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(54) Title: ULTRASONIC PROBE

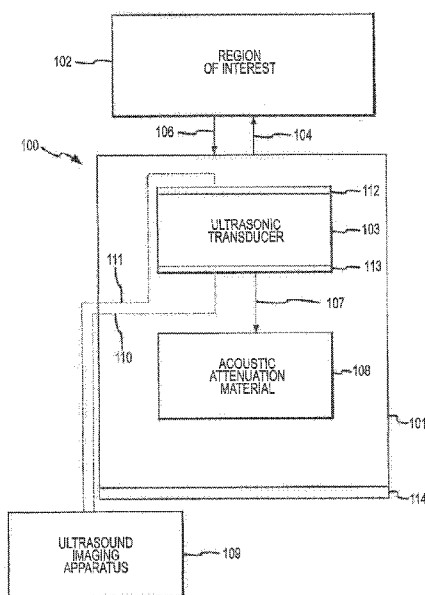


FIG.1

(57) Abstract: An ultrasonic probe that comprises an ultrasonic transducer that includes an array of transducer elements and an attenuation material is provided. The attenuation material comprises a polymer composition that includes a liquid crystalline polymer and a thermally conductive particulate material. The liquid crystalline polymer has a melting temperature of about 270°C or more and a melt viscosity of about 500 Pa·s or less as determined at a temperature of 45°C above the melting temperature and shear rate of 400 s<sup>-1</sup> in accordance with ISO Test No. 11443:2005, and the polymer composition also has a through-plane conductivity of about 0.2 W/m·K or more.



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- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2020/040951

A. CLASSIFICATION OF SUBJECT MATTER  
 IPC(8) - A61B 8/12; B06B 1/06; G01N 29/02; H01L 41/18 (2020.01)  
 CPC - A61B 8/12; B06B 1/06; G01N 29/02; H01L 41/18 (2020.08)

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)

see Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

see Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

see Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 2019/031047 A1 (SONY CORPORATION) 14 February 2019 (14.02.2019) see machine translation	1-22
Y	US 6,022,491 A (SAMUELS et al) 08 February 2000 (08.02.2000) entire document	1-9, 16-22
Y	US 2013/0200297 A1 (SAGA) 08 August 2013 (08.08.2013) entire document	1, 10-15
Y	WO 2004/058915 A1 (E.I. DU PONT DE NEMOURS AND COMPANY) 15 July 2004 (15.07.2004) entire document	6-9
A	US 2016/0145411 A1 (3M INNOVATIVE PROPERTIES COMPANY et al) 26 May 2016 (26.05.2016) entire document	1-22
A	WO 2015/145402 A1 (KONINKLIJKE PHILIPS N.V.) 01 October 2015 (01.10.2015) entire document	1-22

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"D" document cited by the applicant in the international application

"E" earlier application or patent 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

"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

Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2020/040951

**Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1.  Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

see extra sheet(s)

1.  As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2.  As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
  
4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:  
1-22

- Remark on Protest**
- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
  - The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
  - No protest accompanied the payment of additional search fees.

**INTERNATIONAL SEARCH REPORT**

International application No.

PCT/US2020/040951

Continued from Box No. III Observations where unity of invention is lacking

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees need to be paid.

Group I+: claims 1-22 are drawn to ultrasonic probes.

The first invention of Group I+ is restricted to an ultrasonic probe comprising: an ultrasonic transducer that includes an array of transducer elements capable of converting electrical energy to ultrasonic acoustic energy for emission towards a region of interest; and an attenuation material that is capable of inhibiting the return of the ultrasonic acoustic energy back towards the ultrasonic transducer after emission towards the region of interest, wherein the attenuation material comprises a polymer composition that includes a liquid crystalline polymer and a thermally conductive particulate material, wherein the liquid crystalline polymer has a melting temperature of about 270 C or more and a melt viscosity of about 500 Pa-s or less as determined at a temperature of 45 C above the melting temperature and shear rate of 400 s<sup>-1</sup> in accordance with ISO Test No. 11443:2005, and further wherein the polymer composition has a through-plane conductivity of about 0.2 W/m-K or more, wherein the liquid crystalline polymer comprises repeating units (1) to (3) as shown in instant claim 2, wherein Ra, Rb, and Rf are independently absent; and l, m, and q are independently 0. It is believed that claims 1-22 read on this first named invention and thus these claims will be searched without fee to the extent that they read on the above embodiment.

Applicant is invited to elect additional formula(e) for each additional compound to be searched in a specific combination by paying an additional fee for each set of election. Each additional elected formula(e) requires the selection of a single definition for each compound variable. An exemplary election would be an ultrasonic probe comprising: an ultrasonic transducer that includes an array of transducer elements capable of converting electrical energy to ultrasonic acoustic energy for emission towards a region of interest; and an attenuation material that is capable of inhibiting the return of the ultrasonic acoustic energy back towards the ultrasonic transducer after emission towards the region of interest, wherein the attenuation material comprises a polymer composition that includes a liquid crystalline polymer and a thermally conductive particulate material, wherein the liquid crystalline polymer has a melting temperature of about 270 C or more and a melt viscosity of about 500 Pa-s or less as determined at a temperature of 45 C above the melting temperature and shear rate of 400 s<sup>-1</sup> in accordance with ISO Test No. 11443:2005, and further wherein the polymer composition has a through-plane conductivity of about 0.2 W/m-K or more, wherein the liquid crystalline polymer comprises repeating units (1) to (3) as shown in instant claim 2, wherein Ra is halo, wherein the halo is fluorine, wherein the fluorine is in the 2-position, Rb, and Rf are independently absent; and l is 1 and m, and q are independently 0. Additional formula(e) will be searched upon the payment of additional fees. Applicants must specify the claims that read on any additional elected inventions. Applicants must further indicate, if applicable, the claims which read on the first named invention if different than what was indicated above for this group. Failure to clearly identify how any paid additional invention fees are to be applied to the "+" group(s) will result in only the first claimed invention to be searched/examined.

The inventions listed in Groups I+ do not relate to a single general inventive concept under PCT Rule 13.1, because under PCT Rule 13.2 they lack the same or corresponding special technical features for the following reasons:

The Groups I+ formulae do not share a significant structural element requiring the selection of alternatives for the liquid crystalline polymer, and accordingly these groups lack unity a priori.

Additionally, even if Groups I+ were considered to share the technical features of an ultrasonic probe comprising: an ultrasonic transducer that includes an array of transducer elements capable of converting electrical energy to ultrasonic acoustic energy for emission towards a region of interest; and an attenuation material that is capable of inhibiting the return of the ultrasonic acoustic energy back towards the ultrasonic transducer after emission towards the region of interest, wherein the attenuation material comprises a polymer composition that includes a liquid crystalline polymer and a thermally conductive particulate material, wherein the liquid crystalline polymer has a melting temperature of about 270 C or more and a melt viscosity of about 500 Pa-s or less as determined at a temperature of 45 C above the melting temperature and shear rate of 400 s<sup>-1</sup> in accordance with ISO Test No. 11443:2005, and further wherein the polymer composition has a through-plane conductivity of about 0.2 W/m-K or more, these shared technical features do not represent a contribution over the prior art as disclosed by WO 2019/031047 A1 to Sony Corporation and US 2016/0145411 A1 to 3M Innovative Properties Company et al.

WO 2019/031047 A1 to Sony Corporation teaches an ultrasonic probe (See machine translation, Abstract, an ultrasound diagnostic probe) comprising: an ultrasonic transducer that includes an array of transducer elements capable of converting electrical energy to ultrasonic acoustic energy for emission towards a region of interest (See machine translation, Claim 1, A piezoelectric layer made of a piezoelectric material and generating an ultrasonic wave ... The ultrasonic transducer for ultrasonic imaging; Pg. 6, Para. 5, the ultrasonic transducer 100 is an array of transducer elements 150); and an attenuation material that is capable of inhibiting the return of the ultrasonic acoustic energy back towards the ultrasonic transducer after emission towards the region of interest (See machine translation, Claim 1, An acoustic attenuation layer made of an acoustic attenuation material having an acoustic impedance lower than that of the piezoelectric material).

US 2016/0145411 A1 to 3M Innovative Properties Company et al. teach material comprises a polymer composition that includes a liquid crystalline polymer (Para. [0072], the polymer material for the component parts and polymer/boron nitride ... liquid crystalline polymers (LCP)) and a thermally conductive particulate material (Claim 229), A component part produced from a polymer/boron nitride compound, wherein the polymer/boron nitride compound comprises at least one polymer material, at least one thermally conductive filler, and at least one reinforcing filler, and wherein the at least one thermally conductive filler comprises boron nitride agglomerates.), wherein the liquid crystalline polymer has a melting temperature of about 270 C or more and a melt viscosity of about 500 Pa-s or less as determined at a temperature of 45 C above the melting temperature and shear rate of 400 s<sup>-1</sup> in accordance with ISO Test No. 11443:2005, and further wherein the polymer composition has a through-plane conductivity of about 0.2 W/m-K or more (Claim 5; i.e., the composition contains the liquid crystalline polymer and thermally conductive particle material, thus, the composition must inherently exhibit the same properties).

The inventions listed in Groups I+ therefore lack unity under Rule 13 because they do not share a same or corresponding special technical feature.