BESCHWERDEKAMMERN DES EUROPÄISCHEN PATENTAMTS

BOARDS OF APPEAL OF THE EUROPEAN PATENT OFFICE

CHAMBRES DE RECOURS DE L'OFFICE EUROPEEN DES BREVETS

Internal distribution code:
(A) [ ] Publication in OJ
(B) [ ] To Chairmen and Members
(C) [ ] To Chairmen
(D) [X] No distribution

Datasheet for the decision of 11 March 2008

Case Number: T 0975/05 - 3.4.01

Application Number: 99304277.9

Publication Number: 0962999

IPC: H01P 1/12

Language of the proceedings: EN

Title of invention:
Resonator structures

Applicant:
Nokia Corporation

Opponent:
-

Headword:
-

Relevant legal provisions (EPC 1973):
EPC Art. 56

Keyword:
"Inventive step (no: all requests)"

Decisions cited:
-

Catchword:
-

Europäisches Patentamt | European Patent Office | Office européen des brevets

Beschwerdekammern | Boards of Appeal | Chambres de recours

Case Number: T 0975/05 - 3.4.01

D E C I S I O N
of the Technical Board of Appeal 3.4.01
of 11 March 2008

Appellant: Nokia Corporation
Keilalahdentie 4
FI-02150 Espoo (FI)

Representative: Dilg, Andreas
Dilg, Haeusler, Schindelmann
Patentanwaltsgesellschaft mbH
Nußbaumstraße 6
D-80336 München (DE)

Decision under appeal: **Decision of the Examining Division of the European Patent Office posted 18 March 2005 refusing European application No. 99304277.9 pursuant to Article 97(1) EPC 1973.**

Composition of the Board:

Chairman: B. Schachenmann
Members: H. Wolfrum
F. Neumann

Summary of Facts and Submissions

I. European patent application 99 304 277.9 (publication No. EP-A-0 962 999) was refused by a decision of the examining division dispatched on 18 March 2005, for the reason of lack of inventive step (Articles 52(1) and 56 EPC 1973) of the subject-matter of the request then on file.

The examining division had based its decision on prior art given by documents :

D1 : US-A-5 714 917; and
D2 : EP-A-0 709 911.

II. The applicant lodged an appeal against the decision and paid the prescribed fee on 18 May 2005. On 13 July 2005 a statement of grounds of appeal was filed. The appellant requested the grant of a patent on the basis of a set of 11 claims according to a main request or alternatively on the basis of sets of claims according to a first to twelfth auxiliary request, respectively.

III. On 24 September 2007 the appellant was summoned to oral proceedings.

In a communication dated 23 November 2007, the Board drew the appellant's attention to further prior art including *inter alia* the following document which had already been cited in the European Search Report :

D5 : Satoh H. et al : "AN AIR-GAP TYPE PIEZOELECTRIC COMPOSITE THIN FILM RESONATOR", PROCEEDINGS OF THE ANNUAL FREQUENCY CONTROL SYMPOSIUM,

Philadelphia, May 29 - 31 1985, New York, IEEE, US, vol. SYMP. 39, 29 May 1985, pages 361-366.

IV. In response thereto, the appellant filed by letter of 11 February 2008 new sets of claims according to a main request, a first auxiliary request and a second auxiliary request.

V. Oral proceedings were held on 11 March 2008.

After discussion the appellant requested that the decision under appeal be set aside and a patent be granted on the basis of

claims 1 to 9 of 11 February 2008 according to a **main request**;
claims 1 to 7 of 11 February 2008 according to a **first auxiliary request**; or
claims 1 to 6 of 11 February 2008 according to a **second auxiliary request**.

VI. Claim 1 of the appellant's **main request** reads as follows :

"*1. A resonator structure comprising at least one resonator on a substrate (200), which resonator is prepared at least by deposition and patterning of a plurality of layers on the substrate (200),* ***characterized*** *in that :*

- the structure comprises, integrated onto the same substrate with said resonator, at least one switch element prepared at least by deposition and patterning of a plurality of layers on the substrate (200), during same process as the preparation of the resonator, and

- at least one of the layers, other than the substrate, of the resonator is also a layer of said switch element."

Claims 6 and 9 of the main request relate to a filter structure and a mobile communication means, respectively, each comprising a resonator structure according to claim 1.

Claims 2 to 5, 7 and 8 are dependent claims.

Claim 1 of the appellant's **first auxiliary request** differs from claim 1 of the main request in that at least one switch element is defined to be a micromechanical switch and that the at least one of the layers common to the resonator and the switch element is defined to be a conductor.

Claims 4 and 7 of the first auxiliary request relate to a filter structure and a mobile communication means, respectively, each comprising a resonator structure according to claim 1.

Claims 2, 3, 5 and 6 are dependent claims.

Claim 1 of the appellant's **second auxiliary request** reads as follows :

"*1. A resonator structure comprising at least one resonator on a substrate (200), which resonator is prepared at least by deposition and patterning of a plurality of layers on the substrate (200), wherein at least one of the at least one resonator is a bridge-*

type bulk acoustic wave resonator, ***characterized*** *in that :*

- the structure comprises, integrated onto the same substrate with said bridge-type bulk acoustic wave resonator, at least one switch element prepared at least by deposition and patterning of a plurality of layers on the substrate (200), during same process as the preparation of the bridge-type bulk acoustic wave resonator, wherein at least one of said at least one switch element is a micromechanical switch (320),

- a sacrificial layer (140) under a bridge structure of the bridge-type bulk acoustic wave resonator and a sacrificial layer under a switch cantilever (400) of the micromechanical switch (320) being part of a single patterned layer, and

- a metal layer deposited on the substrate and subsequently patterned forms one of the electrodes of the bridge-type bulk acoustic wave resonator and forms one of the electrodes of the micromechanical switch (320)."

Claims 3 and 5 of the second auxiliary request relate to a filter structure and a mobile communication means, respectively, each comprising a resonator structure according to claim 1. Furthermore, the second auxiliary request comprises an independent claim 6 which is directed to a method of fabricating a resonator structure comprising as steps the forming of the various elements of the structure which are defined in claim 1.

Claims 2 and 4 are dependent claims.

VII. In support of inventive step for the subject-matter of its requests, the appellant argued in essence that none of the available documents of the prior art showed the integration of a resonator structure and a switch element in a common substrate. Moreover, the prior art did not provide any hint as to how the different technologies on which resonator structures on the one hand and switch elements on the other hand were based could be integrated at all. More specifically, none of the cited documents addressed the problem of providing a resonator structure which was particularly suitable for portable multi-band telecommunication applications.

Document D2 was exclusively concerned with switch structures and thus did not constitute a viable starting point for a problem-solution analysis for a resonator structure as claimed by the independent requests on file. Furthermore, as far as the document made reference to a possible integration of switch elements in electronic circuits, it relied consistently on hybrid technology. Thus, if a skilled person contemplated at all an integrated implementation of for instance the specific circuit shown by Figure 42 of D2 concerning a switchable bank of bandpass filters, he would have separately assembled, on a common circuit board, modules comprising switch elements and a module comprising a number of bandpass filters. In this context, he would have been incited to resort to filter structures as were shown in Figure 41 of D2. These structures, however, did not include resonator structures of the type claimed but constituted an arrangement of stubs which, because of its inherent size, was not suitable for monolithic integration on a common substrate.

As far as document D5 was concerned, it disclosed piezoelectric resonator structures which were expressly formed with large-sized bonding pads and thus constituted elements for forming hybrid circuits. Therefore, even if, for the sake of the argument, the skilled person had contemplated to use resonator structures as known from document D5 for forming the filters indicated in Figure 42 of document D2, he would still have implemented a hybrid circuit and would not have conceived the synergistic combination of a resonator and a switch integrated on a common substrate according to the present invention.

The inventive approach of integrating resonator structures and switches, which, albeit formed by different technologies, shared a common layer, had to overcome various technical obstacles and even an existing prejudice. Thus the invention behind the subject-matter of claim 1 of the main request should be seen as a paradigm shift in integrated circuit technology.

Claim 1 of each of the first and second auxiliary requests defined the inventive resonator structure in increasing detail and thus further emphasised the inventive achievement of bringing together such diverse technologies as bridge type bulk acoustic wave resonators requiring a high mechanical rigidity and micromechanical switches of the cantilever type requiring high mechanical flexibility. In particular, in order to arrive at the subject-matter of claim 1 of the second auxiliary request, the skilled person had to

exercise at least five steps, none of which was hinted at by the cited prior art.

Reasons for the Decision

1. In the following reference is made to the provisions of the EPC 2000, which entered into force as of 13 December 2007, unless the former provisions of the EPC 1973 still apply to pending applications.

2. The appeal complies with the requirements of Articles 106 to 108 EPC 1973 and Rule 64 EPC 1973 and is, therefore, admissible.

3. **Main request** - inventive step (Article 52(1) EPC and Article 56 EPC 1973)

3.1 Document D2 (cf Figures 4a-e, 5, 6, 9a,b, 14a, 14d, 30a-f and the corresponding description) refers to micromechanical switch elements which are formed on a substrate by layer forming processes that are conventional fabrication steps in integrated circuit (IC) technology. In fact, document D2 expressly foresees incorporation of the thin-film switch elements into integrated circuits and points in this context to the compatibility of the switch structure and its manufacturing processes with both silicon and gallium arsenide integrated circuit technology (cf the abstract; column 2, lines 25 to 28; column 7, lines 9 to 13; column 17, lines 55 to 58; column 18, lines 27 to 31). Furthermore, document D2 shows several specific examples of circuits in which the disclosed thin-film

switches may find application, including a switched filter bank (cf Figure 42 and the corresponding description).

3.2 Knowing from document D2 itself that the switch elements described therein possess a structure which permits their incorporation into integrated circuits, it would be obvious for the skilled person to contemplate implementation of the switched filter bank circuit as shown in Figure 42 in a monolithic integrated form, in particular when an envisaged application has to meet the common demands of miniaturization and low costs. In doing so, the skilled person only has to choose a suitable integrable structure of electronic filters, the structure of the switch elements already being known from document D2. Since such filters are formed from resonators, the selection of a suitable electronic filter reduces to the selection of a suitable integrable resonator structure.

3.3 In this context, document D5 offers a bridge-type bulk acoustic wave resonator structure which is formed by conventional fabrication steps in IC technology and expressly presented as a promising structure for implementation in circuits fabricated in fully monolithic form (cf page 361; page 362, chapter "2.1 Structure"; and page 366, chapter "Summary"). Due to the explicit indications in document D5 concerning the suitability of this type of resonator in monolithic IC technology, the skilled person would at least consider adapting a resonator structure as known from D5 when implementing the switchable filter bank of Figure 42 of document D2 in monolithic form.

3.4 Taking into consideration the fact that common conductive layers which are patterned to establish the necessary electrical interconnections and electrodes of the various circuit elements form a constitutive feature of monolithic circuit integration, at least one of the layers of the resonator will also have to be a layer of the switch element. Thus, the skilled person directly arrives at a resonator structure falling under the terms of claim 1 of the main request when making use of the integrable resonators known from document D5 together with the integrable switch elements known from document D2 in order to implement monolithically a circuit as shown by Figure 42 of document D5.

3.5 The arguments submitted by the appellant in support of the presence of an inventive step are not convincing.

The observation that none of the cited documents of the prior art showed the integration of a resonator structure and a switch element in a common substrate proves nothing but the - uncontested - novelty of the claimed subject-matter.

Contrary to the appellant's opinion, Figure 42 of document D2 does indeed constitute a suitable starting point for assessing the issue of inventive step because it provides an example of the existing need for an electronic circuit which comprises filters (and thus, implicitly, resonators) and switches and, more generally, because the design of a required electrical circuit layout marks the start of any circuit implementation, be it discrete, hybrid or fully integrated.

The appellant's observation that the skilled person had reason to consider implementation of the known circuit in hybrid form from separate resonators and switch elements is certainly correct. Similarly, it is not contested that a combination of micromechanical switches and discrete stub filters, as shown in Figure 41 of document D2, would also be considered. Nevertheless, given the fact that, for decades now, full scale monolithic integration of practically any electrical circuit design constitutes common practice, the skilled person would be well aware of the fact that, compared to hybrid technology, monolithic integration offers an even higher level of miniaturisation. Therefore, if a certain electrical circuit is to be made available for use in a device for which small size is of highest priority, the skilled person in the technical field at issue is expected to contemplate the possibility of providing the respective circuit in monolithically integrated form. In this respect, document D5 (cf page 361, first paragraph of chapter "1. Introduction") specifically points to the need for miniature resonators to be used in VHF or UHF communication systems.

The alleged prejudice against integration of a resonator and a switch on a common substrate does not exist. On the contrary, documents D2 and D5 both emphasise the compatibility of the respective switch elements and resonator structures with IC manufacturing technology. It is an intrinsic feature of IC technology to integrate monolithically virtually any electrical circuit and thus a wide spectrum of active and passive electronic elements serving quite different electrical

functions. For circuit elements being formed as layered structures on top of the common substrate, the only requirement to be met is that the structures can be formed by layer deposition and patterning processes. This is exactly the case for the structures known from documents D2 and D5 which both teach to employ the same layer forming processes conventional in IC technology. Monolithic integration does not require, however, that all circuit structures would have to be formed by exactly the same process steps or would have to perform the same functions. It is a fundamental principle of IC technology that all those elements of the various circuit structures to be integrated which concern identical or corresponding elements (such as identically doped regions, electrodes and interconnects, isolating layers etc.) are formed simultaneously by the same processes whereas individual structural elements are formed separately by making use of proper masking techniques. Therefore, the fact that the moving elements of a switch structure according to document D2 and of a resonator structure according to document D5 have to meet different mechanical requirements does not amount to an incompatibility of technologies, as alleged by the appellant, but these different requirements are achieved by the specific structure given to the respective elements.

Finally, the appellant's argument that the resonator structure known from document D5 was only amenable to hybrid technology because it was provided with large-sized bonding pads, as shown in Figures 1 and 4 of the document, is inconclusive. Document D5 is a scientific paper which reports on the development of a new type of thin film bulk acoustic resonator, *ie* the bridge-type

bulk acoustic wave resonator. Since it is the aim of the paper to present the electrical properties of such a structure, an isolated resonator structure is tested. The large bonding pads are apparently provided only for the convenience of these tests, but do in no way impede full scale monolithic integration of the actual resonator structure. Indeed, the last sentence on page 361 of document D5 indicates the intention to fully integrate the resonator in ICs.

3.6 For the above reasons, claim 1 of the main request does not involve an inventive step within the meaning of Article 56 EPC 1973.

Consequently, the main request is not allowable.

4. **First auxiliary request** - inventive step (Article 52(1) EPC and Article 56 EPC 1973)

4.1 Claim 1 of the first auxiliary request additionally requires the switch element to be a micromechanical switch and the at least one of the layers common to the resonator and the switch element to be a conductor.

4.2 The switch elements discussed in document D2 possess either a cantilever (cf Figures 1a,b) or a movable membrane or flap (cf for instance Figures 4a-f, 9a,b, 14d, 18c, 19a and 20a) and thus represent micromechanical switches.

Moreover, the circuit shown by Figure 42 of document D2 requires an electrical interconnection between switches and filters. In this context, monolithic integration of

a layered structure of electrically interconnected circuit elements implies a common conductor layer, as is explained in point 3.4 above.

Thus, the amendments made to claim 1 of the first auxiliary request do not further distinguish the claimed subject-matter from the pertinent prior art.

Therefore, the considerations concerning the lack of inventive step given above for the subject-matter of claim 1 of the main request apply with equal force to claim 1 of the first auxiliary request.

4.3 Consequently the first auxiliary request is not allowable, either.

5. **Second auxiliary request** - inventive step (Article 52(1) EPC and Article 56 EPC 1973)

5.1 With respect to claim 1 of the main request, claim 1 of the second auxiliary request additionally requires
(i) the resonator to be a bridge-type bulk acoustic wave resonator;
(ii) the switch element to be a micromechanical switch having a cantilever;
(iii)a sacrificial layer under the bridge structure of the bridge-type bulk acoustic wave resonator and a sacrificial layer under the switch cantilever to be part of a single patterned layer; and
(iv) the at least one of the layers common to the resonator and the switch element to be a patterned metal layer forming one electrode each of the resonator and the switch.

5.2 With regard to feature (i), the resonator known from document D5 is a bridge-type bulk acoustic wave resonator.

As has already been noted with respect to the first auxiliary request, the switch elements known from document D2 are micromechanical switches. Although the preferred embodiments have as the moving element a flexible membrane or a flap, document D2, in referring to existing prior art, shows in Figures 1a,b mechanically equivalent switch structures having a cantilever as the moving element. Therefore, with regard to aforementioned feature (ii) the selection of micromechanical switches of the cantilever type as suitable structures for realizing a monolithic integration of the circuit of Figure 42 of document D2 constitutes a mere choice between two equal alternatives.

The structures of a bridge-type bulk acoustic wave resonator known from document D5 and of a micromechanical switch known from document D2 both include a sacrificial layer. The skilled person, when contemplating monolithic integration of the known resonator and switch structures, would not hesitate to devise a design in which the sacrificial layers of the two structures form a single layer which is appropriately patterned, and thus realise aforementioned feature (iii), simply because of the fact that any other course of action, such as for instance the application of separate manufacturing processes or even the use of different materials for the sacrificial layers, would contravene the

fundamental principle of integrated circuit manufacturing technology already referred to in paragraph 3.5 above, according to which like elements are formed in the same processes.

It was argued that the provision of a common sacrificial layer was effectively what permitted the achievement of the different mechanical requirements of the moving elements. It was the common sacrificial layer which allowed the switch to be prepared with a high flexibility and the resonator to be prepared with a high rigidity. However, apart from the fact that this advantage would not be reflected in the wording of the claim under consideration, which simply refers to a common sacrificial layer, which, as shown above is a standard feature of IC manufacturing processes, the argument is incorrect from a technical point of view because the mechanical properties will be determined by the materials and structure of the moving elements which remain after removal of the sacrificial layer.

Finally, aforementioned feature (iv) relates to a characteristic which is likewise ordinary in integrated circuit technology in that necessary electrical interconnections and electrodes of circuit elements are formed by patterning common metal layers.

It follows from these observations that none of the additional features (i) to (iv) contributes to the presence of inventive step.

5.3 According to the appellant at least five inventive steps would have to be performed by the skilled person in order to arrive at, on the basis of Figure 42 of

document D2, the claimed subject-matter. To start with, he would have to replace a switch structure of the membrane type such as shown by Figure 14 of document D2 by a structure of the cantilever type, which allowed for an easier access of etching means to the sacrificial layer. Moreover, he would have to discard the stub-type resonator structure suggested by Figure 41 of document D2 in favour of a bridge-type bulk acoustic wave structure. Then he would have to ignore the evidence pointing at hybrid circuit technology and come up instead with the idea of forming switches and resonator structures on a common substrate. Finally, he would have to think up the particularly advantageous characteristics of a common electrode layer and of a single patterned layer of which the sacrificial layers of the switch element and the resonator form part.

The appellant's argumentation overlooks the fact that the allegedly inventive steps are in practice the inevitable consequence of the obvious desire for a monolithic implementation of the circuit scheme according to Figure 42 of document D2. The task of transforming said circuit scheme into a fully monolithic structure implies that any hybrid solutions are discarded and a common substrate is provided for all circuit elements. Moreover, for the respective circuit elements those structures have to be chosen which are amenable to IC manufacturing technology. Therefore, the skilled person would disregard space-consuming filter/resonator structures, such as those shown by Figure 41 of document D2, in favour of resonator structures such as those known from document D5, which are disclosed as being fully integrable. As

regards the switch elements, the skilled person would consider both types of micromechanical switches shown in document D2, *ie* those having a moving membrane or flap and those having a moving cantilever, to be equally suited for monolithic integration. In this context, the Board regards the appellant's argument that a cantilever structure was easier to manufacture than a membrane structure as an unsubstantiated and implausible allegation. In both cases the identical steps of preparing a movable structure on top of a sacrificial layer are to be performed. Whether the movable structure is patterned as a cantilever (cf Figure 1b of D2) or as a membrane which is perforated with holes to permit access for plasma etching (cf Figures 14b and 22 of D2) is merely a matter of mask layout but does not affect the number and nature of the process steps to be performed. Furthermore, as already explained in paragraph 5.2 above, the provision of a common electrode layer and of a single patterned layer forming the sacrificial layers of the switch element and the resonator constitute inherent elements of a technically meaningful monolithic integration.

5.4 For these reasons, claim 1 of the second auxiliary request does not involve an inventive step within the meaning of Article 56 EPC 1973.

Consequently, the second auxiliary request is also not allowable.

Order

For these reasons it is decided that :

The appeal is dismissed.

The Registrar | The Chairman

R. Schumacher | B. Schachenmann