



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
15.06.2016 Bulletin 2016/24

(51) Int Cl.:
H01P 7/10 (2006.01)

(21) Application number: **14196783.6**

(22) Date of filing: **08.12.2014**

(84) Designated Contracting States:
**AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR**
Designated Extension States:
BA ME

(71) Applicant: **Nokia Solutions and Networks Oy**
02610 Espoo (FI)

(72) Inventor: **Ilmonen, Matias**
91900 Liminka (FI)

(74) Representative: **Borgström, Markus et al**
Nokia Solutions and Networks GmbH & Co. KG
T&I IPR Patent Administration
St.-Martin-Straße 76
80240 München (DE)

(54) **Radio frequency resonator assembly**

(57) This document discloses a resonator assembly comprising: a first ceramic resonator article (100) having determined radio frequency resonance characteristics; a second ceramic resonator article (102) having determined radio frequency resonance characteristics; a coupling sheet (104) attached between the first ceramic res-

onator article (100) and the second ceramic resonator article (102), wherein the coupling sheet (104) is made of electrically conductive material and comprises a pattern in the form of at least one through hole (106) for tuning properties of the resonator assembly.

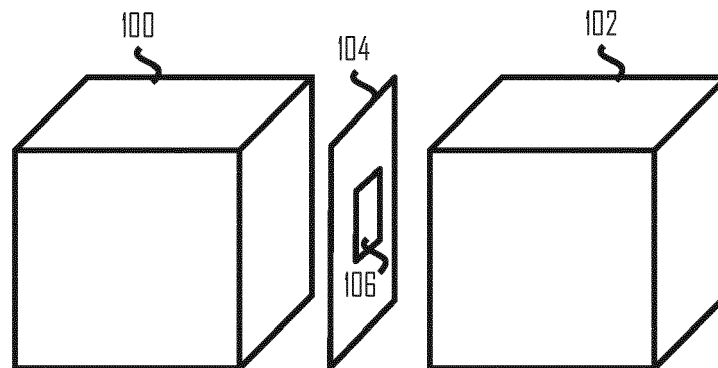


Fig 1A

Description

TECHNICAL FIELD

[0001] The invention relates to radio frequency resonators and, particularly, ceramic resonators.

TECHNICAL BACKGROUND

[0002] Ceramic resonators are widely used to form radio frequency (RF) filters for radio transmitters and radio receivers. Such ceramic filters are typically made of ceramic material that provides a piezo-electric effect and resonates on one or more frequencies. A dual-mode ceramic resonator may resonate on two resonating frequencies, and a triple-mode ceramic resonator may resonate on three resonating frequencies. The ceramic resonators may be combined to each other to form a ceramic filter having desired passband characteristics.

BRIEF DESCRIPTION

[0003] Some aspects of the invention are defined by the subject-matter of the independent claims. Embodiments are defined in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0004] In the following the invention will be described in greater detail by means of preferred embodiments with reference to the accompanying drawings, in which

Figures 1A and 1B, illustrate a resonator assembly according to an embodiment of the invention;
Figure 1C illustrates a resonator assembly according to another embodiment of the invention;
Figure 2 illustrates plating of the resonator assembly according to an embodiment of the invention;
Figure 3 illustrates a resonator assembly according to another embodiment of the invention;
Figure 4 illustrates a resonator assembly according to an embodiment of the invention, provided with electrodes;
Figure 5 illustrates a method for producing a resonator assembly according to an embodiment of the invention;
Figure 6 illustrates a method for plating the resonator assembly according to an embodiment of the invention; and
Figures 7 to 9 illustrate some embodiments for tuning the resonator assembly.

DETAILED DESCRIPTION OF EMBODIMENTS

[0005] The following embodiments are exemplary. Although the specification may refer to "an", "one", or "some" embodiment(s) in several locations, this does not necessarily mean that each such reference is to the same

embodiment(s), or that the feature only applies to a single embodiment. Single features of different embodiments may also be combined to provide other embodiments. Furthermore, words "comprising" and "including" should be understood as not limiting the described embodiments to consist of only those features that have been mentioned and such embodiments may contain also features/structures that have not been specifically mentioned.

[0006] Figures 1A and 1B illustrate a conceptual structure of a resonator assembly according to an embodiment of the invention. The resonator assembly may be comprised of concatenated ceramic resonators designed to provide a pass band on radio frequencies (RF). State-of-the-art manufacturing methods enable manufacturing of ceramic resonators that provide resonating frequencies up to microwave frequencies, e.g. super high frequencies from 0.3 to 30 Gigahertz. As illustrated in Figures 1A and 1B, the resonator assembly may be built from a plurality of ceramic resonator articles 100, 102 attached to each other (see Figure 1 B). A first ceramic resonator article 100 may provide one or more resonance frequencies, while a second ceramic resonator article 102 may provide one or more resonance frequencies on frequencies different from that/those of the first ceramic resonator article 100. Each ceramic resonator article may resonate on more than one frequencies. A dual-mode ceramic resonator may provide two resonance frequencies, while a triple-mode ceramic resonator may provide three resonance frequencies. Combination of resonance frequencies of the ceramic resonator articles attached together may define the pass band of the resonator assembly.

[0007] The resonance properties of the ceramic resonators may be modified by reshaping the ceramic resonators. The reshaping may comprise grinding ceramic material off from the ceramic resonators. This process requires very high accuracy, e.g. the tolerances may be in the order of micrometres, and the reshaping is typically carried out manually which is time-consuming. Another feature of conventional methods is that the ceramic resonators are plated completely with conductive plating and a pattern is formed in the surface of the plating, e.g. by employing laser pattern forming techniques. If the resonator does not have the desired properties, the plating needs to be removed at least from one surface of the ceramic resonator in order to reshape the ceramic material. Then, the plating and the patterning needs to be repeated which is time-consuming.

[0008] Let us now describe a resonator assembly according to an embodiment of the invention with reference to Figures 1A and 1B. The resonator assembly comprises the first ceramic resonator article 100 having determined radio frequency (RF) resonance characteristics, and the second ceramic resonator article 102 having determined radio frequency resonance characteristics. The RF resonance characteristics of the ceramic resonator articles 100, 102 of the resonator assembly may differ from each

other. The resonator assembly further comprises a coupling sheet 104 attached between the first ceramic resonator article 100 and the second ceramic resonator article 102 (see Figure 1B where the ceramic articles 100, 102 and the coupling sheet are attached to each other). The coupling sheet 104 may be made of electrically conductive material and comprise a pattern in the form of at least one through hole 106 tuning properties of the resonator assembly.

[0009] An effect of the present embodiment is that the tuning of the resonator assembly properties may be carried out by modifying or replacing the coupling sheet. This brings the advantage in that the replacement of the coupling sheet is fast and easy to perform.

[0010] In an embodiment, the resonator assembly forms a filter apparatus. The filter apparatus may be a duplex filter or a filter configured to be disposed on a single signal line, e.g. it may comprise only one input and only one output.

[0011] A ceramic resonator article may be an object or a body made of ceramic material. The material, shape, and dimensions of the article may be designed such that the ceramic resonator article has the determined frequency characteristics, e.g. the determined resonance properties.

[0012] The coupling sheet may be soldered to the ceramic resonator articles 100, 102.

[0013] The material of the coupling sheet may be copper, silver, or another metal alloy with high conductive plating.

[0014] In an embodiment, sides of the first ceramic resonator article and the second ceramic resonator article facing the coupling sheet are smooth. In another embodiment, the side(s) of each ceramic resonator article comprised in the apparatus and facing a coupling sheet is/are smooth. By smooth it is meant that the side does not comprise any pattern, recession, protrusion, and/or hole. The smooth surface may improve the positioning of the coupling sheet.

[0015] In an embodiment, at least one of the first ceramic resonator article and the second ceramic resonator article is completely enclosed. In some embodiments, all the ceramic resonator articles of the resonator assembly are completely enclosed. In another embodiment, a subset of the ceramic resonator articles of the resonator assembly is completely enclosed. A completely enclosed ceramic resonator articles may contain no cavities, holes, or recessions.

[0016] The pattern may be formed into the coupling sheet by employing laser cutting, water cutting, stamping, or any other mass production method used in patterning metallic sheets. The pattern may comprise determined geometrical shapes that tune the frequency characteristics of the resonator assembly. One or more rectangular holes is one option for the pattern of the coupling sheet, but the pattern may comprise a plurality of holes having different shapes, e.g. a rectangular shape and a non-rectangular shape. The location(s) and the dimensions

of the hole(s) may define the tuning properties of the coupling sheet. A person skilled in the art is considered to discover appropriate patterns for a resonator assembly by employing routine experimentation.

[0017] The cross-sectional dimensions of the coupling sheet may conform to the cross-sectional dimensions of the ceramic resonator articles. In other words, the surfaces of the coupling sheet and the ceramic resonator article that face each other may have matching dimensions, as illustrated in Figure 1A and 1B. This facilitates the positioning of the coupling sheet between the resonator articles. The thickness of the coupling sheet may be from 0.05 to 1,0mm, for example.

[0018] Figure 1C illustrates an embodiment where a plurality of coupling sheets 104, 110 are disposed between the ceramic resonator articles 100, 102 in a layered manner. The coupling sheets 104, 110 may have the same pattern 106 or different patterns 106, 112, 114. The different pattern may be realized by providing a different number of holes and/or by providing the holes in different shapes in different coupling sheets. The number of layered coupling sheets 104, 110 between two ceramic resonator articles may be two but, in some embodiments, more than two coupling sheets may be used. The coupling sheets 104, 110 may be attached to each other and to the ceramic resonator articles in a similar manner as the single coupling sheet, e.g. by soldering. Providing multiple layers of coupling sheets attached to each other provides for more tuning options.

[0019] Figure 2 illustrates an embodiment where the first ceramic resonator article 100 and the second ceramic resonator article 102 are plated with electrically conductive plating except for the sides 200 arranged to face the coupling sheet(s) 104. The plating is illustrated with the dotted pattern. The use of the electrically conductive coupling sheet may replace the need for the plating on the sides of the adjacent ceramic resonator articles 100, 102 that face one another. The plating may be silver plating that may be formed by dipping, screening, or dispensing silver paste on the surface to be plated and by sintering the ceramic resonator article so that the paste adheres to the surface of the article. An advantage provided by this embodiment is simplified plating process. Since the side(s) facing the coupling sheet(s) is/are not plated, those sides may be gripped in the plating process when dispensing the plating paste on the other sides. As a consequence, the plating of the ceramic resonator article may be made by performing only a single plating and a single sintering operation. In conventional solutions where all sides are plated, the process comprises at least two dispensing and sintering steps. The embodiment of Figure 2 is applicable to the embodiments of Figures 1A, 1B, and 1C in a straightforward manner.

[0020] In some embodiments, the resonator assembly comprises more than two ceramic resonator articles. A coupling sheet may be provided between any two ceramic resonator articles or between all adjacent ceramic resonator articles. The number of the ceramic resonator ar-

ticles may depend on the required bandwidth characteristics of the resonator assembly. Figure 3 illustrates an embodiment of the resonator assembly where the resonator assembly further comprises at least a third ceramic resonator article 300 having determined radio frequency resonance characteristics. The resonator assembly further comprises a second coupling sheet attached between the second ceramic resonator article 102 and the third ceramic resonator article 300. The second coupling sheet 304 may also be made of electrically conductive material and comprise a pattern 302 in the form of at least one through hole tuning properties of the resonator assembly. When combining embodiments of Figure 1C and 3, a plurality of coupling sheets may be provided between any two adjacent ceramic resonator articles.

[0021] As illustrated in the pattern 302 of the second coupling sheet 304 may be different from the pattern 106 of the first coupling sheet 104. In some embodiments, all the coupling sheets of the resonator assembly may have different patterns. However, in other embodiments, at least two coupling sheets of the resonator assembly may have the same pattern.

[0022] As illustrated in Figures 1A to 3, the ceramic resonator articles 100, 102, 300 and the at least one coupling sheet 104, 304 are aligned along a line in the resonator assembly. This forms a resonator assembly having a concatenated structure of alternating ceramic resonator articles and coupling sheets. At the ends of the structure, ceramic resonator articles may be provided. Electrodes 400 may be provided at the ends of the structure, as illustrated in Figure 4. A signal conductor such as a coaxial cable may be coupled to the electrode 400. In an embodiment, the electrode may be provided by drilling a hole or a recession on the surface of the ceramic resonator article at the end of the structure and attaching the electrode inside the hole or the recession. Convention solutions for forming the electrode on the surfaces of the ceramic resonator assembly may be employed.

[0023] Let us now describe a method for producing the resonator assembly according to an embodiment of the invention. With reference to a general embodiment of the method illustrated in Figure 5, the method comprises: producing a first ceramic resonator article having determined radio frequency resonance characteristics (block 500); producing a second ceramic resonator article having determined radio frequency resonance characteristics (block 500); producing a coupling sheet made of electrically conductive material and comprises a pattern in the form of at least one through hole (block 502); and attaching the coupling sheet between the first ceramic resonator article and the second ceramic resonator article (block 504).

[0024] In an embodiment, the method further comprises plating the first ceramic resonator article and the second ceramic resonator article with electrically conductive plating on all sides except for the sides designed to face the coupling sheet. Referring to Figure 6, this embodiment comprises obtaining a plurality of ceramic resonator

articles. The ceramic resonator articles may be manufactured by using state-of-the-art manufacturing methods. In block 602, the ceramic resonator articles are plated according to this embodiment. Block 602 may comprise or consist of a paste dispensing phase where plating paste is dispensed on the surfaces of the ceramic resonator articles to be plated and a sintering phase in which the articles are heated such that the paste attaches to the surfaces. The method may further comprise a step where determined patterns are formed on the plating, e.g. by employing laser-patterning. The patterns may comprise the above-described electrodes and/or any patterns that affect the frequency properties of the ceramic resonator article.

[0025] Let us now consider some embodiments for tuning the resonator assembly with reference to Figures 7 to 9. In Figures 7 to 9, blocks having the same reference number represent substantially similar operations in different Figures. Referring to Figure 7, the tuning process may be carried out after block 504, e.g. when the coupling sheet(s) are soldered or otherwise attached between the ceramic resonator articles. Block 700 comprises measuring frequency properties of the resonator assembly. Block 700 may comprise measuring bandwidth, Q factor, filter's S-parameter, band pass properties, etc. Upon measuring the frequency properties, the measured properties may be compared with specified properties and it may be determined whether or not the measured properties are within tolerances from the specified properties. This may be carried out by a state-of-the-art ceramic filter testing apparatus or testing system. Then, it may be determined, on the basis of the measurements, whether or not the frequency properties need to be tuned (block 702). Upon determining that the frequency properties are sub-optimal and need to be tuned, the process may proceed to block 704 where at least one coupling sheet is replaced with another coupling sheet. Block 704 may comprise determining which one of the coupling sheets of the resonator assembly needs to be replaced on the basis of the measurements, selecting a new coupling sheet that tunes the frequency properties towards the specified frequency properties and replacing the determined coupling sheet with the selected new coupling sheet. Block 704 may comprise replacing one coupling sheet or multiple coupling sheets at once. The new coupling sheet(s) may be attached to the resonator assembly and the process may return to block 700 for new measurements. When it is determined in block 702 that no more tuning is needed, the process may end.

[0026] Figure 8 illustrates an embodiment where the tuning is embedded to the building of the resonator assembly from the ceramic resonator articles and multiple coupling sheets. Referring to Figure 8, the ceramic resonator articles and the coupling sheets are produced or obtained. The coupling sheets may comprise a first subset of coupling sheets having one pattern and at least a second subset having a different pattern. Accordingly, multiple subsets of coupling sheets with different fre-

quency tuning properties are provided. A first coupling sheet is attached between two ceramic resonator articles in block 800. Then, the frequency properties of the resonator assembly may be measured (block 700). On the basis of the measurements, it may be determined how the frequency properties of the resonator assembly built so far need to be tuned. In response to said determining, a second coupling sheet may be selected in block 804, wherein the second coupling sheet comprises a pattern that tunes the frequency properties in a manner determined on the basis of the measurements. Then, the second coupling sheet may be attached between a ceramic resonator article attached to the resonator assembly previously in block 800 and a new ceramic resonator article. Then, the frequency properties of the resonator assembly now comprising three ceramic resonator articles and two coupling sheets may be measured. In this manner, new ceramic resonator articles and new coupling sheets that are selected on the basis of the measurements may be attached to the resonator assembly. When the resonator assembly is determined to be complete (block 802), the process may end.

[0027] The embodiments of Figures 7 and 8 may be combined. For example, the measurements carried out in block 700 of Figure 8 may indicate that one or more coupling sheets attached to the resonator assembly needs to be replaced. The replacement of the coupling sheet(s) with new ones may be carried out according to the embodiment of Figure 7.

[0028] Figure 9 illustrates an embodiment where the tuning is carried out by modifying the ceramic resonator article(s). The process of Figure 9 may be carried out when the resonator assembly has been built, e.g. when the coupling sheets are attached to the resonator assembly. Referring to Figure 9, upon determining, on the basis of the measurements carried out in block 700, that the frequency properties need to be tuned, ceramic material may be removed from a side of at least one ceramic resonator article of the resonator assembly (block 900). The ceramic material may be removed from a non-plated surface of the ceramic resonator article(s), e.g. the side that faces a coupling sheet. Block 900 may comprise disassembling the resonator assembly by separating at least one coupling sheet and a ceramic resonator article, thus exposing an non-plated surface of the ceramic resonator article. The measurements carried out in block 700 may indicate which one or more of the ceramic resonator articles needs to be modified. Then, the non-plated surface may be ground and, thus, the frequency properties of the ceramic resonator article tuned. Upon completing block 900, the resonator assembly may be reassembled. The reassembling may comprise soldering the disassembled parts together, and new measurements may be carried out in block 700. In another embodiment, the reassembling may comprise assembling the disassembled parts together by bringing them into contact with each other without fixing them together, e.g. by soldering. For example, the disassembled parts may be reassembled in a

jig so that they are in contact with each other and, then, new measurements may be made. Since the soldering is not used between the reassembling and the measurements, it is easy to make further modifications if the measurements show that such modifications are still needed. In this manner, the process may be iterated until the resonator assembly has frequency properties that meet the specifications.

[0029] It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

Claims

1. A resonator assembly comprising:

- a first ceramic resonator article having determined radio frequency resonance characteristics;
- a second ceramic resonator article having determined radio frequency resonance characteristics;
- a coupling sheet attached between the first ceramic resonator article and the second ceramic resonator article, wherein the coupling sheet is made of electrically conductive material and comprises a pattern in the form of at least one through hole for tuning properties of the resonator assembly.

2. The resonator assembly of claim 1, wherein sides of the first ceramic resonator article and the second ceramic resonator article facing the coupling sheet are smooth.

3. The resonator assembly of claim 1 or 2, wherein at least one of the first ceramic resonator article and the second ceramic resonator article is completely enclosed.

4. The resonator assembly of claim 3, wherein all ceramic resonator articles of the resonator assembly are completely enclosed.

5. The resonator assembly of any preceding claim, wherein the first ceramic resonator article and the second ceramic resonator article are plated with electrically conductive plating except for the sides arranged to face the coupling sheet.

6. The resonator assembly of any preceding claim further comprising:

- at least a third ceramic resonator article having

- determined radio frequency resonance characteristics;
a second coupling sheet attached between the second ceramic resonator article and the third ceramic resonator article, wherein the second coupling sheet is made of electrically conductive material and comprises a pattern in the form of at least one through hole for tuning properties of the resonator assembly.
7. The resonator assembly of claim 6, wherein the pattern of the second coupling sheet is different from the pattern of the first coupling sheet.
8. The resonator assembly of any preceding claim, wherein the ceramic resonator articles and the at least one coupling sheet are aligned along a line.
9. The resonator assembly of any preceding claim, wherein a plurality of coupling sheets are provided in layers between two ceramic resonator articles.
10. A method for manufacturing a resonator assembly, comprising:
- producing a first ceramic resonator article having determined radio frequency resonance characteristics;
producing a second ceramic resonator article having determined radio frequency resonance characteristics;
producing a coupling sheet made of electrically conductive material and comprises a pattern in the form of at least one through hole; and
attaching the coupling sheet between the first ceramic resonator article and the second ceramic resonator article.
11. The method of claim 10, further comprising: plating the first ceramic resonator article and the second ceramic resonator article with electrically conductive plating on all sides except for the sides designed to face the coupling sheet.
12. The method of claim 10 or 11, further comprising after attaching the coupling sheet:
- measuring frequency properties of the resonator assembly;
determining, on the basis of the measurements, that the frequency properties need to be tuned;
in response to said determining, replacing the coupling sheet with another coupling sheet.
13. The method of any preceding claim 10 to 12, further comprising after attaching the coupling sheet:
- measuring frequency properties of the resonator assembly;
determining, on the basis of the measurements, that the frequency properties need to be tuned;
in response to said determining, removing ceramic material from a side of at least one of the first ceramic resonator article and the second ceramic resonator article that faces the coupling sheet.
14. The method of any preceding claim 10 to 13, further comprising after attaching the coupling sheet:
- measuring frequency properties of the resonator assembly;
determining, on the basis of the measurements, that the frequency properties need to be tuned;
in response to said determining, selecting a second coupling sheet that comprises a pattern that tunes the frequency properties in a manner determined on the basis of the measurements;
attaching the second coupling sheet to a side of the second ceramic resonator article and a third ceramic resonator article to the second coupling sheet.

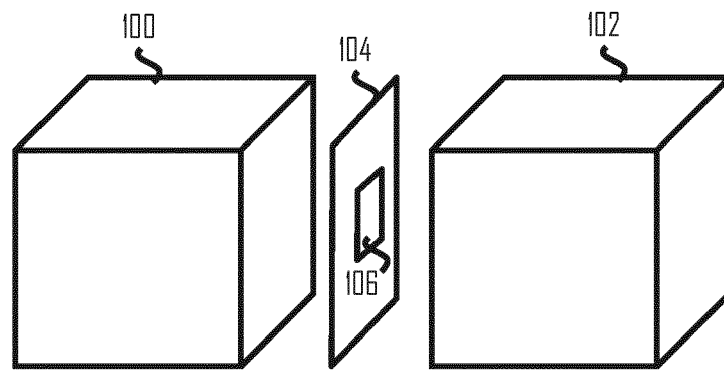


Fig 1A

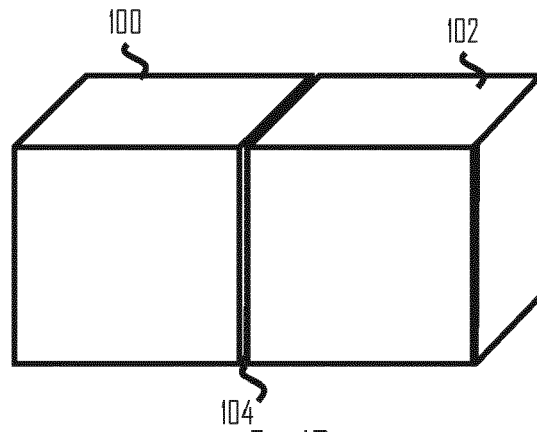


Fig 1B

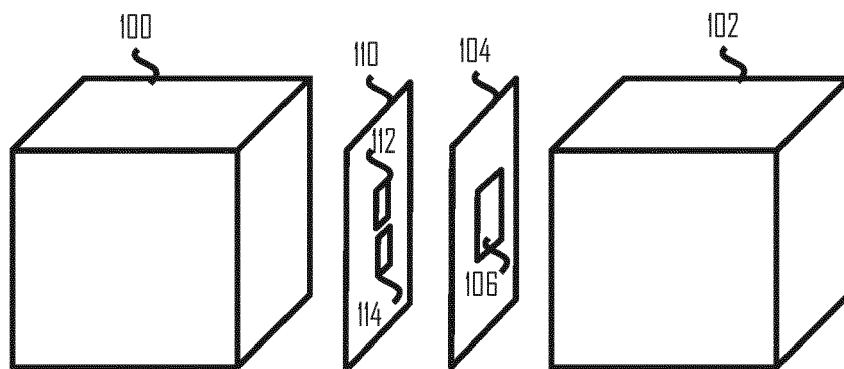


Fig 1C

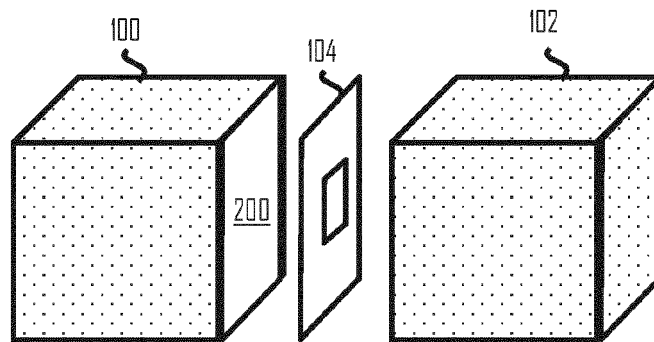


Fig 2

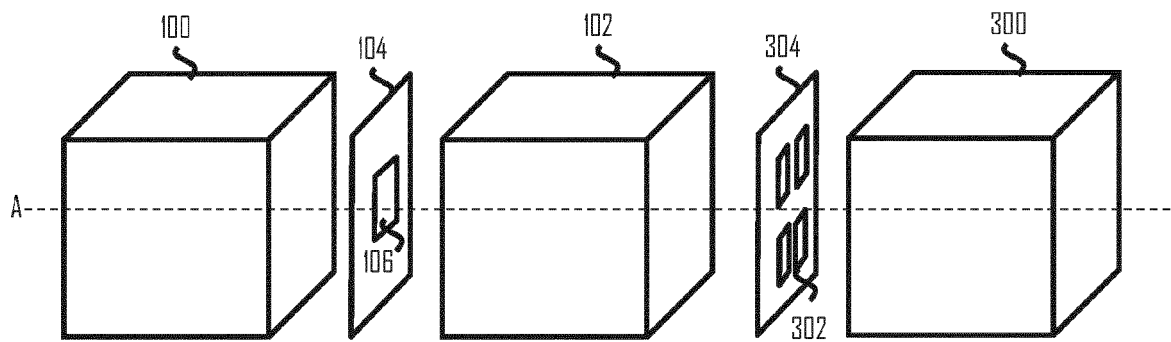


Fig 3

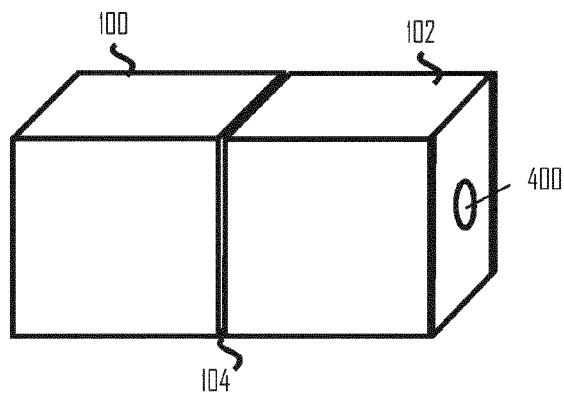


Fig 4

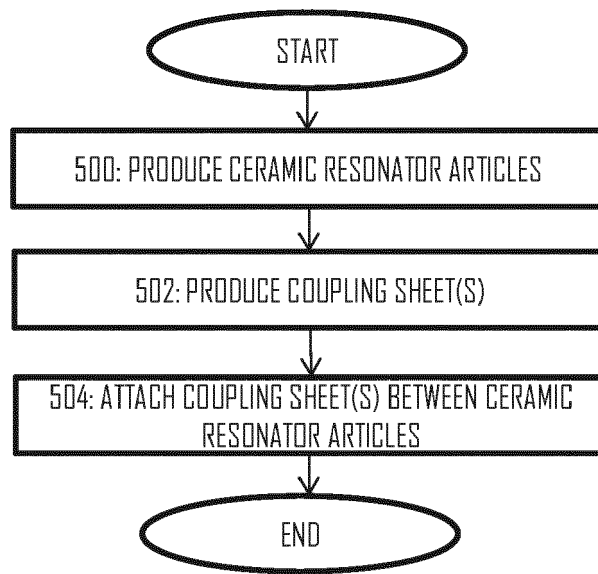


Fig 5

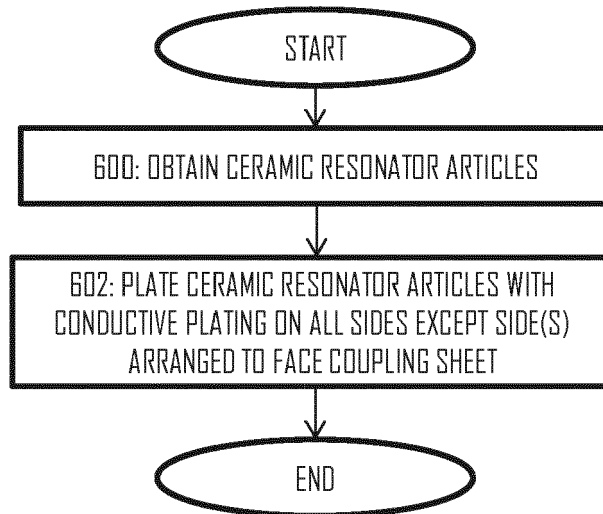


Fig 6

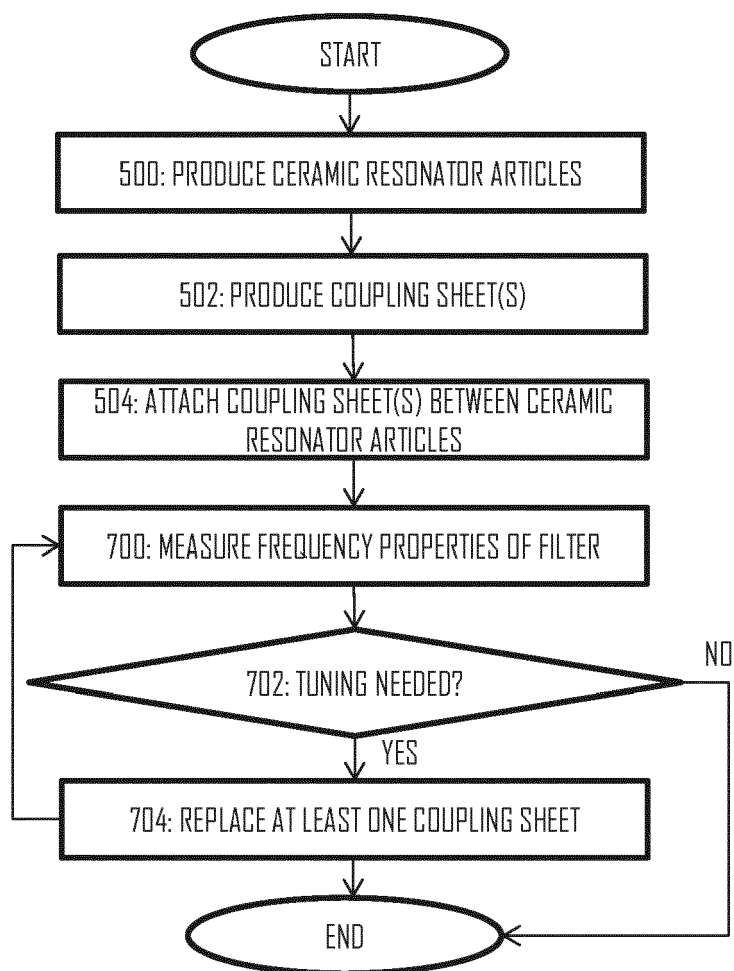


Fig 7

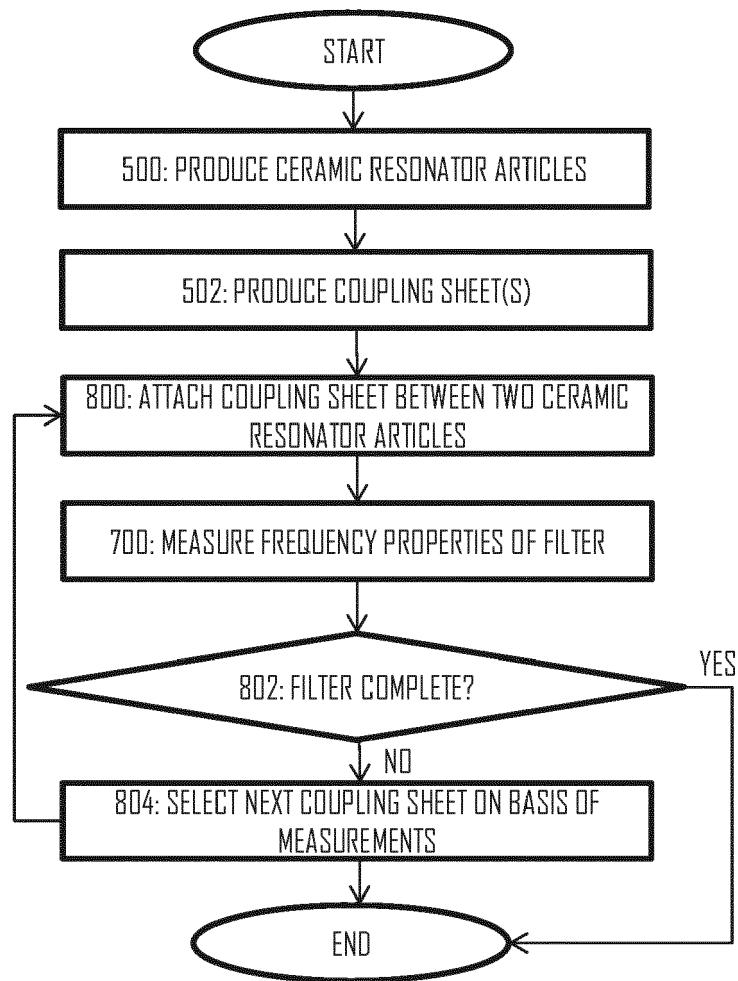


Fig 8

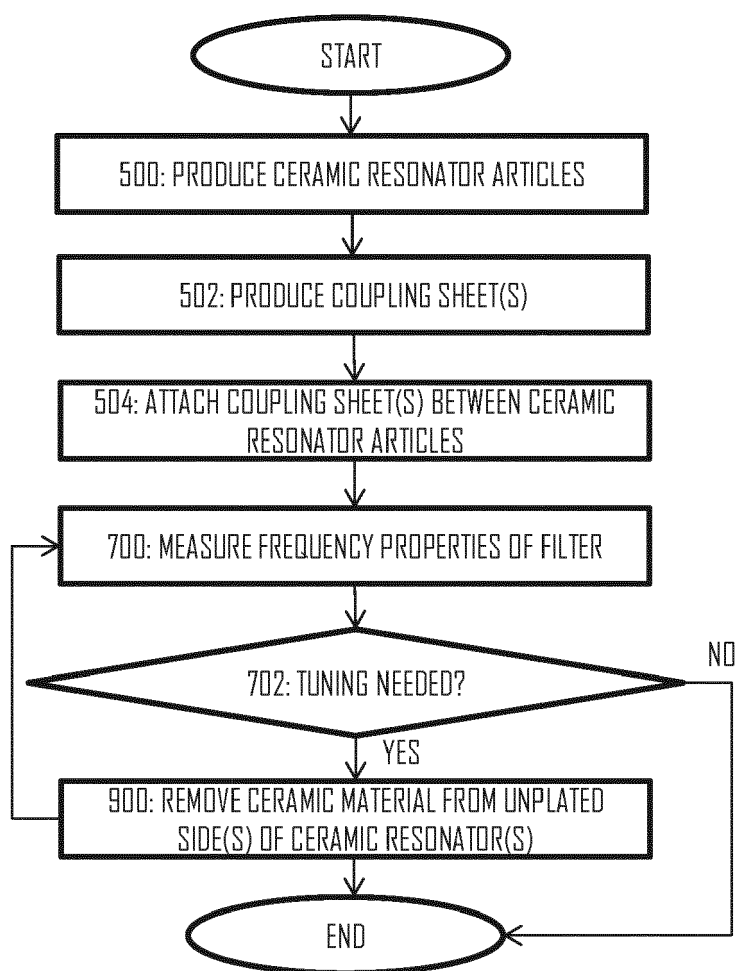


Fig 9



EUROPEAN SEARCH REPORT

Application Number
EP 14 19 6783

5

10

15

20

25

30

35

40

45

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	US 5 812 036 A (ESTRADA ANTHONY J [US]) 22 September 1998 (1998-09-22) * abstract * * column 1, line 21 - line 28 * * column 3, line 3 - column 4, line 3; figures 1A, 1B, 1C *	1-11,13 12,14	INV. H01P7/10
X A	US 2005/116797 A1 (SHAMSAIFAR KHOSRO [US] ET AL) 2 June 2005 (2005-06-02) * abstract * * paragraph [0022] - paragraph [0024]; figures 1, 2 *	1-11,13 12,14	
X A	EP 0 208 424 A1 (MATSUSHITA ELECTRIC IND CO LTD [JP]) 14 January 1987 (1987-01-14) * abstract * * page 4, line 24 - page 9, line 16; figures 3 - 11 *	1-11,13 12,14	
X A	EP 1 544 939 A1 (RADIO FREQUENCY SYSTEMS INC [US]) 22 June 2005 (2005-06-22) * abstract * * paragraph [0035] - paragraph [0046]; figures 1 - 3 * * paragraph [0066] - paragraph [0070]; figures 17 - 19 *	1-11,13 12,14	TECHNICAL FIELDS SEARCHED (IPC) H03H H01P
X A	US 2012/049983 A1 (UHM MAN SEOK [KR] ET AL) 1 March 2012 (2012-03-01) * abstract * * paragraph [0022] - paragraph [0065]; figures 1 - 4 *	1-11,13 12,14	
A	US 2003/151474 A1 (WADA TAKAYA [JP] ET AL) 14 August 2003 (2003-08-14) * paragraph [0027] - paragraph [0037]; figures 1 - 3 *	1-14	
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 27 May 2015	Examiner Trafidlo, Renata
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03/02 (P04C01)

50

55

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 14 19 6783

5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

27-05-2015

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5812036 A	22-09-1998	NONE	
US 2005116797 A1	02-06-2005	NONE	
EP 0208424 A1	14-01-1987	EP 0208424 A1 JP S61285801 A	14-01-1987 16-12-1986
EP 1544939 A1	22-06-2005	AT 486388 T EP 1544939 A1 US 2005128031 A1	15-11-2010 22-06-2005 16-06-2005
US 2012049983 A1	01-03-2012	KR 20120003354 A US 2012049983 A1	10-01-2012 01-03-2012
US 2003151474 A1	14-08-2003	CN 1433102 A JP 2003212649 A KR 20030062266 A US 2003151474 A1	30-07-2003 30-07-2003 23-07-2003 14-08-2003