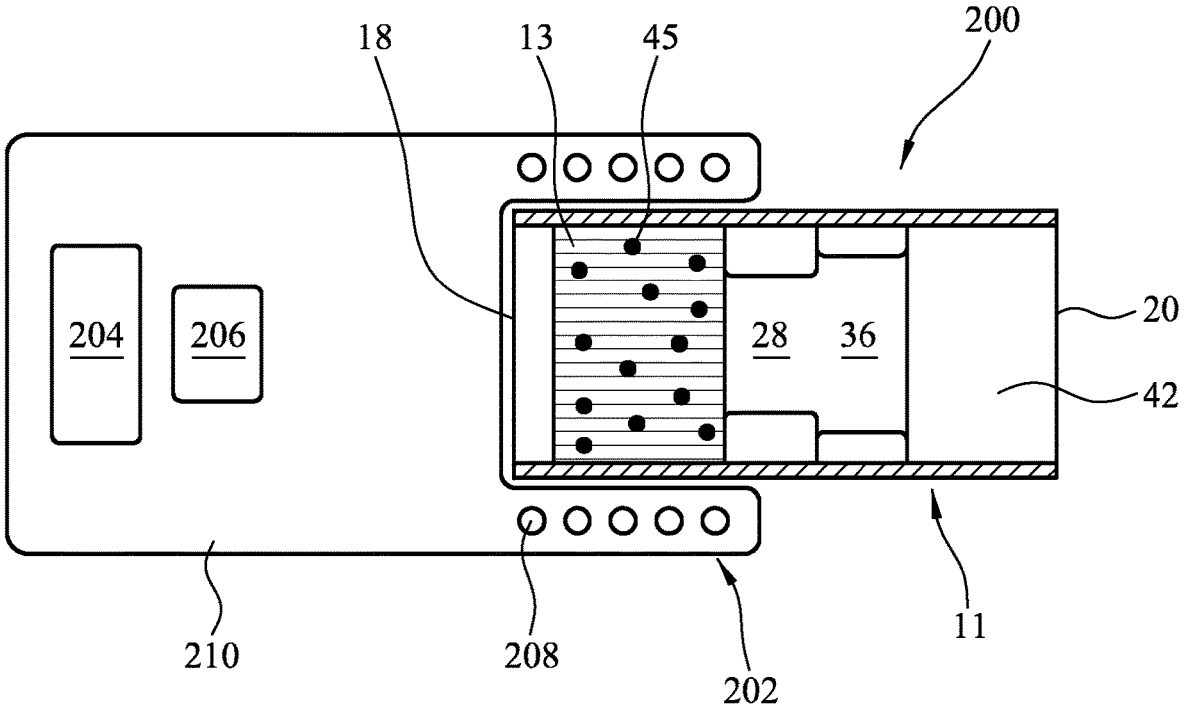


Figure 4

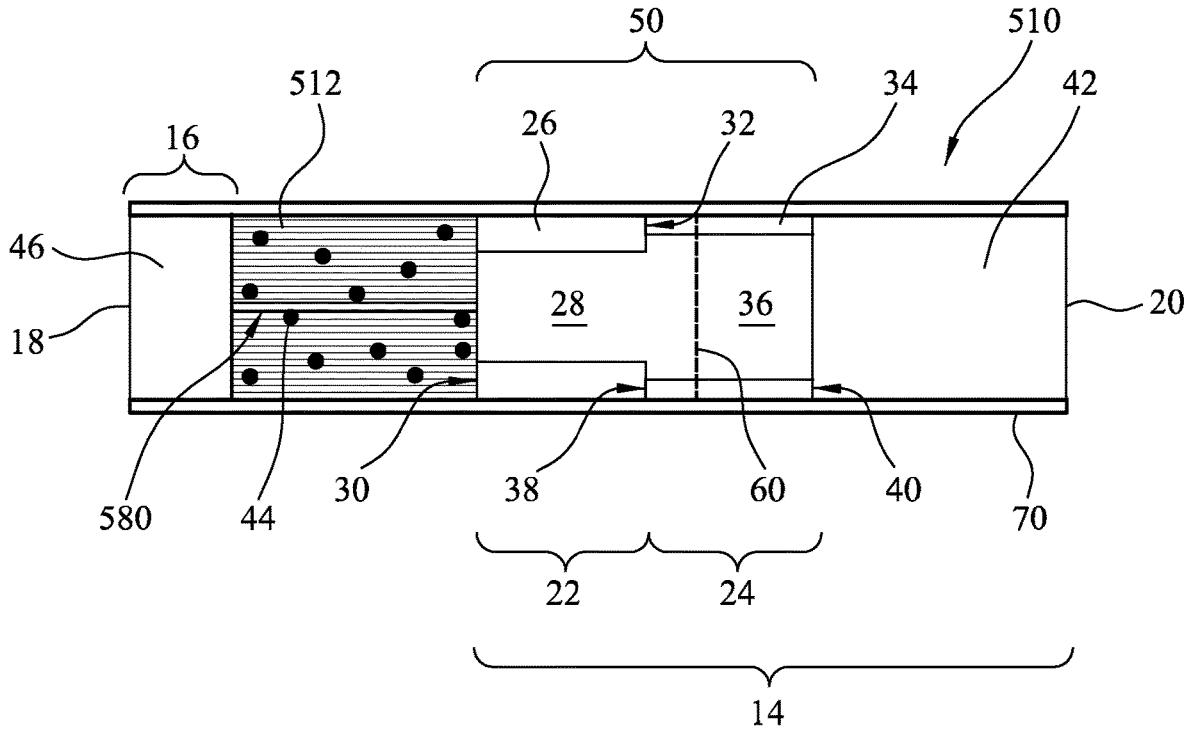


Figure 5

AEROSOL-FORMING SUBSTRATE WITH IMPROVED THERMAL CONDUCTIVITY

[0001] The present disclosure relates to an aerosol-forming substrate, and particularly to an aerosol-forming substrate having improved thermal conductivity. The present disclosure also relates to a method of forming an aerosol-forming substrate, and particularly to a method of making an aerosol-forming substrate having improved thermal conductivity. The present disclosure also relates to an article comprising said substrate, and a system comprising said article.

[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, particularly in aerosol-generating systems in which a blade is inserted into the aerosol-forming substrate and heated in order to heat the aerosol-forming substrate. This is because the low thermal conductivity of the aerosol-forming substrate may lead to a relatively large temperature gradient in the aerosol-forming substrate during use. This may mean that portions of the aerosol-forming substrate which are located furthest from the blade 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. In other words, the low thermal conductivity of the aerosol-forming substrate may undesirably result in a low usage efficiency of the aerosol-forming substrate.

[0004] In addition, known aerosol-forming substrates are typically not heatable to operating temperatures by induction. This means that, for inductive heating, a separate susceptor element is typically required. This can lead to the same issues as discussed above. For example, where an inductively heated susceptor element is placed in a central position in the substrate, portions of the aerosol-forming substrate which are located furthest from the susceptor element may not reach a high temperature and therefore may not many volatile compounds.

[0005] 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.

[0006] It is an aim of the present invention to provide an improved aerosol-forming substrate, for example an aerosol-forming substrate having an increased thermal conductivity.

[0007] According to the present disclosure, there is provided an aerosol-forming substrate. The aerosol-forming substrate may be suitable for use in a heated aerosol-generating article. The aerosol-forming substrate may comprise an aerosol-forming material. The aerosol-forming substrate may comprise particles, for example thermally conductive particles. The aerosol-forming substrate may comprise greater than 0.1 weight percent thermally conductive particles. The thermally conductive particles may be carbon particles.

[0008] Thus, there is provided an aerosol-forming substrate for use in a heated aerosol-generating article, the aerosol-forming substrate comprising an aerosol-forming material and thermally conductive particles.

[0009] There is also provided an aerosol-forming substrate for use in a heated aerosol-generating article, the aerosol-forming substrate comprising an aerosol-forming material and greater than 0.1 weight percent carbon particles, the carbon particles having a volume mean particle size of greater than 10 microns.

[0010] There is also provided an aerosol-forming substrate for use in a heated aerosol-generating article, the aerosol-forming substrate comprising an aerosol-forming material and greater than 0.1 weight percent carbon particles, the carbon particles having a particle size distribution with a D90 particle size and a D10 particles size, wherein the D90 particle size is no more than 25 or 15 times the D10 particle size.

[0011] There is also provided an aerosol-forming substrate for use in a heated aerosol-generating article, the aerosol-forming substrate comprising an aerosol-forming material and greater than 0.1 weight percent carbon particles, the carbon particles having a volume mean particle size of greater than 3 microns and a particle size distribution with a D90 particle size and a D10 particles size, wherein the D90 particle size is no more than 40 times the D10 particle size.

[0012] Advantageously, the thermally conductive particles or carbon particles may increase the thermal conductivity of the aerosol-forming substrate. This may provide a more even temperature distribution throughout the substrate during use. 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. Alternatively, or in addition, the increased thermal conductivity of the substrate may allow a heater, for example a heating blade configured to heat the substrate, to operate at a lower temperature and thus require less power.

[0013] Advantageously, a relatively narrow particle size distribution may provide a more homogeneous substrate in terms of thermal conductivity. This may mean that, in use, temperature gradients in the substrate are minimised.

[0014] Some or each of the thermally conductive particles or carbon particles may have a thermal conductivity greater than 2, 5, 10, 20, 50, 100, 200, 500 or 1000 W/mK.

[0015] Some or each of the thermally conductive particles or carbon particles may exhibit anisotropic thermal conductivities. Some or each of the thermally conductive particles or carbon particles may have a thermal conductivity greater than 2, 5, 10, 20, 50, 100, 200, 500 or 1000 W/mK in at least one direction.

[0016] Advantageously, increasing the thermal conductivity of the thermally conductive particles or carbon particles may increase the thermal conductivity of the aerosol-forming substrate.

[0017] Some or all of the thermally conductive particles may be non-metallic particles. Some or all of the thermally conductive particles may be carbon particles. Some or all of the thermally conductive particles may be graphite particles. Some or all of the thermally conductive particles may be expanded graphite particles. Some or all of the thermally conductive particles may be graphene particles.

[0018] Advantageously, particles such as those listed above, particularly graphite and expanded graphite, may have a high thermal conductivity and a low density, and so are able to substantially improve the thermal conductivity of

the aerosol-forming substrate without significantly increasing the density of the aerosol-forming substrate. It may be advantageous to avoid significantly increasing the density of the aerosol-forming substrate. This is because an increase in density may increase the weight, and therefore the transport costs, for a given volume of the substrate.

[0019] 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/cm^3).

[0020] 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/cm^3).

[0021] 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/cm^3, 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/cm^3).

[0022] The carbon particles may comprise more than 80, 90, 95, 98, 99, 99.5, or 99.9% carbon by weight. The carbon particles may consist of carbon except for trace quantities of impurities.

[0023] The thermally conductive particles may make up less than or equal to 80, 50, 20, 10, or 5 weight percent of the aerosol-forming substrate. The thermally conductive particles may make up more than or equal to 0.1, 0.2, 0.5, 1, 2, 3, 5, 10, 20 or 50 weight percent of the aerosol-forming substrate.

[0024] The carbon particles may make up less than or equal to 80, 50, 20, 10, or 5 weight percent of the aerosol-forming substrate. The carbon particles may make up more than or equal to 0.1, 0.2, 0.5, 1, 2, 3, 5, 10, 20 or 50 weight percent of the aerosol-forming substrate.

[0025] The thermally conductive particles may make up between 0.1 and 20, 0.2 and 20, 0.5 and 20, 1 and 20, 2 and 20, 3 and 20, 5 and 20, 0.1 and 15, 0.2 and 15, 0.5 and 15, 1 and 15, 2 and 15, 3 and 15, 5 and 15, 0.1 and 10, 0.2 and 10, 0.5 and 10, 1 and 10, 2 and 10, 3 and 10, or 5 and 10 weight percent of the aerosol-forming substrate.

[0026] The carbon particles may make up between 0.1 and 20, 0.2 and 20, 0.5 and 20, 1 and 20, 2 and 20, 3 and 20, 5 and 20, 0.1 and 15, 0.2 and 15, 0.5 and 15, 1 and 15, 2 and 15, 3 and 15, 5 and 15, 0.1 and 10, 0.2 and 10, 0.5 and 10, 1 and 10, 2 and 10, 3 and 10, or 5 and 10 weight percent of the aerosol-forming substrate.

[0027] It may be particularly preferable that the thermally conductive particles or carbon particles make up greater than 1 weight percent of the aerosol-forming substrate.

[0028] And it may be particularly preferable that the thermally conductive particles or carbon particles make up less than 20 weight percent of the aerosol-forming substrate.

[0029] Advantageously, the inventors have found that such weight percentages provide an optimal compromise between increasing the thermal conductivity of the aerosol-forming substrate and maintaining enough aerosol-forming material to form an adequate quantity of aerosol.

[0030] It may be particularly preferable that the thermally conductive or carbon particles make up between 1 and 20, 2 and 15, or 3 and 10, weight percent of the aerosol-forming substrate, particularly where the thermally conductive particles are graphite or expanded graphite particles. This is because the inventors have found that, for particular aerosol-forming substrates, these weight percent ranges may provide more consistent glycerol and nicotine deliveries over around 12 puffs. Without wishing to be bound by theory, this is thought to be because having less than 1, 2 or 3 weight percent thermally conductive particles does not have a sufficiently large effect on the thermal conductivity of the substrate, but having greater than 10, 15 or 20 weight percent thermally conductive particles raises local substrate temperatures too high too soon, resulting in relatively high glycerol and nicotine deliveries in early puffs but relatively low glycerol and nicotine deliveries in later puffs.

[0031] In addition, the inventors have surprisingly found that, for particular aerosol-forming substrates, the total yields of glycerol and nicotine over around 12 puffs appear to reach maximums for substrates having between 1 and 20, 2 and 15, or 3 and 10 weight percent thermally conductive particles. This may be advantageous as less substrate may be required to deliver an equal amount of glycerol and nicotine to a user. Data obtained from experiments performed by the inventors suggesting this are shown in Table 1 below.

TABLE 1

Weight percent (wt %) graphite particles in the substrate	Total yield of glycerol over 12 puffs (micrograms)	Total yield of nicotine over 12 puffs (micrograms)
3 wt % graphite particles	3446	1284
5 wt % graphite particles	5827	1709
10 wt % graphite particles	4674	1534

[0032] Some or all of the thermally conductive particles may be metallic particles. Some or all of the thermally conductive particles may be copper particles. Some or all of the thermally conductive particles may be aluminium particles.

[0033] Advantageously, such particles may have a high thermal conductivity and may therefore significantly improve the thermal conductivity of the aerosol-forming substrate.

[0034] The aerosol-forming substrate may be in the form of a rod. As such, there may be provided a rod of aerosol-forming substrate.

[0035] A susceptor element may be located within the rod of aerosol-forming substrate. The susceptor element may be an elongate susceptor element. The susceptor element may extend longitudinally within the rod of aerosol-forming substrate. The rod may be substantially cylindrical, for example right cylindrical, in shape. The susceptor element may be positioned in a radially central position within the rod of aerosol-forming substrate. The susceptor element may extend along a central, longitudinal axis of the rod of aerosol-forming substrate.

[0036] The susceptor element may extend all the way to a downstream end of the rod of aerosol-forming substrate. The susceptor element may extend all the way to an upstream end of the rod of aerosol-forming substrate. The susceptor element may have substantially the same length as the rod of aerosol-forming substrate. The susceptor element may

extend from the upstream end to the downstream end of the rod of aerosol-forming substrate.

[0037] The susceptor element may be in the form of a pin, rod, strip or blade.

[0038] The susceptor element may have a length of between 5 and 15, 6 and 12, or 8 and 10 millimetres. The susceptor element may have a width of between 1 and 5 millimetres. The susceptor element may have a thickness of between 0.01 and 2, 0.5 and 2, or 0.5 and 1 millimetres.

[0039] Alternatively, there may be no susceptor materials present in the aerosol-forming substrate or in the rod of aerosol-forming substrate. Or the thermally conductive particles may comprise or consist of one or more susceptor materials and may be the only susceptor material(s) present in the aerosol-forming substrate or in the rod of aerosol-forming substrate. That is, there may be no susceptor elements present in the aerosol-forming substrate or in the rod of aerosol-forming substrate except for the thermally conductive or carbon particles.

[0040] Some or all of the thermally conductive or carbon particles may be susceptor particles. That is, some or all of the particles may comprise or consist of a susceptor material. As such, the thermally conductive or carbon particles may be configured to be inductively heated.

[0041] Suitable susceptor materials, for example materials for one or both of the susceptor element and the susceptor particles, include, but are not limited to: carbon, carbon-based materials, graphene, graphite, expanded graphite, molybdenum, silicon carbide, stainless steels, niobium, aluminium, nickel, nickel-containing compounds, titanium, and composites of metallic materials. Suitable susceptor materials may comprise a ferromagnetic material, for example, ferritic iron, a ferromagnetic alloy, such as ferromagnetic steel or stainless steel, ferromagnetic particles, and ferrite. A suitable susceptor material may be, or comprise, aluminium. A susceptor material preferably comprises more than 5 percent, preferably more than 20 percent, more preferably more than 50 percent or more than 90 percent of ferromagnetic or paramagnetic materials. Preferred susceptor materials may comprise a metal, metal alloy or carbon.

[0042] Particularly preferred susceptor materials may be, or comprise, carbon, carbon-based materials, graphene, graphite, or expanded graphite. Advantageously, such materials have relatively high thermal conductivities, relatively low densities, and may be inductively heated.

[0043] As explained in more detail later with reference to an aerosol-generating system, in use, susceptor materials may convert electromagnetic energy into heat. This may heat the aerosol-forming material of the aerosol-forming substrate.

[0044] The thermally conductive or carbon particles may have a particle size distribution having a D10 particle size, a D50 particle size, and a D90 particle size. In such a particle size distribution, 10% of the particles have a particle size which is less than or equal to the D10 particle size and 90% of the particles have a particle size which is less than or equal to the D90 particle size. The D50 particle size is the median particle size so 50% of the particles have a particle size which is less than or equal to the D50 particle size.

[0045] The features discussed below with relation to the particle sizes (for example, D10, D50, volume mean, and D90 particle sizes) of carbon particles may be equally applicable to the particle sizes of thermally conductive particles.

[0046] The D90 particle size may be less than or equal to 50, 40, 30, 25, 20, 15, 10, 8, 5, or 3 times the D10 particle size. The D90 particle size may be greater than or equal to 2, 3, 5 or 8 times the D10 particle size.

[0047] The D90 particle size may be between 3 and 50, 3 and 40, 3 and 30, 3 and 25, 3 and 20, 3 and 15, 3 and 10, 3 and 8, 3 and 5, 5 and 50, 5 and 40, 5 and 30, 5 and 25, 5 and 20, 5 and 15, 5 and 10, 5 and 8, 8 and 50, 8 and 40, 8 and 30, 8 and 25, 8 and 20, 8 and 15, 8 and 10, 10 and 50, 10 and 40, 10 and 30, 10 and 25, 10 and 20, 10 and 15, 15 and 50, 15 and 40, 15 and 30, 15 and 25, 15 and 20 times the D10 particle size.

[0048] Preferred particle size distributions may have a D90 particle size between 3 and 25, or 3 and 15, times the D10 particle size. Particularly preferred particle size distributions may have a D90 particle size between 5 and 20, or 5 and 10, times the D10 particle size.

[0049] A compromise must be made in relation to the particle size distribution. A tighter particle size distribution may advantageously provide a more uniform thermal conductivity throughout the aerosol-forming substrate. This is because there will be less variation in particle size in different locations in the substrate. This may advantageously allow for more efficient usage of the aerosol-forming material throughout the aerosol-forming substrate. 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.

[0050] Desired D10 and D90 particle sizes may be obtained by sieving. Sieving may therefore be used to obtain a narrow particle size distribution where desired.

[0051] The D10 particle size of the carbon particles may be greater than or equal to 1, 2, 3, 5, 10, 20, 30, 35, 50, 75, 100, 150, 200, 250, 500, or 900 microns. Each of the carbon particles may have a particle size of greater than or equal to 1, 2, 3, 5, 10, 20, 30, 35, 50, 75, 100, 150, 200, 250, 500, or 900 microns.

[0052] The D10 particle size of the carbon particles may be less than or equal to 1000, 900, 500, 200, 100, 150, 100, 75, 50, 35, 30, 20, 10, 5, 3 or 2 microns. Each of the carbon particles may have a particle size of less than or equal to 1000, 900, 500, 200, 100, 150, 100, 75, 50, 35, 30, 20, 10, 5, 3 or 2 microns.

[0053] The D90 particle size of the carbon particles may be less than or equal to 1000, 900, 500, 200, 100, 150, 100, 75, 50, 35, 30, 20, 10, 5, 3 or 2 microns. Each of the carbon particles may have a particle size of less than or equal to 1000, 900, 500, 200, 100, 150, 100, 75, 50, 35, 30, 20, 10, 5, 3 or 2 microns.

[0054] The D90 particle size of the carbon particles may be greater than or equal to 1, 2, 3, 5, 10, 20, 30, 35, 50, 75, 100, 150, 200, 250, 500, or 900 microns. Each of the carbon particles may have a particle size of greater than or equal to 1, 2, 3, 5, 10, 20, 30, 35, 50, 75, 100, 150, 200, 250, 500, or 900 microns.

[0055] One or both of a D50 particle size and a volume mean particle size of the carbon particles may be greater than or equal to 1, 2, 3, 5, 10, 20, 30, 35, 50, 75, 100, 150, 200, 250, 500, or 900 microns.

[0056] One or both of a D50 particle size and a volume mean particle size of the carbon particles may be less than

or equal to 1000, 900, 500, 200, 100, 150, 100, 75, 50, 35, 30, 20, 10, 5, 3 or 2 microns.

[0057] One or both of a D50 particle size and a volume mean particle size of the carbon particles may be between 1 and 1000, preferably between 35 and 1000, or more preferably between 100 and 900 microns. Alternatively, or in addition, each of the carbon particles may have a particle size of between 1 and 1000, preferably between 35 and 1000, or more preferably between 100 and 900 microns.

[0058] Surprisingly, the inventors have found these relatively large particle size ranges to be particularly effective at increasing the thermal conductivity of an aerosol-forming substrate where the aerosol-forming material comprises, or is in the form of, one or more of: cut-filler, powder particles, granules, pellets, shreds, spaghettis, strips or sheets. In addition, these relatively large particle sizes may advantageously adhere better than smaller particle sizes to aerosol-forming substrate in the form of one or more of: cut-filler, powder particles, granules, pellets, shreds, spaghettis, strips or sheets. It may also be easier to mix particles in this size range with the similarly sized tobacco particles used in some cut-filler. So these particle size ranges may be particularly preferable where the aerosol-forming material comprises, or is in the form of, one or more of: cut-filler, powder particles, granules, pellets, shreds, spaghettis, strips or sheets.

[0059] One or both of a D50 particle size and a volume mean particle size of the carbon particles may be between 1 and 1000, preferably between 10 and 200, more preferably between 30 and 150, or even more preferably between 50 and 75 microns. Alternatively, or in addition, each of the carbon particles may have a particle size of between 1 and 1000, preferably between 10 and 200, more preferably between 30 and 150, or even more preferably between 50 and 75 microns.

[0060] Surprisingly, the inventors have found these relatively small particle size ranges to be particularly effective at increasing the thermal conductivity of an aerosol-forming substrate where the aerosol-forming material comprises, or is in the form of, a sheet, such as a gathered sheet. In addition, these relatively small particle sizes may advantageously result in a more homogeneous sheet of aerosol-forming material in terms of thermal conductivity, and in a sheet having a more even thickness than if larger particle sizes were used. It may also be easier to mix particles in this size range with the similarly sized tobacco particles used in some manufacturing processes for forming an aerosol-forming sheet. So these particle size ranges may be particularly preferable where the aerosol-forming material comprises, or is in the form of, a sheet, such as a gathered sheet.

[0061] The carbon particles may have a volume mean particle size of greater than or equal to 1, 2, 3, 5, 10, 20, 30, 35, 50, 75, 100, 150, 200, 250, 500, or 900 microns.

[0062] It may be particularly preferable that the volume mean particle size of the carbon particles is greater than 10 microns.

[0063] The carbon particles may have a volume mean particle size of less than or equal to 1000, 900, 500, 200, 100, 150, 100, 75, 50, 35, 30, 20, 10, 5, 3 or 2 microns.

[0064] The carbon particles may have a volume mean particle size of between 1 and 1000, 35 and 1000, or 100 and 900 microns. These particle size ranges may be particularly preferable where the aerosol-forming material comprises, or is in the form of, one or more of: cut-filler, powder particles, granules, pellets, shreds, spaghettis, strips or sheets.

[0065] The carbon particles may have a volume mean particle size of between 1 and 1000, 10 and 200, 30 and 150, or 50 and 75 microns. These volume mean particle size ranges may be particularly preferable where the aerosol-forming material comprises, or is in the form of, a sheet, such as a gathered sheet.

[0066] The carbon particles may have a volume mean particle size at least 2, 3, 5, 8, 10, 15, or 20 times the number mean particle size.

[0067] It may be particularly preferable that the thermally conductive particles are, or comprise, graphite particles.

[0068] The graphite particles may have a particle size distribution with a D10 particle size of between 5 and 20, for example 10 and 14, microns, for example around 12 microns. The graphite particles may have a particle size distribution with a D50 particle size of between 25 and 45 microns, for example around 35 microns. The graphite particles may have a particle size distribution with a D90 particle size of between 45 and 75 microns, for example around 55 microns. Advantageously, such particles are commercially available and have been found by the inventors to provide a significant increase in the thermal conductivity of aerosol-forming substrates.

[0069] It may be particularly preferable that the thermally conductive particles are, or comprise, expanded graphite particles.

[0070] The expanded graphite particles may have a particle size distribution with a D10 particle size of between 5 and 20, for example 9 and 12, microns, for example around 10.5 microns. The expanded graphite particles may have a particle size distribution with a D50 particle size of between 15 and 25 microns, for example around 20 microns. The expanded graphite particles may have a particle size distribution with a D90 particle size of between 46 and 66 microns, for example around 56 microns. Advantageously, such particles are commercially available and have been found by the inventors to provide a significant increase in the thermal conductivity of aerosol-forming substrates. The expanded graphite particles may also advantageously reduce the overall density of the aerosol-forming substrate.

[0071] Each of the thermally conductive or carbon particles may have three mutually perpendicular dimensions. A largest dimension of these three dimensions may be no more than 10, 8, 5, 3, or 2 times larger than a smallest dimension of these three dimensions. A largest dimension of these three dimensions being no more than 10, 8, 5, 3, or 2 times larger than a second largest dimension of these three dimensions. Each of these three dimensions may be substantially equal. Each of the thermally conductive or carbon particles may be substantially spherical.

[0072] The thermally conductive or carbon particles may comprise at least 10, 20, 50, 100, 200, 500, or 1000 particles.

[0073] The thermally conductive or carbon particles may be substantially uniformly distributed throughout the aerosol-forming material. The aerosol-forming material may be considered a matrix. Thus, the thermally conductive or carbon particles may be substantially uniformly distributed throughout a matrix of the aerosol-forming material.

[0074] Advantageously, the thermally conductive or carbon particles being substantially uniformly distributed throughout the aerosol-forming material may result in a more even temperature distribution throughout the substrate in use.

[0075] Some or all of the thermally conductive or carbon particles may be enclosed by aerosol-forming material. Advantageously, this may reduce an amount of heat being wasted. That is, this may reduce an amount of heat being transferred from the particles to anything other than the aerosol-forming material.

[0076] Some or all of the thermally conductive or carbon particles may be coated onto the aerosol-forming material, for example coated onto an outer surface of the aerosol-forming material.

[0077] The thermally conductive or carbon particles may have a density lower than or equal to a density of the aerosol-forming material. The thermally conductive or carbon particles may have a density which is at least 1, 2, 5, 10, 15, 20, 25, or 30% less than a density of the aerosol-forming material. The aerosol-forming substrate may have a density of less than 1050, 1000, 950, 900, 850, 800, 850, 800, 750, 700, or 650 kg/m^3. It may be particularly preferable for the aerosol-forming substrate to have a density of between 500 and 900 kg/m^3, for example between 600 and 800 kg/m^3.

[0078] Advantageously, the use of lower density particles may result in a lower density substrate. This may reduce the weight, and therefore the transport costs, for a given volume of the substrate.

[0079] The aerosol-forming substrate may have a thermal conductivity of greater than 0.06, 0.08, 0.1, 0.12, 0.125, 0.13, 0.135, 0.14, 0.145, 0.15, 0.155, 0.16, 0.165, or 0.17 W/mK. The aerosol-forming substrate may have a thermal conductivity of greater than 0.06, 0.08, 0.1, 0.12, 0.125, 0.13, 0.135, 0.14, 0.145, 0.15, 0.155, 0.16, 0.165, or 0.17 W/mK in at least one direction, for example in all directions.

[0080] The aerosol-forming substrate may have a longitudinal direction and a transverse, or radial, direction perpendicular to the longitudinal direction. For example, the aerosol-forming substrate may be in the form of a plug. The plug may be right cylindrical in shape. The plug may have a length extending in the longitudinal direction and a radius extending in the transverse, or radial, direction. The longitudinal direction may refer to a direction extending from an upstream end to a downstream end of the substrate, or to a direction extending from an upstream end to a downstream end of an article of which the substrate is part. The aerosol-forming substrate may have a thermal conductivity of greater than 0.06, 0.08, 0.1, 0.12, 0.125, 0.13, 0.135, 0.14, 0.145, 0.15, 0.155, 0.16, 0.165, or 0.17 W/mK in the transverse, or radial, direction.

[0081] Advantageously, increasing the thermal conductivity of the substrate may reduce temperature gradients in the substrate in use. It may be particularly advantageous to increase the thermal conductivity of the substrate in the transverse direction because, when used with a heating blade, large temperature gradients typically exist in the transverse direction in prior art substrates.

[0082] The aerosol-forming material may comprise one or more organic materials such as tobacco. The aerosol-forming material may comprise one or more of herb leaf, tobacco leaf, fragments of tobacco ribs, reconstituted tobacco, homogenised tobacco, extruded tobacco and expanded tobacco.

[0083] The aerosol-forming material may comprise tobacco particles. The tobacco particles may have a particle size distribution having a D10 tobacco particle size, a D50 tobacco particle size and a D90 tobacco particle size.

[0084] The D10 tobacco particle size may be between 1 and 20, or 1 and 10 microns. The D10 tobacco particle size may be around 3 microns.

[0085] The D90 tobacco particle size may be between 40 and 200 or 40 and 100 microns. The D90 tobacco particle size may be around 70 microns.

[0086] A D10 particle size of the thermally conductive or carbon particles may be between 0.1 and 10, 0.2 and 5, 0.25 and 4, 0.5 and 2, or 0.8 and 1.25 times the D10 tobacco particle size. A D50 particle size of the thermally conductive or carbon particles may be between 0.1 and 10, 0.2 and 5, 0.25 and 4, 0.5 and 2, or 0.8 and 1.25 times the D50 tobacco particle size. A D90 particle size of the thermally conductive or carbon particles may be between 0.1 and 10, 0.2 and 5, 0.25 and 4, 0.5 and 2, or 0.8 and 1.25 times the D90 tobacco particle size. These ranges may advantageously allow better mixing of the thermally conductive particles and the tobacco particles. This may advantageously result in a more homogeneous aerosol-forming substrate.

[0087] The aerosol-forming material may comprise one or more aerosol-formers. Suitable aerosol-formers are well known in the art and include, but are not limited to, one or more aerosol-formers selected from: 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 triacetate; and aliphatic esters of mono-, di- or polycarboxylic acids, such as dimethyl dodecanedioate and dimethyl tetradecanedioate. It may be particularly preferable for the aerosol-former to be or comprise glycerine.

[0088] The aerosol-forming substrate may comprise at least 1, 2, 5, 10, or 15 weight percent aerosol-former. For example, the aerosol-forming substrate may comprise between 12 and 25 weight percent aerosol-former.

[0089] The aerosol-former may be glycerine. The aerosol-forming substrate may comprise at least 1, 2, 5, 10, or 15 weight percent glycerine. For example, the aerosol-forming substrate may comprise between 12 and 25 weight percent glycerine.

[0090] The aerosol-forming material may comprise nicotine.

[0091] The aerosol-forming material may comprise one or more cannabinoid compounds such as one or more of: tetrahydrocannabinol (THC), tetrahydrocannabinolic acid (THCA), cannabidiol (CBD), cannabidiolic acid (CBDA), cannabinol (CBN), cannabigerol (CBG), cannabigerol monomethyl ether (CBGM), cannabivarin (CBV), cannabidivarin (CBDV), tetrahydrocannabivarin (THCV), cannabichromene (CBC), cannabicyclol (CBL), cannabichromevarin (CBCV), cannabigerovarin (CBGV), cannabielsoin (CBE), cannabicitran (CBT). It may be preferable that the cannabinoid compound is CBD or THC. It may be particularly preferable that the cannabinoid compound is CBD.

[0092] The aerosol-forming material may comprise one or more flavourants. The one or more flavourants may comprise one or more of: one or more essential oils such as eugenol, peppermint oil and spearmint oil; one or both of menthol and eugenol; one or both of anethole and linalool; and a herbaceous material. Suitable herbaceous material includes herb leaf or other herbaceous material from herbaceous plants including, but not limited to, mints, such as peppermint and spearmint, lemon balm, basil, cinnamon,

lemon basil, chive, coriander, lavender, sage, tea, thyme and caraway. The one or more flavourants may comprise a tobacco material.

[0093] The aerosol-forming material may comprise, or may be in the form of, one or more of: powder particles, granules, pellets, shreds, spaghettis, strips or sheets.

[0094] The aerosol-forming material may comprise, or may be in the form of, cut-filler. The cut width of the cut-filler may be between 0.3 and 2, 0.5 and 1.2, or 0.6 and 0.9 millimetres.

[0095] The cut width may affect the distribution of heat in the aerosol-forming substrate, the resistance to draw of the aerosol-forming substrate, and the overall density of the aerosol-forming substrate. The inventors have found that the above cut width ranges may be desirable in terms of heat distribution, resistance to draw, and density.

[0096] The aerosol-forming material may comprise, or may be in the form of, one or more sheets, for example one or more gathered sheets. The or each sheet, for example gathered sheet, may have a width of at least about 10, 25, 50, or 100 millimetres. The or each sheet, for example gathered sheet, may have a length of at least about 3, 5 or 10 millimetres. The or each sheet, for example gathered sheet, may have a thickness of at least about 100, 150 or 200 microns. The or each sheet, for example gathered sheet, may have a thickness of less than about 500, 400 or 300 microns. The or each sheet, for example gathered sheet, may have a thickness between 100 and 500, 170 and 400, or 200 and 300 microns. The or each sheet, for example gathered sheet, may have a thickness of around 235 microns.

[0097] The aerosol-forming material may comprise, or may be in the form of, a plurality of strips. Each of the plurality of strips may extend in a substantially longitudinal direction of the aerosol-forming substrate or aerosol-generating article. Each of the plurality of strips may have a length of at least about 3, 5 or 10 millimetres. Each of the plurality of strips may have a width of less than about 3, 2 or 1 millimetres.

[0098] A number of particularly preferred aerosol-forming substrates are set out below.

[0099] A first particularly preferred aerosol-forming substrate is for use in a heated aerosol-generating article and comprises an aerosol-forming material and thermally conductive particles. The thermally conductive particles are carbon particles, for example graphite, expanded graphite, or graphene particles. The substrate comprises greater than 0.1 weight percent carbon particles. The carbon particles have a volume mean particle size of greater than 10 microns.

[0100] A second particularly preferred aerosol-forming substrate is for use in a heated aerosol-generating article and comprises an aerosol-forming material and thermally conductive particles. The thermally conductive particles are carbon particles, for example graphite, expanded graphite, or graphene particles. The substrate comprises greater than 0.1 weight percent carbon particles. The carbon particles have a volume mean particle size of between 1 and 1000 microns. The aerosol-forming material comprises, or is in the form of, one or more of: cut-filler, powder particles, granules, pellets, shreds, spaghettis, strips or sheets. Thus, as explained in more detail above, it may be preferable for the particles of this substrate to have a volume mean particle size of between 35 and 1000, or 100 and 900 microns.

[0101] A third particularly preferred aerosol-forming substrate is for use in a heated aerosol-generating article and comprises an aerosol-forming material and thermally conductive particles. The thermally conductive particles are carbon particles, for example graphite, expanded graphite, or graphene particles. The substrate comprises greater than 0.1 weight percent carbon particles. The carbon particles have a volume mean particle size of between 1 and 1000 microns. The aerosol-forming material comprises, or is in the form of, a sheet, such as a gathered sheet. Thus, as explained in more detail above, it may be preferable for the particles of this substrate to have a volume mean particle size of between 10 and 200, 30 and 150, or 50 and 75 microns.

[0102] As would be apparent to a person skilled in the art after reading this disclosure, features described above in relation to the aerosol-forming substrate according may be equally applicable to these first, second and third preferred aerosol-forming substrates.

[0103] According to the present disclosure, there is provided an aerosol-generating article comprising an aerosol-forming substrate. Any features described above in relation to an aerosol-forming substrate may be applicable to the aerosol-forming substrate of the aerosol-generating article. The aerosol-forming substrate may be any of the first, second or third preferred aerosol-forming substrates described above.

[0104] The aerosol-generating article may be for use with an electrical aerosol-generating device.

[0105] The aerosol-generating article may comprise a plurality of elements. The plurality of elements may be assembled in the form of a rod.

[0106] The plurality of elements may include an upstream element. The plurality of elements may include the aerosol-forming substrate. The plurality of elements may include a support element. The plurality of elements may include an aerosol-cooling element. The plurality of elements may include a mouthpiece element.

[0107] The aerosol-generating article may comprise an intermediate hollow section. The intermediate hollow section may be located between the rod of aerosol-generating substrate and the mouthpiece element. The intermediate hollow section may comprise one or both of the support element and the aerosol-cooling element. The intermediate hollow section may consist of one or both of the support element and the aerosol-cooling element.

[0108] The upstream element may be located at an upstream end of the article. The aerosol-forming substrate may be located downstream, for example immediately downstream, of the upstream element. Alternatively, the aerosol-forming substrate may be located at an upstream end of the article, for example where no upstream element is present. The support element may be located downstream, for example immediately downstream, of the aerosol-forming substrate. The aerosol-cooling element may be located downstream, for example immediately downstream, of the support element. The mouthpiece element may be located downstream, for example immediately downstream, of the aerosol-cooling element. The mouthpiece element may be located at a downstream end, or mouth end, of the article.

[0109] The upstream element may advantageously prevent direct physical contact with an upstream end of the aerosol-forming substrate. The upstream element may also advantageously reduce the likelihood of material from the aerosol-forming substrate falling out of the article. The support element may advantageously provide support to the article

and help to properly locate other components of the article. The aerosol-cooling element may advantageously allow an aerosol to cool so it is a more desirable temperature when it reaches a user. The mouthpiece element may advantageously act as a filter.

[0110] The elements of the aerosol-generating article may be assembled by means of a suitable wrapper, for example a cigarette paper. A cigarette paper may be any suitable material for wrapping components of an aerosol-generating article in the form of a rod. Suitable materials for the wrapper are well-known in the art. The cigarette paper may grip the component elements of the aerosol-generating article when the article is assembled. The cigarette paper may hold component elements in position within the rod.

[0111] The upstream element may be in the form of a plug, for example a porous plug. The upstream element may comprise one or more longitudinally extending cavities. The upstream element may comprise a slit or aperture. The slit or aperture may extend from the upstream end to the downstream end of the upstream element. The slit of aperture may be suitable for allowing a heating pin, rod or blade to pass therethrough in use. The upstream element may be made of a porous material. The upstream element may be made of the same material as used for one of the other components of the aerosol-generating article, such as the mouthpiece element, the aerosol-cooling element, or the support element. The upstream element may comprise, or be formed from, one or more of a filter material, ceramic, polymer material, cellulose acetate, cardboard, zeolite or aerosol-generating substrate. It may be preferable that the upstream element comprises, or is formed from, cellulose acetate, for example a plug of cellulose acetate.

[0112] The upstream element may have an external diameter that is approximately equal to the external diameter of the aerosol-generating article. The upstream element may have an external diameter of between 5 and 12, 5 and 10, or 5 and 8, 6 and 12, 6 and 10, or 6 and 8 millimetres. The upstream element may have an external diameter of approximately 7.2 millimetres.

[0113] The upstream element may have a length of between 1 and 10, 3 and 8, or 4 and 6 millimetres. The upstream element may have a length of about 5 millimetres.

[0114] Advantageously, the upstream element may prevent a consumer from seeing the thermally conductive or carbon particles through an upstream end of the article.

[0115] The support element may comprise, or be, a hollow tube, for example a substantially cylindrical hollow tube. The hollow tube may define an internal cavity. The internal cavity may extend in the longitudinal direction. Airflow through the internal cavity may be substantially unrestricted. Thus, the hollow tube may not substantially contribute to a resistance to draw (RTD) of the article. A thickness of the wall of the hollow tube may be between 2 and 4 millimetres.

[0116] The support element may be formed from any suitable material or combination of materials. For example, the support element may be formed from one or more materials selected from the group consisting of: cellulose acetate; cardboard; crimped paper, such as crimped heat resistant paper or crimped parchment paper; and polymeric materials, such as low density polyethylene (LDPE). In a preferred embodiment, the support element is formed from cellulose acetate. Other suitable materials include polyhydroxyalkanoate (PHA) fibres. It may be particularly preferred that the support element comprises or is formed from cellulose acetate.

[0117] The support element may have an external diameter that is approximately equal to the external diameter of the aerosol-generating article. The support element may have an external diameter of between 5 and 12, 5 and 10, or 5 and 8, 6 and 12, 6 and 10, or 6 and 8 millimetres. The support element may have an external diameter of approximately 7.2 millimetres.

[0118] A peripheral wall of the support element may have a thickness of at least 1, 1.5 or 2 millimetres, for example where the support element comprises or is a second hollow tube.

[0119] The support element may have a length of at least 5, 6, 7 or 8 millimetres. Alternatively or in addition, the support element may have a length of less than 15, 12 or 10 millimetres.

[0120] The aerosol-cooling element may comprise, or be, a second hollow tube, for example a substantially cylindrical second hollow tube. The second hollow tube may define a second internal cavity. The second internal cavity may extend in the longitudinal direction. Airflow through the second internal cavity may be substantially unrestricted. Thus, the second hollow tube may not substantially contribute to a resistance to draw (RTD) of the article. A thickness of the wall of the second hollow tube may be between 1 and 3 millimetres.

[0121] The aerosol-cooling element may comprise, or be formed from, any suitable material or combination of materials. For example, the aerosol-cooling element may comprise or be formed from one or more materials selected from the list consisting of: cellulose acetate; cardboard; crimped paper, such as crimped heat resistant paper or crimped parchment paper; and polymeric materials, such as low density polyethylene (LDPE). Other suitable materials include polyhydroxyalkanoate (PHA) fibres. It may be preferable that the aerosol-cooling element comprises or is formed from cellulose acetate.

[0122] The aerosol-cooling element may have an external diameter that is approximately equal to the external diameter of the aerosol-generating article. The aerosol-cooling element may have an external diameter of between 5 and 12, 5 and 10, or 5 and 8, 6 and 12, 6 and 10, or 6 and 8 millimetres. The aerosol-cooling element may have an external diameter of approximately 7.2 millimetres.

[0123] The aerosol-cooling element may have an internal diameter of at least about 2, 2.5, or 3 millimetres, for example where the aerosol-cooling element comprises or is a second hollow tube.

[0124] A peripheral wall of the aerosol-cooling element may have a thickness of less than about 2.5, 1.5, 1.25, 1, 0.9, or 0.8 millimetres, for example where the aerosol-cooling element comprises or is a second hollow tube.

[0125] The aerosol-cooling element may have a length of at least 5, 6, 7 or 8 millimetres. Alternatively or in addition, the aerosol-cooling element may have a length of less than 15, 12 or 10 millimetres.

[0126] The mouthpiece element may comprise a filtration material, for example a fibrous filtration material. The mouthpiece element may comprise, or be, a plug of cellulose acetate. The mouthpiece element may be translucent or opaque. Advantageously, the mouthpiece element may pre-

vent a consumer from seeing the thermally conductive or carbon particles through a downstream end of the article.

[0127] A mouthpiece element may be particularly beneficial in an aerosol-generating article comprising an aerosol-forming substrate comprising thermally conductive particles, for example carbon particles. This is because the mouthpiece element may reduce the likelihood of the thermally conductive particles being inhaled.

[0128] The mouthpiece element may have an external diameter that is approximately equal to the external diameter of the aerosol-generating article. The mouthpiece element may have an external diameter of between 5 and 12, 5 and 10, or 5 and 8, 6 and 12, 6 and 10, or 6 and 8 millimetres. The mouthpiece element may have an external diameter of approximately 7.2 millimetres.

[0129] The mouthpiece element may have a length of at least 5, 8 or 10 millimetres. Alternatively or in addition, the mouthpiece element may have a length of less than 25, 20 or 15 millimetres. The mouthpiece element may have a length of approximately 12 millimetres.

[0130] Advantageously, a longer mouthpiece element may be more resilient to deformation, or better adapted to recover its initial shape after deformation, and may provide for improved grip by the consumer to facilitate insertion of the aerosol-generating article into a heating device. In addition, a longer mouthpiece element may provide a higher level of filtration and removal of undesirable aerosol constituents so that a higher quality aerosol can be delivered. In addition, the use of a longer mouthpiece element enables a more complex mouthpiece to be provided since there is more space for the incorporation of mouthpiece components such as capsules, threads and restrictors.

[0131] The aerosol-generating article may have an overall length of between 38 and 70, 40 and 70, 42 and 70, 38 and 60, 40 and 60, or 42 and 60, 38 and 50, 40 and 50, or 42 and 50 millimetres. The aerosol-generating article may have an overall length of around 45 millimetres.

[0132] The aerosol-generating article may have an external diameter of at least about 5, 6, or 7 millimetres. The aerosol-generating article may have an external diameter of less than about 12, 10 or 8 millimetres. The aerosol-generating article may have an external diameter of about 7.25 millimetres.

[0133] According to the present disclosure, there is provided an aerosol-generating system comprising an aerosol-generating article as described above and an aerosol-generating device.

[0134] The aerosol-generating device may be an electrical aerosol-generating device. The aerosol-generating device may be engageable with, and disengageable from, the aerosol-generating article. For example, the aerosol-generating device may be configured to receive at least a portion of the aerosol-generating article.

[0135] The aerosol-generating device may be configured to heat the aerosol-generating article. The aerosol-generating device may be configured to resistively heat the aerosol-generating article. The device may comprise a heating element. The heating element may be configured to contact, for example penetrate, the aerosol-forming substrate in use. The heating element may be configured to be resistively heated. The heating element may comprise an electrically resistive track. In use, a current may be passed through the track to resistively heat the track. The heating element may be in the form of a pin, rod or blade.

[0136] The aerosol-generating device may be configured to inductively heat the aerosol-generating article. The device may comprise an inductor, such as an inductor coil. The device may be configured to generate a fluctuating electromagnetic field. In use, this fluctuating electromagnetic field may induce eddy currents in a susceptor material, for example a susceptor material of the thermally conductive particles, or a susceptor material of a heating element of the device, or both. Where the device comprises an inductively heatable heating element, such a heating element may be configured to contact, for example penetrate, the aerosol-forming substrate in use. The heating element may be in the form of a pin, rod or blade. The eddy currents may heat up the susceptor material and thereby heat up the aerosol-forming substrate in use.

[0137] According to the present disclosure, there is provided a method of forming an aerosol-forming substrate. The method may comprise forming a slurry, for example a slurry comprising an organic material and thermally conductive particles. The method may comprise homogenising the slurry. The method may comprise casting the slurry. The method may comprise drying the slurry to form an aerosol-forming substrate.

[0138] Thus, there is provided a method of forming an aerosol-forming substrate comprising:

[0139] forming a slurry comprising an organic material and thermally conductive particles;

[0140] homogenising the slurry; and

[0141] casting and drying the slurry to form an aerosol-forming substrate.

[0142] Any features described in relation to an aerosol-forming substrate may be applicable to the aerosol-forming substrate of this method. The thermally conductive particles may be carbon particles. Any features described in relation to the thermally conductive or carbon particles may be applicable to the thermally conductive particles of this method. Any features described in relation to an aerosol-forming material above may be applicable to the aerosol-forming material of this method.

[0143] The method may be used to form any of the aerosol-forming substrates described above, for example or any of the first, second or third particularly preferred aerosol-forming substrates described above.

[0144] The slurry may comprise one or more of the following: organic material, thermally conductive particles, water, one or more binders, one or more aerosol-formers, tobacco particles, tobacco fibres, non-tobacco fibres, one or more humectants, one or more plasticisers, one or more flavourants, one or more fillers, one or more aqueous solvents and one or more non-aqueous solvents. Thus, forming the slurry may comprise mixing one or more of the above constituents of the slurry.

[0145] The organic material may comprise one or both of a tobacco material and a herbaceous material. The organic material may be shredded. For example, the organic material may be or comprise a finely shredded tobacco material. The organic material may comprise or be in the form of a powder such as tobacco powder.

[0146] Where the slurry comprises tobacco particles, the tobacco particles may have a particle size distribution having a D10 tobacco particle size, a D50 tobacco particle size and a D90 tobacco particle size.

[0147] The D10 tobacco particle size may be between 1 and 20, or 1 and 10 microns. The D10 tobacco particle size may be around 3 microns.

[0148] The D90 tobacco particle size may be between 40 and 200 or 40 and 100 microns. The D90 tobacco particle size may be around 70 microns.

[0149] A D10 particle size of the thermally conductive or carbon particles may be between 0.1 and 10, 0.2 and 5, 0.25 and 4, 0.5 and 2, or 0.8 and 1.25 times the D10 tobacco particle size. A D50 particle size of the thermally conductive or carbon particles may be between 0.1 and 10, 0.2 and 5, 0.25 and 4, 0.5 and 2, or 0.8 and 1.25 times the D50 tobacco particle size. A D90 particle size of the thermally conductive or carbon particles may be between 0.1 and 10, 0.2 and 5, 0.25 and 4, 0.5 and 2, or 0.8 and 1.25 times the D90 tobacco particle size. These ranges may advantageously allow better mixing of the thermally conductive particles and the tobacco particles. This may advantageously result in a more homogeneous aerosol-forming substrate.

[0150] 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 derivitized 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.

[0151] Suitable aerosol-formers are well-known in the art and include, but are not limited to, 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 triacetate; and aliphatic esters of mono-, di- or polycarboxylic acids, such as dimethyl dodecanedioate and dimethyl tetradecanedioate. It may be particularly preferable for the aerosol-former to be or comprise glycerine.

[0152] Forming the slurry may comprise pre-mixing one or more binders with one or more aerosol-formers to form a pre-mixture. Forming the slurry may comprise mixing further ingredients with the pre-mixture. Forming the slurry may comprise mixing the thermally conductive particles with the pre-mixture.

[0153] Advantageously, pre-mixing the binder and the aerosol-former may reduce the likelihood of the binder gelling, for example when the binder contacts water. Such gelling may lead to an unintended non-uniform mixing of the slurry.

[0154] Homogenising the slurry may comprise mixing the slurry using a mixing apparatus such as a high-shear mixer.

[0155] Casting the slurry may comprise casting the slurry onto a support surface. The support surface may be a surface of a moving conveyor belt.

[0156] Drying the slurry may form a sheet of aerosol-forming substrate. The sheet may be gathered and cut.

[0157] According to the present disclosure, there is provided a method of forming an aerosol-generating article comprising the method described above.

[0158] The method may comprise preparing a rod, or plug, of the aerosol-forming substrate.

[0159] The method may comprise assembling the aerosol-generating article from a plurality of components, the plurality of components including the aerosol-forming substrate, for example the rod or plug of aerosol-forming substrate.

[0160] The method may comprise circumscribing components of the aerosol-generating article in a wrapper, for example circumscribing in a wrapper one or more of an upstream element, an aerosol-forming substrate, an aerosol-cooling element, a support element and a mouthpiece element.

[0161] According to the present disclosure, there is provided a second method of forming an aerosol-forming substrate. The method may comprise providing an aerosol-forming material. The method may comprise coating thermally conductive particles onto the aerosol-forming material to form the aerosol-forming substrate.

[0162] Thus, there is provided a method of forming an aerosol-forming substrate comprising:

[0163] providing an aerosol-forming material; and

[0164] coating thermally conductive particles onto the aerosol-forming material to form the aerosol-forming substrate.

[0165] Any features described in relation to an aerosol-forming substrate above may be applicable to the aerosol-forming substrate of this second method. The thermally conductive particle may be carbon particles. Any features described in relation to the thermally conductive or carbon particles above may be applicable to the thermally conductive particles of this second method. Any features described in relation to an aerosol-forming material above may be applicable to the aerosol-forming material of this second method.

[0166] The method may be used to form any aerosol-forming substrate described above or any of the first, second or third particularly preferred aerosol-forming substrates described above.

[0167] For the second method, the aerosol-forming material may comprise, or may be in the form of, one or more of: cut-filler, powder particles, granules, pellets, shreds, spaghettis, strips or sheets. The cut width of the cut-filler may be between 0.3 and 2, 0.5 and 1.2, or 0.6 and 0.9 millimetres. The skilled person would be aware of appropriate methods for providing such an aerosol-forming material.

[0168] The method may comprise coating the coating thermally conductive particles onto the aerosol-forming material before adding one or more flavourants onto the aerosol-forming material.

[0169] According to the present disclosure, there is provided a method of forming an aerosol-generating article comprising the second method described above.

[0170] The method may comprise preparing a rod, or plug, of the aerosol-forming substrate.

[0171] The method may comprise assembling the aerosol-generating article from a plurality of components, the plurality of components including the aerosol-forming substrate, for example the rod or plug of aerosol-forming substrate.

[0172] The method may comprise circumscribing components of the aerosol-generating article in a wrapper, for example circumscribing in a wrapper one or more of an upstream element, an aerosol-forming substrate, an aerosol-cooling element, a support element and a mouthpiece element.

[0173] 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.

[0174] As used herein, the term "thermally conductive particles" may refer to particles having a thermal conductivity greater than 1 W/mK. The particles may exhibit anisotropic thermal conductivity. In this case, the term "thermally conductive particles" may refer to particles having a thermal conductivity greater than 1 W/mK in at least one direction.

[0175] 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.

[0176] 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.

[0177] As used herein, the term "volume mean particle size" may refer to a mean calculated using the equation below, where d[4,3] is the volume mean particle size and d is the particle size.

$$d[4,3] = \frac{\sum d^4}{\sum d^3}$$

[0178] In other words, the volume mean particle size may refer to a mean calculated by dividing the sum of the particle sizes to the fourth power by the sum of the particle sizes to the third power.

[0179] 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).

[0180] As used herein, the term "aerosol-generating article" may refer to an article able to generate, or release, an aerosol.

[0181] As used herein, the term "heated aerosol-generating article" may refer to an article configured to generate, or release, an aerosol when heated.

[0182] 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.

[0183] As used herein, the term "transverse" may refer to a direction perpendicular to the longitudinal direction.

[0184] 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.

[0185] As used herein, the term "gathered sheet" may refer to a sheet of an aerosol-forming substrate or aerosol-generating article that is convoluted, folded, or otherwise compressed or constricted substantially transversely to a longitudinal axis of the aerosol-forming substrate, or aerosol-generating article.

[0186] 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.

[0187] 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.

[0188] 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.

[0189] As used herein, the term "aerosol-cooling element" may refer to a component of an aerosol-generating article located downstream of the aerosol-forming substrate such that, in use, an aerosol formed by the substrate or by volatile compounds released from the aerosol-forming substrate passes through and is cooled by the aerosol-cooling element before being inhaled by a user.

[0190] As used herein, the term "rod" may refer to a generally cylindrical element of substantially circular, oval or elliptical cross-section.

[0191] As used herein, the term "crimped" may refer to a sheet having a plurality of substantially parallel ridges or corrugations. When present in a component of an aerosol-generating article, the substantially parallel ridges or corrugations may extend in a longitudinal direction with respect to the aerosol-generating article.

[0192] As used herein, the term "ventilation level" may refer to a volume ratio between the airflow admitted into an aerosol-generating article via the ventilation zone (ventilation airflow) and the sum of the aerosol airflow and the

ventilation airflow. The greater the ventilation level, the higher the dilution of the aerosol flow delivered to the consumer.

[0193] 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 described above, for example any one or more features of another example, embodiment, or aspect described herein.

[0194] Example Ex 1. An aerosol-forming substrate for use in a heated aerosol-generating article, the aerosol-forming substrate comprising thermally conductive particles and an aerosol-forming material.

[0195] Example Ex 2. An aerosol-forming substrate according to example Ex 1, wherein each of the thermally conductive particles has a thermal conductivity greater than 1, 2, 5, 10, 20, 50, 100, 200, 500 or 1000 W/mK.

[0196] Example Ex 3. An aerosol-forming substrate according to any preceding example, wherein the thermally conductive particles make up less than or equal to 80, 50, 20, 10, or 5 weight percent of the aerosol-forming substrate.

[0197] Example Ex 4. An aerosol-forming substrate according to any preceding example, wherein the thermally conductive particles make up more than or equal to 0.1, 0.2, 0.5, 1, 2, 3, 5, 10, 20 or 50 weight percent of the aerosol-forming substrate.

[0198] Example Ex 5. An aerosol-forming substrate according to any preceding example, wherein the thermally conductive particles make up between 1 and 20, 2 and 20, 3 and 20, 5 and 20, 3 and 15, 5 and 15, or 3 and 10 weight percent of the aerosol-forming substrate.

[0199] Example Ex 6. An aerosol-forming substrate according to any preceding example, wherein some or all of the thermally conductive particles are non-metallic particles.

[0200] Example Ex 7. An aerosol-forming substrate according to any preceding example, wherein some or all of the thermally conductive particles are carbon particles.

[0201] Example Ex 8. An aerosol-forming substrate according to any preceding example, wherein some or all of the thermally conductive particles are graphite particles.

[0202] Example Ex 9. An aerosol-forming substrate according to any preceding example, wherein some or all of the thermally conductive particles are expanded graphite particles.

[0203] Example Ex 10. An aerosol-forming substrate according to any preceding example, wherein some or all of the thermally conductive particles are graphene particles.

[0204] Example Ex 11. An aerosol-forming substrate according to any preceding example, wherein some or all of the thermally conductive particles are metallic particles.

[0205] Example Ex 12. An aerosol-forming substrate according to any preceding example, wherein some or all of the thermally conductive particles are copper particles.

[0206] Example Ex 13. An aerosol-forming substrate according to any preceding example, wherein some or all of the thermally conductive particles are aluminium particles.

[0207] Example Ex 14. An aerosol-forming substrate according to any preceding example, wherein the thermally conductive particles have a particle size distribution having a D10 particle size and a D90 particle size, wherein the D90 particles size is less than or equal to 50, 40, 30, 25, 20, 15, 10, 8, 5, or 3 times the D10 particle size.

[0208] Example Ex 15. An aerosol-forming substrate according to any preceding example, wherein the thermally conductive particles have a particle size distribution such that a D10 particle size of the thermally conductive particles is greater than or equal to 1, 2, 3, 5, 10, 20, 30, 35, 50, 75, 100, 150, 200, 250, 500, or 900 microns.

[0209] Example Ex 16. An aerosol-forming substrate according to any preceding example, wherein the thermally conductive particles have a particle size distribution such that a D90 particle size of the thermally conductive particles is less than or equal to 1000, 900, 500, 200, 100, 150, 100, 75, 50, 35, 30, 20, 10, 5, 3 or 2 microns.

[0210] Example Ex 17. An aerosol-forming substrate according to any preceding example, wherein the thermally conductive particles have a particle size distribution such that a D50 particle size of the thermally conductive particles is between 1 and 1000, 35 and 1000, or 100 and 900 microns.

[0211] Example Ex 18. An aerosol-forming substrate according to any preceding example, wherein the thermally conductive particles have a particle size distribution such that a D50 particle size of the thermally conductive particles is between 1 and 1000, 10 and 200, 30 and 150, or 50 and 75 microns.

[0212] Example Ex 19. An aerosol-forming substrate according to any preceding example, wherein each of the thermally conductive particles has a particle size of greater than or equal to 1, 2, 3, 5, 10, 20, 30, 35, 50, 75, 100, 150, 200, 250, 500, or 900 microns.

[0213] Example Ex 20. An aerosol-forming substrate according to any preceding example, wherein each of the thermally conductive particles has a particle size of less than or equal to 1000, 900, 500, 200, 100, 150, 100, 75, 50, 35, 30, 20, 10, 5, 3 or 2 microns.

[0214] Example Ex 21. An aerosol-forming substrate according to any preceding example, wherein each of the thermally conductive particles has a particle size of between 1 and 1000, 35 and 1000, or 100 and 900 microns.

[0215] Example Ex 22. An aerosol-forming substrate according to any preceding example, wherein each of the thermally conductive particles has a particle size of between 1 and 1000, 10 and 200, 30 and 150, or 50 and 75 microns.

[0216] Example Ex 23. An aerosol-forming substrate according to any preceding example, wherein the thermally conductive particles have a volume mean particle size of greater than or equal to 1, 2, 3, 5, 10, 20, 30, 35, 50, 75, 100, 150, 200, 250, 500, or 900 microns.

[0217] Example Ex 24. An aerosol-forming substrate according to any preceding example, wherein the thermally conductive particles have a volume mean particle size of less than or equal to 1000, 900, 500, 200, 100, 150, 100, 75, 50, 35, 30, 20, 10, 5, 3 or 2 microns.

[0218] Example Ex 25. An aerosol-forming substrate according to any preceding example, wherein the thermally conductive particles have a volume mean particle size of between 1 and 1000, 35 and 1000, or 100 and 900 microns.

[0219] Example Ex 26. An aerosol-forming substrate according to any preceding example, wherein the thermally conductive particles have a volume mean particle size of between 1 and 1000, 10 and 200, 30 and 150, or 50 and 75 microns.

[0220] Example Ex 27. An aerosol-forming substrate according to any preceding example, wherein each of the thermally conductive particles has three mutually perpendicular dimensions, a largest dimension of the three dimen-

sions being no more than 10, 8, 5, 3, or 2 times larger than a smallest dimension of the three dimensions.

[0221] Example Ex 28. An aerosol-forming substrate according to any preceding example, wherein 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.

[0222] Example Ex 29. An aerosol-forming substrate according to any preceding example, wherein each of the thermally conductive particles is substantially spherical.

[0223] Example Ex 30. An aerosol-forming substrate according to any preceding example, wherein the thermally conductive particles comprise at least 10, 20, 50, 100, 200, 500, or 1000 particles.

[0224] Example Ex 31. An aerosol-forming substrate according to any preceding example, wherein some or each of the thermally conductive particles comprises a susceptor material.

[0225] Example Ex 32. An aerosol-forming substrate according to any preceding example, wherein each of the thermally conductive particles has a lower density than the aerosol-forming material.

[0226] Example Ex 33. An aerosol-forming substrate according to any preceding example, wherein each of the thermally conductive particles have a density which is at least 1, 2, 5, 10, 15, 20, 25, or 30% less than a density of the aerosol-forming material.

[0227] Example Ex 34. An aerosol-forming substrate according to any preceding example, wherein the aerosol-forming substrate has a thermal conductivity of greater than 0.06, 0.08, 0.1, 0.125, 0.13, 0.135, 0.14, 0.145, 0.15, 0.155, 0.16, 0.165, or 0.17 W/mK.

[0228] Example Ex 35. An aerosol-forming substrate according to any preceding example, wherein the aerosol-forming substrate has a density of less than 1050, 1000, 950, 900, 850, 800, 850, 800, 750, 700, or 650 kg/m^3, preferably a density of between 500 and 900 or 600 and 800 kg/m^3.

[0229] Example Ex 36. An aerosol-forming substrate according to any preceding example, wherein the aerosol-forming material comprises one or more organic materials such as tobacco.

[0230] Example Ex 37. An aerosol-forming substrate according to any preceding example, wherein the aerosol-forming material comprises one or more of herb leaf, tobacco leaf, fragments of tobacco ribs, reconstituted tobacco, homogenised tobacco, extruded tobacco and expanded tobacco.

[0231] Example Ex 38. An aerosol-forming substrate according to any preceding example, wherein the aerosol-forming material comprises one or more aerosol-formers.

[0232] Example Ex 39. An aerosol-forming substrate according to any preceding example, wherein the aerosol-forming material comprises one or more aerosol-formers selected from: 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 triacetate; and aliphatic esters of mono-, di- or polycarboxylic acids, such as dimethyl dodecanedioate and dimethyl tetradecanedioate.

[0233] Example Ex 40. An aerosol-forming substrate according to any preceding example, wherein the aerosol-forming substrate comprises glycerine.

[0234] Example Ex 41. An aerosol-forming substrate according to any preceding example, wherein the aerosol-forming material comprises nicotine.

[0235] Example Ex 42. An aerosol-forming substrate according to any preceding example, wherein the aerosol-forming material comprises, or is in the form of, one or more of: cut-filler, powder particles, granules, pellets, shreds, spaghettis, strips or sheets.

[0236] Example Ex 43. An aerosol-forming substrate according to any preceding example, wherein the aerosol-forming material comprises, or is in the form of, one or more sheets.

[0237] Example Ex 44. An aerosol-forming substrate according to any preceding example, wherein the aerosol-forming material comprises, or is in the form of, one or more gathered sheets.

[0238] Example Ex 45. An aerosol-forming substrate according to example Ex 44, wherein the or each gathered sheet has a width of at least about 10, 25, 50, or 100 mm.

[0239] Example Ex 46. An aerosol-forming substrate according to any preceding example, wherein the aerosol-forming material comprises, or is in the form of, a plurality of strips.

[0240] Example Ex 47. An aerosol-forming substrate according to example Ex 46, wherein each of the plurality of strips extends in a substantially longitudinal direction of the aerosol-generating article.

[0241] Example Ex 48. An aerosol-forming substrate according to any of examples Ex 46 to Ex 47, wherein each of the plurality of strips has a length of at least about 3, 5 or 10 mm.

[0242] Example Ex 49. An aerosol-forming substrate according to any of examples Ex 46 to Ex 48, wherein each of the plurality of strips has a width of less than about 3, 2 or 1 mm.

[0243] Example Ex 50. An aerosol-forming substrate according to any preceding example, wherein the thermally conductive particles are carbon particles and make up greater than 0.1 weight percent of the aerosol-forming substrate, and wherein the carbon particles have a volume mean particle size of greater than 3 microns and a particle size distribution with a D90 particle size and a D10 particle size, the D90 particle size being no more than 40 times the D10 particle size.

[0244] Example Ex 51. An aerosol-forming substrate according to any preceding example, wherein the thermally conductive particles are carbon particles and make up greater than 0.1 weight percent of the aerosol-forming substrate, and wherein the carbon particles have a volume mean particle size of greater than 10 microns.

[0245] Example Ex 52. An aerosol-forming substrate according to any preceding example, wherein the thermally conductive particles are carbon particles and make up greater than 0.1 weight percent of the aerosol-forming substrate, and wherein the carbon particles have a particle size distribution with a D90 particle size and a D10 particle size, the D90 particle size being no more than 25 or 15 times the D10 particle size.

[0246] Example Ex 53. An aerosol-generating article comprising an aerosol-forming substrate according to any preceding example.

[0247] Example Ex 54. An aerosol-generating article according to example Ex 53, wherein the aerosol-generating article is for use with an electrical aerosol-generating device.

[0248] Example Ex 55. An aerosol-generating system comprising an aerosol-generating article according to example Ex 53 or Ex 54 and an electrical aerosol-generating device.

[0249] Example Ex 56. An aerosol-generating system according to example Ex 55, wherein the electrical aerosol-generating device is configured to resistively heat the aerosol-generating article in use.

[0250] Example Ex 57. An aerosol-generating system according to example Ex 55, wherein the electrical aerosol-generating device is configured to inductively heat the aerosol-generating article in use.

[0251] Example Ex 58. A method of forming an aerosol-forming substrate, the method comprising: forming a slurry comprising an organic material and thermally conductive particles; homogenising the slurry; and casting and drying the slurry to form the aerosol-forming substrate.

[0252] Example Ex 59. A method according to example Ex 58, wherein the method is a method of forming an aerosol-forming substrate according to any of examples Ex 1 to Ex 52.

[0253] Example Ex 60. A method according to any of examples Ex 58 to Ex 59, wherein the slurry comprises water.

[0254] Example Ex 61. A method according to any of examples Ex 58 to Ex 60, wherein the slurry comprises cellulose fibres.

[0255] Example Ex 62. A method according to any of examples Ex 58 to Ex 61, wherein the slurry comprises one or more binders.

[0256] Example Ex 63. A method according to any of examples Ex 58 to Ex 62, wherein the slurry comprises one or more aerosol-formers.

[0257] Example Ex 64. A method according to any of examples Ex 58 to Ex 63, wherein the organic material is, or comprises, tobacco material such as tobacco powder.

[0258] Example Ex 65. A method of forming an aerosol-forming substrate, the method comprising: providing an aerosol-forming material; and coating thermally conductive particles onto the aerosol-forming material to form the aerosol-forming substrate.

[0259] Example Ex 66. A method according to example Ex 65, wherein the method is a method of forming an aerosol-forming substrate according to any of examples Ex 1 to Ex 52.

[0260] Example Ex 67. A method according to any of examples Ex 65 to Ex 66, wherein the aerosol-forming material comprises an organic material.

[0261] Example Ex 68. A method according to example Ex 67, wherein the organic material is, or comprises, tobacco material.

[0262] Example EX 69. An aerosol-forming substrate for use in a heated aerosol-generating article, the aerosol-forming substrate comprising an aerosol-forming material and greater than 0.1 weight percent carbon particles, the carbon particles having a volume mean particle size of greater than 10 microns; wherein the carbon particles have a particle size distribution having a D10 particle size and a D90 particle size, wherein the D90 particle size is less than 20 times the D10 particle size.

[0263] Example EX 70. An aerosol-forming substrate for use in a heated aerosol-generating article, the aerosol-forming substrate comprising an aerosol-forming material and greater than 0.1 weight percent carbon particles, the carbon particles having a volume mean particle size of greater than 10 microns; wherein the carbon particles consist of one or both of expanded graphite particles and graphene particles.

[0264] Example EX 71. An aerosol-forming substrate for use in a heated aerosol-generating article, the aerosol-forming substrate comprising an aerosol-forming material and between 0.1 and 15 percent by weight percent carbon particles, the carbon particles having a volume mean particle size of between 10 and 75 microns.

[0265] Examples will now be further described with reference to the figures in which:

[0266] FIG. **1** shows a schematic cross-sectional view of a first embodiment of an aerosol-generating article;

[0267] FIG. **2** shows a schematic cross-sectional view of a second embodiment of an aerosol-generating article;

[0268] FIG. **3** shows a schematic cross-sectional view of a first embodiment of an aerosol-generating system;

[0269] FIG. **4** shows a schematic cross-sectional view of a second embodiment of an aerosol-generating system; and

[0270] FIG. **5** shows a schematic cross-sectional view of a third embodiment of an aerosol-generating article.

[0271] FIG. **1** shows a schematic cross-sectional view of a first embodiment of an aerosol-generating article **10**. The aerosol-generating article **10** comprises a rod **12** of aerosol-forming substrate and a downstream section **14** at a location downstream of the rod **12** of aerosol-forming substrate. Further, the aerosol-generating article **10** comprises an upstream section **16** at a location upstream of the rod **12** of aerosol-forming substrate. Thus, the aerosol-generating article **10** extends from an upstream or distal end **18** to a downstream or proximal or mouth end **20**.

[0272] The aerosol-generating article has an overall length of about 45 millimetres.

[0273] The downstream section **14** comprises a support element **22** located immediately downstream of the rod **12** of aerosol-forming substrate, the support element **22** being in longitudinal alignment with the rod **12**. In the embodiment of FIG. **1**, the upstream end of the support element **22** abuts the downstream end of the rod **12** of aerosol-generating substrate. In addition, the downstream section **14** comprises an aerosol-cooling element **24** located immediately downstream of the support element **22**, the aerosol-cooling element **24** being in longitudinal alignment with the rod **12** and the support element **22**. In the embodiment of FIG. **1**, the upstream end of the aerosol-cooling element **24** abuts the downstream end of the support element **22**.

[0274] As will become apparent from the following description, the support element **22** and the aerosol-cooling element **24** together define an intermediate hollow section **50** of the aerosol-generating article **10**. As a whole, the intermediate hollow section **50** does not substantially contribute to the overall RTD of the aerosol-generating article. An RTD of the intermediate hollow section **26** as a whole is substantially 0 millimetres H_2O.

[0275] The support element **22** comprises a first hollow tubular segment **26**. The first hollow tubular segment **26** is provided in the form of a hollow cylindrical tube made of cellulose acetate. The first hollow tubular segment **26** defines an internal cavity **28** that extends all the way from an upstream end **30** of the first hollow tubular segment to a downstream end **32** of the first hollow tubular segment **20**. The internal cavity **28** is substantially empty, and so substantially unrestricted airflow is enabled along the internal cavity **28**. The first hollow tubular segment **26**—and, as a

consequence, the support element **22**—does not substantially contribute to the overall RTD of the aerosol-generating article **10**. In more detail, the RTD of the first hollow tubular segment **26** (which is essentially the RTD of the support element **22**) is substantially 0 millimetres H_2O.

[0276] The first hollow tubular segment **26** has a length of about 8 millimetres, an external diameter of about 7.25 millimetres, and an internal diameter (D_{FTS}) of about 1.9 millimetres. Thus, a thickness of a peripheral wall of the first hollow tubular segment **26** is about 2.67 millimetres.

[0277] The aerosol-cooling element **24** comprises a second hollow tubular segment **34**. The second hollow tubular segment **34** is provided in the form of a hollow cylindrical tube made of cellulose acetate. The second hollow tubular segment **34** defines an internal cavity **36** that extends all the way from an upstream end **38** of the second hollow tubular segment to a downstream end **40** of the second hollow tubular segment **34**. The internal cavity **36** is substantially empty, and so substantially unrestricted airflow is enabled along the internal cavity **36**. The second hollow tubular segment **28**—and, as a consequence, the aerosol-cooling element **24**—does not substantially contribute to the overall RTD of the aerosol-generating article **10**. In more detail, the RTD of the second hollow tubular segment **34** (which is essentially the RTD of the aerosol-cooling element **24**) is substantially 0 millimetres H_2O.

[0278] The second hollow tubular segment **34** has a length of about 8 millimetres, an external diameter of about 7.25 millimetres, and an internal diameter (D_{STS}) of about 3.25 millimetres. Thus, a thickness of a peripheral wall of the second hollow tubular segment **34** is about 2 millimetres. Thus, a ratio between the internal diameter (D_{FTS}) of the first hollow tubular segment **26** and the internal diameter (D_{STS}) of the second hollow tubular segment **34** is about 0.75.

[0279] The aerosol-generating article **10** comprises a ventilation zone **60** provided at a location along the second hollow tubular segment **34**. In more detail, the ventilation zone is provided at about 2 millimetres from the upstream end of the second hollow tubular segment **34**. In this embodiment, the ventilation zone **60** comprises a circumferential row of perforations through a paper wrapper **70** and a ventilation level of the aerosol-generating article **10** is about 25 percent.

[0280] In the embodiment of FIG. **1**, the downstream section **14** further comprises a mouthpiece element **42** at a location downstream of the intermediate hollow section **50**. In more detail, the mouthpiece element **42** is positioned immediately downstream of the aerosol-cooling element **24**. As shown in the drawing of FIG. **1**, an upstream end of the mouthpiece element **42** abuts the downstream end **40** of the aerosol-cooling element **24**.

[0281] The mouthpiece element **42** is provided in the form of a cylindrical plug of low-density cellulose acetate.

[0282] The mouthpiece element **42** has a length of about 12 millimetres and an external diameter of about 7.25 millimetres. The RTD of the mouthpiece element **42** is about 12 millimetres H_2O. The ratio of the length of the mouthpiece element **42** to the length of the intermediate hollow section **50** is approximately 0.6.

[0283] The rod **12** of aerosol-forming substrate has an external diameter of about 7.25 millimetres and a length of about 12 millimetres.

[0284] The upstream section **16** comprises an upstream element **46** located immediately upstream of the rod **12** of aerosol-forming substrate, the upstream element **46** being in longitudinal alignment with the rod **12**. In the embodiment of FIG. **1**, the downstream end of the upstream element **46** abuts the upstream end of the rod **12** of aerosol-forming substrate. The upstream element **46** is provided in the form of a cylindrical plug of cellulose acetate. The upstream element **46** has a length of about 5 millimetres. The RTD of the upstream element **46** is about 30 millimetres H_2O.

[0285] The upstream element **46**, rod **12** of aerosol-forming substrate, support element **22**, aerosol-cooling element **24**, and mouthpiece element **42** are circumscribed by the paper wrapper **70**.

[0286] The rod **12** of aerosol-forming substrate comprises an aerosol-forming material and thermally conductive particles **44**. The aerosol-forming material comprises a reconstituted and gathered sheet comprising tobacco material and glycerine. The thermally conductive particles **44** are carbon particles, specifically expanded graphite particles, having 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. The aerosol-forming substrate, including the aerosol-forming material and the thermally conductive particles **44**, have a combined density of around 760 kilograms per metre cubed. The expanded graphite particles make up approximately 5% of the aerosol-forming substrate by weight.

[0287] The rod **12** of aerosol-forming substrate is formed by a process including the following steps:

[0288] pre-mixing a binder, guar gum, with an aerosol-former, glycerine, to form a first pre-mixture;

[0289] pre-mixing finely shredded tobacco material and a powder consisting of the expanded graphite particles **44** and having a bulk density of around 0.065 grams per centimetre cubed, to form a second pre-mixture;

[0290] mixing the first and second pre-mixtures with water to form a slurry;

[0291] homogenising the slurry using a high-shear mixer;

[0292] casting the slurry onto a conveyor belt;

[0293] controlling a thickness of the slurry and drying the slurry to form a large sheet of aerosol-forming substrate; and

[0294] gathering and cutting the large sheet of aerosol-forming substrate to form the rod **12** of aerosol-forming substrate.

[0295] After forming the rod **12** of aerosol-forming substrate, the aerosol-generating article **10** is assembled by positioning the various components of the article **10** and wrapping the components in the wrapper **70**.

[0296] FIG. **2** shows a schematic cross-sectional view of a second embodiment of an aerosol-generating article **11**. This second embodiment is identical to the first embodiment of FIG. **1** except that the rod **12** of aerosol-forming substrate has been replaced by an alternative rod **13** of aerosol-forming substrate. Identical reference numerals have been used for identical components in the embodiments of FIGS. **1** and **2**.

[0297] In the rod **13** of the second embodiment, the aerosol-forming substrate comprises an aerosol-forming material and thermally conductive particles **45**. The aerosol-forming material comprises tobacco and glycerine and is in the form of cut-filler. The cut-filler comprises shreds of aerosol-forming material, the shreds having widths between 0.3 and 2 millimetres. The thermally conductive particles **45** are graphite particles, rather than expanded graphite particles, with a particle size distribution with a D10 particle size of 6 microns, a D50 particle size of 21 microns, and a D90 particle size of 55 microns. Each of the graphite particles has a particle size greater than 2 microns and less than 100 microns. The graphite particles have a volume mean particle size of around 35 microns. Each of the graphite particles is substantially spherical in shape. The graphite particles have a density of around 2200 kilograms per metre cubed. The aerosol-forming substrate, including the aerosol-forming material and the thermally conductive particles **45**, have a combined density of around 960 kilograms per metre cubed. The graphite particles make up approximately 5% of the aerosol-forming substrate by weight.

[0298] The rod **13** of aerosol-forming substrate is formed by a process including the following steps:

[0299] pre-mixing a binder, guar gum, with an aerosol-former, glycerine, to form a first pre-mixture;

[0300] pre-mixing finely shredded tobacco material and water to form a second pre-mixture;

[0301] mixing the first and second pre-mixtures to form a slurry;

[0302] homogenising the slurry using a high-shear mixer;

[0303] casting the slurry onto a conveyor belt;

[0304] controlling a thickness of the slurry and drying the slurry to form a large sheet of reconstituted, substantially homogeneous, tobacco-containing, aerosol-forming material;

[0305] shredding the large sheet of reconstituted and substantially homogeneous aerosol-forming material to form cut-filler;

[0306] mixing a powder consisting of the graphite particles **45** having a bulk density of around 560 kilograms per metre cubed with the cut-filler, thereby coating the graphite particles **45** onto the cut-filler;

[0307] adding flavourants to the cut-filler with graphite particles **45** coated thereon; and

[0308] forming the cut-filler (with graphite particles **45** and flavourants) into a plug for use as the rod **13** of aerosol-forming substrate.

[0309] After forming the rod **13** of aerosol-forming substrate, the aerosol-generating article **11** is assembled by positioning the various components of the article **11** and wrapping the components in the wrapper **70**.

[0310] FIG. **3** shows a schematic cross-sectional view of a first embodiment of an aerosol-generating system **100**. The system **100** comprises an aerosol-generating device **102** and the aerosol-generating article **10** of FIG. **1**.

[0311] 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.

[0312] 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.

[0313] 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.

[0314] In use, a user inserts the article **10** into the cavity, causing the heating blade **108** to penetrate the upstream element **46** and rod **12** of aerosol-forming substrate of the article **10**. FIG. **3** shows the article **10** inserted into the cavity of the device **102**.

[0315] Then, 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**, from the upstream end **18** to the downstream end **20**, and into the mouth of the user.

[0316] 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 **12** of aerosol-forming substrate, which is in contact with the heating blade **108**.

[0317] The expanded graphite particles **44** have a significantly higher thermal conductivity than the surrounding aerosol-forming material. As such, these particles may act as local hot-spots and provide a more even temperature throughout the aerosol-forming substrate, particularly in a radial direction from the heating blade **108** where, with prior art substrates, there would be a significant temperature gradient. 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.

[0318] Heating of the aerosol-forming substrate cause the aerosol-forming substrate to release volatile compounds. These compounds are entrained by the air flowing from the upstream end **18** of the article **10** towards the downstream end **20** of the article **10**. The compounds cool and condense to form an aerosol as they pass through the internal cavities **28**, **36** of the support element and the aerosol-cooling element. The aerosol then passes through the mouthpiece element **42**, which may filter out unwanted particles entrained in the air flow, and into the mouth of the user.

[0319] 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.

[0320] After a number of puffs on the article **10**, the user may choose to replace the article **10** with a fresh article.

[0321] FIG. **4** 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 the aerosol-generating article **11** of FIG. **2**.

[0322] The aerosol-generating device **202** comprises a battery **204**, a controller **206**, an inductor coil **208**, and a puff-detection mechanism (not shown). The controller **206** is coupled to the battery **204**, the inductor coil **208** and the puff-detection mechanism.

[0323] The aerosol-generating device **202** further comprises a housing **210** defining a substantially cylindrical cavity for receiving a portion of the article **11**. The inductor coil **208** spirals around the cavity.

[0324] The battery **204** is coupled to the inductor coil **208** so as to be able to pass an alternating current through the inductor coil **208**.

[0325] In use, a user inserts the article **11** into the cavity. FIG. **4** shows the article **11** inserted into the cavity of the device **202**.

[0326] Then, the user puffs on the downstream end of the article **11**. This causes air to flow through an air inlet (not shown) of the device **202**, then through the article **11**, from the upstream end **18** to the downstream end **20**, and into the mouth of the user.

[0327] The user puffing on the article **11** 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 **206** accordingly. The controller **206** then controls the battery **204** so as to pass an alternating current through the inductor coil **208**. This causes the inductor coil **208** to generate a fluctuating electromagnetic field. The rod **13** of aerosol-forming substrate is located within this fluctuating electromagnetic field and graphite, the material of the particles **45**, is a susceptor material. Thus, the fluctuating electromagnetic field causes eddy currents in the particles **45**. This causes the particles **45** to heat up, thereby also heating nearby aerosol-forming material.

[0328] Heating of the aerosol-forming material cause the aerosol-forming material to release volatile compounds. These compounds are entrained by the air flowing from the upstream end **18** of the article **11** towards the downstream end **20** of the article **11**. The compounds cool and condense to form an aerosol as they pass through the internal cavities **28**, **36** of the support element and the aerosol-cooling element. The aerosol then passes through the mouthpiece element **42**, which may filter out unwanted particles entrained in the air flow, and into the mouth of the user.

[0329] When the user stops inhaling on the article **11**, 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 **206** accordingly. The controller **206** then controls the battery **204** so as to reduce the current being passed through the electrically resistive track to zero.

[0330] After a number of puffs on the article **11**, the user may choose to replace the article **11** with a fresh article.

[0331] FIG. **5** shows a schematic cross-sectional view of a third embodiment of an aerosol-generating article **510**. This third embodiment is identical to the first embodiment of FIG. **1** except that the rod **12** of aerosol-forming substrate has been replaced by an alternative rod **512** of aerosol-forming substrate. Identical reference numerals have been used for identical components in the embodiments of FIGS. **1** and **5**.

[0332] The rod **512** of aerosol-forming substrate of the third embodiment of FIG. **5** is identical to the rod **12** of aerosol-forming substrate of the first embodiment of FIG. **1** except that the rod **512** of aerosol-forming substrate of the third embodiment of FIG. **5** additionally includes an elongate susceptor element **580**.

[0333] The susceptor element **580** is arranged substantially longitudinally within the rod **512** of aerosol-forming substrate so as to be approximately parallel with a longitudinal axis of the rod **512** of aerosol-forming substrate. As shown in the drawing of FIG. **5**, the susceptor element **580** is positioned in a radially central position within the rod and extends along the longitudinal axis of the rod **12**.

[0334] The susceptor element **580** extends all the way from an upstream end to a downstream end of the rod **512** of aerosol-forming substrate. As such, the susceptor element **580** has substantially the same length as the rod **512** of aerosol-forming substrate.

[0335] In the embodiment of FIG. **5**, the susceptor element **580** is provided in the form of a strip of a ferromagnetic steel and has a length of about 12 millimetres, a thickness of about 60 micrometres, and a width of about 4 millimetres.

[0336] The aerosol-generating article **510** of FIG. **5** may be used with the aerosol-generating device **202** of FIG. **4** in the same way as the aerosol-generating article **11** of FIG. **2**. Notably, the inclusion of the susceptor element **580** means that the article **510** may be inductively heated regardless of whether the thermally conductive particles comprise a suitable susceptor material for inductive heating.

[0337] 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.-15. (canceled)

16. An aerosol-forming substrate for a heatable aerosol-generating article, the aerosol-forming substrate comprising:

an aerosol-forming material and between 0.1 and 15 weight percent carbon particles,

wherein the carbon particles have a volume mean particle size of greater than 10 microns,

wherein the carbon particles have a particle size distribution having a D10 particle size and a D90 particle size, and

wherein the D90 particle size is less than 20 times the D10 particle size.

17. The aerosol-forming substrate according to claim **16**, wherein the carbon particles consist of one or more of: graphite particles, expanded graphite particles, and graphene particles.

18. The aerosol-forming substrate according to claim **16**, wherein the aerosol-forming material comprises an organic material, an aerosol-former, and a binder.

19. The aerosol-forming substrate according to claim **16**, wherein the aerosol-forming material is in a form of one or more of: cut-filler, powder particles, granules, pellets, shreds, spaghettis, strips, or sheets, and

wherein the carbon particles have a volume mean particle size of between 10 and 1,000 microns.

20. The aerosol-forming substrate according to claim **16**, wherein the aerosol-forming material is in a form of a gathered sheet and the carbon particles have a volume mean particle size of between 10 microns and 200 microns.

21. The aerosol-forming substrate according to claim **20**, wherein the carbon particles have a volume mean particle size of between 30 microns and 150 microns.

22. The aerosol-forming substrate according to claim **16**, wherein the aerosol-forming substrate has a thermal conductivity of greater than 0.06 W/mK in at least one direction.

23. The aerosol-forming substrate according to claim **16**, wherein the aerosol-forming substrate has a density of less than 1,000 kg/m^3.

24. The aerosol-forming substrate according to claim **16**, wherein the carbon particles consist of one or both of expanded graphite particles and graphene particles.

25. The aerosol-forming substrate according to claim **16**, wherein the carbon particles have a volume mean particle size of between 10 microns and 75 microns.

26. The aerosol-forming substrate according to claim **16**, wherein one or both of a volume mean particle size and a D50 particle size of the carbon particles is greater than or equal to 150 microns.

27. A method of forming an aerosol-forming substrate according to claim **16**, the method comprising:

forming a slurry comprising an organic material and carbon particles having a volume mean particle size of greater than 10 microns and a particle size distribution having a D10 particle size and a D90 particle size, wherein the D90 particle size is less than 20 times the D10 particle size;

homogenising the slurry; and

casting and drying the slurry to form the aerosol-forming substrate.

28. A method of forming an aerosol-forming substrate according to claim **16**, the method comprising:

providing an aerosol-forming material; and

coating carbon particles having a volume mean particle size of greater than 10 microns onto the aerosol-forming material to form the aerosol-forming substrate.

29. An aerosol-generating article comprising an aerosol-forming substrate according to claim **16**.

30. An aerosol-generating system comprising an aerosol-generating article according to claim **29** and an electrical aerosol-generating device configured to heat the aerosol-generating article so as to generate an aerosol.

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