



(51) International Patent Classification:

G12B 17/02 (2006.01) B82Y 30/00 (2011.01)
H05K 9/00 (2006.01)

(21) International Application Number:

PCT/US2017/055604

(22) International Filing Date:

06 October 2017 (06.10.2017)

(25) Filing Language:

English

(26) Publication Language:

English

(71) Applicant: **HEWLETT-PACKARD DEVELOPMENT COMPANY, L.P.** [US/US]; 11445 Compaq Center Drive W, Houston, TX 77070 (US).

(72) Inventors: **WU, Kuan-Ting**; 10F, No. 66, Jing Mao 2 Rd., NanGang District, Taipei City, 11568 (TW). **TSENG, Weiming**; 10F, No. 66, Jing Mao 2 Rd., NanGang District, Taipei City, 11568 (TW). **LI, Ai-Tsung**; 10F, No. 66, Jing Mao 2 Rd., NanGang District, Taipei City, 11568 (TW). **HUANG, Chi-Chih**; 10F, No. 66, Jing Mao 2 Rd., NanGang District, Taipei City, 11568 (TW).

(74) Agent: **MAISAMI, Ceyda Azakli**; HP Inc., 3390 E Harmony Road, Fort Collins, CO 80528 (US).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,

SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- as to the identity of the inventor (Rule 4.17(i))
- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))

Published:

- with international search report (Art. 21(3))

(54) Title: RADIO-FREQUENCY ABSORPTION IN ELECTRONIC DEVICES

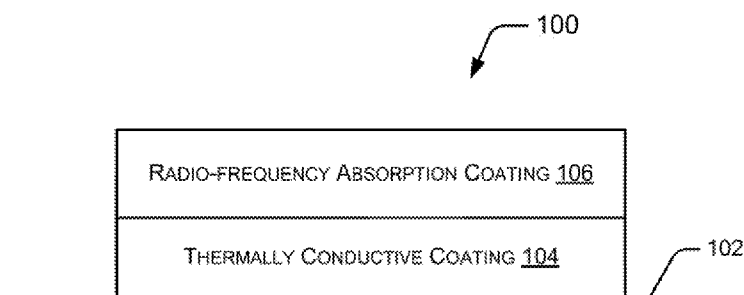


Fig. 1

(57) Abstract: The present subject matter relates to radio-frequency absorption in electronic devices. In an example implementation, a thermally conductive coating or material is disposed on a surface in an electronic device, and a radio-frequency absorption coating is coated on the thermally conductive coating or material.



RADIO-FREQUENCY ABSORPTION IN ELECTRONIC DEVICES

BACKGROUND

[0001] Electronic devices, such as computers, tablets, and smartphones, are commonly used for a variety of purposes, including communication. Such electronic devices may communicate with other devices over a wireless connection. Wireless communication to and from the electronic devices may involve reception and transmission of radio-frequency signals.

BRIEF DESCRIPTION OF DRAWINGS

[0002] The following detailed description references the drawings, wherein:

[0003] Fig. 1 illustrates a sectional view of a surface of an enclosure, according to an example implementation of the present subject matter;

[0004] Fig. 2 illustrates a sectional view of a surface of an enclosure, according to an example implementation of the present subject matter;

[0005] Fig. 3 illustrates a sectional view of a surface of an enclosure, according to an example implementation of the present subject matter;

[0006] Fig. 4 illustrates a sectional view of a surface of an enclosure, according to an example implementation of the present subject matter; and

[0007] Fig. 5 illustrates an electronic device, according to an example implementation of the present subject matter.

DETAILED DESCRIPTION

[0008] Radio-frequency (RF) signals utilized for wireless communication may cause electromagnetic interference in electrical circuits of electronic devices. RF signals, in a frequency range of 10^4 to 10^{11} Hz, may be generated internally in the electronic device, or emitted from an external source. The electromagnetic interference due to RF signals may degrade or disrupt the performance of electrical circuits and therefore of the associated electronic devices. In an example, the quality of displays on a display screen of an electronic device may

degrade, and the processing speed of the central processing unit (CPU) of an electronic device may reduce, due to electromagnetic interference.

[0009] Electronic devices may be provided with coatings that can absorb RF signals. An RF absorption coating that is generally used has a low RF absorption capacity. Further, the RF signals absorbed by such a coating are converted into heat. Heating of the RF absorption coating degrades the RF absorption capacity of the RF absorption coating. Also, heat in the RF absorption coating may add up with the heat generated by other electrical circuits, such as a CPU, in the vicinity of the RF absorption coating to create heat spots inside the electronic device. Such heat spots may affect the performance of electrical circuits in the electronic devices.

[0010] Further, the RF absorption coating is generally coated on an inner surface of an enclosure or a body panel of the electronic device. Excessive heating of the RF absorption coating due to absorption of RF signals and absorption of heat from electrical circuits may create heat spots on the outer surface of the enclosure. Heat spots on the outer surface may cause inconvenience to users.

[0011] The present subject matter relates to absorption of RF signals in electronic devices. The present subject matter describes a combination of coatings on a surface of an enclosure, or a body panel, of an electronic device having high RF absorption capacity and heat dissipation characteristic. In accordance with the present subject matter, high RF absorption capacity facilitates in reducing electromagnetic interferences in the electronic device, and heat dissipation characteristic facilitates in reducing heat spots inside the enclosure of the electronic device.

[0012] In an example implementation of the present subject matter, a thermally conductive coating is disposed on a surface of an enclosure of an electronic device. The thermally conductive coating absorbs heat from surrounding regions and allows the absorbed heat to flow through it. Further, an RF absorption coating is coated on the thermally conductive coating. The RF absorption coating absorbs RF signals from the surrounding regions. The surface on which the thermally conductive coating is coated may be an inner surface of

the enclosure. With the thermally conductive coating coated on the surface of the enclosure and the RF absorption coating coated on the thermally conductive coatings, the heat generated within the RF absorption coating due to absorption of RF signals gets dissipated through the thermally conductive coating. Continuous dissipation of heat from the RF absorption coating helps in maintaining a substantially constant temperature of the RF absorption coating, which in turn facilitates in substantially uniform RF absorption by the RF absorption coating.

[0013] In an example implementation of the present subject matter, the RF absorption coating is made of a resin mixture including 5 to 30 weight% (wt%) of conductive polymers, and aerogels including at least one of 0.05 to 3 wt% of carbon nanotube aerogel and 0.05 to 3 wt% of graphene aerogel. The RF absorption coating with the chemical composition and concentrations of constituents, as described above, has high RF absorption capacity. For example, more than 90% of RF signals are absorbed by the RF absorption coating of the present subject matter.

[0014] Further, in an example implementation of the present subject matter, the enclosure may include a heat insulation coating coated between the surface of the enclosure and the thermally conductive coating. The heat insulation coating prevents heat to be conducted from the thermally conductive coating to the surface of the enclosure, thereby avoiding formation of heat spots on the outer side of the surface of the enclosure.

[0015] The following detailed description refers to the accompanying drawings. Wherever possible, the same reference numbers are used in the drawings and the following description to refer to the same or similar parts. While several examples are described in the description, modifications, adaptations, and other implementations are possible. Accordingly, the following detailed description does not limit the disclosed examples. Instead, the proper scope of the disclosed examples may be defined by the appended claims.

[0016] Fig. 1 illustrates a sectional view of a surface 102 of an enclosure 100, according to an example implementation of the present subject matter. The enclosure 100 may be a body panel of an electronic device (not shown). The

surface 102 may be an inner surface of the body panel, which is not exposed to the external environment. The electronic device may, for example, include a computer, a laptop, a tablet, a smartphone, and such. The body panel may, for example, include a top cover panel, a bottom cover panel, side cover panel, or other outer casing of the electronic device. In an example, the enclosure 100 may be made of a plastic material.

[0017] The enclosure 100 has a thermally conductive coating 104 on the surface 102. The thermally conductive coating 104 may be coated on a portion of the surface 102. In an example implementation, the thermally conductive coating 104 is made of one of nano-sized powder of aluminum, copper, silver, graphene, carbon nanotube, diamond, graphite, silicon carbide, boron nitride, and synthetic thermally conductive materials in polymeric resins. The thermally conductive coating 104 may have a thickness in a range of 5 micrometer (μm) to 15 μm . The thermally conductive coating 104 may be spray coated on the surface 102. In an example implementation, the surface 102 may be cleaned before coating the thermally conductive coating 104. Further, after spray coating the thermally conductive coating, the surface 102 may be heated at a temperature in a range of 60 degree Celsius ($^{\circ}\text{C}$) to 80 $^{\circ}\text{C}$ for a time duration in a range of 15 minutes to 40 minutes for curing the thermally conductive coating 104.

[0018] Further, as shown in Fig. 1, the enclosure 100 has an RF absorption coating 106 coated on the thermally conductive coating 104. The RF absorption coating 106 may be coated on a portion of or on the entire of the thermally conductive coating 104. The RF absorption coating 106 is made of a resin mixture including conductive polymers and aerogels. The conductive polymers have a concentration of 5 to 30 by wt%. The aerogels include at least one of carbon nanotube aerogel and graphene aerogel. The concentration of carbon nanotube aerogel and graphene aerogel is 0.05 to 3 by wt%. Further, the conductive polymers may include poly-3,4-ethylenedioxythiophene (PEDOT), polyacetylene, polyphenylenevinylene, polythienylenevinylene, polythiophene, poly-3-alkylthiophene, polypyrrole, polyaniline, polyphenylene, polyphenylene sulfide, polyfuran and perfluoroalkylsulfonyl compounds, and a combination thereof. In an example implementation, the resin mixture also includes polyacrylic,

polycarbonate, polyurethane, silicone, polyvinyl chloride, epoxy, polyester, polypropylene, urethane-acrylate, and a combination thereof.

[0019] Further, in an example implementation, the RF absorption coating 106 may have a thickness in a range of 10 μm to 50 μm . The RF absorption coating 106 may be spray coated on the thermally conductive coating 104. In an example implementation, after spray coating the RF absorption coating, the surface 102 may be heated at a temperature in a range of 50 $^{\circ}\text{C}$ to 60 $^{\circ}\text{C}$ for a time duration in a range of 5 minutes to 15 minutes for curing the RF absorption coating 106. After such a thermal curing, the RF absorption coating 106 is cured under ultraviolet (UV) radiations. The RF absorption coating 106 may be exposed to UV radiation of an energy dose of 0.7 Joules/centimeter² (J/cm^2) to 1.2 J/cm^2 for a time duration in a range of 10 seconds to 30 seconds.

[0020] The RF absorption coating 106 absorbs more than 90% of RF signals that may be generated from internal electrical circuits of the electronic device associated with the enclosure 100, or from an external source. RF waves associated with the RF signals are trapped in the carbon nanotube aerogel or graphene aerogel in the RF absorption coating 106. The trapped RF waves get absorbed by the conductive polymers in the RF absorption coating 106 and are converted into heat. The heat from the RF absorption coating 106 gets transferred to the thermally conductive coating 104. The transfer of heat from the RF absorption coating 106 to the thermally conductive coating 104 is continuous, which facilitates in maintaining the temperature of the RF absorption coating 106 for uniform absorption of RF signals.

[0021] Fig. 2 illustrates a sectional view of a surface 202 of an enclosure 200, according to an example implementation of the present subject matter. The enclosure 200 may be a body panel of an electronic device (not shown), as described earlier. The enclosure 200 has a heat insulation coating 204 coated on the surface 202. The heat insulation coating 204 may be coated on a portion of the surface 202. In an example implementation, the heat insulation coating 204 is made of fiberglass, mineral wools, cellulose, calcium silicate, cellular glass, elastomeric foam, phenolic foam, vermiculite, polyurethane foam, silica aerogel, polystyrene foam in polymeric resins, and a combination thereof.

[0022] The heat insulation coating 204 may have a thickness in a range of 5 μm to 20 μm . The heat insulation coating 204 may be spray coated on the surface 202. In an example implementation, the surface 202 may be cleaned before coating the heat insulation coating 204. Further, after spray coating the heat insulation coating, the surface 202 may be heated at a temperature in a range of 60 $^{\circ}\text{C}$ to 80 $^{\circ}\text{C}$ for a time duration in a range of 15 minutes to 40 minutes for curing the heat insulation coating 204.

[0023] Further, as shown in Fig. 2, the enclosure 200 has a thermally conductive coating 206 coated on the heat insulation coating 204, and has an RF absorption coating 208 coated on the thermally conductive coating 206. The thermally conductive coating 206 may be coated on a portion of or on the entire of the heat insulation coating 204, and the RF absorption coating 208 may be coated on a portion of or on the entire of the thermally conductive coating 206. The thermally conductive coating 206 is the same as the thermally conductive coating 104 described through description of Fig. 1. The RF absorption coating 208 is the same as the RF absorption coating 106 described through description of Fig. 1.

[0024] The heat insulation coating 204 prevents heat to be conducted from the thermally conductive coating 206 to the surface 202 of the enclosure 200. This facilitates in preventing heat spots of the outer surface of the enclosure 200.

[0025] Fig. 3 illustrates a sectional view of a surface 302 of an enclosure 300, according to an example implementation of the present subject matter. The enclosure 300 may be a body panel of an electronic device (not shown), as described earlier. The enclosure 300 has a thermally conductive material 304 disposed on the surface 302 of the enclosure 300. The thermally conductive material 304 may be disposed on a portion of the surface 302. The thermally conductive material 304 may be prefabricated block or sheet. The thermally conductive material 304 comprising one of a copper foil, an aluminum foil, a composite foil, a graphite film, graphene on a metal deposition film, and a graphene film. The thermally conductive material 304 has a thickness in a range of 0.015 mm to 0.3 mm. In an example implementation, the thermally conductive material 304 may be pasted on the surface 302 using an adhesive.

[0026] Further, as shown in Fig. 3, the enclosure 300 has an RF absorption coating 306 coated on the thermally conductive material 304. The RF absorption coating 306 may be coated on a portion of or on the entire of the thermally conductive material 304. The RF absorption coating 306 is the same as the RF absorption coating 106 described through description of Fig. 1. The RF absorption coating 306 absorbs more than 90% of RF signals that may be generated from internal electrical circuits of the electronic device associated with the enclosure 100, or from an external source. RF waves associated with the RF signals are trapped in the carbon nanotube aerogel or graphene aerogel in the RF absorption coating 306. The trapped RF waves get absorbed by the conductive polymers in the RF absorption coating 306 and are converted into heat. The heat from the RF absorption coating 306 get transferred to the thermally conductive material 304. The transfer of heat from the RF absorption coating 306 to the thermally conductive material 304 is continuous, which facilitates in maintaining the temperature of the RF absorption coating 306 for uniform absorption of RF signals.

[0027] Fig. 4 illustrates a sectional view of a surface 402 of an enclosure 400, according to an example implementation of the present subject matter. The enclosure 400 may be a body panel of an electronic device (not shown), as described earlier. The enclosure 400 has a heat insulation coating 404 coated on the surface 402 of the enclosure 400. The heat insulation coating 404 may be coated on a portion of the surface 402. The heat insulation coating 404 is the same as the heat insulation coating 204 described through the description of Fig. 2.

[0028] Further, as shown in Fig. 4, the enclosure 400 has a thermally conductive material 406 disposed on the heat insulation coating 404, and has an RF absorption coating 408 coated on the thermally conductive material 406. The thermally conductive material 406 may be disposed on a portion of or on the entire of the heat insulation coating 404, and the RF absorption coating 408 may be coated on a portion of or on the entire of the thermally conductive material 406. The thermally conductive material 406 is the same as the thermally conductive material 304 described through description of Fig. 3. The RF absorption coating

408 is the same as the RF absorption coating 106 described through description of Fig. 1. The heat insulation coating 404 prevents heat to be conducted from the thermally conductive material 406 to the surface 402 of the enclosure 400. This facilitates in preventing heat spots of the outer surface of the enclosure 400.

[0029] Fig. 5 illustrates an electronic device 500, according to an example implementation of the present subject matter. It may be noted that although a laptop is shown in Fig. 5, the electronic device 500 may be any other electronic device, such as tablet, a smartphone, and the like. The electronic device 500 includes a body panel 502. The body panel 502, also referred to as an enclosure, includes a top cover panel, a bottom cover panel, side cover panel, or other outer casing of the electronic device 500. In an example, the body panel 502 may be made of a plastic material.

[0030] As illustrated in a magnified sectional view of region A of the electronic device 500, the electronic device 500 includes a thermally conductor 506 disposed on a surface 504 of the body panel 502. The thermally conductor 506 may be disposed on a portion of the surface 504. The surface 504 is an inner surface of the body panel 502, which is not exposed to the external environment. The thermally conductor 506 may be the same as the thermally conductive coating 104 as described through the description of Fig. 1, or the same as the thermally conductive material 304 as described through the description of Fig. 3.

[0031] Further, as shown in Fig. 5, the electronic device 500 has an RF absorption coating 508 coated on the thermally conductor 506. The RF absorption coating 508 may be coated on a portion of or on the entire of the thermally conductor 506. The RF absorption coating 508 is the same as the RF absorption coating 106 described through description of Fig. 1.

[0032] It may be noted that region A is shown to be at the bottom cover panel, the thermally conductor 506 and the RF absorption coating 508 may be disposed at any other body panel, such as the top cover panel or the side cover panel. The thermally conductor 506 and the RF absorption coating 508 are disposed on a portion of inner surface of the body panel.

[0033] In an example implementation, the electronic device 500 may have a heat insulation coating (not shown in Fig. 5) between the surface 504 of the body

panel 502 and the thermally conductor 506. The heat insulation coating may be the same as the heat insulation coating 204, as described through description of Fig. 2. The heat insulation coating may be coated on a portion of the surface 504. The thermally conductor may be disposed on a portion of or on the entire of the heat insulation coating. The RF absorption coating may be coated on a portion of or on the entire of the thermally conductor.

[0034] Although examples for the present disclosure have been described in language specific to structural features, it is to be understood that the appended claims are not limited to the specific features described herein. Rather, the specific features are disclosed and explained as examples of the present disclosure.

We claim:

1. An enclosure of an electronic device, comprising:
 - a thermally conductive coating disposed on a surface of the enclosure; and
 - a radio-frequency (RF) absorption coating on the thermally conductive coating.
2. The enclosure as claimed in claim 1, wherein the RF absorption coating is made of a resin mixture comprising:
 - 5 to 30 wt% of conductive polymers; and
 - aerogels including at least one of 0.05 to 3 wt% of carbon nanotube aerogel and 0.05 to 3 wt% of graphene aerogel.
3. The enclosure as claimed in claim 2, wherein the resin mixture comprises polyacrylic, polycarbonate, polyurethane, silicone, polyvinyl chloride, epoxy, polyester, polypropylene, urethane-acrylate, and a combination thereof.
4. The enclosure as claimed in claim 2, wherein the conductive polymers comprise poly-3,4-ethylenedioxythiophene (PEDOT), polyacetylene, polyphenylenevinylene, polythienylenevinylene, polythiophene, poly-3-alkylthiophene, polypyrrole, polyaniline, polyphenylene, polyphenylene sulfide, polyfuran and perfluoroalkylsulfonyl compounds, and a combination thereof.
5. The enclosure as claimed in claim 1, wherein the RF absorption coating has a thickness in a range of 10 μm to 50 μm .
6. The enclosure as claimed in claim 1, wherein the thermally conductive coating is made of one of nano-sized powder of aluminum, copper, silver, graphene, carbon nanotube, diamond, graphite, silicon carbide, boron nitride, and synthetic thermally conductive materials in polymeric resins.

7. The enclosure as claimed in claim 1, wherein the thermally conductive coating has a thickness in a range of 5 μm to 15 μm .
8. The enclosure as claimed in claim 1, comprising a heat insulation coating between the surface of the enclosure and the thermally conductive coating.
9. The enclosure as claimed in claim 8, wherein the heat insulation coating has a thickness in a range of 5 μm to 20 μm , and is made of fiberglass, mineral wools, cellulose, calcium silicate, cellular glass, elastomeric foam, phenolic foam, vermiculite, polyurethane foam, silica aerogel, polystyrene foam in polymeric resins, and a combination thereof.
10. An enclosure of an electronic device, comprising:
a thermally conductive material disposed on a surface of the enclosure, the thermally conductive material comprising one of a copper foil, an aluminum foil, a composite foil, a graphite film, graphene on a metal deposition film, and a graphene film; and
a radio-frequency (RF) absorption coating on the thermally conductive material, the RF absorption coating being made of a resin mixture comprising:
5 to 30 wt% of conductive polymers; and
aerogels including at least one of 0.05 to 3 wt% of carbon nanotube aerogel and 0.05 to 3 wt% of graphene aerogel.
11. The enclosure as claimed in claim 10, wherein the RF absorption coating has a thickness in a range of 10 μm to 50 μm .
12. The enclosure as claimed in claim 10, wherein the thermally conductive material has a thickness in a range of 0.015 mm to 0.3 mm.
13. An electronic device comprising:
a body panel;
a thermal conductor disposed on a surface of the body panel; and

a radio-frequency (RF) absorption coating on the thermal conductor, the RF absorption coating being made of a resin mixture comprising:

5 to 30 wt% of conductive polymers; and

aerogels including at least one of 0.05 to 3 wt% of carbon nanotube aerogel and 0.05 to 3 wt% of graphene aerogel.

14. The electronic device as claimed in claim 13, wherein

the resin mixture comprises polyacrylic, polycarbonate, polyurethane, silicone, polyvinyl chloride, epoxy, polyester, polypropylene, urethane-acrylate, and a combination thereof; and

the conductive polymers comprise poly-3,4-ethylenedioxythiophene (PEDOT), polyacetylene, polyphenylenevinylene, polythienylenevinylene, polythiophene, poly-3-alkylthiophene, polypyrrole, polyaniline, polyphenylene, polyphenylene sulfide, polyfuran and perfluoroalkylsulfonyl compounds, and a combination thereof.

15. The electronic device as claimed in claim 13, comprising a heat insulation coating between the surface of the body panel and the thermal conductor.

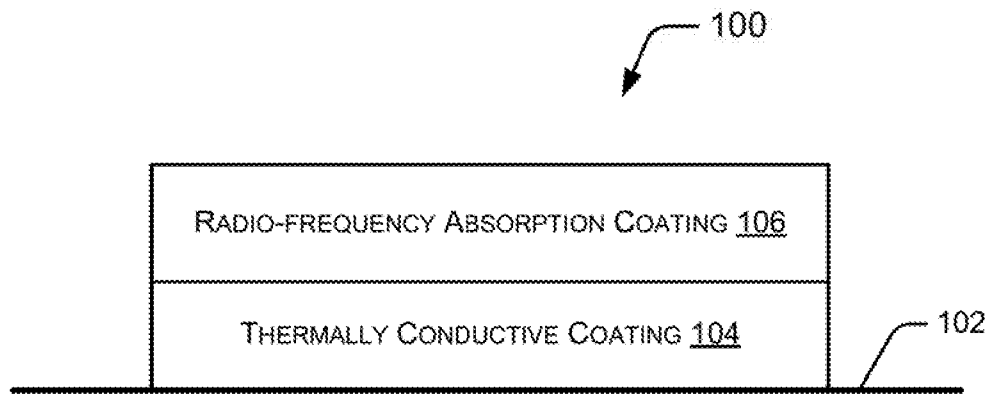


Fig. 1

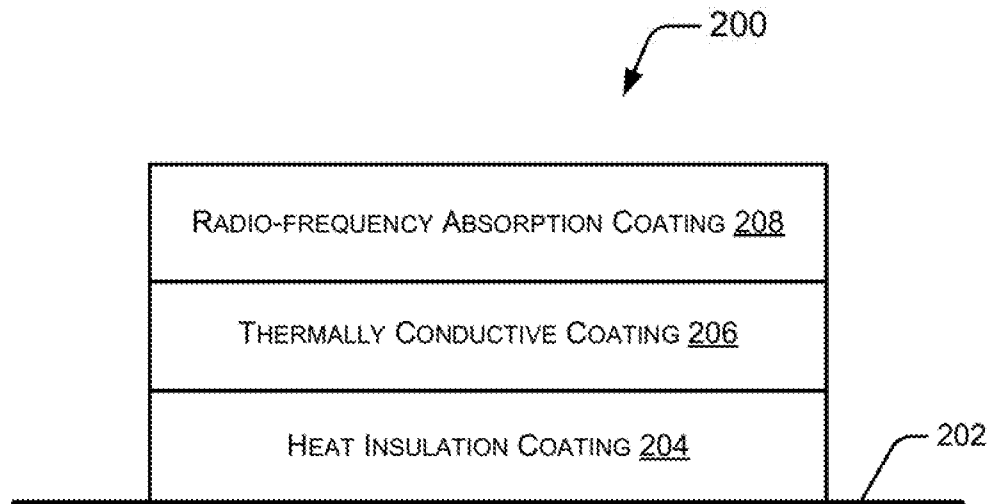


Fig. 2

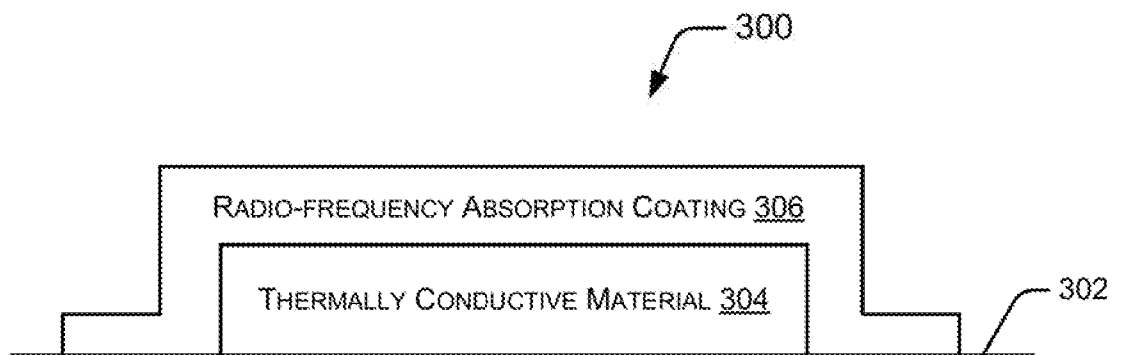


Fig. 3

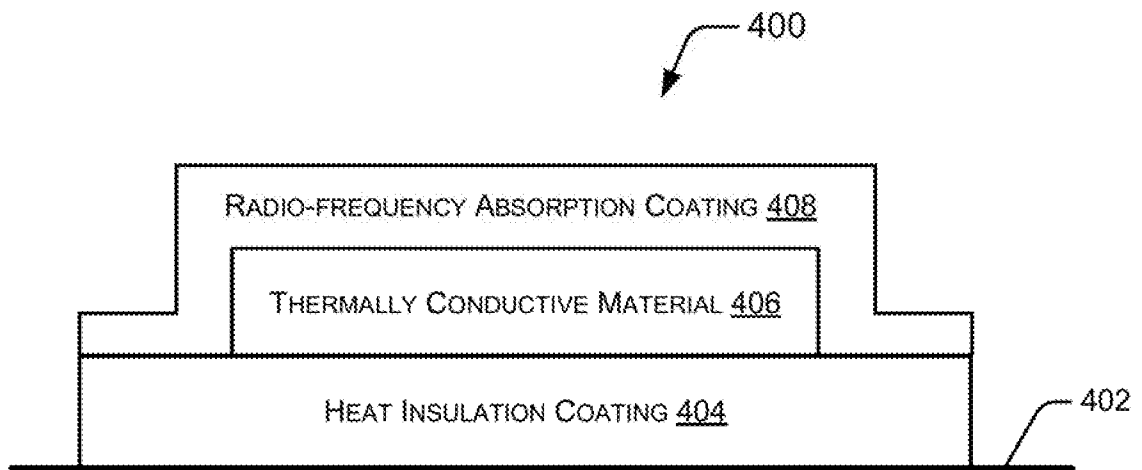


Fig. 4

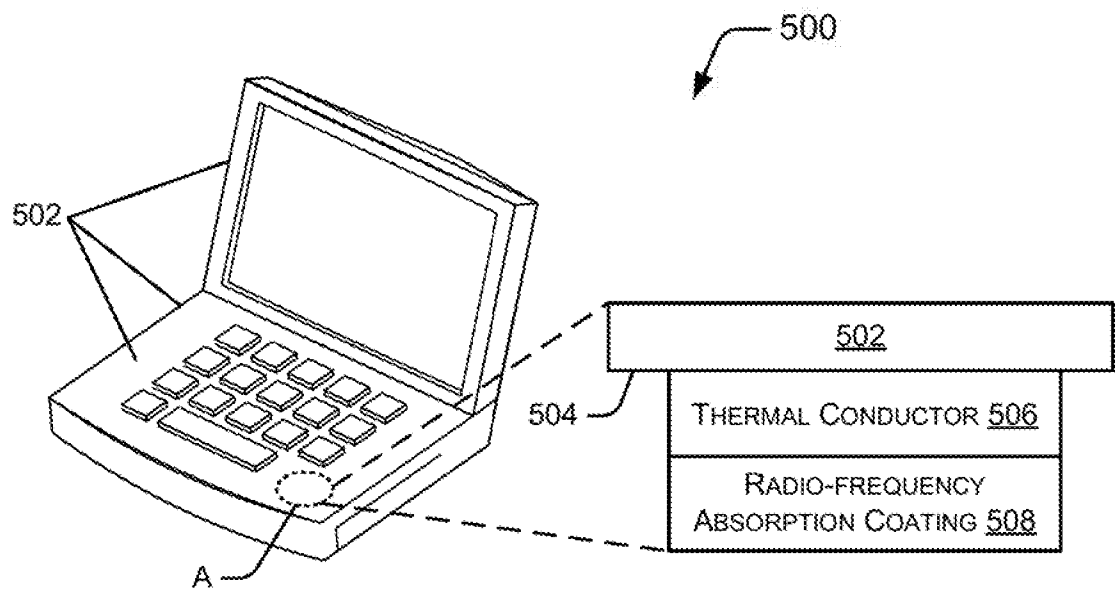


Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2017/055604

A. CLASSIFICATION OF SUBJECT MATTER		
G12B 17/02 (2006.01) H05K 9/00 (2006.01) B82Y 30/00 (2011.01)		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
G12B 17/00, 17/02, H05K 9/00, 13/00, H01B 1/00, 1/04, 1/22, B05D 3/00, 3/02, B82Y 30/00		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, DWPI, EAPATIS, PATENTSCOPE, Information Retrieval System of FIPS		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6763576 B2 (PARKER-HANNIFIN CORPORATION) 20.07.2004, fig. 3, Ref. no. 14, 32, 42, 50, col. 3, lines 9-49, col. 4, lines 32-50, col. 5, lines 13-32, 65-67, col. 7, lines 6-56	1, 5
Y		6-9
A		2-4, 10-15
Y	US 5518758 A (EMI-TEC ELECTRONISCHE MATERIALIEN GMBH) 21.05.1996, col.3, lines 23-32, col.5, lines 25-36	6-7
Y	US 2007/0209833 A1 (GERALD ROBERT INGLISH) 13.09.2007, fig.2, Ref. no 130, 140, [0047]-[0049]	8-9
☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family	
"A" document defining the general state of the art which is not considered to be of particular relevance		
"E" earlier document but published on or after the international filing date		
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)		
"O" document referring to an oral disclosure, use, exhibition or other means		
"P" document published prior to the international filing date but later than the priority date claimed		
Date of the actual completion of the international search	Date of mailing of the international search report	
27 June 2018 (27.06.2018)	02 August 2018 (02.08.2018)	
Name and mailing address of the ISA/RU: Federal Institute of Industrial Property, Berezhkovskaya nab., 30-1, Moscow, G-59, GSP-3, Russia, 125993 Facsimile No: (8-495) 531-63-18, (8-499) 243-33-37	Authorized officer O. Gudkova Telephone No. (499) 240-25-91	

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2017/055604

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2014/0178289 A1 (LAWRENCE LIVERMORE NATIONAL SECURITY, LLC) 26.06.2014	1-15
A	US 2009/0291608 A1 (JEONGWAN CHOI et al) 26.11.2009	1-15