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ELECTRICALLY-POWERED SEMICONDUCTOR HEATER ~~FOR FLAVOR GENERATING ARTICLES~~

Background Of The Invention

This invention relates to articles in which flavor generating media are heated to release tobacco flavors. More particularly, this invention relates to electrical heaters for electrically heated flavor generating articles.

An electrically heated flavor generating article is described in commonly-assigned United States Patent No. 5,060,671, which is hereby incorporated by reference in its entirety. That patent describes an electrically heated flavor generating article which is provided with a disposable set of electrical heating elements on each of which is deposited an individual charge of flavor generating medium containing, for example, tobacco or tobacco-derived material. The disposable heater/flavor unit is mated to a more or less permanent unit containing a source of electrical energy such as a battery or capacitor, as well as control circuitry to actuate the heating elements in response to a puff by a consumer on the article or the depression of a manual switch. The circuitry is designed so that at least one but less than all of the heating elements are actuated for any one puff, so that a predetermined number of puffs, each containing a pre-measured amount of flavor-containing substance, is

is relatively low (e.g., about 2.3 g/cm^3 to 2.6 g/cm^3 at 27°C, in comparison to that of, say, steel, which is about 7-8 g/cm^3 at 27°C), the flavor generating articles made with the electrical heaters of the present invention can be light in weight and will heat up quickly and efficiently transfer heat to the flavor generating medium.

Although FIG. 1 shows the electrical resistivity of silicon for only two types of dopant impurities -- phosphorus atoms and boron atoms --, it is understood that other dopants could as well be used. For example, alternate dopants might include antimony, _____, _____, _____, _____, _____ and _____ ~~[PLEASE LIST ALL DOPANTS POSSIBLE].~~ As used herein, the term "dopant impurity" is defined to mean any substance, particle, defect, vacancy or complex, or the like, or any combination thereof, that is capable of altering the electrical resistivity of the semiconductor material through its incorporation therein.

The only restrictions on the types of dopant impurities that can be used are that they must provide an electrical resistivity in a range that allows the heater to achieve a surface temperature from about 350°C to about 900°C when in contact with a flavor generating medium in a flavor generating article, and they must have a low enough reactivity to avoid toxicological or other reactive effects. Alternatively, an encapsulant, such as ceramic or the like, can be employed if the reactivity of the doped silicon is too high at the expected operating temperatures. Suitable materials for encapsulation of the heaters include silica, alumina, sol gels and _____. Additionally, a protective layer of SiO_2 or some other silicon-based oxide (SiO_x) can be

provided on the surface of the silicon heater to serve as an encapsulant.

What ever type of dopant is used, it can be incorporated into the silicon semiconductor material using any known method. Preferably, it is incorporated into the silicon during initial crystal growth. However, it can also be added at a later stage by, for example, diffusion, epitaxial processes, or ion implantation processes.

Although it is preferably that the dopant impurities of the present invention be substantially uniformly distributed throughout the bulk of the silicon semiconductor material, this does not have to be the case. It will be understood that other dopant profiles could also be used to achieve a graded or other non-uniform composition. For example, profiles with dopants concentrated near a surface could be used to provide high surface concentration of electrical conduction, and thus heat generation.

Although FIG. 1 shows the electrical resistivity for only silicon as a function of dopant impurity concentration, it will be apparent that other semiconductors could as well be used to fabricate the heater of the present invention. The only restrictions on the types of semiconductor materials that can be used, as is the case with dopant impurities, are that they must provide an electrical resistivity in a range that allows the heater to achieve a surface temperature from about 350°C to about 900°C when in contact with a flavor generating medium in a flavor generating article and they must have a low enough reactivity to avoid toxicological or other reactive effects. Alternatively, an encapsulant, such as those discussed above with respect to the use of dopant impurities, can be employed if the reactivity of the semiconductor

silicon carbide.

material is too high at the expected operating temperatures.

For example, alternate semiconductor materials might include _____, _____, _____, _____ and _____. It will be apparent that other semiconductor materials could be used as well.

A first preferred embodiment of a heater unit 10 according to the present invention is shown in FIGS. 2 and 3. Heater unit 10, which is to be employed in a flavor generating article, includes heater unit base 5 and a plurality of heaters 11-18, which are preferably made from the doped silicon semiconductor material discussed above. Each heater 11-18 preferably is substantially rectangular and has two ends, labelled 11A-18A and 11B-18B, respectively, for providing ohmic electrical contacts to the heater. Base 5 is preferably fabricated out of electrically insulating and thermally stable material.

Heater ends 11A-18A are attached to base 5 at collar 4 on the circumference of base 5. Heater ends 11A-18A provide the common connection for heater unit 10 and should therefore all be electrically connected together at a point adjacent collar 4. Preferably, collar 4 is electrically conducting under the regions where heater ends 11-18 contact collar 4. In the alternative, if collar 4 is made from electrically insulating material, then heater ends 11A-18A should be electrically connected together by some other means adjacent collar 4.

Terminals 21-28 are provided for individually contacting heaters ends 11B-18B. Individual wire connections can be provided from each heater end 11B-18B to its corresponding terminal 21-28, respectively. These individual wires (not shown) can run down center

region 6 of unit 10, at the periphery 7 of unit 10, adjacent any of heaters 11-18 or by any other means which allows a connection to heater ends 11B-18B. Terminals 21-28, although shown as cylindrical in FIGS. 2 and 3, can be any shape, corresponding to the shape of mating sockets on a source of electrical energy (e.g., batteries or other portable energy sources), to allow heaters 11-18 to be individually electrically activated.

In the alternative, instead of heater ends 11A-18A providing the common connection, heater ends 11B-18B could be used to provide the common connection. Under this alternative, terminals 21-28 would be insulated from ends 11B-18B and individually electrically connected to ends 11A-18A, respectively, and heater ends 11B-18B would be connected together. Preferably, under this alternative, collar 4 would be made from electrically insulating material.

Although not shown in FIGS. 2 and 3, flavor generating material is positioned adjacent one or both flat sides of each heaters 11-18 (e.g., sides 13C and 13D of heater 13). Preferably, heater unit 10 is permanent, and a disposable flavor generating material unit is inserted into a permanent heater unit 10. Suitable disposable flavor generating units are described in above-incorporated United States patent applications Serial Nos. 07/666,926 and 07/_____ (PM-1550). Accordingly, flavor generating material can be inserted into center region 6 to provide a "center-draw" embodiment (e.g., flavor generating material in thermal contact with side 13C of heater 13), or can be placed adajcent periphery 7 to provide a "peripheral-draw" embodiment (e.g., flavor generating material in thermal contact with side 13D of heater 13).

In the alternative, the flavor generating material can be an integral part of heater unit 10 to provide a "disposable" flavor generating/heater unit composite that is preferably discarded after each heater 11-18 is activated once. Such a disposable composite flavor generating/heater unit composite, although having a different design, is described in the above-incorporated United States Patent No. 5,060,671. For this alternative configuration, heater terminals 21-28 and the common terminal (not shown) should be adapted to be easily inserted and removed from the power source and other "permanent" portions of the flavor generating article.

Whether heater unit 10 is "permanent" or "disposable," if desired, base 5 may include one or more air passageways (not shown) to allow air to be drawn from the region adjacent terminals 21-28, through base 5, to center region 6 of unit 10.

A second embodiment of a heater unit 40 according to the present invention is shown in FIGS. 4 and 5. Heater unit 40 includes heater unit base 35 and a plurality of heaters 41-48, which are respectively inserted into receptacles 61-68, to provide a radial, rather than circumferential, orientation. Otherwise, heater unit 40 is similar to heater unit 10 shown in FIGS. 2 and 3.

Although FIGS. 2 and 4 show only two embodiments of the heater unit of the present invention, it will be understood that other designs could also be used. Whatever type of heater unit is employed, ohmic contacts having low resistance should be provided to the ends of the silicon electrical heaters so as to concentrate the generation of heat in the bulk of the silicon semiconductor material. Thus, if the silicon is doped with an n-type dopant, an

n-type ohmic contact to the semiconductor should be provided. For example, _____ _____ _____. Similarly, if the silicon is doped with a p-type dopant, a p-type ohmic contact to the semiconductor should be provided. For example, _____ _____.

In addition to having low electrical resistance, the contacts, as well as the heaters, should also be able to withstand the mechanical stresses involved in inserting the flavor generating material into the cavity of the article. This is the case whether or not the heaters are disposable. Accordingly, the contacts can be provided (a) by mechanical "clips" that grab opposing sides of the heater, (b) by thermosonic bonding, or (c) by bonding using multilayer diffusion processes. Any other known bonding or contacting technique may also be used.

In accordance with the principles of the present invention, a variety of electrical heaters having dimensions of about 14-16 mm in length, about 1.5 mm in width and about 0.36 mm (14 mils) in thickness, have been fabricated out of silicon doped with phosphorous at levels resulting in electrical resistivities of approximately 4.3×10^{-3} Ω-cm. These heaters had resistances of approximately 1.2 Ω. One second pulses at potentials of about 4.5 volts across these heaters produced surface temperatures ranging from about 500°C to about 700°C in still air.

Although the heater of the present invention has been discussed above with reference to FIGS. 2-5, wherein the flavor generating material is preferably in intimate thermal contact with the heater, this does not have to be the case. For example, the heater of the

present invention can be placed adjacent a source of liquid flavor generating material wherein the heater heats a quantity of liquid flavor generating material that is brought into contact with the heater.

Thus it is seen that an electrical heater for use in flavor generating articles is provided. One skilled in the art will appreciate that the present invention can be practiced by other than the described embodiments, which are presented for purposes of illustration and not of limitation, and the present invention is limited only by the claims which follow.

WHAT IS CLAIMED IS:

1. A heater for heating a flavor generating medium for delivering to a consumer a flavor-containing substance, the heater comprising semiconductor material.

2. The heater of claim 1 wherein the semiconductor material is doped with dopant impurities to provide a predetermined electrical resistivity.

3. The heater of claim 2 wherein the dopant impurities are a n-type dopant.

4. The heater of claim 3 wherein the heater has a resistance of between about 0.5 Ω and about 3.0 Ω.

5. The heater of claim 4 wherein the heater has a resistance of between about 1.0 Ω and about 1.6 Ω.

6. The heater of claim 5 wherein the heater is substantially rectangular.

7. The heater of claim 2 wherein the dopant impurities are a p-type dopant.

8. The heater of claim 7 wherein the heater has a resistance of between about 0.5 Ω and about 3.0 Ω.

9. The heater of claim 8 wherein the heater has a resistance of between about 1.0 Ω and about 1.6 Ω.

10. The heater of claim 9 wherein the heater is substantially rectangular.

11. The heater of claim 2 wherein the semiconductor material is non-uniformly doped with dopant impurities to provide a predetermined electrical resistivity profile.

12. The heater of claim 11 wherein the heater has a resistance of between about 0.5 Ω and about 3.0 Ω.

13. The heater of claim 12 wherein the heater has a resistance of between about 1.0 Ω and about 1.6 Ω.

14. The heater of claim 12 wherein the heater is substantially rectangular.

15. The heater of claim 1 wherein the semiconductor material is silicon.

16. The heater of claim 15 wherein the silicon semiconductor material is doped with dopant impurities to provide a predetermined electrical resistivity.

17. The heater of claim 16 wherein the dopant impurities are a n-type dopant.

18. The heater of claim 17 wherein the n-type dopant impurities are phosphorus impurities.

19. The heater of claim 18 wherein the silicon semiconductor material is doped with phosphorus

impurities to a level in the range of between about 1×10^{18} impurities/cm^3 and about 1×10^{20} impurities/cm^3.

20. The heater of claim 19 wherein the heater has a resistance of between about 0.5 Ω and about 3.0 Ω.

21. The heater of claim 20 wherein the heater has a resistance of between about 1.0 Ω and about 1.6 Ω.

22. The heater of claim 19 wherein the silicon semiconductor material is doped to a level in the range of between about 5×10^{18} impurities/cm^3 and about 5×10^{19} impurities/cm^3.

23. The heater of claim 22 wherein the heater is substantially rectangular.

24. The heater of claim 16 wherein the dopant impurities are a p-type dopant.

25. The heater of claim 24 wherein the p-type dopant impurities are boron impurities.

26. The heater of claim 25 wherein the silicon semiconductor material is doped with boron impurities to a level in the range of between about 1×10^{18} impurities/cm^3 and about 1×10^{20} impurities/cm^3.

27. The heater of claim 26 wherein the heater has a resistance of between about 0.5 Ω and about 3.0 Ω.

28. The heater of claim 27 wherein the heater has a resistance of between about 1.0 Ω and about 1.6 Ω.

29. The heater of claim 26 wherein the silicon semiconductor material is doped to a level in the range of between about 5×10^{18} impurities/cm^3 and about 5×10^{19} impurities/cm^3.

30. The heater of claim 29 wherein the heater is substantially rectangular.

31. The heater of claim 15 wherein the silicon semiconductor material is non-uniformly doped with dopant impurities to provide a predetermined electrical resistivity profile.

32. The heater of claim 31 wherein the heater has a resistance of between about 0.5 Ω and about 3.0 Ω.

33. The heater of claim 32 wherein the heater has a resistance of between about 1.0 Ω and about 1.6 Ω.

34. The heater of claim 33 wherein the heater is substantially rectangular.

35. The heater of claim 17 wherein the n-type dopant impurities are antimony impurities.

36. A heater unit for heating a flavor generating medium for delivering to a consumer a

flavor-containing substance, the heater unit comprising:

a heater base having a plurality of electrical terminals; and

a plurality of semiconductor electrical heaters disposed on the heater base, said heaters each having at least one surface adapted for making thermal contact with the flavor generating medium and each making electrical contact to a respective one of said plurality of electrical terminals, wherein when any one of said plurality of electrical heaters is activated, a respective fraction of said flavor generating medium in thermal contact with said one of said electrical heaters is heated, generating a predetermined quantity of flavor-containing substance for delivery to the consumer.

37. The heater unit of claim 36 wherein the heater base is substantially cylindrical and each of the plurality of electrical heaters has two opposing flat surfaces defining a plane, wherein the heaters are arranged with their respective planes aligned radially outward from the center of said cylinder.

38. The heater unit of claim 37 wherein the semiconductor electrical heaters are comprised of silicon semiconductor material.

39. The heater unit of claim 38 wherein the silicon semiconductor material is doped with dopant impurities to provide a predetermined electrical resistivity.

40. The heater unit of claim 39 wherein the dopant impurities are a n-type dopant.

41. The heater unit of claim 40 wherein the n-type dopant impurities are phosphorus impurities.

42. The heater unit of claim 41 wherein the silicon semiconductor material is doped with phosphorus impurities to a level in the range of between about 1×10^{18} impurities/cm^3 and about 1×10^{20} impurities/cm^3.

43. The heater unit of claim 42 wherein the heater has a resistance of between about 0.5 Ω and about 3.0 Ω.

44. The heater unit of claim 43 wherein the heater has a resistance of between about 1.0 Ω and about 1.6 Ω.

45. The heater unit of claim 42 wherein the silicon semiconductor material is doped to a level in the range of between about 5×10^{18} impurities/cm^3 and about 5×10^{19} impurities/cm^3.

46. The heater unit of claim 45 wherein each of the plurality of heaters are substantially rectangular.

47. The heater unit of claim 39 wherein the dopant impurities are a p-type dopant.

48. The heater unit of claim 47 wherein the p-type dopant impurities are boron impurities.

49. The heater unit of claim 48 wherein the silicon semiconductor material is doped with boron

impurities to a level in the range of between about 1×10^{18} impurities/cm^3 and about 1×10^{20} impurities/cm^3.

50. The heater unit of claim 49 wherein the heater has a resistance of between about 0.5 Ω and about 3.0 Ω.

51. The heater unit of claim 50 wherein the heater has a resistance of between about 1.0 Ω and about 1.6 Ω.

52. The heater unit of claim 49 wherein the silicon semiconductor material is doped to a level in the range of between about 5×10^{18} impurities/cm^3 and about 5×10^{19} impurities/cm^3.

53. The heater unit of claim 52 wherein each of the plurality of heaters are substantially rectangular.

54. The heater unit of claim 36 wherein the heater base is substantially cylindrical and each of the plurality of electrical heaters has two opposing flat surfaces, wherein the heaters are arranged circumferentially so that the flat surfaces are along the periphery of the heater base.

55. The heater unit of claim 54 wherein the semiconductor electrical heaters are comprised of silicon semiconductor material.

56. The heater unit of claim 55 wherein the silicon semiconductor material is doped with dopant

impurities to provide a predetermined electrical resistivity.

57. The heater unit of claim 56 wherein the dopant impurities are a n-type dopant.

58. The heater unit of claim 57 wherein the n-type dopant impurities are phosphorus impurities.

59. The heater unit of claim 58 wherein the silicon semiconductor material is doped with phosphorus impurities to a level in the range of between about 1×10^{18} impurities/cm^3 and about 1×10^{20} impurities/cm^3.

60. The heater unit of claim 59 wherein the heater has a resistance of between about 0.5 Ω and about 3.0 Ω.

61. The heater unit of claim 60 wherein the heater has a resistance of between about 1.0 Ω and about 1.6 Ω.

62. The heater unit of claim 60 wherein the silicon semiconductor material is doped to a level in the range of between about 5×10^{18} impurities/cm^3 and about 5×10^{19} impurities/cm^3.

63. The heater unit of claim 62 wherein each of the plurality of heaters are substantially rectangular.

64. The heater unit of claim 56 wherein the dopant impurities are a p-type dopant.

65. The heater unit of claim 64 wherein the p-type dopant impurities are boron impurities.

66. The heater unit of claim 65 wherein the silicon semiconductor material is doped with boron impurities to a level in the range of between about 1×10^{18} impurities/cm^3 and about 1×10^{20} impurities/cm^3.

67. The heater unit of claim 66 wherein the heater has a resistance of between about 0.5 Ω and about 3.0 Ω.

68. The heater unit of claim 67 wherein the heater has a resistance of between about 1.0 Ω and about 1.6 Ω.

69. The heater unit of claim 66 wherein the silicon semiconductor material is doped to a level in the range of between about 5×10^{18} impurities/cm^3 and about 5×10^{19} impurities/cm^3.

70. The heater unit of claim 69 wherein each of the plurality of heaters are substantially rectangular.

71. An article for delivering to a consumer a flavor-containing substance, said article comprising:

a heater base having a plurality of electrical terminals;

a plurality of semiconductor electrical heaters disposed on the heater base, said heaters each having at least one surface for making thermal contact to a flavor generating medium and each making

electrical contact to a respective one of said plurality of electrical terminals;

flavor generating medium disposed adjacent said heaters;

a source of electrical energy for powering said plurality of heaters through said electrical terminals; and

control means for applying said electrical energy to said heaters to heat at least one but fewer than all of said plurality of heaters;

wherein when any one of said plurality of semiconductor electrical heaters is activated, a respective fraction of said flavor generating medium in thermal contact with said one of said heaters is heated, generating a predetermined quantity of flavor-containing substance for delivery to the consumer.

72. The article of claim 71 wherein the semiconductor electrical heaters are comprised of silicon semiconductor material.

73. The article of claim 72 wherein the silicon semiconductor material is doped with dopant impurities to provide a predetermined electrical resistivity.

74. The article of claim 73 wherein the dopant impurities are a n-type dopant.

75. The article of claim 74 wherein the n-type dopant impurities are phosphorus impurities.

76. The article of claim 75 wherein the silicon semiconductor material is doped with phosphorus impurities to a level in the range of between about

1 x 10^{18} impurities/cm^3 and about 1 x 10^{20} impurities/cm^3.

77. The article of claim 76 wherein the heater has a resistance of between about 0.5 Ω and about 3.0 Ω.

78. The article of claim 77 wherein the heater has a resistance of between about 1.0 Ω and about 1.6 Ω.

79. The article of claim 76 wherein the silicon semiconductor material is doped to a level in the range of between about 5 x 10^{18} impurities/cm^3 and about 5 x 10^{19} impurities/cm^3.

80. The article of claim 79 wherein each of the plurality of heaters are substantially rectangular.

81. The article of claim 71 wherein said source of electrical energy comprises a battery.

~~82.~~ 83. The article of claim 71 wherein the heater base is substantially cylindrical and each of the plurality of electrical heaters has two opposing flat surfaces defining a plane, wherein the heaters are arranged with their respective planes aligned radially outward from the center of said cylinder.

~~83.~~ 84. The article of claim 71 wherein the heater base is substantially cylindrical and each of the plurality of electrical heaters has two opposing flat surfaces, wherein the heaters are arranged circumferentially so that the flat surfaces are along the periphery of the heater base.

82. The article of claim 81 wherein the batteries are rechargeable

84. The article of claim 83 wherein the flavor generating medium is disposed adjacent the flat surfaces of the heaters facing the inside periphery of the heater base.

85. The article of claim 83 wherein the flavor generating medium is disposed adjacent the flat surfaces of the heaters facing the outside periphery of the heater base.

86. The article of claim 73 wherein the dopant impurities are a p-type dopant.

87. The article of claim 86 wherein the p-type dopant impurities are boron impurities.

88. The article of claim 87 wherein the silicon semiconductor material is doped with boron impurities to a level in the range of between about 1×10^{18} impurities/cm^3 and about 1×10^{20} impurities/cm^3.

~~89~~ 90. The article of claim 88 wherein the heater has a resistance of between about 0.5 Ω and about 3.0 Ω.

90 91. The article of claim ~~89~~ wherein the heater has a resistance of between about 1.0 Ω and about 1.6 Ω.

91 92. The article of claim 88 wherein the silicon semiconductor material is doped to a level in the range of between about 5×10^{18} impurities/cm^3 and about 5×10^{19} impurities/cm^3.

92. The article of claim 91 wherein each of the plurality heaters are substantially rectangular.

93. The article of claim 73 comprising eight semiconductor electrical heaters so as to provide eight discrete heating regions to heat the flavor generating medium.

ELECTRICALLY-POWERED SEMICONDUCTOR HEATER ~~FOR FLAVOR GENERATING ARTICLES~~

Abstract Of The Disclosure

An electrical heater for use in electrically-heated flavor generating articles is provided. The heater is made from silicon or some other type of semiconductor material doped with n-type or p-type impurities to provide a predetermined electrical resistivity. When incorporated into flavor generating articles and made from silicon semiconductor material, such heaters can have resistances in the range of from about 0.5 Ω to about 3 Ω and are able to achieve operating temperatures in the range of from about 350°C to about 900°C, when in contact with flavor generating material, by pulsing with short-duration low-voltage pulses. An electrical heater unit containing a plurality of the heaters is also provided. Additionally, a flavor generating article containing the electrical heater unit is provided.

is relatively low (e.g., about 2.3 g/cm^3-2.6 g/cm^3 at 27°C, in comparison to that of, say, steel, which is about 7-8 g/cm^3 at 27°C), the flavor generating articles made with the electrical heaters of the present invention can be light in weight and will heat up quickly and efficiently transfer heat to the flavor generating medium.

Although FIG. 1 shows the electrical resistivity of silicon for only two types of ~~dopant~~ impurities -- phosphorus atoms and boron atoms --, it is understood that other ~~dopants~~ could as well be used. For example, alternate ~~dopants~~ might include antimony. As used herein, the term "~~dopant impurity~~" ~~is defined~~ to mean any substance, particle, defect, vacancy or complex, or the like, or any combination thereof, that is capable of altering the electrical resistivity of the semiconductor material through its incorporation therein.

The only restrictions on the types of dopant impurities that can be used are that they must provide an electrical resistivity in a range that allows the heater to achieve a surface temperature from about 350°C to about 900°C when in contact with a flavor generating medium in a flavor generating article, and they must have a low enough reactivity to avoid toxicological or other reactive effects. Alternatively, an encapsulant, such as ceramic or the like, can be employed if the reactivity of the doped silicon is too high at the expected operating temperatures. Suitable materials for encapsulation of the heaters include silica, alumina and sol gels. Additionally, a protective layer of SiO_2 or some other silicon-based oxide (SiO_x) can be provided on the surface of the silicon heater to serve as an encapsulant.

Terminals 21-28, although shown as cylindrical in FIGS. 2 and 3, can be any shape, corresponding to the shape of mating sockets on a source of electrical energy (e.g., batteries, which can be rechargeable if desired, or other portable energy sources), to allow heaters 11-18 to be individually electrically activated.

In the alternative, instead of heater ends 11A-18A providing the common connection, heater ends 11B-18B could be used to provide the common connection. Under this alternative, terminals 21-28 would be insulated from ends 11B-18B and individually electrically connected to ends 11A-18A, respectively, and heater ends 11B-18B would be connected together. Preferably, under this alternative, collar 4 would be made from electrically insulating material.

Although not shown in FIGS. 2 and 3, flavor generating material is positioned adjacent one or both flat sides of each heaters 11-18 (e.g., sides 13C and 13D of heater 13). Preferably, heater unit 10 is permanent, and a disposable flavor generating material unit is inserted into a permanent heater unit 10. Suitable disposable flavor generating units are described in above-incorporated United States patent applications Serial Nos. 07/666,926 and 07/_____ (PM-1550). Accordingly, flavor generating material can be inserted into center region 6 to provide a "center-draw" embodiment (e.g., flavor generating material in thermal contact with side 13C of heater 13), or can be placed adjacent periphery 7 to provide a "peripheral-draw" embodiment (e.g., flavor generating material in thermal contact with side 13D of heater 13).

In the alternative, the flavor generating material can be an integral part of heater unit 10 to provide a "disposable" flavor generating/heater unit

1 x 10^{18} impurities/cm^3 and about 1 x 10^{20} impurities/cm^3.

77. The article of claim 76 wherein the heater has a resistance of between about 0.5 Ω and about 3.0 Ω.

78. The article of claim 77 wherein the heater has a resistance of between about 1.0 Ω and about 1.6 Ω.

79. The article of claim 76 wherein the silicon semiconductor material is doped to a level in the range of between about 5 x 10^{18} impurities/cm^3 and about 5 x 10^{19} impurities/cm^3.

80. The article of claim 79 wherein each of the plurality of heaters are substantially rectangular.

81. The article of claim 71 wherein said source of electrical energy comprises a battery.

82. The article of claim 71 wherein the batteries are rechargeable.

83. The article of claim 71 wherein the heater base is substantially cylindrical and each of the plurality of electrical heaters has two opposing flat surfaces defining a plane, wherein the heaters are arranged with their respective planes aligned radially outward from the center of said cylinder.

84. The article of claim 71 wherein the heater base is substantially cylindrical and each of the plurality of electrical heaters has two opposing