

RF Acoustic Wave Filters

Patent Landscape Analysis – October 2019

SAW and BAW filters are still key components of today's mobile communications. How will players align their IP strategy with their technology developments to embrace 5G's arrival?



A second acceleration of AWF-related patenting activity.

REPORT OUTLINE

- RF acoustic wave filter
- Patent landscape analysis
- October 2019
- Ref.: KM19006
- PDF > 160 slides
- Excel file > 18,500 patents
- €6,490 for a multi-user license

REPORT'S KEY FEATURES:

- **IP trends**, including time-evolution of published patents, countries of patent filings, etc.
- Ranking of **main patent assignees**
- **Main technologies** IP analysis:
 - Temperature-compensated acoustic wave filters
 - Packaging (flip-chip, wafer-level packaging)
 - Functions and modules (duplexers, multiplexers)
- **IP players' key patents**
- **Key players' IP position and relative strength** of their patent portfolios
- **IP profile of key players:** Murata, TDK, Taiyo Yuden, Skyworks, Qualcomm, Broadcom, Qorvo, Samsung Electro Mechanics, Akoustis, Resonant, Infineon, CETC
- **Excel database** containing all patents analyzed in the report, including technology and application segmentations

RELATED REPORTS

- [RF Acoustic Wave Filters – Patent Monitoring Service \(Knowmade\)](#)
- [RF Acoustic Wave Filter – Patent Landscape 2017 \(Knowmade\)](#)
- [RF Front-End Modules for Cellphones - Patent Landscape 2017 \(Knowmade\)](#)
- [5G's Impact on RF Front-End Module and Connectivity for Cell Phones 2019 \(Yole Développement\)](#)
- [RF Front-End Module Comparison 2018 \(System Plus Consulting\)](#)

In 2017, Knowmade forecasted an acceleration of the patenting activity related to acoustic wave filters (AWF), whose growth is being driven mostly by the developments of bulk acoustic wave (BAW) filters due to the new opportunities offered by 5G. Indeed, while the SAW-related IP landscape was already well established, the battle to become the next main IP player related to BAW devices was intense. Players like **Taiyo Yuden** and **Broadcom** had an advantage thank to their strong former patenting activity, but many smaller IP players had entered the landscape (**Akoustis**, **Resonant**, **JCAP**, etc.) or increased their patenting activity (**Qualcomm**, **RF 360**, **Qorvo**), making them serious IP challengers.

Today, the previous trend is confirmed. Indeed, the SAW-related patent landscape is still dominated by **Murata**, which has maintained a very high level of patenting activity related to **SAW filters** and their integration in complex modules. Like in 2017, IP competition is limited, but **Skyworks**, **Taiyo Yuden**, **TDK**, and **Qualcomm** have perpetuated a fair level of patenting activity and constitute the group of **IP challengers**. Despite being well established, recent SAW-related patenting activity describes some new trends regarding manufacturing and design of SAW filters. Indeed, in the view of 5G, all IP players involved in the development of **SAW filters** have started filing patents related to a **complex module with a high level of integration**. Wafer-level packaging has become a major packaging technology investigated by players. At the same time, IP players have strongly accelerated their patenting activity related to multiplexers that could support carrier aggregation operations. To bolster the development of highly integrated modules, IP players have improved their SAW filter designs. One main solution is the use of **thin-film SAW**, which reduces the substrate losses and thus increases the resonant frequency while improving thermal stability. This solution, originally developed by **Murata**, is now also asserted in **Kyocera**, **Qualcomm**, and **Skyworks** patents.

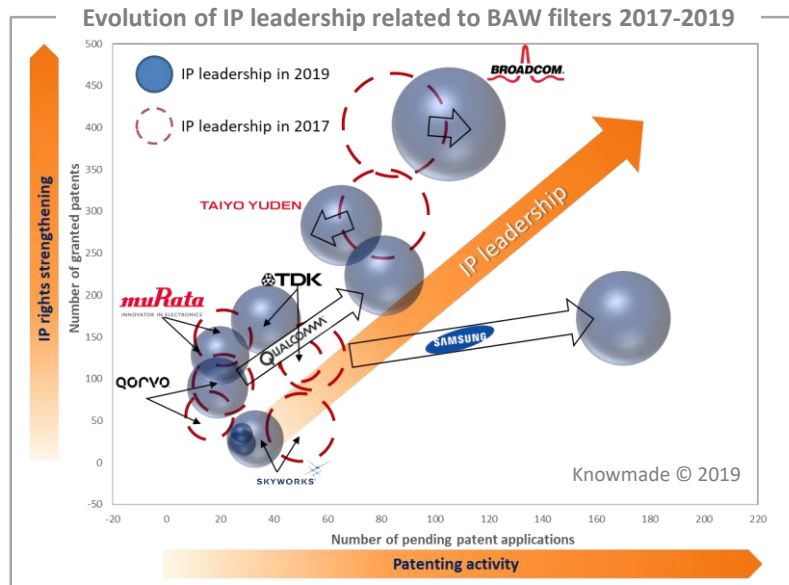
For the **BAW-related IP landscape**, recent developments are related to device manufacturing. Indeed, to fulfill 5G's requirements, players are working to improve the electro-mechanical coupling in order to reach high frequency, while keeping low losses and large bandwidth. Among all the players involved in BAW filter development, **Broadcom** remains the most important. However, these last two years have seen the rise of **Qualcomm** and the emergence of **Samsung Electro Mechanics**. These three players drive today's IP activity related to BAW. However, some smaller IP players such as **Akoustis**, **Infineon**, and **Resonant** have refined their development and now hold interesting IP portfolios.

Main patent assignees and their IP activity

Assignee	Patent families	BAW	SMR	FBAR	SAW	Temperature compensated
MURATA	1154	72	7	71	1102	95
TAIYO YUDEN	524	138	15	144	414	43
TDK EPCOS	449	102	50	74	368	34
SKYWORKS	457	69	22	64	400	31
KYOCERA	410	40	5	39	374	40
QUALCOMM	306	135	62	101	197	36
BROADCOM	292	271	133	226	34	41
HITACHI	272	22	3	26	257	9
TOSHIBA	194	55	4	56	140	7
TOYO COMMUNICATION EQUIPMENT	193				193	3
SAMSUNG ELECTRO MECHANICS	182	131	1	122	56	6
QORVO	156	78	39	50	102	22
SEIKO EPSON	143	12	1	17	131	19
OKI	141				141	
LG INNOTEK	107	35	1	35	74	1
NDC	105	5		8	101	2
NEC	97	3		3	96	3
EPSON TOYOCOM	80	1	1		79	2
SANYO ELECTRIC	78	3		4	75	1
SAMSUNG ELECTRONICS	74	57	1	56	21	4

Analysis of recent dynamics: what has happened in the last two years?

In this report, Knowmade has manually selected more than 7,500 patent families (inventions) related to SAW and BAW filters. We provide a general overview of today’s IP landscape trends and dynamics, as well as specific analysis related to the patenting activity of the last two years. Via manual segmentation, Knowmade delivers an understanding and analysis of the current evolutions of the two key technologies (SAW and BAW). This analysis shows an important difference between SAW and BAW IP activity. Indeed, on one hand, the development of SAW filters has reached a high maturity level, and players have begun exploring module design and architectures in order to keep improving their technologies for 5G applications. On the other hand, the BAW IP landscape’s dynamic shows that there is still room for BAW manufacturers to improve their devices by developing new manufacturing processes and BAW designs.



Main IP players’ portfolio analysis

This report provides a detailed comparison of the seven main IP players: Murata, TDK, Taiyo Yuden, Skyworks, Qualcomm, Broadcom, and Qorvo. For each player, Knowmade highlights their strength and weaknesses, and provides information regarding their recent and future technology developments. Also, a detailed description and analysis of key patents is provided. Finally, System Plus Consulting and Knowmade have joined forces to provide a mapping of the current links between the main players’ products and patents. The same analysis has been done for five IP newcomers: Samsung Electro Mechanics, Akoustis, Resonant, Infineon, and CETC.

Main IP players’ packaging-related IP activity

Assignee	Patent families	Wafer Level			Flip chip		
		Patent families	Granted	Pending	Patent families	Granted	Pending
MURATA	1154	67	101	80	128	284	29
TAIYO YUDEN	524	16	28	2	121	239	42
TDK EPCOS	449	12	17	15	92	125	11
SKYWORKS	457	10	14	9	34	38	9
KYOCERA	410	27	41	12	117	104	
QUALCOMM	306	10	17	22	57	127	20
BROADCOM	292	18	51	10	22	70	6
HITACHI	272	2		2	20	28	4
TOSHIBA	194	1			19	13	1
TOYO COMMUNICATION EQUIPMENT	193	3	6		19	6	
SAMSUNG ELECTRO MECHANICS	182	35	13	37	17	3	2
QORVO	156	13	12	4	13	25	1
SEIKO EPSON	143	4	9		11	9	

Analysis of main technology developments

5G’s arrival has mainly impacted the patenting activity of AWF-related IP players. Indeed, the need to develop modules that can manage carrier aggregation and multi-band operations has pushed the main IP players to file patents related to complex filter systems (duplexers, multiplexers, etc.) and their integration into one module. In this report, Knowmade has thoroughly analyzed the IP dynamics and trends related to packaging and modules in order to realize the current technological developments and understand how players are addressing the issues related to the integration of complex acoustic filters into small, cost-effective modules.

Report’s main assets

- Understanding the key players’ patented technologies and current IP strategies**
More than 960 patent applicants are involved in the RF acoustic wave filter patent landscape. This report reveals the IP position of key players through a detailed analysis of their patent portfolios. We also describe these players’ patented technologies, their IP strategy, and their ability to limit other firms’ patenting activity and freedom-to-operate.
- Analyzing IP players’ position on promising applications and developed technologies**
This report furnishes an understanding of IP players’ positions on promising applications. Main IP players and key patents are presented for each segment, along with an understanding of the current technical challenges addressed in the patents.
- Identifying and understanding key patents related to RF acoustic wave filters**
This report offers a detailed analysis of key patents (seminal, blocking) related to SAW and BAW filters. Furthermore, for each segment a selection of seminal, blocking, and most promising patents is highlighted.
- Useful Excel patent database**
This report also includes an Excel database with the >18,500 patents and patent applications analyzed in this study. This useful patent database allows for multi-criteria searches and includes patent publication numbers, hyperlinks to the original documents, priority date, title, abstract, patent assignees, patent’s current legal status, and technological and application segments.

COMPANIES MENTIONED IN THIS REPORT (NON-EXHAUSTIVE LIST)

MURATA, TAIYO YUDEN, TDK EPCOS, SKYWORKS, KYOCERA, QUALCOMM, BROADCOM, HITACHI, TOSHIBA, TOYO COMMUNICATION EQUIPMENT, SAMSUNG ELECTRO MECHANICS, QORVO, SEIKO EPSON, OKI ELECTRIC INDUSTRY, LG INNOTEK, NDK, NEC, EPSON TOYOCOM, SANYO ELECTRIC, SAMSUNG ELECTRONICS, NGK INSULATORS, PHILIPS, INTEL, JAPAN RADIO, NOKIA, THALES, ADVANCED SAW PRODUCTS, MOTOROLA, WISOL, UBE INDUSTRIES, MITSUBISHI ELECTRIC, SUMITOMO ELECTRIC INDUSTRIES, LG ELECTRONICS, CHINA ELECTRONICS TECHNOLOGY, ALPS ELECTRIC, TIANJIN UNIVERSITY, TOKO, HANGZHOU SAPPLAND MICROELECTRONICS TECHNOLOGY, ZENITH RADIO, TEXAS INSTRUMENTS, SONY, INTELLECTUAL VENTURES HOLDING, RESONANT, STMICROELECTRONICS, INSTITUTE OF ACOUSTICS CHINESE ACADEMY OF SCIENCES, MITSUBISHI MATERIALS, CEA, SHOULDER ELECTRONICS, and more.

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ABOUT KNOWMADE

Knowmade is a technology intelligence and IP strategy consulting company specialized in the analysis of patents and scientific information. The company helps R&D organizations, investors, and innovative companies to understand their competitive landscape, follow technology trends, and discover opportunities and threats in terms of technology and patents.

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