

Knowles MEMS Microphones in Apple iPhone 7 Plus

Patent-to-Product Mapping

March 2017

REPORT
SAMPLE

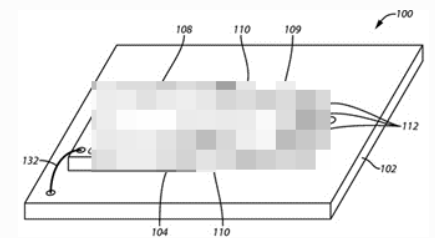
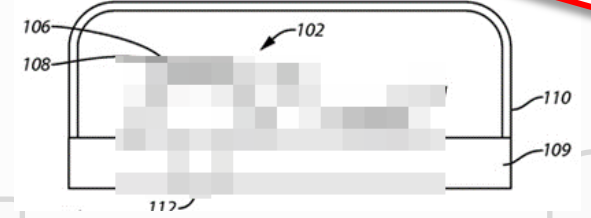
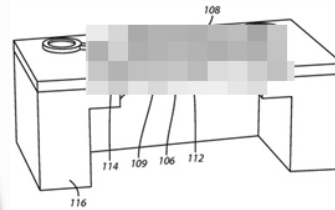


TABLE OF CONTENTS



INTRODUCTION	6
Company profile	7
Scope of the report	9
Key features of the report	11
Related reports	12
METHODOLOGY	13
Teardown analysis and patent mapping	14
Patent database and tools	15
Terminology for patent analysis	16
TEAR DOWN	18
PATENT LANDSCAPE OVERVIEW	22
Knowles IP portfolio	23
Time evolution of patent publications	25
Patent distribution by legal status	26
Mapping of granted patents and pending applications	27
Patent List	28
Inventors	33
Patent citations analysis	34
IP blocking potential of the patent families	35

PATENT-TO-PRODUCT MAPPING	36
Packaging : Housing & RF shielding	37
Embedded capacitance	44
MEMS die	51
Diaphragm	54
Backplate: Perforation & support structure	63
MEMS cavity & bottom acoustic port	77
PATENT LITIGATIONS	87
Introduction	88
Knowles vs Company A	90
Knowles vs Company B	91
Knowles vs Company C	94
Knowles vs Akustica	95
Knowles vs Company D	96
Knowles vs Company E	98
CONCLUSION	99
KNOWMADE PRESENTATION	102



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Brice Sagot

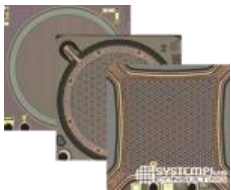
Brice is COO and co-founder of Knowmade. He leads the Biotechnology and Life Sciences department. He holds a PhD in molecular biology from the University of Nice Sophia-Antipolis, France.



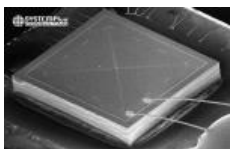
Romain Fraux

Romain is the CTO of System Plus Consulting. He is in charge of costing analyses for Advanced Packaging, MEMS and Integrated Circuits. He has published more than 50 Reverse Costing reports on various MEMS devices including inertial, pressure, microphones or RF sensors.

You may also be interested in those market analysis reports of our partners System Plus Consulting and Yole Développement:



- Apple iPhone 7 Plus: MEMS Microphones (2016) ([link](#))



- Vesper VM1000 Piezoelectric Microphone (2017) ([link](#))



- Acoustic MEMS (Microphone, Microspeaker) and Audio Solutions (2017) (to be published)



INTRODUCTION

INTRODUCTION

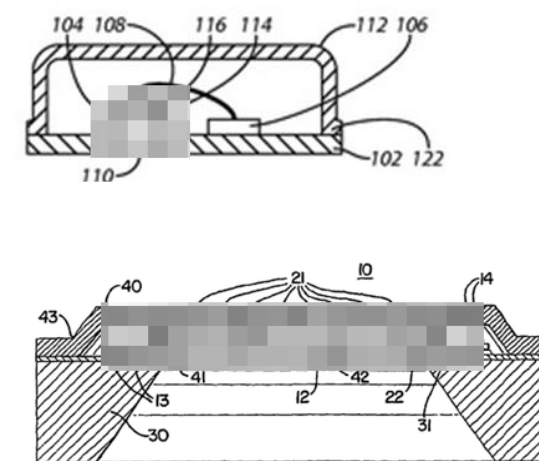
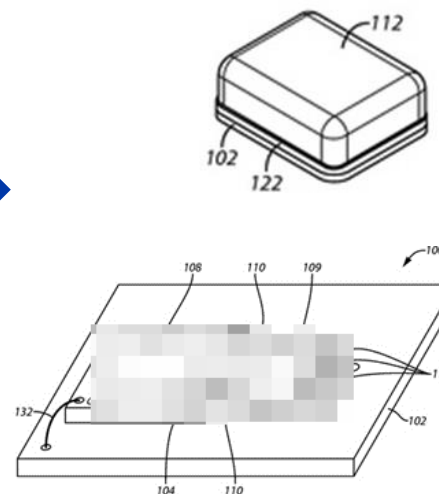
Scope of the Report

This report provides a patent-to-product mapping of the recent **MEMS Microphones supplied by Knowles** for the **iPhone 7 Plus of Apple**.

REPORT
SAMPLE



Patent-to-product
mapping



INTRODUCTION

Scope of the Report



This report provides a patent-to-product mapping of the recent **MEMS Microphones supplied by Knowles** for the **iPhone 7 Plus of Apple**.

The patent-to-product mapping study is focused on following features:

- ✓ **Process:** Diaphragm Structure, Anti-Stiction Bumps
- ✓ **Design:** Acoustic Holes Shape, Transducer Number & Shape
- ✓ **Packaging:** Port Structure, Housing, Embedded Capacitance, RF Shielding

The patent-to-product mapping study is not related to the following features:

- ✓ ASIC Die
- ✓ Dicing
- ✓ Wire Bonding

INTRODUCTION

Key Features of the Report

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- **Essential IP analysis** of Knowles' patent portfolio related to KSM1/KSM2 and KMM1 MEMS microphones found in Apple iPhone 7 Plus, including:
 - Time evolution of patent publications and countries of patent filings
 - Current legal status of patents
 - Citation network and competitive IP networks
 - Inventor identification
- **Deep insight on technology data**, including teardown analysis, of the Knowles microphone's components
- **Key patents related to Knowles** microphone's features and held by Knowles

METHODOLOGY

METHODOLOGY

Teardown Analysis and Patent Mapping

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Teardown Analysis

- Package is analyzed and measured
- The dies are extracted in order to get overall data: dimensions, main blocks, pad number and pin out, die marking



Comparative Study

- A set of product features and manufacturing processes is selected regarding their interest in terms of IP study



Patent Search

- Patents are extracted from Questel-Orbit worldwide patent database by using keyword-based queries
- The selection of relevant patents is done manually by expert review of the subject-matter of inventions
- The patents are manually categorized regarding the selected product features



Patent Mapping

- The links between the patented technologies and the target product features are established



- The data were extracted from the FamPat worldwide database (Questel-ORBIT) which provides 90+ million patent documents from 95 offices.
- The patents search was performed in January and February 2017, hence patents published after this date will not be available in this report.
- The patent selection was done manually.

**Number of selected patent families related to KSM1/KSM2 and KMM1 MEMS Microphones developed
by Knowles and found in Apple iPhone 7 Plus:
20 patent families**

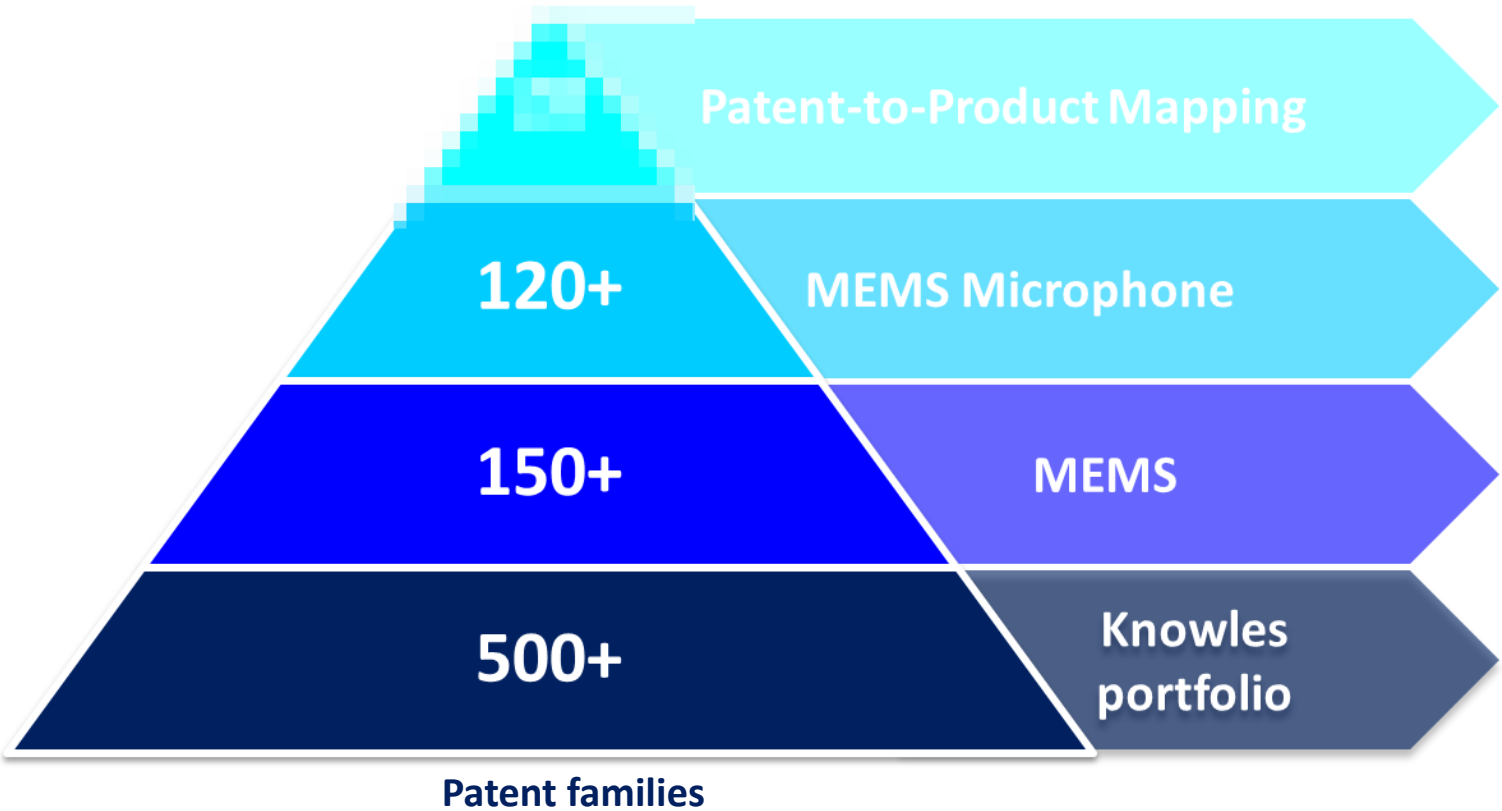
- The statistical analysis was performed with Questel Orbit IP Business Intelligence software.
- The patents were manually categorized using keyword analysis of patent title, abstract and claims, in conjunction with expert review of the subject-matter of inventions.
- The patents were organized according to FamPat's family rules (variation of EPO strict family): A *Patent Family* comprises patents linked by exactly same priority numbers (strict family), plus comparison of priority and application numbers, specific rules by country and information gathered from other sources (national files, legal status ...).

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PATENT LANDSCAPE OVERVIEW



Knowles IP Portfolio



XX families related to the MEMS microphones of Knowles (KSM1/2 and KMM1) found in Apple iPhone 7 Plus have been identified in this Patent-to-Product Mapping

The MEMS portfolio of Knowles is mainly turn toward MEMS microphones (120 families out of 150)

Over 150 families of Knowles portfolio are related to MEMS

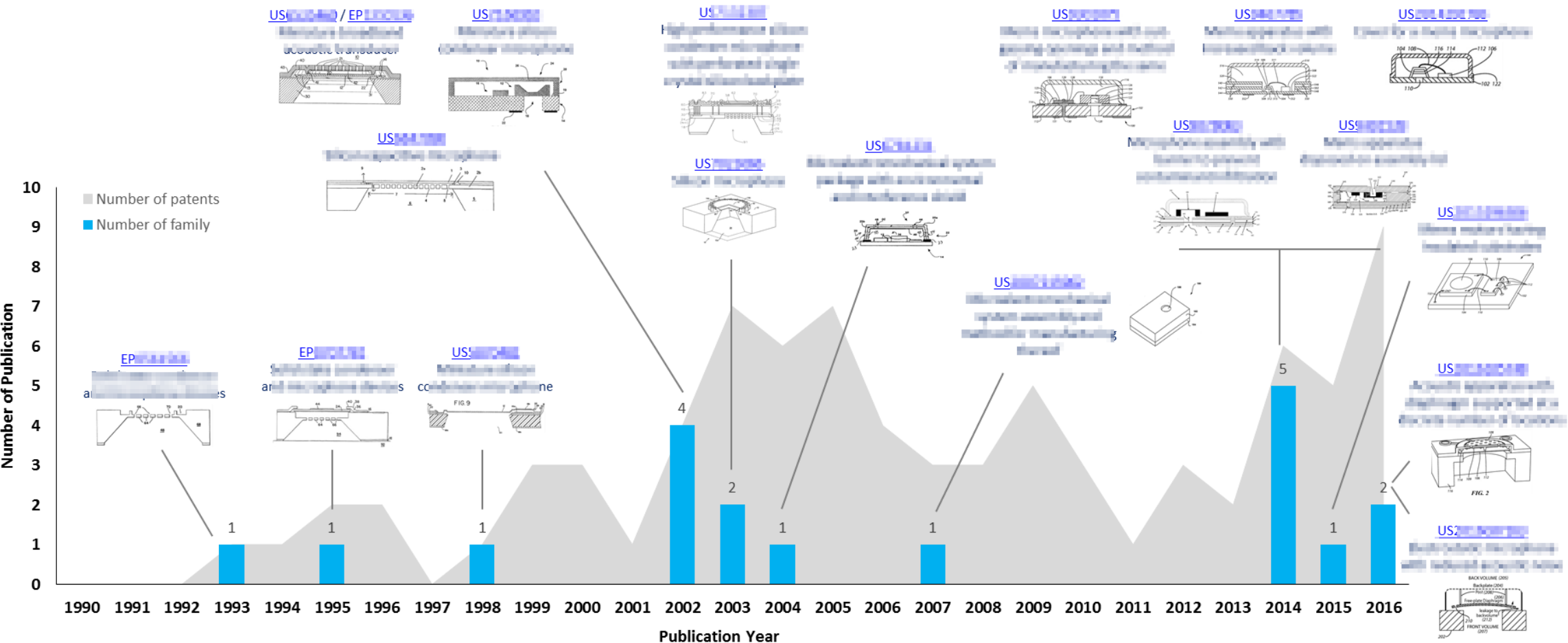
Knowles owns over 500 patent families worldwide. USA are by far the major country of filings, before China and Europe. The portfolio of Knowles is dedicated to audio and acoustic technologies, for examples: hearing aids, microphones, MEMS microphones,...

PATENT LANDSCAPE OVERVIEW

Time Evolution of Patent Publications

REPORT
SAMPLE

Knowles owns more than 500 patent families and over 120 families are dedicated to MEMS microphones. In this Patent-to-Product Mapping, we have identified **20 patent families of Knowles related to the MEMS microphones of the company found in the iPhone 7 Plus (KMM1/KSM1/KSM2 microphones)**. This represents over 150 patents or applications.



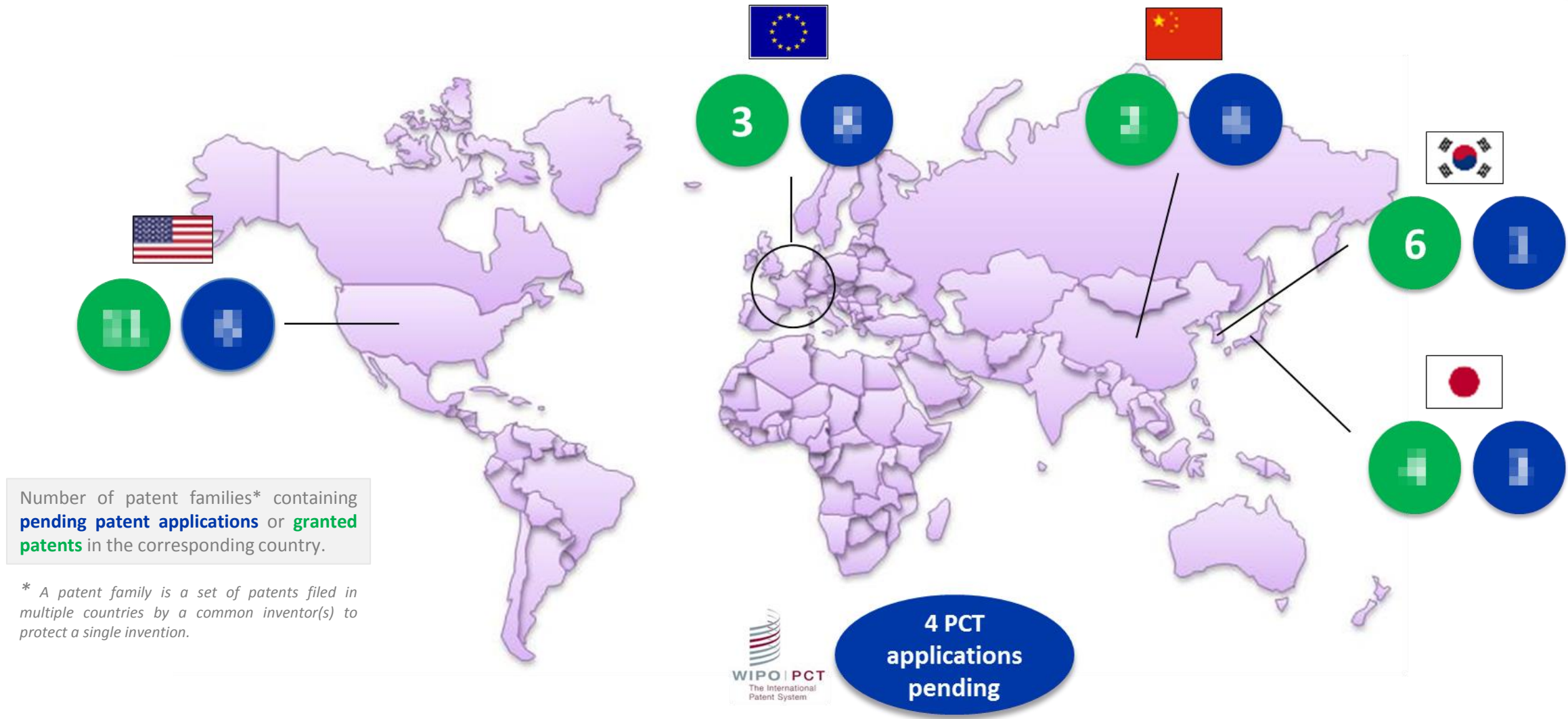
Note: Due to the delay between the filing of patents and the publications by patent offices, usually 18 months, the data corresponding to the year 2016 and 2017 may not be complete since most patents filed during these years are not published yet.

PATENT LANDSCAPE OVERVIEW

Mapping of Granted Patents and Pending Applications

REPORT
SAMPLE

Knowles has filed the patents related to the features identified for the KMM1/KSM1/KSM2 microphones worldwide.



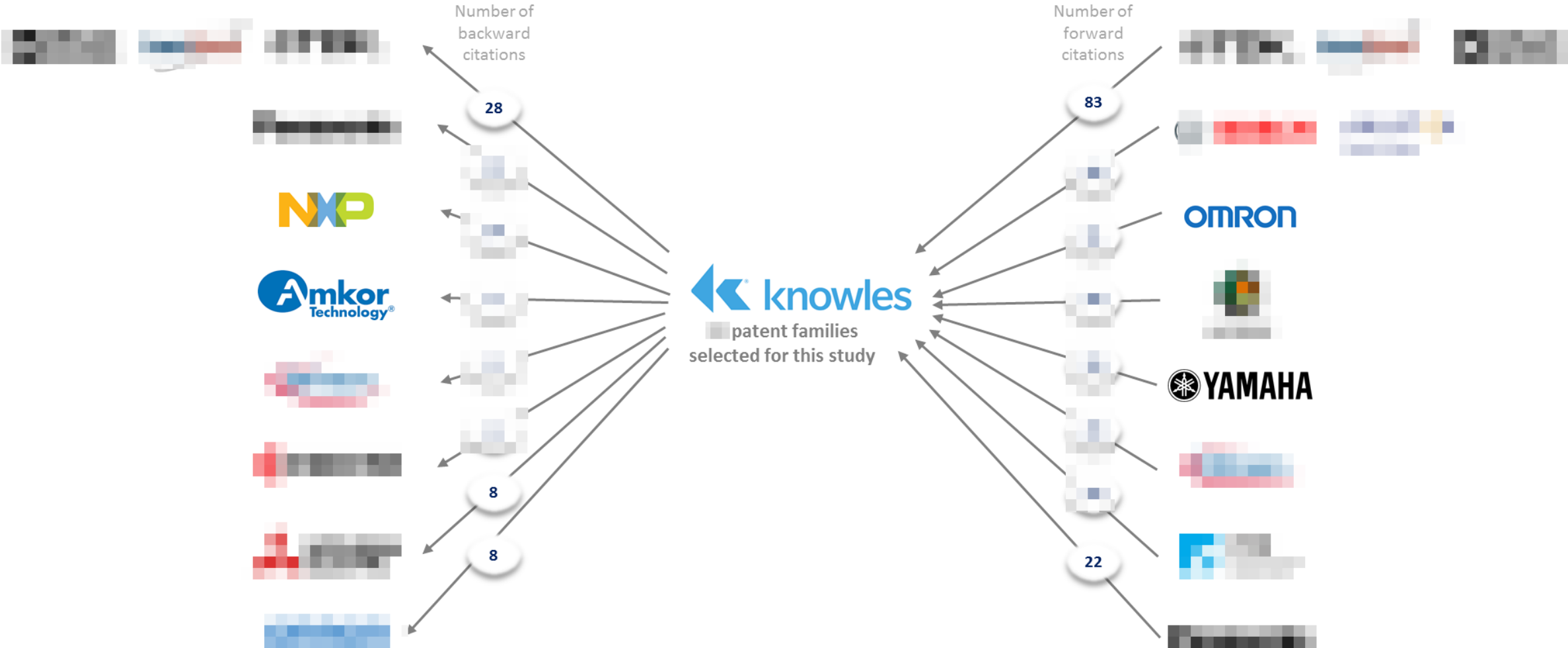
PATENT LANDSCAPE OVERVIEW

Patent Citation Analysis

REPORT
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Main companies cited in selected Knowles patents

Main companies citing selected Knowles patents

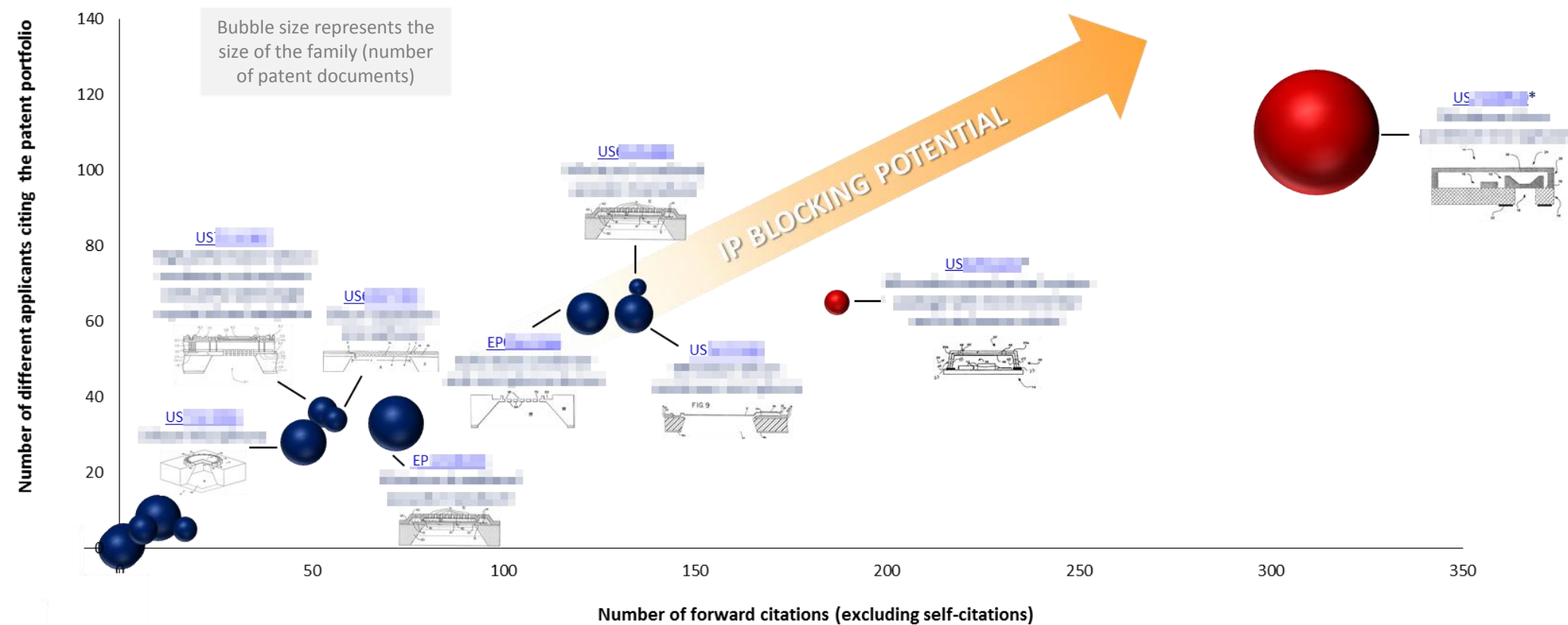


PATENT LANDSCAPE OVERVIEW

IP Blocking Potential of the Patent Families

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The patent [USxxxxxxx](#) and its associated family show a very high IP blocking potential. This patents and other US members of the family have been at the center of different patent litigations filed by Knowles against several competitors. Thus, it represents a key technology for Knowles. Over 35 patents of this family are currently granted in the US. Patents are also granted in Europe, Korea and Japan. Patent [USxxxxxxx](#) also has a high IP blocking potential. It has also been subject to patent litigations. Both patent families are related to the packaging of MEMS microphone and the RF shielding.



Note: The more the number of forward citations from different patent applicants is high, the more the capacity to hamper the other firms' attempts to patent a related invention is important. Note, however, that the identification of a "Blocking patent" requires an in-depth specific analysis of each patents.

*These patents have been the subject of patent litigations.

REPORT
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PATENT-TO-PRODUCT MAPPING

PATENT-TO-PRODUCT MAPPING

Packaging : Housing & RF Shielding

REPORT
SAMPLE

TEARDOWN

Packaging:

The device is covered with a [redacted]
[redacted]
[redacted]



Metal Lid removed – Optical View



Cross-Section Overview – SEM View

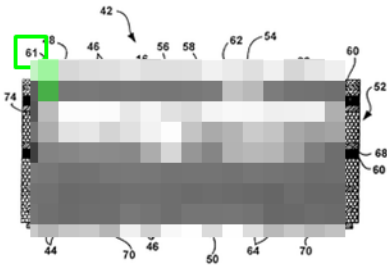


IDENTIFIED PATENT FAMILIES

Patent family	Claims	Description	Legal
US: [redacted] (2001) [redacted] [redacted]	Claim 1: A mems transducer comprising: a printed circuit board comprising a plurality of layers, at least one layer comprising a conductive material and at least one layer comprising an insulating material, a cover comprising a conductive layer, the printed circuit board and the cover forming at least a portion of a housing, the housing comprising an aperture for receiving a signal and an inner lining, the lining is electrically coupled to an element, the element is electrically coupled to the conductive layer, the conductive layer is formed by the conductive material, at least one layer of a conductive material is disposed between the conductive layer and the inner lining, the space between the conductive layer and the inner lining is filled with the printed circuit board material, the conductive layer is electrically coupled to the conductive material, the conductive material providing a portion of the inner lining, a transducer is mounted within the housing.	The [redacted] 16 includes an inner lining 18. The inner lining 18 is provided by the conductive material. It should be understood that the inner lining may include portions of conductive material in the conductive material may electrically couple the conductive material. The inner lining 18 provides the [redacted] 16 against electromagnetic interference and the [redacted] 16, such as a faraday cage.	US: [redacted] EP: [redacted] JP: [redacted] CN: [redacted] KR: [redacted] TW: [redacted]

Selected images

- 16: amplifier
- 42: [redacted]
- 44, [redacted]
- nor [redacted]
- 50: [redacted]
- 52: [redacted]
- 54: port
- 56: chamber



- 58: transducer
- 60: [redacted]
- 61: [redacted]
- 62: [redacted]
- 64: [redacted]
- 66: [redacted]
- 70: solder pads
- 74: side walls

PATENT-TO-PRODUCT MAPPING

Packaging : Housing & RF Shielding

REPORT
SAMPLE

TEARDOWN

Packaging:

The device is covered with a



Metal Lid removed – Optical View



Cross-Section Overview – SEM View

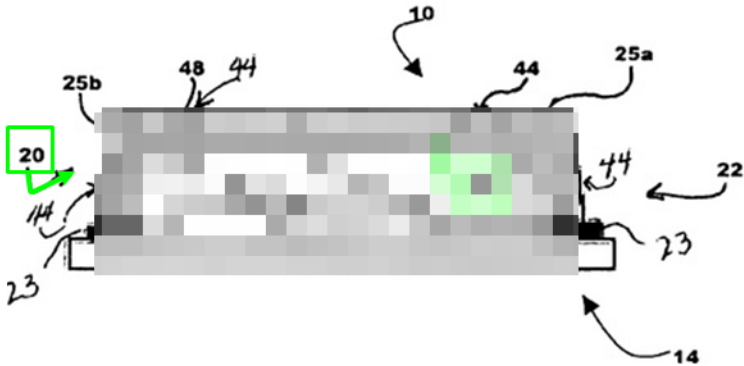


IDENTIFIED PATENT FAMILIES

Patent family	Claims	Description	Legal
US (2002)	<p>Claim1: A microelectromechanical system package comprising:</p> <p>a microelectromechanical system microphone; a substrate comprising a surface for supporting</p>	<p>The housing 22 includes a top portion and a bottom</p>	US: EP: JP: CN: KR: TW:

Note: This patent has been part of infringement litigations introduced by Knowles (see Patent Litigations section)

Selected images



- 12:
- 14:
- 20:
- 22: housing
- 23: conductive adhesive or solder
- 25: outer ad inner cups
- 36:
- 40:
- 44:
- 48:

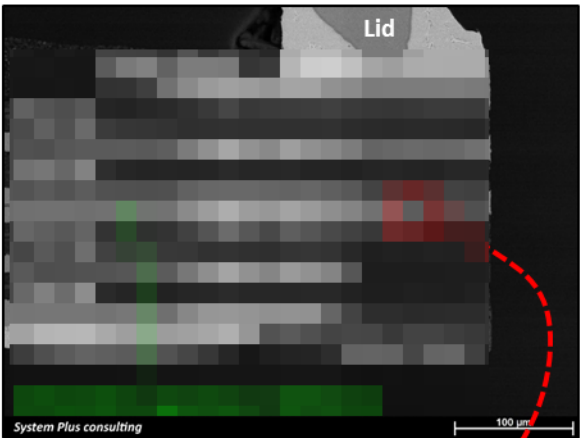
PATENT-TO-PRODUCT MAPPING

Embedded Capacitance

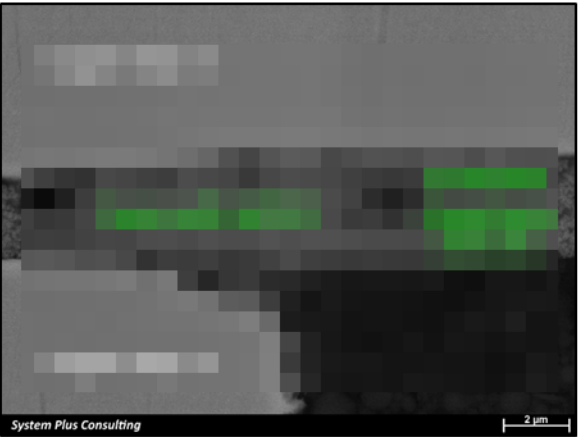
REPORT
SAMPLE

TEARDOWN

Embedded Capacitance:



PCB Cross-Section – SEM View

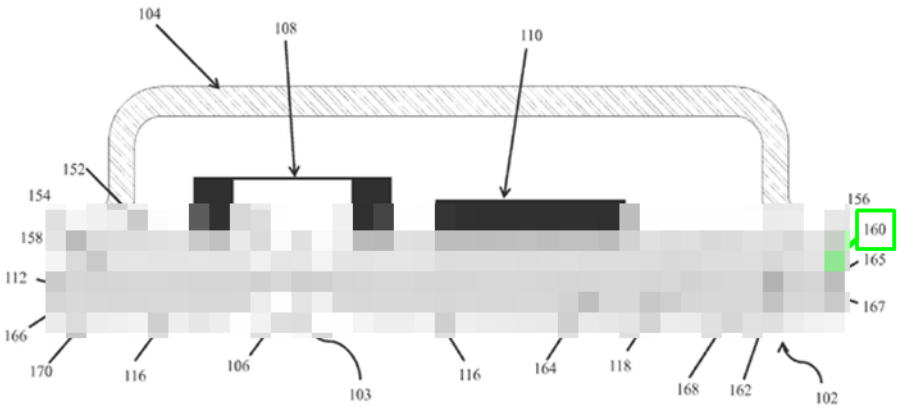


Embedded Capacitor Cross-Section – SEM View

IDENTIFIED PATENT FAMILIES

Patent family	Claims	Description	Legal
US (2013)	Claim 6: A MEMS microphone according to claim 5, wherein the substrate further comprises a	The base 102 in this example includes a first solder mask 152, a first metal layer 154, a first core layer 156, a second	US: EP: JP: CN: KR: TW:

Selected images



- 102: base
- 104: lid
- 106: port
- 108: MEMS apparatus
- 110: integrated circuit
- 112:
- 118:
- 154, 156, 158, 160, 162, 164, 166, 168, 170, 172, 174, 176, 178, 180, 182, 184, 186, 188, 190, 192, 194, 196, 198, 200

PATENT-TO-PRODUCT MAPPING

Backplate: Support Structure

REPORT
SAMPLE

TEARDOWN

Design and Packaging:

MEMS Microphone uses a



Backplate – Optical View



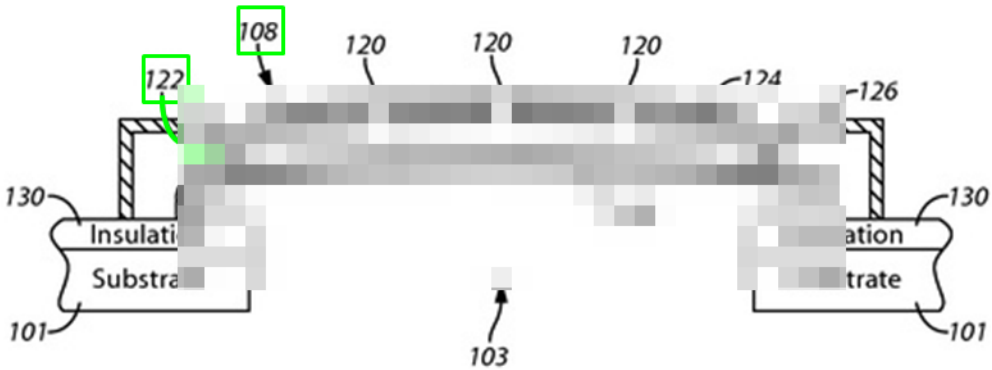
MEMS Cross-section – Optical View



IDENTIFIED PATENT FAMILIES

Patent family	Claims	Description	Legal
US (2015)	<p>Claim 1: A microelectromechanical system (MEMS) die comprising: a substrate; an insulation layer disposed adjacent to the substrate;</p>	<p>The back plate 108 includes a plurality of</p>	<p>US: EP: JP: CN: KR: TW: *WO:</p>

Selected images



- 101: substrate
- 103: port
- 106: diaphragm
- 108: backplate
- 120: insulation layer
- 122: port opening
- 124: port opening
- 126: port opening

PATENT-TO-PRODUCT MAPPING

MEMS Cavity & Bottom Acoustic Port

REPORT
SAMPLE

TEARDOWN

MEMS Cavity & Acoustic Port:

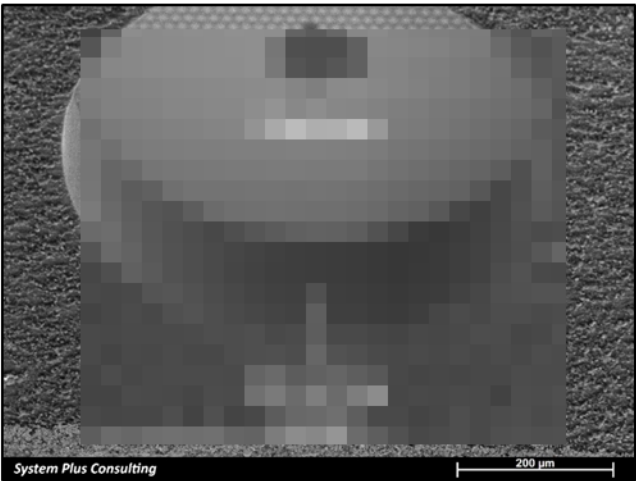
The diaphragm is located above



Cross-Section Overview – SEM View



MEMS Cross-section Overview



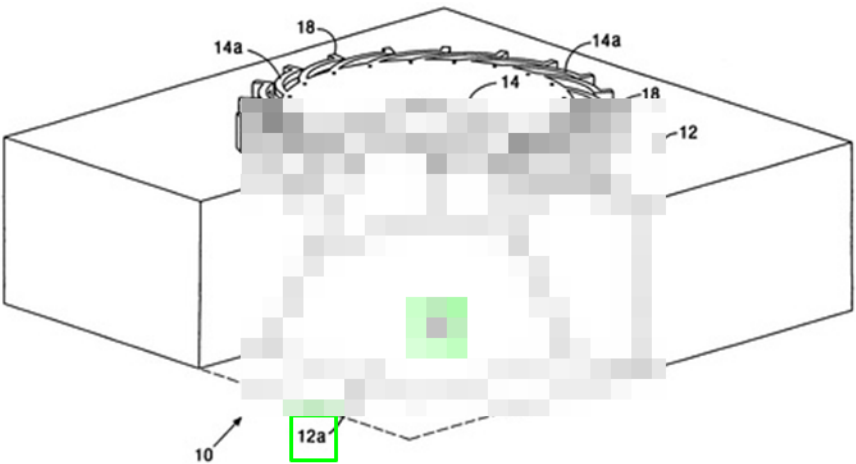
MEMS Die – Bottom Tilted SEM View



IDENTIFIED PATENT FAMILIES

Patent family	Claims	Description	Legal
US (2001)	Claim 1: A solid-state transducer comprising: a substrate forming a support structure and	The transducer 10 comprises a semi-conductor substrate [...] Referring again to FIG.[below], the substrate 12 is shown commonly found in bulk micro-machined silicon structures.	US: EP: JP: CN: KR: TW:

Selected images



10: transducer

12a:
14: c
18: s
20: s
24: b

REPORT
SAMPLE

PATENT LITIGATIONS

PATENT LITIGATIONS

Introduction

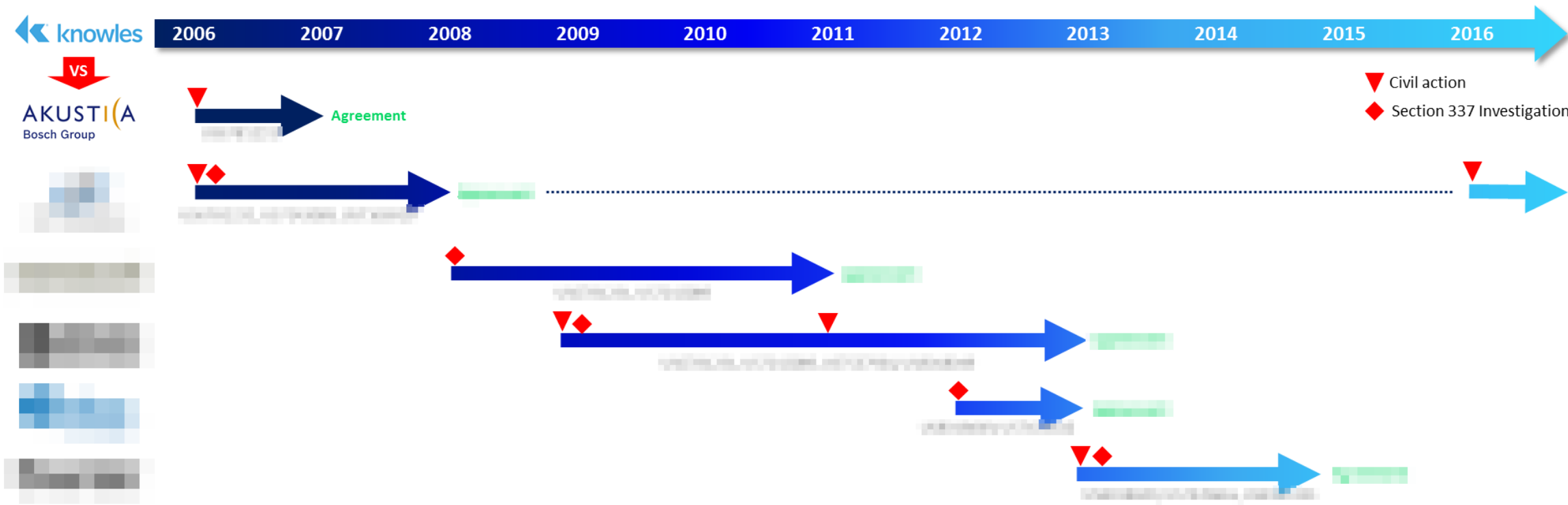
REPORT
SAMPLE

Knowles is the leader on the MEMS microphone market. According to our partner Yole Développement, **Knowles** represented over XX% of the market share for MEMS microphones in 2016*. On the IP side, the company defends its interests against potential infringement by its competitors. Indeed, several patents identified in this Patent-to-Product Mapping are involved in lawsuits introduced by **Knowles** in the USA. These patents belong to 2 families : [USxxxxxxxxxx](#) and [WOxxxxxxxxxx](#). Defendants in these lawsuits are **Company XXX, Company XXX, Company XXX, Company XXX, Company XXX** and **Company XXX**.

GoerTek is the 2nd market player behind Knowles on the MEMS microphone market, it owned XX% of the market share in 2016*. **Company XXX** is shortly in front of **Company XXX**, 3rd market player. **Company XXX**(acquired by Bosch in 2005), **Company XXX** (acquired by InvenSense and then TDK), **Company XXX** and **Company XXX** represented each less than XX% of the market share in 2016*.

The patent litigations are mostly related to packaging technology for MEMS microphones. They were all settled by an agreement between Knowles and the defendants.

**Source: Yole Développement, Acoustic MEMS (Microphone, Microspeaker) and Audio Solutions 2017 report (to be published)*



ORDER FORM

Knowles MEMS Microphones in Apple iPhone 7 Plus – Patent-to-Product Mapping

Ref.:KM17004

SHIP TO

Name (Mr/Ms/Dr/Pr):

Job Title:

Company:

Address:

City:

State:

Postcode/Zip:

Country:

VAT ID Number for EU members:

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Email:

Date:

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The Seller shall by no means be responsible for any delay in respect of article 2.2 above, and including in cases where a new event or access to new contradictory information would require for the analyst extra time to compute or compare the data in order to enable the Seller to deliver a high quality Products.

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2.5 The person receiving the Products on behalf of the Buyer shall immediately verify the quality of the Products and their conformity to the order. Any claim for apparent defects or for non-conformity shall be

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BIC or SWIFT code: CCBPFRPPNCE

IBAN: : FR76 1560 7000 6360 6214 5695 126

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3.3 Payment is due by the Buyer to the Seller within 30 days from invoice date, except in the case of a particular written agreement. If the Buyer fails to pay within this time and fails to contact the Seller, the latter shall be entitled to invoice interest in arrears based on the annual rate Refi of the «BCE» + 7 points, in accordance with article L. 441-6 of the French Commercial Code. Our publications (report, database, tool...) are delivered only after reception of the payment.

3.4 In the event of termination of the contract, or of misconduct, during the contract, the Seller will have the right to invoice at the stage in progress, and to take legal action for damages.

4. LIABILITIES

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b) any claim attributable to errors, omissions or other inaccuracies in the Product or interpretations thereof.

4.4 All the information contained in the Products has been obtained from sources believed to be reliable. The Seller does not warrant the accuracy, completeness adequacy or reliability of such information, which cannot be guaranteed to be free from errors.

4.5 All the Products that the Seller sells may, upon prior notice to the Buyer from time to time be modified by or substituted with similar Products meeting the needs of the Buyer. This modification shall not lead to the liability of the Seller, provided that the Seller ensures the substituted Product is similar to the Product initially ordered.

4.6 In the case where, after inspection, it is acknowledged that the Products contain defects, the Seller undertakes to replace the defective products as far as the supplies allow and without indemnities or compensation of any kind for labor costs, delays, loss caused or any other reason. The replacement is guaranteed for a maximum of two months starting from the delivery date. Any replacement is excluded for any event as set out in article 5 below.

4.7 The deadlines that the Seller is asked to state for the mailing of the Products are given for information only and are not guaranteed. If such deadlines are not met, it shall not lead to any damages or cancellation of the orders, except for non-acceptable delays exceeding [4] months from the stated deadline, without information from the Seller. In such case only, the Buyer shall be entitled to ask for a reimbursement of its first down payment to the exclusion of any further damages.

4.8 The Seller does not make any warranties, express or implied, including, without limitation, those of

saleability and fitness for a particular purpose, with respect to the Products. Although the Seller shall take reasonable steps to screen Products for infection of viruses, worms, Trojan horses or other codes containing contaminating or destructive properties before making the Products available, the Seller cannot guarantee that any Product will be free from infection.

5. FORCE MAJEURE

The Seller shall not be liable for any delay in performance directly or indirectly caused by or resulting from acts of nature, fire, flood, accident, riot, war, government intervention, embargoes, strikes, labor difficulties, equipment failure, late deliveries by suppliers or other difficulties which are beyond the control, and not the fault of the Seller.

6. PROTECTION OF THE SELLER’S IPR

6.1 All the IPR attached to the Products are and remain the property of the Seller and are protected under French and international copyright law and conventions.

6.2 The Buyer agreed not to disclose, copy, reproduce, redistribute, resell or publish the Product, or any part of it to any other party other than employees of its company. The Buyer shall have the right to use the Products solely for its own internal information purposes. In particular, the Buyer shall therefore not use the Product for purposes such as:

- Information storage and retrieval systems;

- Recordings and re-transmittals over any network (including any local area network);

- use in any timesharing, service bureau, bulletin board or similar arrangement or public display;

- Posting any Product to any other online service (including bulletin boards or the Internet);

- Licensing, leasing, selling, offering for sale or assigning the Product.

6.3 The Buyer shall be solely responsible towards the Seller of all infringements of this obligation, whether this infringement comes from its employees or any person to whom the Buyer has sent the Products and shall personally take care of any related proceedings, and the Buyer shall bear related financial consequences in their entirety.

6.4 The Buyer shall define within its company point of contact for the needs of the contract. This person will be the recipient of each new report in PDF format. This person shall also be responsible for respect of the copyrights and will guaranty that the Products are not disseminated out of the company.

7. TERMINATION

7.1 If the Buyer cancels the order in whole or in part or postpones the date of mailing, the Buyer shall indemnify the Seller for the entire costs that have been incurred as at the date of notification by the Buyer of such delay or cancellation. This may also apply for any other direct or indirect consequential loss that may be borne by the Seller, following this decision.

7.2 In the event of breach by one Party under these conditions or the order, the non-breaching Party may send a notification to the other by recorded delivery letter upon which, after a period of thirty (30) days without solving the problem, the non-breaching Party shall be entitled to terminate all the pending orders, without being liable for any compensation.

8. MISCELLANEOUS

All the provisions of these Terms and Conditions are for the benefit of the Seller itself, but also for its licensors, employees and agents. Each of them is entitled to assert and enforce those provisions against the Buyer.

Any notices under these Terms and Conditions shall be given in writing. They shall be effective upon receipt by the other Party.

The Seller may, from time to time, update these Terms and Conditions and the Buyer, is deemed to have accepted the latest version of these terms and conditions, provided they have been communicated to him in due time.

9. GOVERNING LAW AND JURISDICTION

9.1 Any dispute arising out or linked to these Terms and Conditions or to any contract (orders) entered into in application of these Terms and Conditions shall be settled by the French Commercial Courts of Grasse, which shall have exclusive jurisdiction upon such issues.

9.2 French law shall govern the relation between the Buyer and the Seller, in accordance with these Terms and Conditions.



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