

SAMPLE

PATENT MONITOR

RF Acoustic Wave Filter

Quarterly Report

Q1 2019

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PATENT MONITOR

Take advantage of periodic updates on IP activities



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Monthly IP database (Excel file)

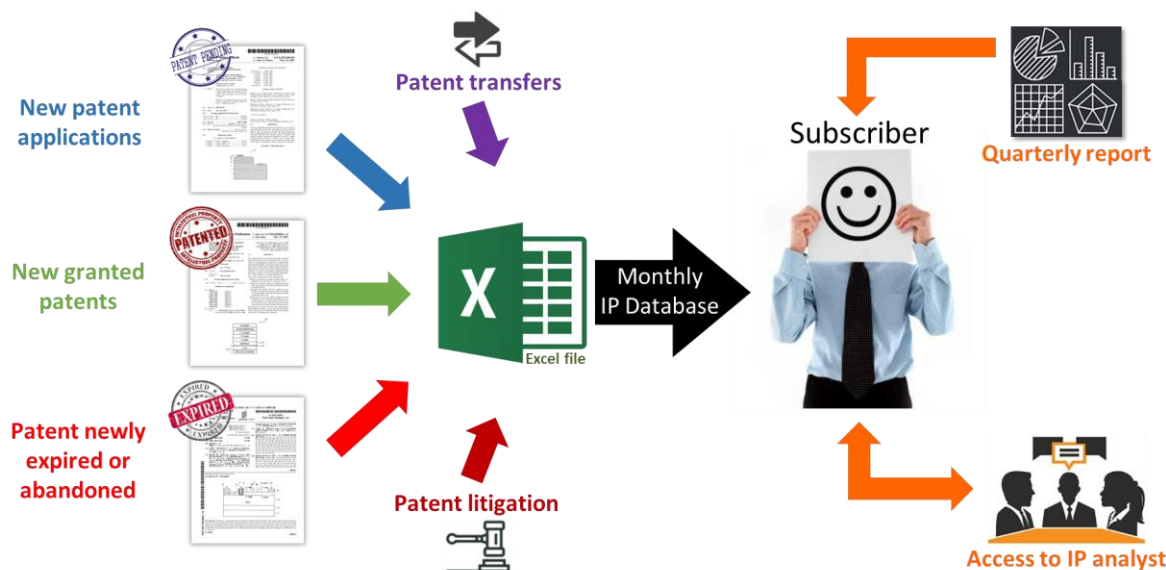
- New patent applications
- Patents newly granted
- Patents expired or abandoned
- Transfer of IP rights (re-assignment, licensing)
- Patent litigation & opposition

Quarterly report (PDF slide deck)

On a quarterly basis, this report will provide the IP trends over the last three months, with a close look to key IP players and key patented technologies.

Access to IP analysts (100h a year)

On-demand Q&A and discussion session with our analysts on specific patented technologies or company IP portfolios

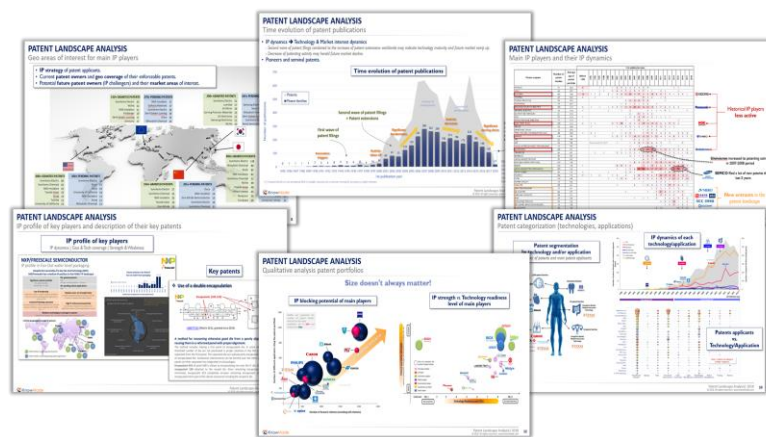


WHY YOU SHOULD SUBSCRIBE

- ✓ Track your **competitors**, partners or clients
- ✓ Identify **newcomers** to your technology field
- ✓ Early detect **opportunities** and risks for your business strategy
- ✓ Be ahead of **technology trends**
- ✓ Identify emerging research areas and **cutting-edge technology** developments
- ✓ Mitigate patent **infringement risks**
- ✓ Take advantage of **free technologies**

On a quarterly basis, this report will provide the IP trends over the last three months, with a close look to key IP players and key patented technologies.

- Main patent applicants, their notable patent filings and technologies.
- New entrants and their patents.
- Technology trends and notable patented technical solutions.
- Key patents newly granted, their owners and claimed inventions.
- Main IP right transfers (reassignments, licensing agreements).
- Key patents newly expired or abandoned, their owners and their potential market impact.
- Noteworthy news on patent litigation and opposition, plaintiffs and defendants, patents and products involved.



QUARTERLY REPORT

Monthly IP database

SAMPLE

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1	KnowMode																						
2	New patent families published in January 2019																						
3	Patent family in a set of patents filed in multiple countries to protect a single invention (a common invention); A first application in a new country; The priority country; and in the extended in another country.																						
4																							
5																							
6	Family number (Harvard case file) (US Patent #)	Patent number (US Patent #)	Publication date (US Patent #)	Expiry date (US Patent #)	Original country (US Patent #)	Application number (US Patent #)	Priority date (US Patent #)	Priority date (US Patent #)	Expiry date (US Patent #)	Current legal status (US Patent #)	Grant date (US Patent #)	Current status (US Patent #)	Title (US Patent #)	Abstract (US Patent #)	Claims (US Patent #)	Info (US Patent #)	Info (US Patent #)	Info (US Patent #)	Info (US Patent #)	Info (US Patent #)	Info (US Patent #)	Info (US Patent #)	Info (US Patent #)
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42	8326165	WO/2018/022236	2018-01-31	2018-01-31	DATA	WO/2018/022236	2018-01-31	2018-01-31	2018-01-31	PENDING			WO/2018/022236	The present invention relates to a...	WO/2018/022236	X							
43	8326165	WO/2018/022236	2018-01-31	2018-01-31	DATA	WO/2018/022236	2018-01-31	2018-01-31	2018-01-31	PENDING			WO/2018/022236	The present invention relates to a...	WO/2018/022236	X							
44	8326165	WO/2018/022236	2018-01-31	2018-01-31	DATA	WO/2018/022236	2018-01-31	2018-01-31	2018-01-31	PENDING			WO/2018/022236	The present invention relates to a...	WO/2018/022236	X							
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51	8326165	WO/2018/022236	2018-01-31	2018-01-31	DATA	WO/2018/022236	2018-01-31	2018-01-31	2018-01-31	PENDING			WO/2018/022236	The present invention relates to a...	WO/2018/022236	X							
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53	8326165	WO/2018/022																					

Segments

(a X indicate a patent belonging to the segment)

Patent segmentation
(technology, applications, value chain, etc)

Excel worksheet listing the latest **patent litigation and opposition**

Excel worksheet listing the **changes in ownership** during the past month

Excel worksheet listing the **patents expired or abandoned** during the past mont

➡ Excel worksheet listing the **patents newly granted** during the past month

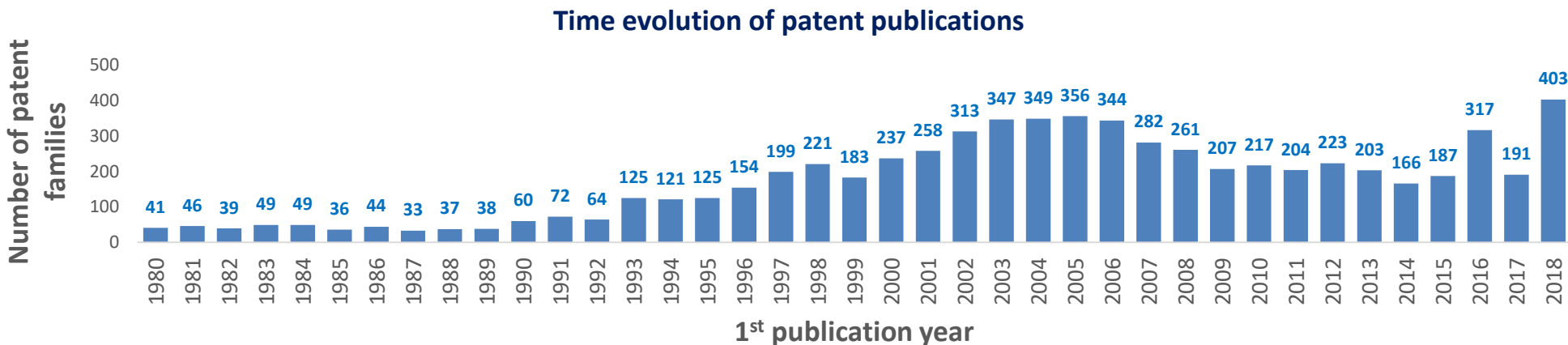
Excel worksheet listing the **new patent applications** published during the past month

Acoustic Wave Filters IP Landscape Overview

RF Acoustic Wave Filters

Patent landscape overview

SAMPLE



Number of patent families related to each technology for the main patent assignees

Assignees	AW Filters	SAW	FBAR	SMR
MURATA	1063	1019	70	6
TAIYO YUDEN	651	516	176	19
SKYWORKS	465	374	83	35
KYOCERA	393	352	41	5
BROADCOM	269	38	203	124
HITACHI	264	248	25	3
TDK	222	184	32	22
QUALCOMM	216	153	63	37
TOYO COM.	204	204	0	0
SAMSUNG	163	69	102	1
SEIKO EPSON	137	126	17	1
QORVO	122	71	39	35

- Acoustic wave filters IP landscape and market are now well consolidated.
- **Murata** leads the IP landscape related to **SAW filters** and its IP activity has remained high since the end of the 90's. **Kyocera**, **Skyworks**, **Taiyo Yuden** and **TDK EPCOS (Now RF360)** are the other main IP players regarding **SAW filters**. Indeed, despite their smaller and weaker portfolio, these IP players have exhibited a growing IP activity and also benefit from a high number of forward citations attesting of a solid prior art contribution.
- Regarding **BAW filters**, the IP landscape is dominated by **Broadcom** and **Taiyo Yuden** but it appears **less consolidated** than the SAW IP landscape. Indeed, the decrease of Broadcom IP activity in the last 10 years and **the rise of RF 360, Qorvo** and **Samsung** has reshuffled the IP landscape related to BAW filters as they are progressively closing the gap with the two IP leaders.

1st Quarter, 2019

(January – February - March)

Q1 2019

Introduction

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- This report covers patents published worldwide in **Q1 2019**, from January 2019 to March 2019, and it provides a detailed picture of the IP activity related **RF acoustic wave filter** dedicated to **mobile applications**. In that period, Knowmade has selected and analyzed all patents related to RF acoustic filters : SAW, TC_SAW, BAW, FBAR, SMR, duplexers, diplexers, multiplexers, filter modules, etc. dedicated to telecommunication applications.
- The data are extracted from the **FamPat worldwide patent database** (Questel-ORBIT) which provides 100+ million patent documents from 95 worldwide patent offices.
- The patents are grouped in **patent families**. A patent family is a set of patent applications filed in multiple countries to protect a single invention by a common inventor(s). A first patent application is filed in one country – the priority country – and is then extended to other countries.
- The **selection of relevant patents** are **manually** performed using **keywords analysis** of patent title, abstract and claims, combined with **patent classes** (IPC, CPC), in conjunction with **expert review** of the subject-matter of inventions.
- The patents are **manually categorized in technical/application segments** by manual analysis of each patent title, abstract, descriptions, illustrations and claims, combined with patent classes (IPC, CPC) and in conjunction with expert review of the subject-matter of inventions.

Note: the numbers represent the number of **patent families**. A patent family can belong to multiple segments.

	Q1 2019	SEGMENT			
		SAW	BAW	Duplexers	Multiplexer
New patent families (inventions)	115	73	55	16	31
Patent newly granted	53	30	27	12	1
Patent expired or abandoned	41	41	4	1	0

Q1 2019 OVERVIEW

New patents

SAMPLE

Assignees	Number of new patent families	SAW	BAW	FBAR	SMR	Duplexer	Multiplexer
MURATA MANUFACTURING	30	29	7			2	19
TAIYO YUDEN	11	5	7	7		4	7
SAMSUNG ELECTRO MECHANICS	11	2	9	8		1	
KYOCERA	9	9				5	1
RF360 EUROPE	6	2	4	1	2	1	2
SAPPLAND	4	3	2	1			
CETC DEQING HUAYING ELECTRONICS	3	3					
HUAYAN MICRO ELECTRONIC TECHNOLOGY	2	2					
JCAP	2	2	4				
QORVO	2	2	1				
XI'AN UNIVERSITY OF SCIENCE 1 TECHNOLOGY	2	2					
SKYWORKS SOLUTIONS	2	2				1	
AKOUSTIS	2		2				
CHOICORE PHOTOELECTRIC TECHNOLOGY	2		2				
NGK INSULATOR	2		2				
WISOL	1	1					1

Most notable new patents (manual selection by Knowmade analyst)	Segment
US20190058455 – Bulk acoustic wave resonator (Samsung Electro Mechanics)	BAW
US20190058451 – Bulk acoustic wave resonator (Samsung Electro Mechanics)	BAW
US20190019939 – Acoustic wave device and method of manufacturing the same (Samsung Electro Mechanics)	BAW
US20190013792 – Acoustic resonator and method for manufacturing the same (Samsung Electro Mechanics)	BAW
WO2019029911 – Baw resonator with reduced losses, rf filter comprising a baw resonator and method for manufacturing a baw resonator (RF360)	BAW
US20190044207 – Filter circuits having a resonator-based filter and a magnetically-coupled filter (Qorvo)	BAW
US20190068159 – Temperature compensated acoustic wave devices (Resonant)	SAW
DE102017127713 – Electro-acoustic filter with a reduced acoustic coupling, method of reducing acoustic coupling and multiplexer (RF360)	SAW
JP2019022093 – Acoustic wave device (Taiyo Yuden)	SAW
US20190058452 – Multiplexer (Murata)	SAW / Multiplexers
WO201917422 – Multiplexer, high-frequency front end circuit, and communication device (Murata)	SAW / Multiplexers
US20180375496 – Multiplexer, transmission device, and reception device (Murata)	SAW / Multiplexers

- The **IP activity of the first quarter of 2019** is in good adequation with the general IP trends for **RF acoustic wave filters**. Indeed, the **patenting activity** is dominated by the IP leaders that keep **strengthening their positions**. Especially, **Murata** continues to lead the patent landscape related to **SAW** but also develops its IP position related to **multiplexers** and other modules as assert the **19 new patents** published in Q1 2019.
- **Kyocera** had a **noticeable patenting activity** this quarter. Indeed, the company had reduced its patenting activity since 2011 to about 5 new publications per year between 2010 and 2017.
- **Samsung Electro Mechanics** and **RF360** have filed several noticeable patents that will most likely increase their **portfolio strength and prior art contribution**.
- We have identified **4 IP newcomers** : **JCAP** (Jiangyin Changdian Advanced Packaging – see [here](#)), **RFHIC**, **Xi'an University of Science and Technology (XUST)** and **Choicore**. All these new comers are **Chinese IP players** that had never published patents related to acoustic wave filters before.

Q1 2019 OVERVIEW

Patents newly granted

Assignees	Number of newly granted patent families	SAW	BAW	FBAR	SMR	Duplexer	Multiplexer
MURATA MANUFACTURING	12	12	3			4	2
SAMSUNG ELECTRO MECHANICS	5		5	2		2	
BROADCOM	3	2	2	1	1	1	
RF360 EUROPE	3	1	2	1	2	1	
ERICSSON	2	2	2				
JIANGSU CHANGJIANG ELECTRONICS TECHNOLOGY	2	2					
KYOCERA	2	2					
QUALCOMM & EPCOS	2	2	1				
RUIDIKE MICRO ELECTRONIC	2		2	2			
SKYWORKS SOLUTIONS	2	2				1	
TAIYO YUDEN	2	1	1	1	1	1	
HUAWEI	1	1	1				
NIHON DEMPA KOGYO	1	1					
QORVO	1		1		1		
WISOL	2	2					

Most notable patents newly granted

(manual selection by Knowmade analyst)

[JP6441761](#) - Piezoelectric thin film resonator, filter, and duplexer (**Taiyo Yuden**)
[US10218334](#) - Acoustic wave device (**Taiyo Yuden**)
[US10177734](#) - Surface acoustic wave resonator (**Broadcom**)
[JP6437834](#) - Demultiplexer (**Kyocera**)
[US10158341](#) - Filter device (**Murata**)
[JP6467077](#) - High-pass filter (**Panasonic & Skyworks**)
[US10164602](#) - Acoustic wave device and method of manufacturing the same (**Samsung Electro Mechanics**)
[US10177736](#) - Bulk acoustic wave resonator comprising multiple acoustic reflectors (**Broadcom**)
[EP3210306](#) - Radio frequency multiplexer (**Ericsson**)

Segment

BAW / Duplexer
 SAW
 SAW
 SAW
 SAW / multiplexer
 SAW / Duplexer
 BAW
 BAW
 Multiplexer

- In Q1 2019, both **IP and market leaders** have seen their patent portfolios strengthened by the **grant of several patents**. Especially **Murata** has once again increased its IP leadership regarding **SAW filters** with 10 inventions newly granted in the quarter.
- **Broadcom** which holds a patent portfolio mainly related to FBAR filters, has also strengthen its portfolio related to **SMR BAW and SAW filters**. Regarding the BAW filters, Broadcom has developed resonator structures with **multiple active areas over a common substrate to provide improved power handling**. The structure can be adapted to **FBAR or SMR resonators**. Regarding the SAW filter, Broadcom invention describe in patent **US10177734** provides a device having a an acoustic wave suppression layer that reduce the incidence of spurious modes in the piezoelectric layer.

Q1 2019 OVERVIEW

Patents expired or abandoned

Assignees	Number of newly expired patents	SAW	BAW	FBAR	SMR	Duplexer	Multiplexer
MURATA MANUFACTURING	13	13				1	
EPCOS	7	6	1				
BEIJING ZHONGXUNSIFANG TECHNOLOGY	6	6					
QUALCOMM	3	3					
EPSON TOYOCOM	2	2					
INTELLECTUAL VENTURES HOLDING	2	2					
SEIKO EPSON	2	2					
THALES	2	2					
HUATIAN TECHNOLOGY ELECTRONICS	1						
INTEL	1		1	1			
NIHON DEMP A KOGYO	1	1					
OKI SEMICONDUCTOR	1	1					
SAMSUNG ELECTRO MECHANICS	1		1	1			
SIEMENS	1	1					
SKYWORKS SOLUTIONS	1	1					
X CYTE	1	1					

Most notable patents expired or abandoned (manual selection by Knowmade analyst)

[US7128941](#) - Method for fabricating film bulk acoustic resonator (FBAR) device (**Samsung Electro Mechanics**)

[US6722030](#) - Process for manufacturing an electronic component, in particular a surface-wave component working with acoustic surface waves (**EPCOS**)

[US6208062](#) - Surface acoustic wave modulator (**X CYTE**)

[US6104260](#) - Surface acoustic wave filter with first and second filter tracks and balanced or unbalanced terminals (**Skyworks**)

[US6031435](#) - Multiple-stage ladder type saw filter having series resonators with decreasing electrode pitches (**Intellectual Ventures**)

[US6154105](#) - Surface acoustic wave device with specific electrode materials and quartz substrate euler angles (**Murata**)

[JP3301399](#) - Surface acoustic wave device (**Murata**)

[US6208223](#) - Receiving filter of a saw separator with greater electrode interdigitated width in first stage parallel resonator (**Intellectual Ventures**)

[US6329888](#) - Reflection inversion surface acoustic wave transducer and filter (**Seiko Epson**)

Segment

BAW

SAW

SAW

SAW

SAW

SAW

SAW

SAW

- Almost all **patents expired or abandoned** during the first quarter of 2019 are related to **SAW filters**. Especially, 13 of Murata's patents, that were maintained alive for 20 years, expired this quarter. Among these patents, **JP3301399** and **US6154105** were the two last alive member of their families, both of which were extended in more than 6 countries.
- The **most noticeable** expired patent is the **US7128941** held by **Samsung** and that have been abandoned after for 12 years. The invention is now free of any IP rights. The patent describes **BAW based filters** in which several **FBAR** components with various resonant frequencies are arranged. The resonant frequency tuning is achieved by having a membrane with a plurality of active regions with different thicknesses.
- **Intellectual Ventures**, non-practicing entity (NPE, or "patent troll") has seen 2 of its US patents (**US6208223**, **US6031435**) expired this quarter reducing its blocking potential in the acoustic wave filter IP domain. The Japan members of the 2 expired families were filed in 1998 and then abandoned by OKI electronic in 2004 and 2013 respectively.
- **Seiko Epson** which shows almost no IP activity related to SAW filters in the last decade lost 2 main US patent this quarter : **US6329888** and **US6369674** that are related to **SAW filters with reflectors**. The 2 patents belong to families held by Toyo Communication and Seiko Epson. While Toyo communication abandoned its members couple of years ago, Seiko Epson kept its US patents alive until the end of the legal period of 20 years.

Focus on main IP players of the quarter

Note: the numbers represent the number of **patent families**. A patent family can belong to multiple segments.

	Q1 2019	SEGMENT			
		SAW	BAW	Duplexers	Multiplexer
New patents	30	29	7	0	19
Patent newly granted	12	12	3	0	1
Patent expired or abandoned	13	13	0	0	0

- **Murata** is the most active IP player of the quarter. Its patenting activity is mainly related to **SAW devices for low bands applications** and **multiplexers**. Notable new patents [US20190058452](#), [WO2019017422](#) and [US10158342](#) are described in the next page. Murata continues to increase its IP leadership in SAW devices and to strengthen its IP position in RF acoustic filter related patent landscape.
- The **recent IP activity of Murata** is in **adequation with the business development** of the company it has been doing for more than 5 year. Indeed, **Murata's** recent patents are related to **reduce filters and multiplexer insertion loss and sizes** as well as **enhancing impedance matching**. While the race to 5G and high frequency filters has pushed many players to look into new technologies and higher bands (mm waves, sub 6GHz) Murata's IP new patents are still focused on manufacturing **SAW filters** and **multiplexers** working around **2GHz** or in the **LTE band20**. Thus Murata strategy seems to be to secure its strong IP and market position in the low bands by **enlarging its patent portfolio with modules related patents**.
- Acoustic filters are part of Murata's piezo-electric products which include multiband, multi-mode, SAW filters that play an active role. As telecommunications standards have evolved from 3G to LTE and to 4G, the trend is towards multiband and multi-mode portable devices. According to the company press release and products, it appears that **SAW filters** and **duplexers/multiplexers** are the current and main **products under developments** which is in line with their recent patenting activity and IP strategy.

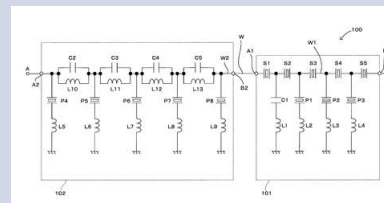
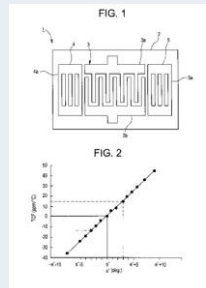
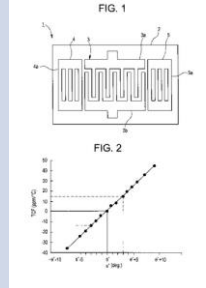


Murata Manufacturing: notable patents selected by Knowmade analyst

Status	Patent number and title	Patent details	
New patent	US20190058452 Multiplexer 1 st publication : 2019-02-21 Counterparts : Pending : JP, US, KR, CN	Preferred embodiments of the present invention provide multiplexers that reduce or prevent degradation of insertion characteristics and that have improved isolation characteristics both in the transmission band and in the reception band . The transmission-side filter is a ladder elastic wave filter circuit, that includes series arm resonators and parallel arm resonators and inductors that are preferably used for, for example, a transmission in Band8 of an LTE (Long Term Evolution) standard .	
New patent	US10158342 Multiplexer, transmission device, and reception device 1 st publication : 2018-12-18 Counterparts : Pending : JP, CN US, KR Granted : US (2018-12-18)	the present invention provides multiplexers that each include a mounting substrate including an inductance element therein and that is capable of obtaining excellent impedance matching at an antenna terminal. The multiplexer according to a preferred embodiment of the invention includes a mounting substrate, one first elastic wave filter and one or more second elastic wave filters that are provided on one principal surface of the mounting substrate and have different pass bands from each other (Band66 and band25)	
New patent	WO201917422 Multiplexer, high-frequency front end circuit, and communication device 1 st publication : 2019-01-24 Counterparts : Pending : EP	This multiplexer is provided with a reception-side filter and a reception-side filter having a higher pass band frequency than the reception-side filter thank to a design where the suppression of the surface acoustic wave filter of the narrow pass band width is possible.	
Newly granted	US10158341 Filter device 1 st publication : 2016-07-28 (PCT) Counterparts : Pending : CN, DE Granted : JP (2018-12-05), KR (2019-01-31), US (2018-12-18)	The present invention provides filter devices that enable impedance matching circuits to be omitted . The band pass filters working in one of the three next bands : f1: low-band cellular band, about 699 MHz to about 960 MHz , f2: GPS, GLONASS and BEIDOU band, about 1559 MHz to about 1608 MHz or f3: middle-band cellular band, about 1700 MHz to about 2170 MHz . All filters are preferably surface acoustic wave resonators.	



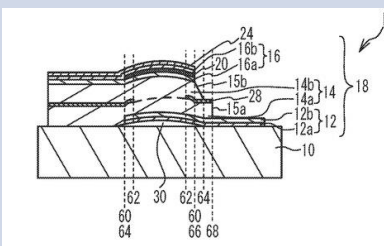
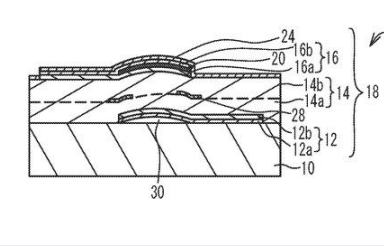
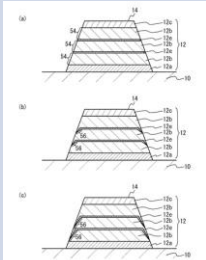
Murata Manufacturing: notable patents selected by Knowmade analyst

Status	Patent number and title	Patent details	
Newly granted	JP6439799 Bandpass filter and filter module 1 st publication : 2016-01-28 (PCT) Counterparts : Pending : CN, US Granted : JP (2018-12-19)	The present invention provides band pass filters having improved attenuation characteristics and filter modules including such band pass filters. The band pass filter includes a first LC filter and 2 elastic wave resonators having a resonant and anti-resonant frequencies.	
Patent expired	US6154105 Surface acoustic wave device with specific electrode materials and quartz substrate euler angles 1 st publication : 1999 – 08 -18 Expired 2019-02-15 in US Counterparts : Expired (2019-02) : JP, TW, KR, CN, SG, DE and EP	The present invention provides a surface acoustic wave device which is inexpensive , has an electrode structure that is easily formed, and has excellent, stable resonant characteristics . The present SAW filter uses Ta and W electrodes . These materials are inexpensive, as compared with gold electrodes, so that the cost of the surface acoustic wave device is significantly reduced. Moreover, as compared with Au, either Ta and W is easily processed. Thus, the surface acoustic wave device according to preferred embodiments of the present invention has excellent resonant characteristics and is constructed so as to be formed with high stability and with high precision.	
Patent expired	JP3301399 Surface acoustic wave device 1 st publication : 1999 – 08 -18 Expired 2019-01-11 in JP Counterparts : Expired (2019-01) : US, TW, KR, CN, SG, DE and EP	The present invention provides an inexpensive surface acoustic wave device which has its electrode structure that is easily machined and also has its satisfactory and stable characteristic by using an IDT which is formed on a crystal substrate having a specific Eulerian angle (0 to 90°) and constituted of an electrode material containing tungsten .	

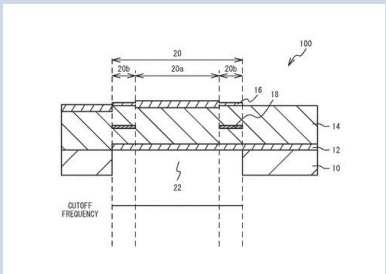
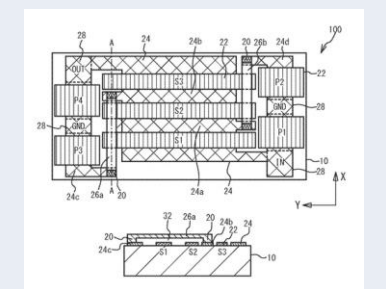
Note: the numbers represent the number of **patent families**. A patent family can belong to multiple segments.

	Q1 2019	SEGMENT			
		SAW	BAW	Duplexers	Multiplexer
New patents	11	5	7	4	7
Patent newly granted	2	1	1	1	0
Patent expired or abandoned	0	0	0	0	0

- **Taiyo Yuden** used to be Broadcom main IP competitor on the BAW segment. However, **Taiyo Yuden** benefits from Broadcom lack of IP activity and is now the **leading IP player of the BAW segment**. Furthermore, with no expired patents and 2 new granted ones, **Taiyo Yuden** has also increased its blocking potential during this quarter.
- In this quarter, **Taiyo Yuden** exhibits the most balanced IP activity that covers both **BAW** and **SAW** filters as well as **multiplexers** based on these technologies.
- **Taiyo Yuden's IP activity** reflects a R&D developments focused on **BAW filter downsizing**, enhancing heat dissipation and reducing mechanical damages and leakages. Furthermore, **Taiyo Yuden's** patents describe their use in **multiplexer** devices.
- Regarding **SAW filters**, **Taiyo Yuden** has developed a **metal stack that used as an electrode** allows to reduced the thermal stress and enhance the power durability. Furthermore, **Taiyo Yuden** also uses specific **thermal compensation layers** (SiO2) in order reduce the thermal stress in the piezoelectric layer.
- According to **Taiyo Yuden** product line, all its acoustic wave filters are used for LTE band 1, 2, 3, 4 or 5 applications. Based on its current IP activity it seems that **Taiyo Yuden** will keep its focus on these bands.
- Like Murata for SAW filters, **Taiyo Yuden** recent IP activity is in the continuity of its last 5 years patenting activity. Its current IP activity attests of a will to enhance the acoustic wave **reliability**.

Status	Patent number and title	Patent details	Images
New patent	US20190007029 Piezoelectric thin film resonator, filter, and multiplexer 1 st publication : 2019-01-03 (US) Counterparts : Pending : JP, US	The invention provides a method to manufacture a FBAR resonator filter where the piezoelectric film thickness can be controlled in the way that the lower piezoelectric film has a substantially uniform film thickness between an upper end of the first end face and a lower end of the second end face . Thus, the damages caused by mechanical stresses can be reduced .	
New patent	US20190007021 Piezoelectric thin film resonator and fabrication method of the same, filter, and multiplexer 1 st publication : 2019-01-03 (US) Counterparts : Pending : JP, US	According to a first aspect of the present invention, there is provided a piezoelectric thin film resonator that includes an insulating film that is located between the lower piezoelectric film and the upper piezoelectric film in a region other than the at least a part of the resonance region and contains silicon oxide . Thus, it is possible to suppress a decrease in the electromechanical coupling coefficient .	
New patent	JP2019022093 Acoustic wave device 1 st publication : 2017-07-18 Counterparts : Pending : JP	The invention provides a acoustic wave device where the power durability is improved . A piezoelectric substrate, wherein the piezoelectric substrate is provided on the piezoelectric substrate to an inclined surface so as to become larger in width the second metal as a main component has a second metal film, wherein the first inclined surface of the metal film so as to cover the at least a portion of the first metal is provided in contact with the first melting point and high electrical resistivity than the metal mainly composed of a metal 2 the first metal film and the second, wherein the first metal film 2 so as to cover the inclined surface of the first metal film provided in contact with the 2 on 1 3 the first metal film and the first metal as a main component, having a plurality of electrode fingers and excite the acoustic waves, the acoustic wave device comprising.	

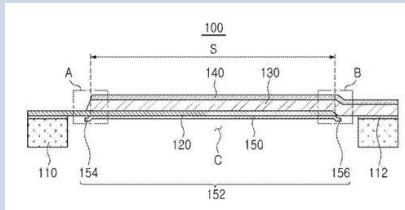
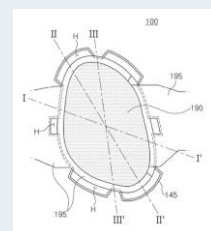
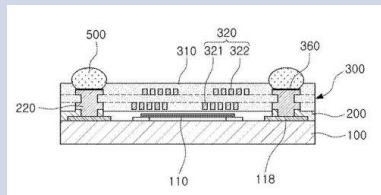
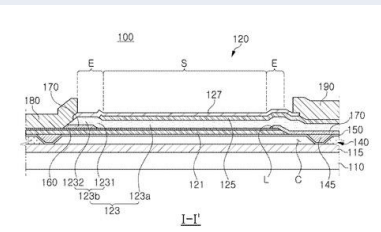
Taiyo Yuden: notable patents selected by Knowmade analyst

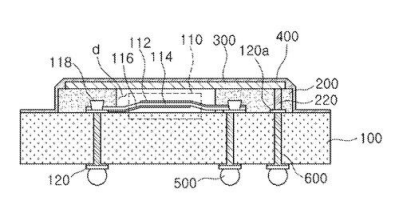
Status	Patent number and title	Patent details	Images
Newly granted	US10177732 Piezoelectric thin film resonator, filter, and duplexer 1 st publication : 2017-02-02 (US) Counterparts : Granted US (2019-01-08) Granted JP (2018-12-19)	<p>The present invention relates to a piezoelectric thin film resonator, a filter, and a duplexer. The invention provides a piezoelectric thin film resonator including: a substrate; a piezoelectric film that is located on the substrate and has a Poisson's ratio of 0.33 or less; a lower electrode and an upper electrode that face each other across the piezoelectric film; and an insertion film that is located in the piezoelectric film or on a lower surface or an upper surface of the piezoelectric film in an outer peripheral region within a resonance region, in which the lower electrode and the upper electrode face each other across the piezoelectric film, and is not located in a center region of the resonance region, wherein at least one of the lower electrode, the piezoelectric film, and the upper electrode in the outer peripheral region within the resonance region is thinner than the at least one of the lower electrode, the piezoelectric film, and the upper electrode in the center region of the resonance region.</p>	
Newly grant	US10218334 Acoustic wave device 1 st publication : 2016-09-22 (US) Counterparts : Granted US (2019-01-26) Granted JP (2019-02-12)	<p>The invention provides a acoustic wave device where the distance between the wiring lines interconnecting the acoustic wave resonators can be reduced. Thus, by limiting the capacitance between the wiring lines the acoustic wave filter downsizing is possible.</p>	

Note: the numbers represent the number of **patent families**. A patent family can belong to multiple segments.

	Q1 2019	SEGMENT			
		SAW	BAW	Duplexers	Multiplexer
New patents	11	2	9	1	0
Patent newly granted	5	0	5	2	0
Patent expired or abandoned	0	0	0	0	0

- **Samsung Electro Mechanics (SEMCO)** is the second main active player of the quarter and confirms the resurgence of activity that started in 2016. This quarter SEMCO's new patents focus on **FBAR manufacturing process** which is in good adequation with its past IP activity. Thanks to its increasing patenting activity over the last 3 years, the company is today one of the **top IP players regarding the BAW segment** and is a serious IP competitor to Taiyo Yuden and Broadcom.
- With **no expired patents** and **3 new granted inventions** related to **BAW** filters, SEMCO keep increasing its blocking potential.
- Contrary to Taiyo Yuden or Murata that have started to direct their development toward modules (multiplexers, duplexers, front end modules) **SEMCO's** IP activity relates to **BAW (FBAR) manufacturing improvement**.
- Regarding the manufacturing process, SEMCO's recent patents are related to **electrode materials and etching method**. In its patents, SEMCO also increases the piezoelectric layer and its interfaces characteristics by using **single crystal AlN layer** with or without doping (Scandium doping for example) in order to enhance the filter performances by improving the electromechanics coupling.

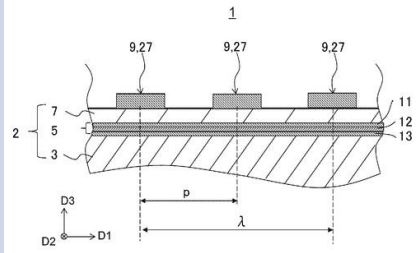
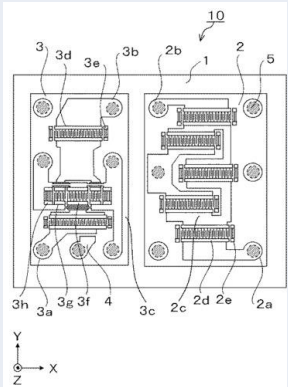
Status	Patent number and title	Patent details	Images
New patent	US20190058455 Bulk acoustic wave resonator 1 st publication : 2019-02-21 Counterparts : Pending : CN, US	The invention provides a bulk-acoustic wave resonator comprising a protruding portion formed on the membrane layer and formed into the cavity in a direction that extends away from the membrane layer . The addition of the protruding portion limits the decrease of some characteristics (e.g., Kt2 characteristics) and an area of an inner region of the frame is increased to suppress a decrease in Q performance and attenuation performance.	
New patent	US20190058451 Bulk acoustic wave resonator 1 st publication : 2019-02-21 Counterparts : Pending : JP, US, CN	The invention provides a bulk acoustic wave resonator that includes electrodes wherein either one or both of the lower electrode and the upper electrode includes a layer of aluminum alloy including scandium (Sc) . By using AlSc alloy the mechanical properties may be conserved, the while occurrence of a hillock by electromigration or mechanical deformation is suppressed.	
New patent	US20190019939 Acoustic wave device and method of manufacturing the same 1 st publication : 2019-01-17 Counterparts : Pending : CN, US	An acoustic wave device includes an acoustic wave generator, a support portion, a protective member, and at least one element embedded in the protective member . The protective member may be disposed to be spaced apart from the acoustic wave generator by the support portion. Therefore, an empty space or void may be formed between the acoustic wave generator and the protective member by the support portion, and the empty space may be used as a resonator-accommodating space of the acoustic wave generator when the acoustic wave device is driven.	
New patent	US20190013792 Acoustic resonator and method for manufacturing the same 1 st publication : 2019-01-10 Counterparts : Pending : CN, US	An acoustic resonator includes a substrate, a center portion, an extending portion, and a barrier layer that reduce the frequency dispersion due to loss of the first electrode . The extending portion is configured to extend from the center portion, and includes an insertion layer disposed below the piezoelectric layer . The barrier layer may be formed of a dielectric having a hexagonal close-packed (HCP) structure or a metal (Ti).	

Status	Patent number and title	Patent details	Images
Newly granted	US10164602 Acoustic wave device and method of manufacturing the same 1 st publication : 2017-03-16 Counterparts : Granted : US (2018-12-25) Pending : CN	An acoustic wave device includes a substrate comprising a shielding member electrically connected to a ground pad and blocking reception or emission of electromagnetic waves at the acoustic wave generator. Therefore, since there is no need to add a separate shielding member , the size of the acoustic wave device may be significantly decreased , and at the same time, the blocking effect against the electromagnetic waves may be improved .	

Note: the numbers represent the number of **patent families**. A patent family can belong to multiple segments.

	Q1 2019	SEGMENT			
		SAW	BAW	Duplexers	Multiplexer
New patents	9	9	0	5	0
Patent newly granted	2	2	0	2	0
Patent expired or abandoned	0	0	0	0	0

- **Kyocera** knew a strong **decrease of its patenting activity** from 2008 to 2015. Since 2016, the company has strongly increased its activity related to SAW filters. The publications of **9 new patent families in Q1 2019 confirms the recent R&D effort of Kyocera** in the surface acoustic wave filter domain. Furthermore, the lack of IP activity related to BAW devices is here again not surprising as **Kyocera** activity and product have always been focus on SAW filters, duplexers and multiplexers.
- Especially **Kyocera’s patents** published in this 1st quarter 2019 are related to **SAW filters material and duplexers/multiplexers design** in order to enhance their selectivity and power handling. To do so, **Kyocera** claims several design and their related process using new piezoelectric substrate such as Lithium tantalite substrate, specific metal alloys such as CuAl2.

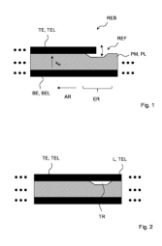
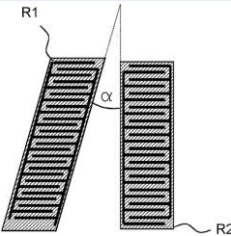
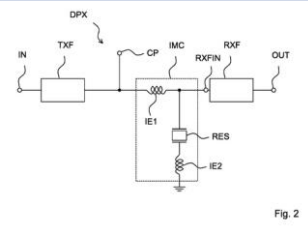
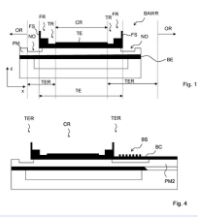
Status	Patent number and title	Patent details	Image
New patent	WO201922236 Elastic wave device, duplexer, and communication device 1 st publication : 2019-01-31	<p>The present disclosure, an electronic component using the elastic wave acoustic wave device, the elastic wave duplexer and a communication apparatus including the device. The present invention has: a substrate, a multilayer film positioned on the substrate; an LT layer positioned on the multilayer film, and constituted from a single crystal of LiTaO₃; and an IDT electrode positioned on the LT layer. An elastic wave device such that the differential D of the multilayer film 5 is negative, the differential D being obtained by subtracting the total value obtained by multiplying the density and thickness of a film having a sound speed higher than the lateral wave sound speed of the LT layer from the total value obtained by multiplying the density and thickness of a film having a sound speed slower than the lateral wave sound speed of the LT layer, and when the pitch of the electrode finger of the IDT electrode is defined as “p”, the thickness of the LT layer is less than 2 “p”.</p>	
Newly granted	JP6437834 Demultiplexer 1 st publication : 2016-08-04 Counterparts : Granted : JP (2018-12-12)	<p>To provide a demultiplexer for improving isolation characteristics. In a demultiplexer, a first common terminal and a transmission signal input terminal which are mounted to a wire board are formed, a transmission elastic surface wave element including a transmission filter between the first common terminal and the transmission signal input terminal and a second common terminal and a reception signal output terminal which are mounted to the wire board is formed, and a reception elastic surface wave element including a reception filter between the second common terminal and the reception signal output terminal is comprised. The reception elastic surface wave element is formed so that one end part of a grand pattern arranged on the side of transmission elastic surface wave element of reception signal output terminal is capacitive coupled with a part of the reception filter, and the other end part is electrically connected to a ground wiring</p>	

Note: the numbers represent the number of **patent families**. A patent family can belong to multiple segments.

	Q1 2019	SEGMENT			
		SAW	BAW	Duplexers	Multiplexer
New patents	6	2	4	1	2
Patent newly granted	3	1	2	1	0
Patent expired or abandoned	3	3	0	0	0

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Patents held by Qualcomm

- **RF360** results from the merger of **TDK and Qualcomm activity related to RF Front End modules** and their components. Before the joint venture creation, both Qualcomm and TDK were rising IP players. Indeed, TDK showed a high patenting activity related to SAW filters and both players were active in the BAW filter segment.
- The IP analysis of the **first quarter of 2019** shows that by combining their activity the **RF360 joint venture has kept its R&D activity on both technologies** and remains a serious IP challenger. Indeed, the recent patenting activity is transversal and among the most intense.
- In addition to address BAW and SAW technologies, **RF360** is the only IP player to develop **SMR BAW filters**. Its developments are related to energy dissipation reduction in SMR.
- **RF360 patenting activity** is mainly related to **BAW or SAW filters with reduced losses** thanks to design improvements or impedance matching solutions.
- Among RF360’s recent patents we also find one patent related to **multiplexer** and which is also oriented to **carrier aggregation applications and thus 5G technologies**. The patented technology remains focused on the 770 MHz – 2GHz frequency bands that RF360 has been developed for small cell applications since 2017 (see [here](#))

Status	Patent number and title	Patent details	Images
New patent	WO2019029911 Baw resonator with reduced losses, rf filter comprising a baw resonator and method for manufacturing a baw resonator 1 st publication : 2019-02-07 Counterparts : Pending : DE, PCT	The invention provides a BAW resonator with reduced lateral losses, and a RF filter with a BAW resonator and a method of manufacturing a BAW resonator. The BAW resonator has a bottom electrode layer, a top electrode layer and an acoustic reflector between the bottom electrode layer and the top electrode layer. The reflector is arranged in the edge region surrounding the active region and follows the perimeter of the resonator. The reflector may be realized by a recess in the piezoelectric material . The top electrode may fully or partially cover the recess.	
New patent	DE102017127713 Electro-acoustic filter with a reduced acoustic coupling, method of reducing acoustic coupling and multiplexer 1 st publication : 2019-02-28 Counterparts : Pending : DE	The invention provides an electro-acoustic filter having a reduced acoustic coupling . The filter includes two electro-acoustic resonators. Two opposite sides of the electro-acoustic resonators are aligned out of parallel . By using unparallel orientation of the side of the electroacoustic resonators or by the electroacoustic waves having a phase difference of the two received, it is possible to completely or partially destructive interference at the second electroacoustic resonator.	
New patent	WO2019034383 Duplexer or quadplexer having impedance matching for carrier aggregation 1 st publication : 2019-02-21 Counterparts : Pending : DE, PCT	A duplexer topology with improved electrical properties and compatible with carrier aggregation modes is provided. The duplexer comprises a transmission filter between an input port and a common port and a reception filter between the common port and an output port. An impedance matching circuit is connected between the reception filter, the transmission filter and the common port. At the common port a matched impedance is provided for transmission signals and reception signals of a first transmission frequency band and an open circuit impedance is presented for transmission signals and for reception signals of a second transmission frequency band. Thus, unwanted signals such as signals from the second frequency band will see an open circuit-like configuration at the common port and do not disturb the proper working of the duplexer in the first frequency band.	
New patent	WO2019029912 Baw resonator with reduced spurious modes and increased quality factor 1 st publication : 2018-12-27 Counterparts : Pending : DE, PCT	The present invention refers to BAW resonators, e.g. for RF filters, having improved acoustic and electric properties. The resonator has a center region and a termination region surrounding the center region. A trench in a top electrode; a frame on the top electrode, a flap structure connected to the frame and a notch in a piezoelectric layer reduce spurious modes and increase the quality factor of the resonator. A lateral Bragg reflector may be realized with a Bragg structure on a signal conductor in the top electrode layer spanning the notch. Thanks to the design, unwanted spurious modes are reduced and thus the quality factor is enhanced.	



JCAP (Jiangyin Changdian Advanced Packaging Co., Ltd – see [here](#)) is a Chinese national high-tech enterprise integrating the R&D and manufacturing. **JCAP** develops advanced packaging technology, R&D service platform and semiconductor packaging & testing industry. This quarter **JCAP** has published **2 Chinese patents** related to **SAW filter chip and the package** ([CN109244230](#), [CN109244231](#)).



RFHIC is specialized in the design and manufacture of RF & Microwave component with a comprehensive product portfolio from discrete to integrated high power amplifiers (see [here](#)). Especially **RFHIC** develops hybrid solutions of GaN (in partnership with CREE) and is a cost effective solution provider to the customers. This quarter **RFHIC** has published a new patent families on **Bulk acoustic wave filter** ([US20180367119](#) ; patent filed with PCT procedure, currently pending applications in US and Taiwan).



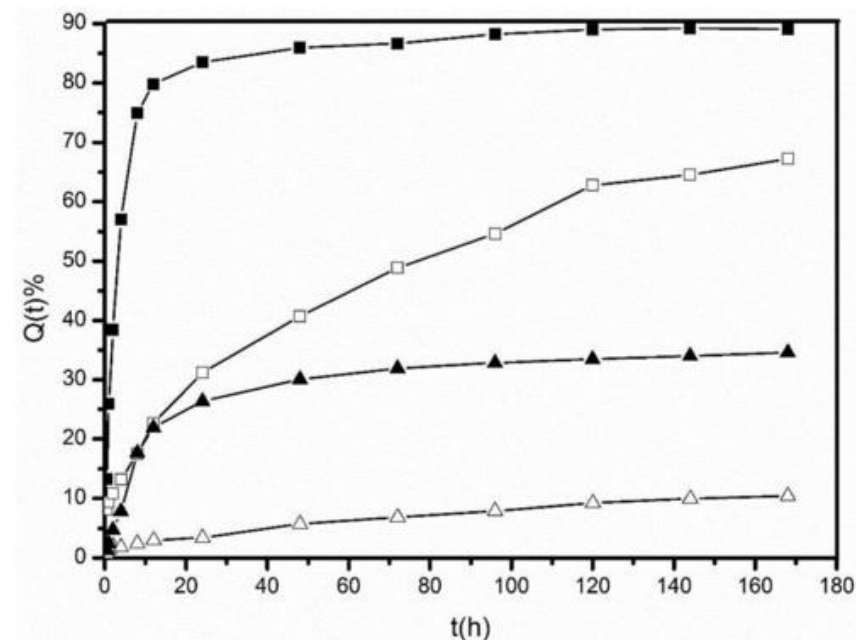
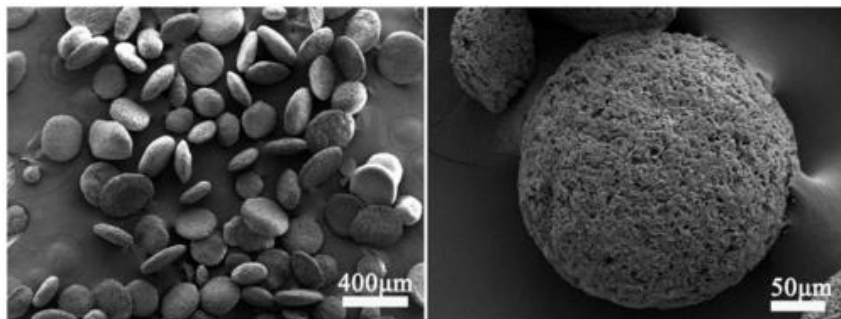
Established in 1978, **Xi'an University of Science and Technology (XUST)** is a non-profit public higher education institution located in Xi'an. This quarter XUST has published **2 Chinese patents** related to Method for wideband delay line surface acoustic wave device of the oscillator circuit ([CN208353308](#)) and Method for narrow-band delay line surface acoustic wave device of the oscillator circuit ([CN208209912](#)).



Choicore is a high-tech enterprise with third-generation semiconductor materials and devices with international leading technology, especially the development, production and sales of silicon-based high-power LED epitaxial chips (see [here](#)). This quarter **Choicore** has published **2 Chinese patents** on thin film body acoustic resonator and its preparation method ([CN109302158](#)) and composite substrate of a thin film acoustic resonator body ([CN109302159](#)).



Shoulder Electronics (see [here](#)), a Chinese company specialized in the development and production of **SAW filters**, **SAW duplexers** and **SAW resonators**, and the department of Materials Science and Eng. of **Tsinghua University**, led by Pr. PAN Feng, have collaborated in order to develop a **SAW filter based on ion implanted quartz substrate and metal doped ZnO with enhanced temperature properties** ([CN109217842](#) - Near-zero temperature coefficient of surface acoustic wave filter and its preparation method)



Focus on main IP transfers

This Quarter Qorvo has acquired 4 US patents from the start-up Abtum Inc* (California).
All reassignment occurred on the 2018-12-17.



In front. In tune.



Reassignment date	Patent information	Patent details
2018-12-17	US10038458 Granted Publication date : 2017-04-06 Reflection-based radio-frequency multiplexers	The invention provides a radio frequency multiplexer , which supports a plurality of frequency bands . More specifically, the disclosure relates to a method and system for reflection-based radio frequency (RF) multiplexers wherein one or more of the filter and the one or more other filters comprise one or more surface acoustic wave (SAW) or bulk acoustic wave (BAW) filters .
2018-12-17	US9866201 Granted Publication date : 2018-01-09 All-acoustic duplexers using directional couplers	An all-acoustic filter includes acoustic directional couplers and acoustic filters . More specifically, certain embodiments of the disclosure relate to a method and system for all-acoustic duplexers that use acoustic directional couplers and acoustic filters (BAW or SAW) for various communication systems including frequency division duplex, multi-standard, multi-antenna, or multi-band communication standards
2018-12-17	US20180309464 Pending Publication date : 2018-01-09 Hybrid-coupler-based radio frequency multiplexers	The invention provides architectural solutions that enable realization of highly-selective, low-loss multiplexers with high-isolation between the ports . The multiplexer is based on acoustic resonators (e.g., SAW or BAW resonators) that have lower loss (or higher Q) or are more compact, especially at higher frequencies. The RF multiplexers includes RF bandpass filters (BPF) with distinct pass band frequencies that are connected to a common port using a passive network or a number of passive networks.
2018-12-17	US20180083591 Pending Publication date : 2018-03-22 Enhancing isolation in hybrid-based radio frequency duplexers and multiplexers	The present disclosure relate to radio frequency (RF) duplexers that may be used in wireless communication systems, for example. More specifically, certain embodiments of the disclosure relate to a method and system for enhancing isolation in hybrid-based RF duplexers and multiplexers . The inventions describe a tunable or reconfigurable RF duplexer with high isolation and low insertion loss, under all desired settings, that may be realized by adding tunable capacitors to the tunable RF duplexer which includes the quadrature hybrid couplers and tunable RF filters



*Abtum Inc. develops and supplies radio frequency (RF) filters and multiplexer products such as duplexer and quadplexer. The company's RF front-end filters are used by mobile and infrastructure devices to address carrier aggregation and 5G issues. It caters to automotive mobile broadband and the Internet of Things (IoT) industries. The company was incorporated in 2010 and is based in Irvine, California.

Focus on main patent litigation

**No complaint related to acoustic wave filters
has been neither filed or closed in Q1 2019**

Last US patent litigation

TriQuint vs. Avago (1/2)



[USXXXXXXX](#) Click to link pdf document

SAMPLE

Plaintiff	TriQuint Semiconductor
Defendant	Avago Technologies
Case number	2:09-cv-01531 (click to open)
Court	District of Arizona
Filed	July 23th, 2009
Closed	May 17 th , 2012
Cause of action	Willful Patent Infringement
Accused Product	Acoustic wave apparatus
Patents in suit	TriQuint’s patents: US6114635, US5231327, US5894647 Avago’s patents: US7365619, US7268436, US6933807, US6841922, US6864619, US6909340, US6377137, US6812619, US6262637, US6051907, US6384697, US6472954, US6879224

Summary: In July 2009, **TriQuint** filed a lawsuit against **Avago** in the Arizona District Court. According to the lawsuit, **Avago has been contacting TriQuint customers and advising them that TriQuint's products infringe** on at least **three Avago patents**. Avago also told customers that it has not licensed its patents to any competitors and that if customers purchase certain RF products from suppliers other than Avago, they will not be protected against Avago's patents, according to the filing. **TriQuint's suit seeks**, among other things, a declaration that four patents held by Avago are invalid and that TriQuint products do not infringe them. The suit also seeks damages paid to **TriQuint by Avago for the alleged infringement of three patents** held by TriQuint.

Closed case: After 4 years of tenacious patent litigations, **Avago Technologies Ltd. and TriQuint Semiconductor Inc. announced in 2012 a patent cross-licensing agreement** and agreed to dismiss all related litigation between them. The specific terms of the settlement and the resulting licensing agreement remain confidential.

After this decision, **Avago bought and scrapped TriQuint’s principal source for BAWs** as well as intimidated its customers. Finally, prompting **TriQuint to merge with RF Micro Devices to form Qorvo**, which allowed it to regain its footing and keep its number two position in BAW filters.

In its original complaint, TriQuint asserted that Avago’s products infringe **three TriQuint patents**:

Patent information	Patent details
US6114635 (expired) Chip-scale electronic component package	The invention provides A chip-scale sized package for acoustic wave devices, acoustic resonators and similar acoustic devices located upon, or fabricated upon, or as part of, a die.
US5231327 (expired) Method for optimizing piezoelectric resonator-based networks	This invention relates to piezoelectric resonators and, specifically, to a method for optimizing the topology of a piezoelectric resonator-based network so that it may be implemented, either in monolithic or discrete form, with interconnects on one or either principal face of a piezoelectric plate or membrane
US5894647 (expired) Method for fabricating piezoelectric resonators and product	The invention provides a method for fabricating piezoelectric resonators on a substrate such that the resonant frequency of one resonator is shifted by a small amount from another of the resonators.

Last US patent litigation

TriQuint vs. Avago (2/2)



[USXXXXXXX](#) Click to link pdf document

SAMPLE

The patents asserted by **Avago** in this case are :

Patent information	Patent details
US6262637 (granted) Duplexer incorporating thin-film bulk acoustic resonators (FBARS)	The invention provides a bandpass filter comprising shunt elements and series elements in which the series elements and the shunt elements are connected to form a ladder circuit, and each of the elements includes an FBAR.
US6377137 (granted) Acoustic resonator	This invention relates to the manufacturing of acoustic resonators, and, more particularly, to the manufacturing of resonators that may be used as filters for electronic circuits.
US6384697 (granted) Cavity spanning bottom electrode of a substrate-mounted bulk wave acoustic resonator	It has been found that in order to achieve a high filter Q, a further 10% to 20% improvement was a result of moving the release holes from the center of the free-standing portion to the edges of the cavity.
US6472954 (granted) Controlled effective coupling coefficients for film bulk acoustic resonators	The invention relates generally to acoustic resonators and more particularly to controlling the effective coupling coefficient of a film bulk acoustic resonator.
US6909340 (granted) Bulk acoustic wave filter	The inventive design of the bulk acoustic wave resonators enables optimal suppression of interference modes without influencing the impedance level of the filter.
US6879224 (granted) Integrated filter and impedance matching network	A filter and impedance matching network uses acoustic resonators in place of capacitors. A resonator, e.g. FBAR, behaves similar to a capacitor outside of its resonant frequency and so does not impact the function of the network, outside of its resonant frequency. At this resonant frequency, the resonator quickly transitions from capacitor to short circuit to open circuit and back to capacitor
US6864619 (granted) Piezoelectric resonator device with a detuning layer sequence	It is the object of the present invention to provide a piezoelectric resonator device and a filter, the resonance frequency of which can be trimmed over a great frequency range without detuning leaving a tolerance range.
US6933807 (granted) Acoustic reflector for BAW resonator	The present invention preferably involves BAW filters for RF applications, and here in particular BAW filters for RF applications in which excellent selectivity and steep transition bands are required. It has been found that strong reflections of the waves from the backside occurred after polishing, which were not present in the samples with the rough backside.
US6841922 (granted) Piezoelectric resonator device comprising an acoustic reflector	it is the object of the present invention to provide an improved resonator apparatus in which the above-stated problems associated with the manufacturing of thick layers, associated with parasitic capacitances and with different temperature coefficients can be minimized or avoided
US7365619 (granted) Baw ladder filter with baw apparatus as parallel and as series element	It can be said from there that BAW devices according to invention make it possible to reduce and/or extinguish nonlinear effects for example in BAW filters, in which antiparallely switched pairs of resonators or groups of resonators in these filters is used.
US6812619 (granted) Resonator structure and a filter comprising such a resonator structure	The invention relates in general to piezoelectric resonators and to filters having piezoelectric resonators. In particular, the invention relates to a resonator structure, which is quite simple to manufacture and has good electrical properties.
US6051907 (expired) Method for tuning thin film FBARS	A method for tuning a Thin Film Bulk Acoustic Wave Resonator (FBAR) located on a wafer. The FBAR comprises a plurality of layers having respective thicknesses. The FBAR exhibits at least one of a series resonance and a parallel resonance at respective frequencies that are a function of the thickness of at least one of the layers.
US7268436 (abandoned) Electronic device with cavity and a method for producing the same	An electronic device can include a top side with circuit structures. The circuit structures form the bottom region of a cavity. Each cavity can be surrounded by a cavity frame made of plastic and can have a cavity cover made of semiconductor material



www.knowmade.com

contact@knowmade.fr

KnowMade S.A.R.L., 2405 route des Dolines, CS 10065, 06902 Sophia Antipolis, France