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(54) Title: ACOUSTIC LENS FOR ULTRASONIC TRANSDUCER PROBE WITH A MANUFACTURED TEXTURED SURFACE

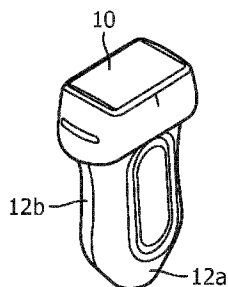


FIG. 1a

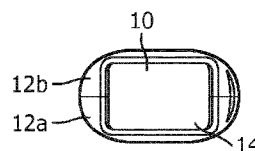


FIG. 1b

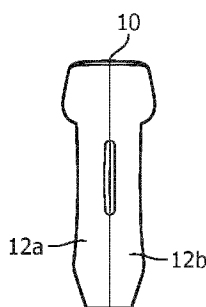


FIG. 1c

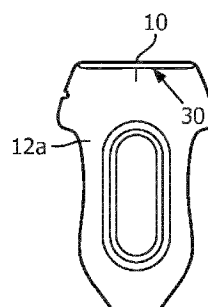


FIG. 1d

(57) Abstract: An ultrasound probe has an acoustic window (10) or lens (20) through which ultrasound is transmitted and received by a transducer array (30) located behind the lens or window inside a probe enclosure. The external, patient-contacting surface (24) of the acoustic lens or window is textured. The texturing of the surface of the lens or window better retains gel spread over the lens or window for an ultrasound procedure, reduces reverberation artifacts, and diminishes the appearance of scratches on the lens or window.



**(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).

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ACOUSTIC LENS FOR ULTRASONIC TRANSDUCER PROBE  
WITH A MANUFACTURED TEXTURED SURFACE

5 This invention relates to transducer probes for  
medical diagnostic ultrasound systems and, in  
particular, to acoustic lenses for ultrasound probes  
having a textured outer surface.

10 An ultrasound probe is the hand-held instrument  
with which a sonographer scans a patient. The probe  
contains an ultrasonic transducer element or array of  
elements that transmit ultrasonic energy through a  
portion of the probe case referred to as an acoustic  
window or acoustic lens. Ultrasonic echo signals  
returning from the body of the patient pass through  
15 the acoustic window or lens and are received by the  
transducer elements which convert them to electrical  
signals. The electrical signals are coupled by a  
probe cable and connector to the ultrasound system  
used to energize the transducer and to process and  
20 display the received echo signals. The transducer  
array is usually constructed as an acoustic stack,  
including layers of acoustic matching material on the  
front (emitting) surface of the elements and a layer  
of acoustic damping material behind the elements.  
25 Many transducer stacks also include a microbeamformer  
integrated circuit that can be coupled to an array.  
The microbeamformer drives the elements with  
electrical signals for transmission and receives and  
partially beamforms received echo signals.  
30 Microbeamformers are common in two dimensional array  
transducer probes which must operate and control many  
thousands of transducer elements.

35 In order to form ultrasound images of high  
diagnostic quality it is desirable to achieve the  
highest possible signal-to-noise ratios for the

received echo signals. To do this it is necessary to effectively acoustically couple ultrasound energy between the transducer array and the body of the patient. This is done, for example, by bonding the transducer stack to the inside of the acoustic lens, generally with an epoxy. Alternatively, the lens can be cast on the array. The acoustic lens or window must be made of a material which is highly transmissive of ultrasound. The probe is then acoustically coupled to the skin of the patient by applying a coating of acoustic gel to the face of the acoustic lens. The acoustic gel is somewhat viscous and very slippery. Moreover, the coating of gel will often adhere to the initial location of the skin contacted by the probe, and will mostly remain in that location as the probe is manipulated over the skin surface during a scanning procedure. Thus, it is frequently necessary to apply a large quantity of gel to the probe and to reapply gel frequently during the procedure. Additionally, insufficient gel on the lens surface can result in the entrapment of air bubbles, which give rise to shadowing artifacts in the image. It would thus be desirable to improve the gel retention characteristic of the acoustic lens so that less gel can be used during a procedure and less frequent reapplication of gel is needed.

In accordance with the principles of the present invention, an acoustic window or lens of an ultrasound probe has a textured external surface. The texturing provides tiny recesses or valleys in the lens surface which help retain gel in place on the lens. While conventional understanding would lead one to believe that a textured surface would give rise to deleterious artifacts in the received echo signals, it has been found that texturing can

actually reduce artifacts by improving the reverberation characteristics of the lens.

Furthermore, it has been found that texturing can reduce the visibility of small scratches incurred during probe use and handling. These favorable characteristics can be achieved by producing probe windows and lenses with a range of depths and densities of texturing as described below.

In the drawings:

FIGURE 1 illustrates an ultrasound probe case for a two dimensional array transducer with a textured acoustic window constructed in accordance with the principles of the present invention.

FIGURE 2 illustrates different views of the textured acoustic window of the probe of FIGURE 1.

FIGURE 3 illustrates a textured acoustic window for a probe with a one dimensional array transducer constructed in accordance with the principles of the present invention.

FIGURE 4 shows three examples of the textured surface of an acoustic window or lens of the present invention.

Referring first to FIGURE 1a, a probe enclosure or case and acoustic window for an ultrasound probe of the present invention is shown in a perspective view. The probe case illustrated here is of a clam shell design with a front portion 12a and a mating back portion 12b both made of a polymeric material. Located at the distal end of the probe at the top of the drawing is an acoustic window part 10. The acoustic window part 10 is made of a molded polymer, such as an injection molded polymer, preferably a thermoplastic polyolefin, and is rectangular in shape with rounded corners. This particular acoustic window, shown in a plan view of the distal

(transmitting and receiving) end of the probe in  
FIGURE 1b, is such that the inner surface is slightly  
larger than the two dimensional array transducer 30  
used in the probe. In a constructed implementation,  
5 the two dimensional array measures at least 6.8cm<sup>2</sup>  
(17mm by 40mm) and preferably 8.0cm<sup>2</sup> (20mm by 40mm)  
for excellent image quality in a variety of  
applications, including vascular imaging, 3D  
panoramic imaging, and 3D vessel cast imaging. The  
10 external surface 14 of the acoustic window is  
textured as described below. In this implementation  
the acoustic window is very slightly curved in the  
elevation dimension as shown in the side view of the  
probe case and acoustic window of FIGURE 1c. The two  
15 dimensional array transducer is bonded to the inside  
surface of the acoustic window piece 10 as indicated  
by the arrow 30 in FIGURE 1d.

The acoustic window 10 of FIGURE 1 is shown in  
the enlarged views of FIGURE 2. This particular  
20 acoustic window piece is formed with a raised lip  
around the sides as FIGURE 2 shows. The arrow R in  
FIGURE 2a indicates the slight rounding of the  
corners of the piece 10. The raised lip gives the  
piece a dish-like shape as best shown in FIGURES 2b  
25 and 2c, which fits inside the distal end of the probe  
case. The array transducer 30 is bonded to the inner  
surface of the acoustic window, the surface facing  
upward in FIGURE 2b. The outer surface 14 is  
textured in accordance with the present invention as  
30 best shown in FIGURE 2c.

An acoustic lens 20 for a one dimensional array  
transducer is shown in FIGURE 3. Like the acoustic  
window piece 10 of FIGURE 2, the acoustic lens 20 of  
FIGURE 3 is formed of an injection molded  
35 thermoplastic olefin and has a raised lip around the

sides that fits with the probe case, as best shown in  
FIGURE 3c. The outer surface 24 of the acoustic lens  
20 which faces the viewer in FIGURE 3a is textured as  
described below. The cross-sectional view of FIGURE  
5 3b shows the acoustic lens 20 with an array  
transducer 30 bonded to its inner surface. The  
horizontal dimension of FIGURE 3a is the azimuth  
dimension of the array transducer and the vertical  
dimension is the elevation dimension of the array.  
10 As FIGURE 3b shows, the acoustic lens surface 24 is  
curved in the elevation dimension to provide focusing  
of the acoustic energy in the elevation dimension.

In accordance with the principles of the present  
invention the external surface of the acoustic window  
15 and acoustic lens of the preceding drawings is  
textured as illustrated in the surface images of  
FIGURE 4. The texturing produces a surface of raised  
and recessed regions as these drawings illustrate.  
The texturing of the surface is both visible to the  
20 naked eye as FIGURE 4 illustrates, and can be felt  
tactilely when a finger is rubbed against the  
surface. The pattern of the texturing can be a  
regular pattern or a randomized pattern as shown in  
these examples, with a randomized pattern being  
25 preferred. The most desirable difference in height  
between the most elevated points and the deepest  
points of the texturing can vary from one mil  
(0.001") to four mils (0.004"); when the texturing  
depth exceeds four mils, some users may sense that  
30 the texture is becoming rough to the touch. In the  
example of FIGURE 4a the texturing has a depth of one  
mil, whereas the examples of FIGURES 4b and 4c show  
samples with 1.5 mil deep texturing. The density of  
the peaks and valleys of the texturing over the  
35 surface area can vary, for example, over a wide range

from 5% and 95%, 10% and 90%, 20% and 80%, 30% and 70%, 40% and 60%, or 60% and 40%. That is, 20% of the surface can be recessed valleys and 80% can be projections at one extreme, and 80% of the surface can be recessed valleys and 20% can be projections at the other. In most implementations the ratio of peaks to valleys will be near 50%, such as 60%/40% or 60%/50%. The areas of the peaks can be very small, less than one mil, or much larger such as the larger, more planar raised areas which give the surface a mottled appearance as shown in the example of FIGURE 4c. All of the illustrated examples have exhibited a superior ability retain gel that is spread over the surface of the window or lens, as the gel will fill the valleys of the textured surface which better retains it in place. The external surface 14 of the acoustic lens of FIGURE 1b has a surface area of over 12cm<sup>2</sup>. It is difficult to retain gel over a lens area this large during use of the probe, a problem which is addressed by the texturing of the external surface of the lens. The textured surfaces have further been found to retain the gel better as the gel-covered lens is moved over the skin of a subject, as the recesses of the texture retain some gel even while the probe is moved in contact with the skin. And as mentioned above, the textured surface also has been found to exhibit better reverberation performance. When the probe is used in the vicinity of strong reflectors, such as the ribs when doing cardiac scanning, ultrasound waves reflected back from the ribs can be reflected from a smooth lens surface back into the subject, causing unwanted reverberation echoes. The textured surface will provide some scattering to these back-reflected waves, reflecting more discontinuous wavefronts that cause reduced

reverberation artifacts in an image. The visibility of scratches on the lens arising during normal probe handling and use is also markedly diminished with the textured lens surface.

5           While the texturing can be formed on the surface of a previously produced smooth lens, the preferred technique is to form the textured surface during injection molding of the lens or window. The surface of the mold which forms the external surface of the  
10 lens or window is impressed, embossed, etched, or otherwise constructed to have a reverse of the textured surface so that the injection molding of the lens or window will produce the finished piece with the desired textured surface. Alternatively,  
15 texturing can be produced using a cast material, such as RTV or polyurethane.

          It should be noted that the limitations of the following claims are not written in means-plus-function format and are not intended to be  
20 interpreted based on 35 U.S.C. 112, sixth paragraph, unless and until such claim limitations expressly use the phrase "means for" followed by a statement of function devoid of further structure.

25

WHAT IS CLAIMED IS:

1. An ultrasound probe comprising:  
a probe enclosure;  
5 a transducer array located in the probe enclosure; and  
an acoustic lens or window, forming a part of the probe enclosure between the transducer array and the exterior of the enclosure, the acoustic lens or  
10 window having a manufactured textured external surface.
2. The ultrasound probe of Claim 1, wherein the lens or window is formed of a molded polymer.  
15
3. The ultrasound probe of Claim 2, wherein the polymeric material further comprises a thermoplastic polyolefin.
- 20 4. The ultrasound probe of Claim 1, wherein the textured surface further exhibits a regular pattern.
5. The ultrasound probe of Claim 4, wherein  
25 the textured surface further exhibits a randomized pattern.
6. The ultrasound probe of Claim 1, wherein the textured surface further comprises a plurality of  
30 peaks and valleys.
7. The ultrasound probe of Claim 6, wherein the difference between the height of the peaks and valleys is within a range of one to four mils (0.001"  
35 to 0.004").

8. The ultrasound probe of Claim 7, wherein the difference between the height of the peaks and valleys is approximately 1.5 mils (0.015").

5

9. The ultrasound probe of Claim 1, wherein the ratio of the peaks to the valleys of the textured surface is within a range of 20% to 80%.

10

10. The ultrasound probe of Claim 9, wherein the ratio of the peaks to the valleys of the textured surface is within a range of 40% to 60%.

15

11. The ultrasound probe of Claim 1, wherein the transducer array further comprises a one dimensional transducer array.

20

12. The ultrasound probe of Claim 1, wherein the transducer array further comprises a two dimensional transducer array.

25

13. The ultrasound probe of Claim 12, wherein the transducer array has an area of at least 6.8cm<sup>2</sup>.

14. The ultrasound probe of Claim 13, wherein the transducer array has an area of at least 8.0cm<sup>2</sup>.

30

15. The ultrasound probe of Claim 1, wherein the texturing of the external surface is both visible and has a tactility that can be felt.

1/2

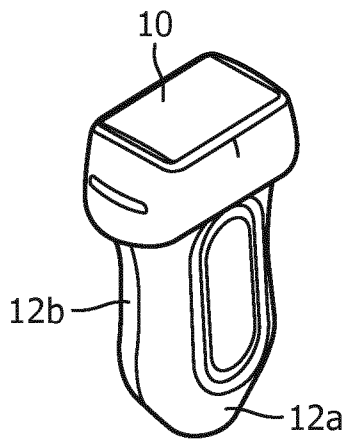


FIG. 1a

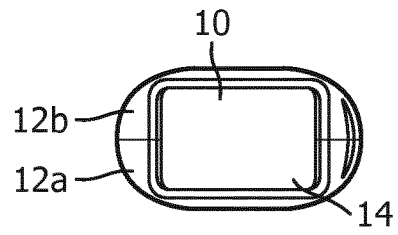


FIG. 1b

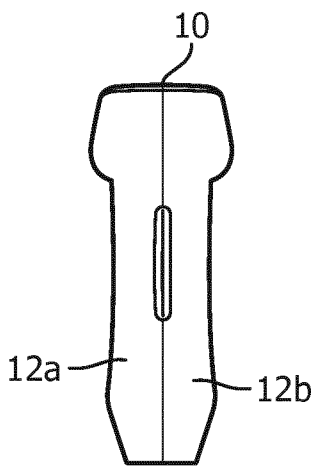


FIG. 1c

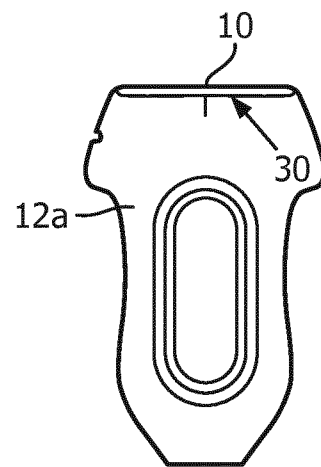


FIG. 1d

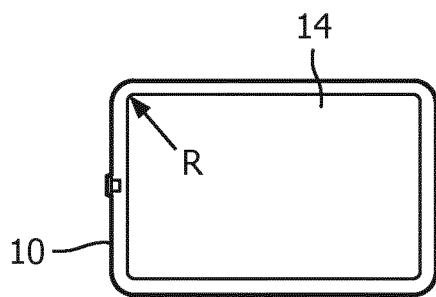


FIG. 2a

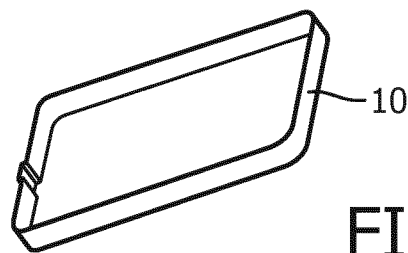


FIG. 2b

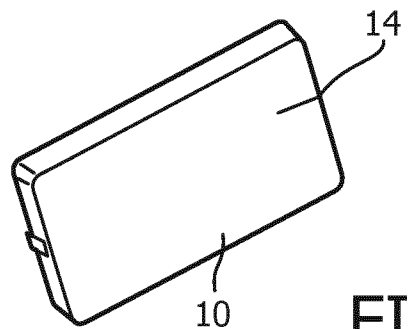


FIG. 2c

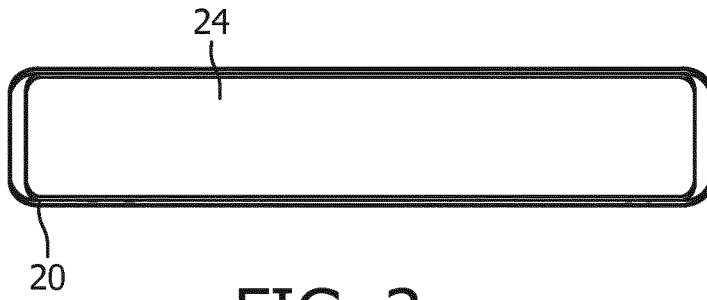


FIG. 3a

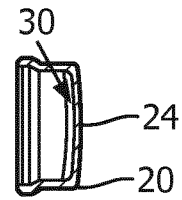


FIG. 3b

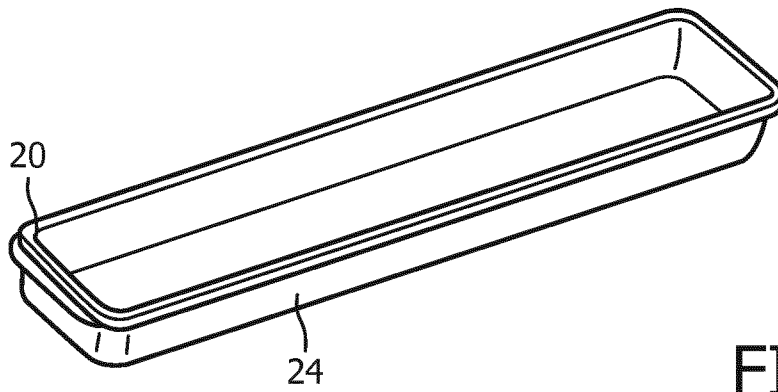


FIG. 3c

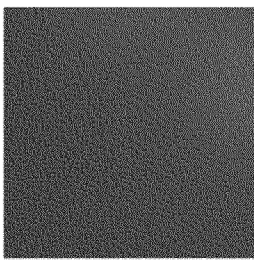


FIG. 4a

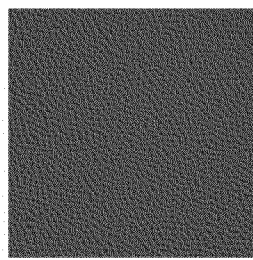


FIG. 4b

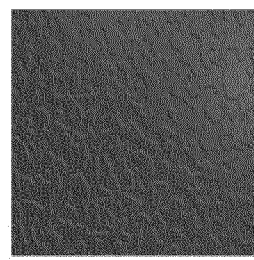


FIG. 4c

INTERNATIONAL SEARCH REPORT

International application No  
PCT/EP2018/058355

A. CLASSIFICATION OF SUBJECT MATTER  
INV. A61B8/00 G10K11/30  
ADD.  
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)  
A61B G10K

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)  
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP H07 114393 A (NIPPON DENSO CO) 2 May 1995 (1995-05-02) the whole document	1-15
X	WO 2015/117185 A1 (SIGNOSTICS LTD [AU]) 13 August 2015 (2015-08-13) page 2, lines 17-24 page 5, lines 2-24 page 12, lines 16-24 claims 1-4 figure 12	1-15

Further documents are listed in the continuation of Box C.  See patent family annex.

\* Special categories of cited documents :

<p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier application or patent but published on or after the international filing date</p> <p>"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)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"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</p> <p>"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</p> <p>"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</p> <p>"&amp;" document member of the same patent family</p>
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Date of the actual completion of the international search  31 May 2018	Date of mailing of the international search report  12/06/2018
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Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer  Willig, Hendrik
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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2018/058355

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP H07114393	A	02-05-1995	NONE
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WO 2015117185	A1	13-08-2015	AU 2015213467 A1 22-09-2016
			US 2016345933 A1 01-12-2016
			WO 2015117185 A1 13-08-2015
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专利名称(译)	具有结构化表面的超声波探头的声学透镜		
公开(公告)号	<a href="#">EP3600057A1</a>	公开(公告)日	2020-02-05
申请号	EP2018719451	申请日	2018-03-30
[标]申请(专利权)人(译)	皇家飞利浦电子股份有限公司		
申请(专利权)人(译)	皇家飞利浦N.V.		
当前申请(专利权)人(译)	皇家飞利浦N.V.		
[标]发明人	CUSCUNA DINO FRANCESCO BRUNELLE ELIZABETH DAVIDSEN LORIANN WILSON MARTHA GAIL GREWE HART JEFFREY SCOTT KUNKEL III HARRY AMON		
发明人	CUSCUNA, DINO FRANCESCO BRUNELLE, ELIZABETH DAVIDSEN, LORIANN WILSON, MARTHA GAIL GREWE HART, JEFFREY SCOTT KUNKEL III, HARRY AMON PRICE, GERRED ALLEN HACKENBERRY, JAMES WILLIAM		
IPC分类号	A61B8/00 G10K11/30		
CPC分类号	A61B8/4281 A61B8/4444 B06B2201/76 G10K11/30		
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优先权	62/479657 2017-03-31 US		
外部链接	<a href="#">Espacenet</a>		

#### 摘要(译)

超声探头具有声窗 ( 10 ) 或透镜 ( 20 ) , 位于探头罩内部的透镜或窗后面的换能器阵列 ( 30 ) 通过该声窗发送和接收超声。声透镜或窗口的外部患者接触表面 ( 24 ) 带有纹理。镜片或窗口表面的纹理化可以更好地保留凝胶, 以便在超声过程中散布在镜片或窗口上, 减少混响伪影, 并减少镜片或窗口上划痕的出现。