



RIVER ELETEC CORPORATION

Company Profile (as of Mar. 31. 2024)

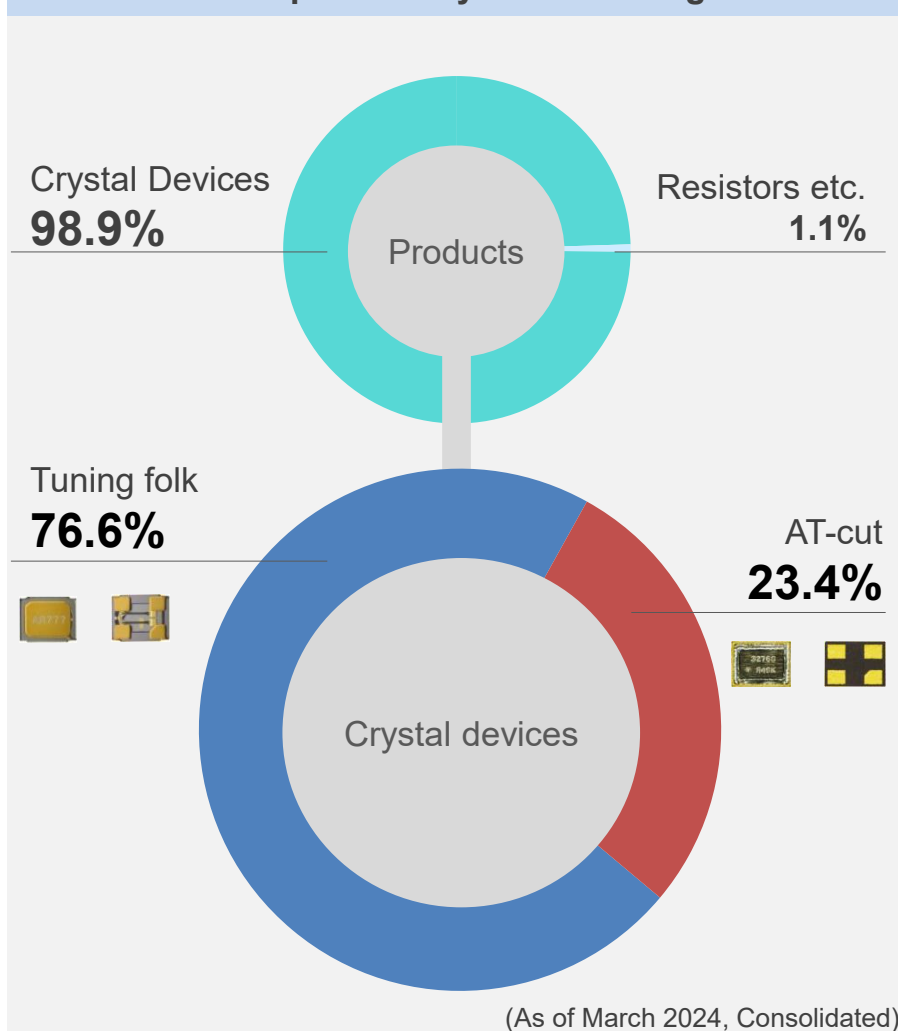
RIVER ELETEC is a manufacturer that develops, manufactures, and sells crystal devices used in all kinds of electronic devices such as smartphones.

Name of Company	RIVER ELETEC CORPORATION
Establishment	March 9, 1951
Capital	1,681 million yen (\$ 11.85 million*) *1 USD = 141.83JPY
Business Lines	Development, manufacturing, and sales of quartz crystal units, quartz crystal oscillators, and other components.
Number of Employees	208 (Consolidated), 67 (Non-consolidated) *Executives, seconded employees and contract workers etc. are not included.
Annual Sales	5,454 million yen (Consolidated) (\$ 38.45 million*) *1 USD = 141.83JPY
Group Companies	Aomori River Techno Corporation(Japan), Taiwan River Co., Ltd (Taiwan), River Electronics (Singapore) Pte. Ltd. (Singapore), Xi'an River Electronics Corporation(China)
Major Customers	ALPSALPINE, AzureWave, BBK GROUP, Canon, Cypress, Digi Singapore,D&M Holdings, Foxconn GROUP, Fujitsu, FUJITSU GENERAL, GBM, Hitachi, Kioxia, KURODA ELECTRIC, LG GROUP, Luxshare, MEDiatek, MinebeaMitsumi, Murata Manufacturing, New Japan Radio, NIDEC MOBILITY, NIKON, Oki Electric Industry, OMRON, Panasonic, PEGATRON, PIONEER, QUALCOMM, Quectel Wireless Solutions, Renesas Electronics, SAMSUNG GROUP, Sharp, Sony, Starkey, TAIYO YUDEN, TOSHIBA, UNISOC, USI, Wacom (In alphabetical order)

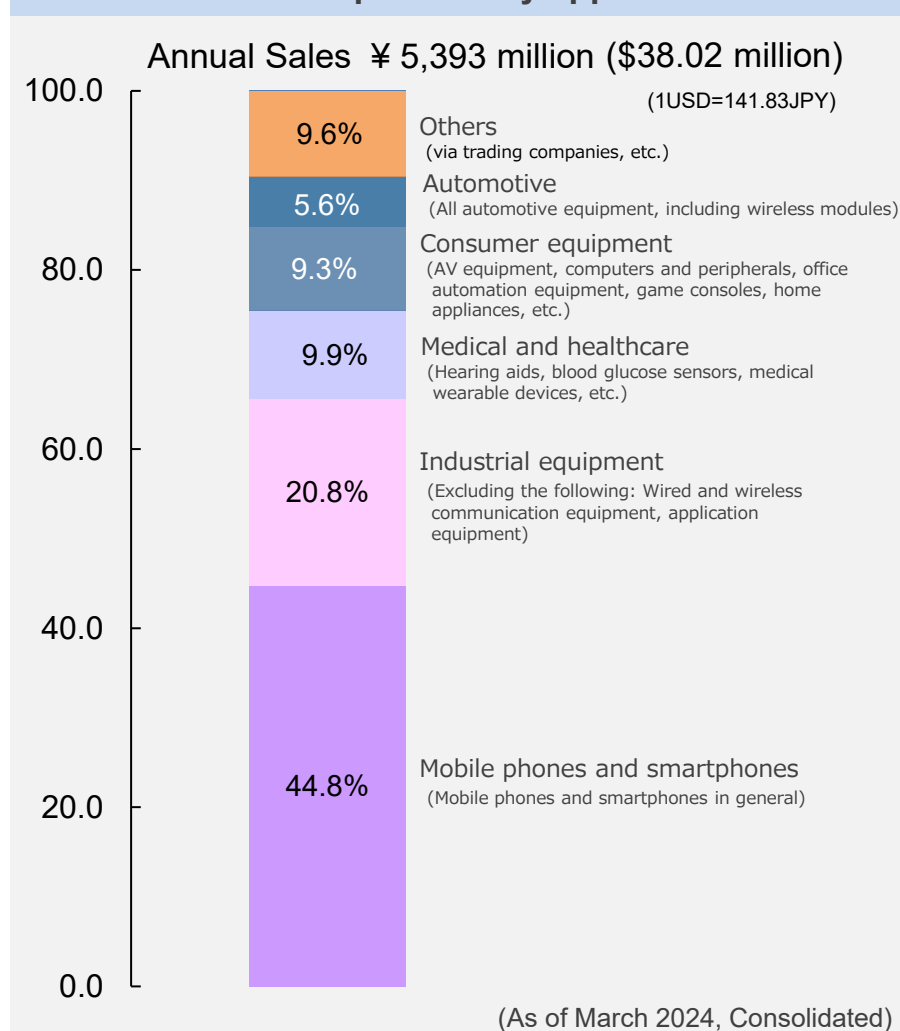
We focus on crystal device business

Our net sales in crystal devices account for over 90% of total net sales.

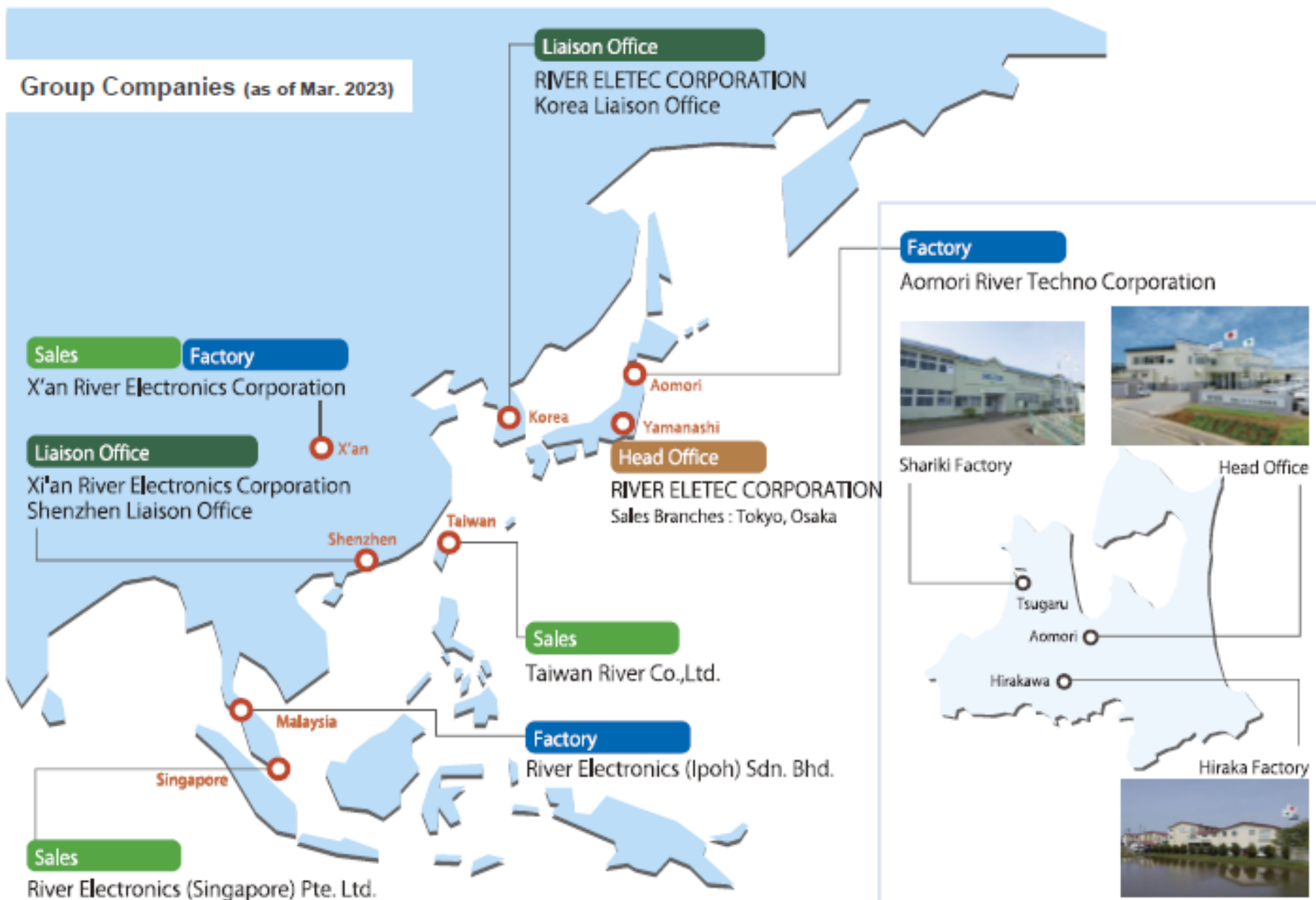
Sales composition by business segment



Sales composition by application



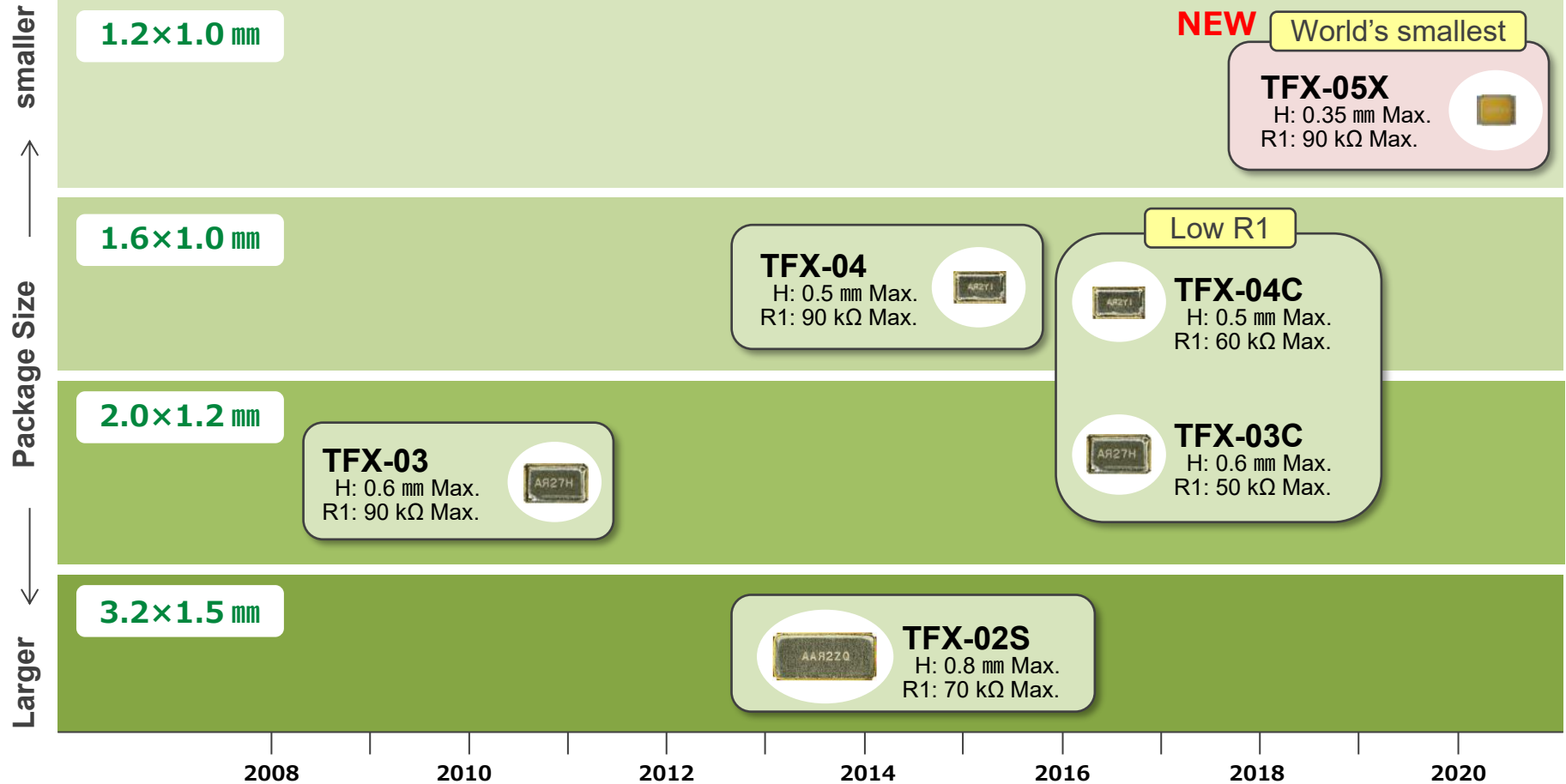
Group Companies (as of Mar. 2023)



KHz Tuning-Fork Crystal Resonator

- ☑ Freq. tolerance: ± 10 ppm
- ☑ CL: < 4.0 pF~ available*2

- ☑ AEC-Q200 available
- ☑ RoHS-compliant, Lead-free available



*1: Except for TFX-05X

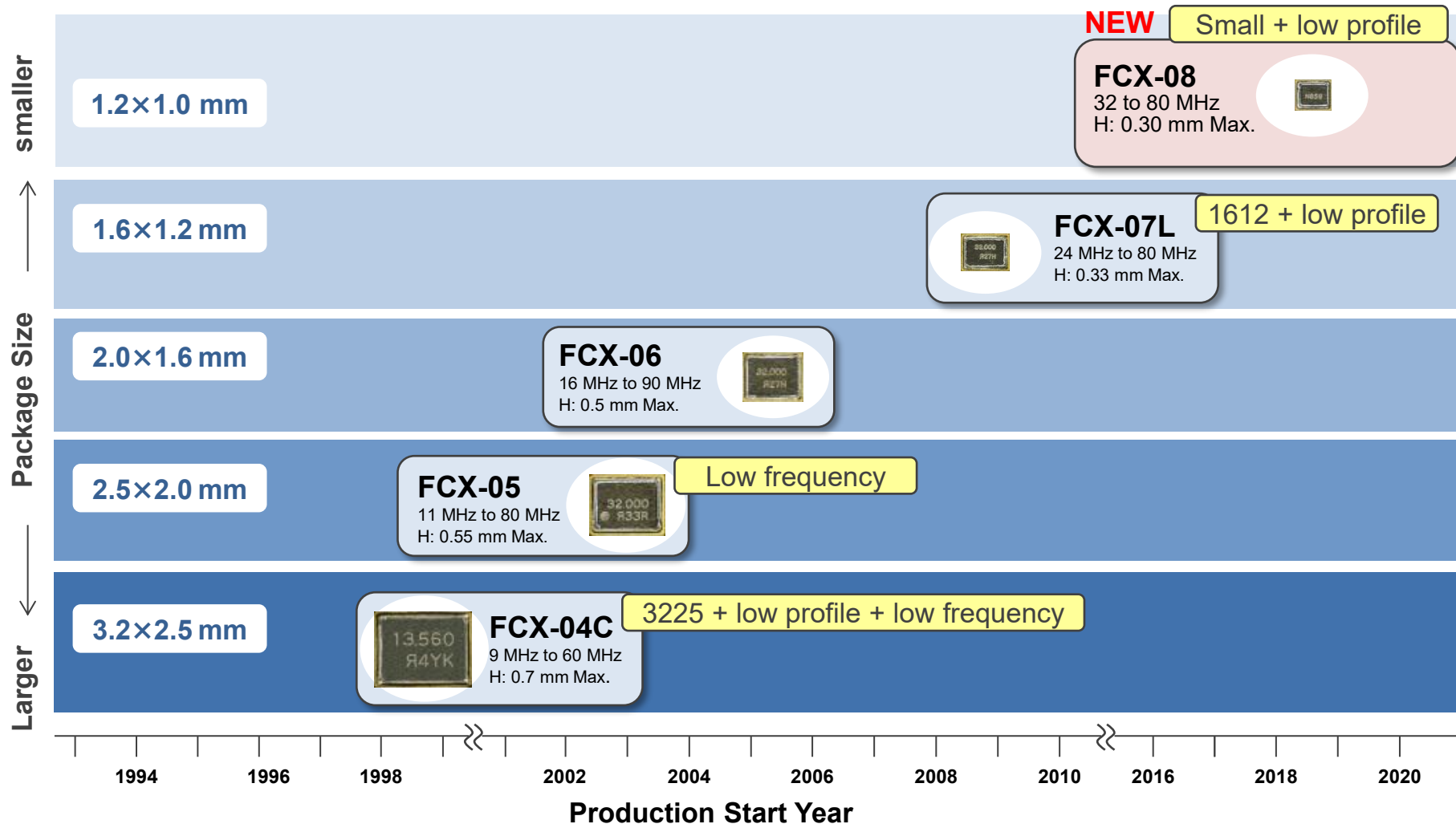
*2: Except for TFX-02S

Production Start Year

MHz AT-cut Crystal Resonators

- ☑ Freq. tolerance: ± 7 ppm
- ☑ CL: Available from 5.0 pF

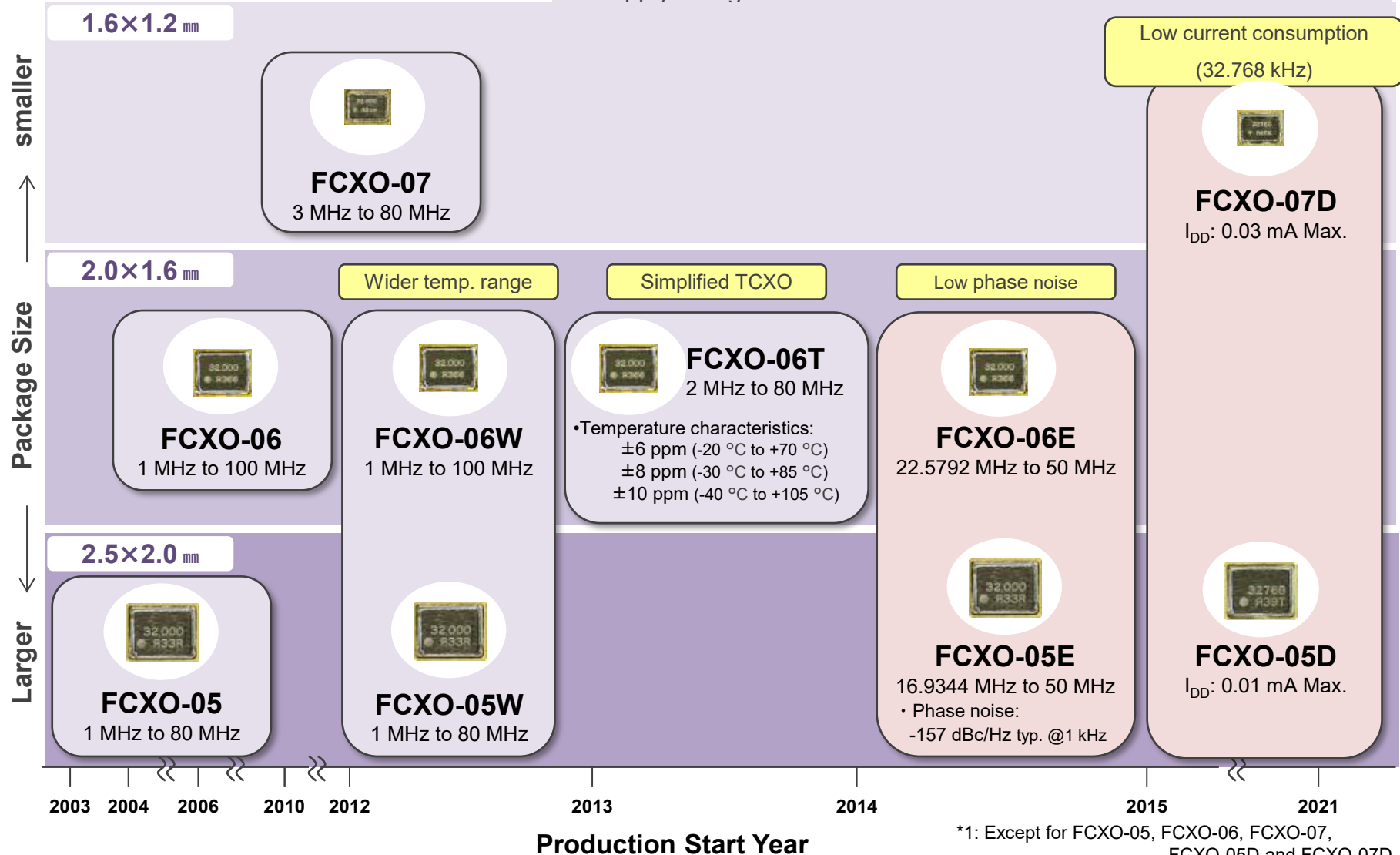
- ☑ AEC-Q200 available
- ☑ RoHS-compliant, Lead-free available



KHz & MHz Crystal Oscillators

- ☑ Freq. tolerance: ± 7 ppm
- ☑ -40 °C to $+105$ °C operable*1
- ☑ Supply voltage: 1.6 V to 3.63 V

- ☑ AEC-Q200 available*1
- ☑ RoHS-compliant, Lead-free available

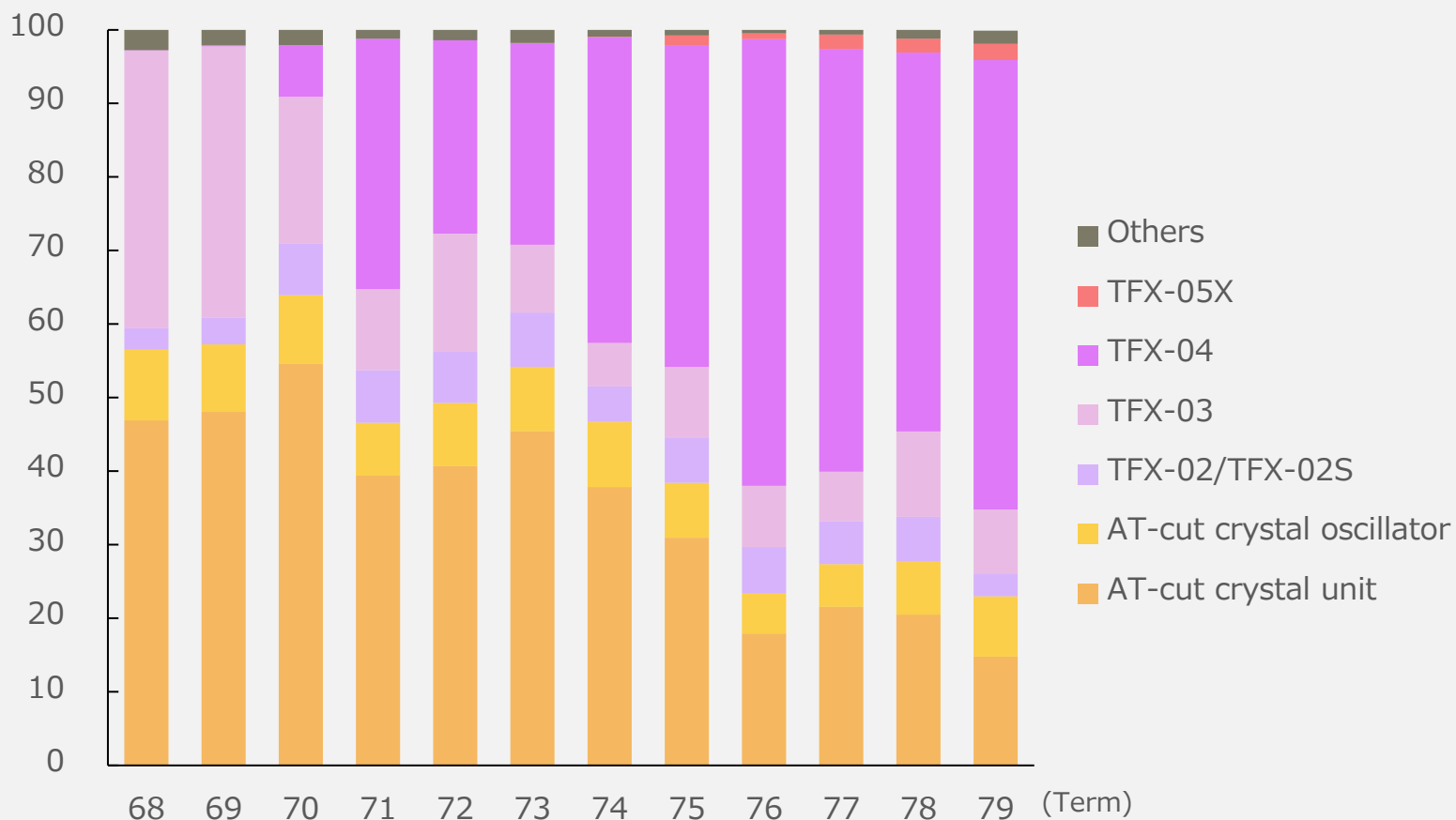


*1: Except for FCXO-05, FCXO-06, FCXO-07, FCXO-05D and FCXO-07D

We focus on crystal device business

We strive to further expand sales on our flagship product, TFX-04, and aim to gain number 1 share in the market

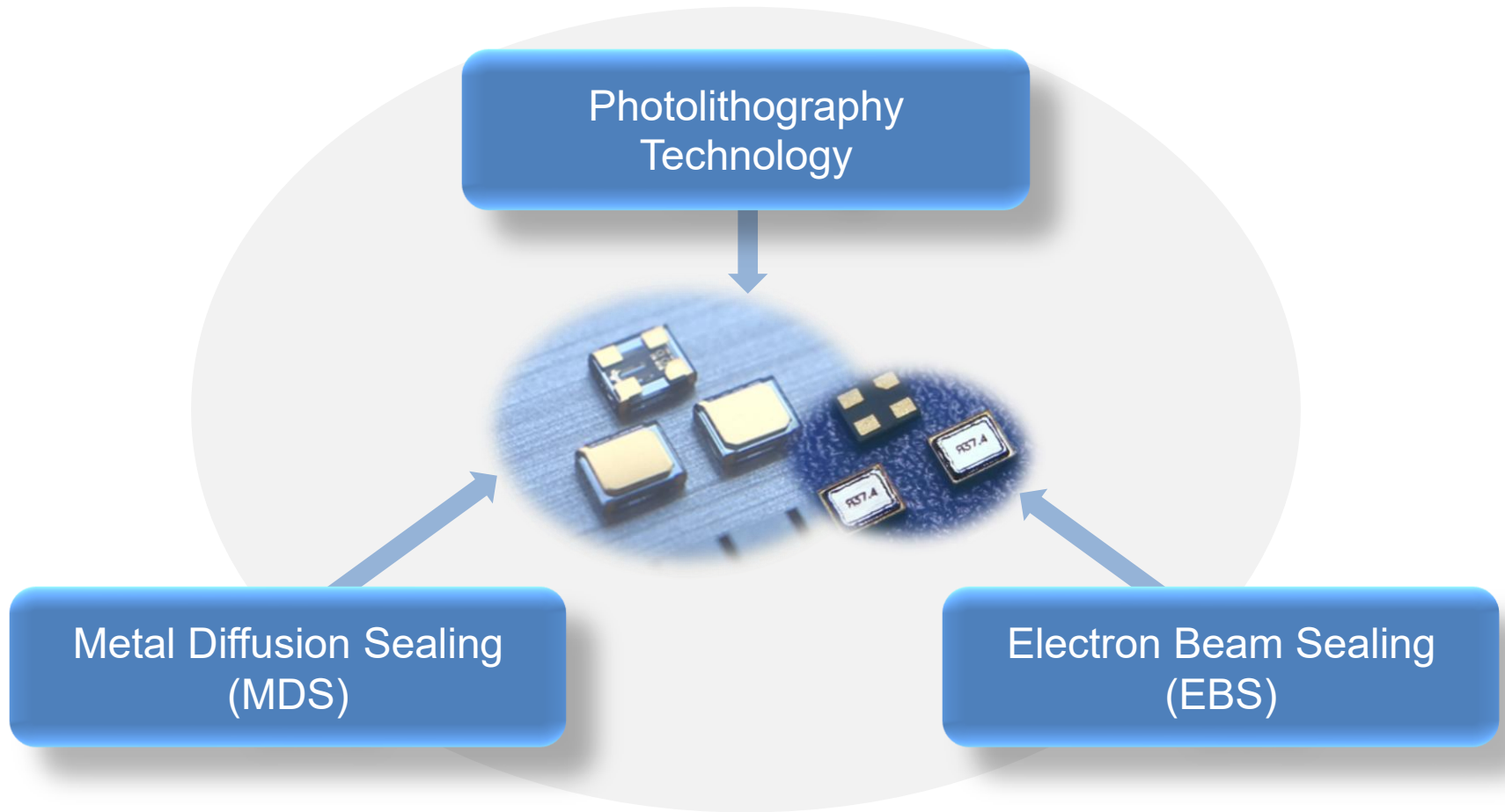
Changes in sales composition ratio by product



(As of March 2024, Consolidated)

RIVER's Unique, Cutting-Edge Technologies

3 key unique technologies are used to achieve superior quality and reliability in RIVER's products while meeting customer's needs for miniaturization.

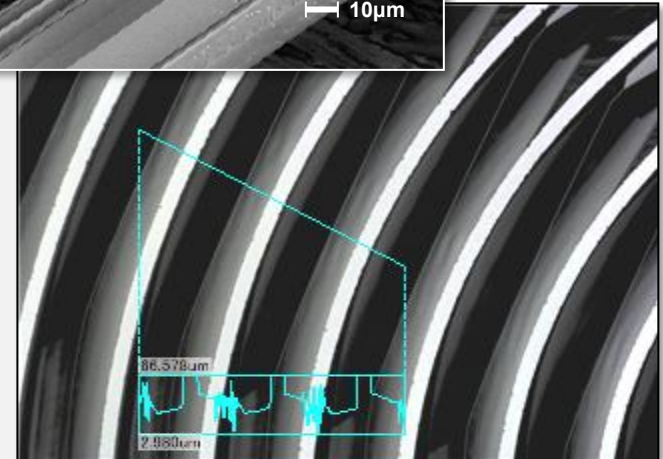
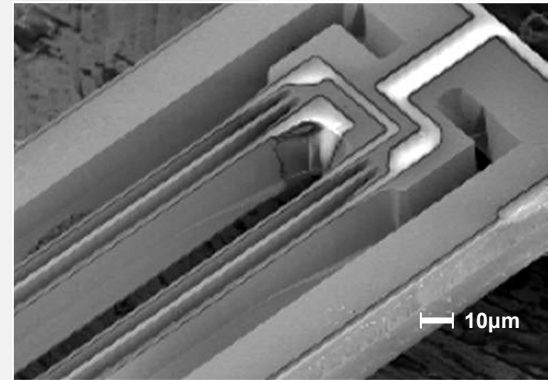
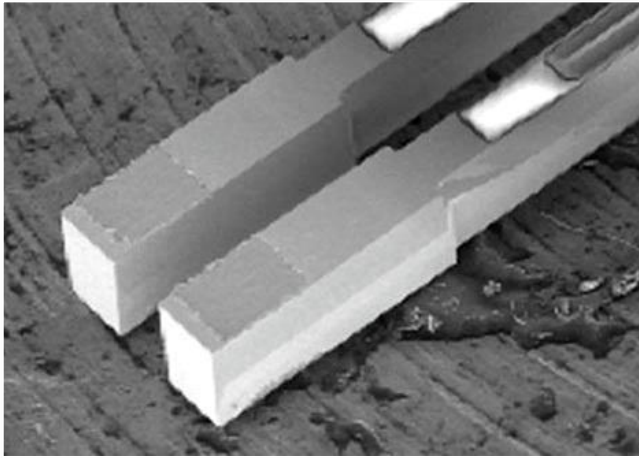


Sophisticated Photolithography Technology of Quartz Crystal

Photolithography is a unique tool deployed to obtain micron-scale ultrafine patterns on quartz crystal. Without such technology, miniaturization can be very challenging to maintain good quality and product yield.

Example of micro-scale pattern of TFX-05X

Groove depth	Groove width	Beam width
40 μm	18 μm	2 μm

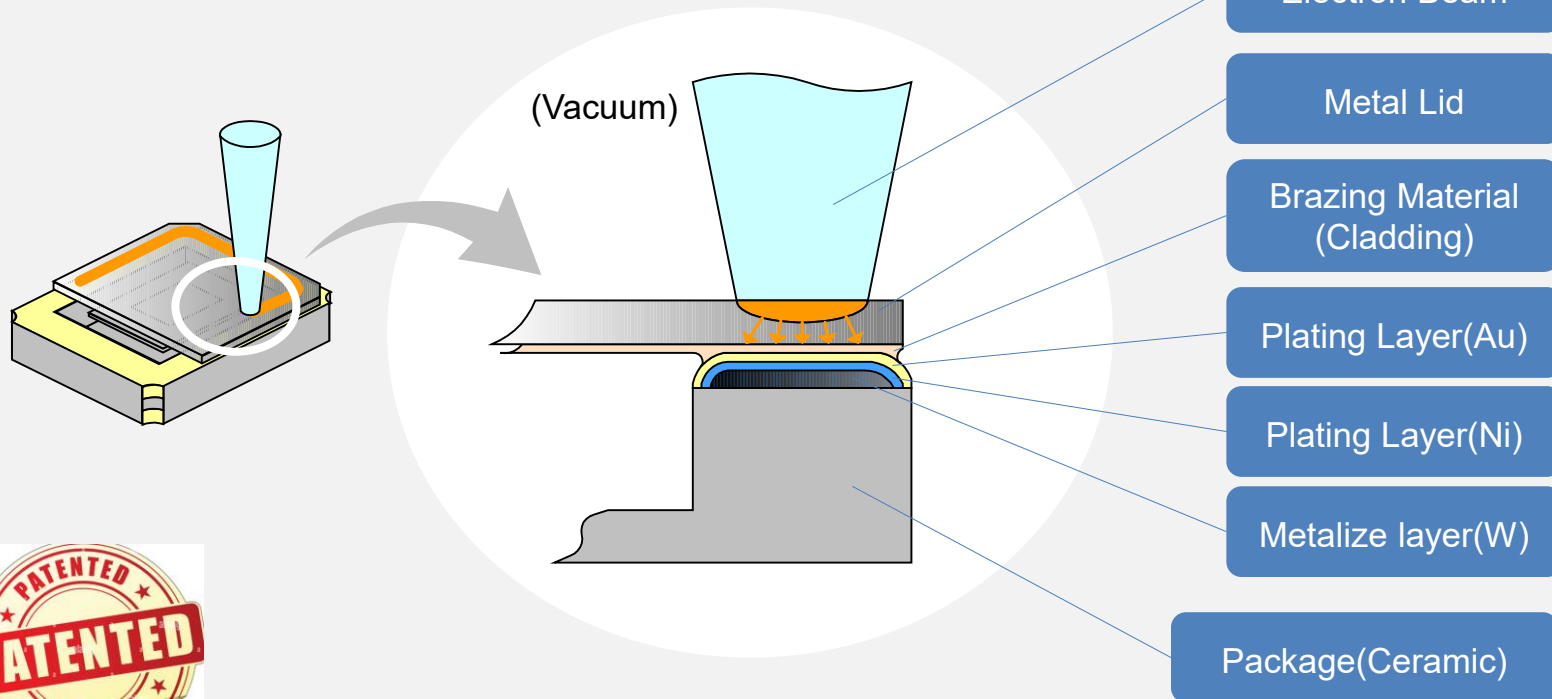


Self Developed Electron Beam Sealing (EBS)

EBS is one of RIVER's patented know-hows by using electron beam in a vacuum environment to seal the ceramic package that house the crystal blank.

The benefits of this technology when use for miniature products are:
High precision; Low ESR; Good ageing; Cost effective.

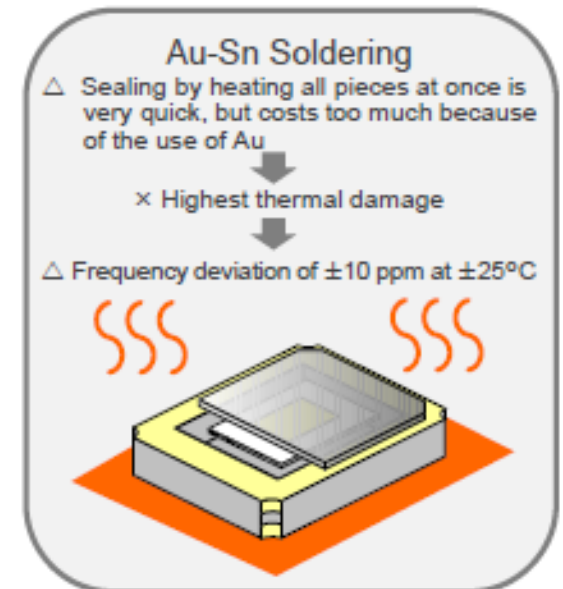
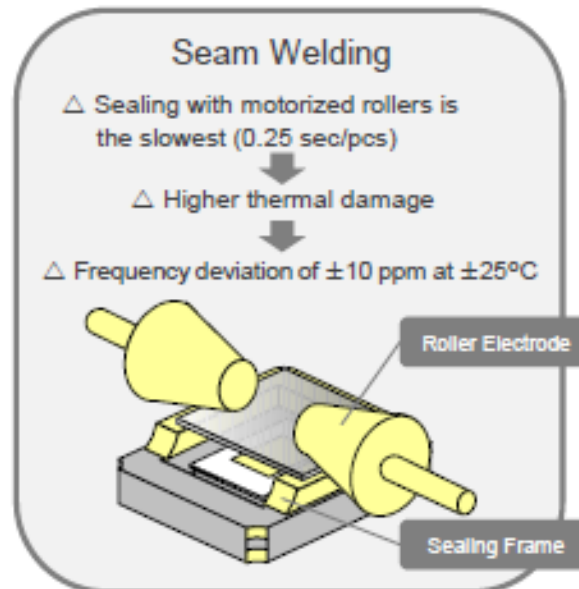
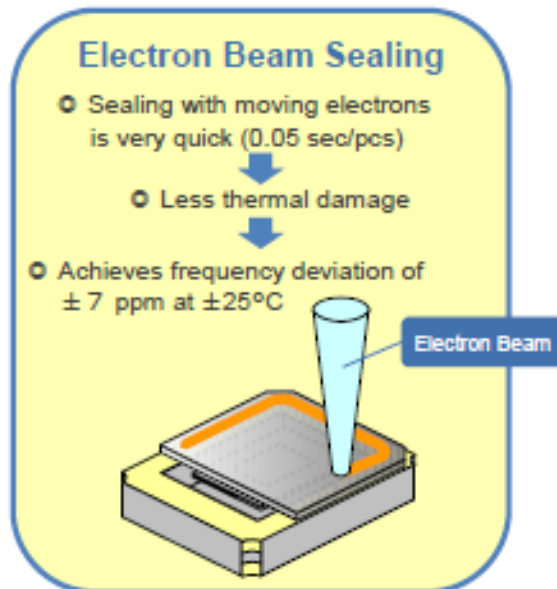
The Mechanism of EBS Method
(Japanese patent No. 4405636 etc.)



Comparison of EBS and Other Sealing Methods

The electron beam sealing method enables quick processing, high accuracy, and high reliability.

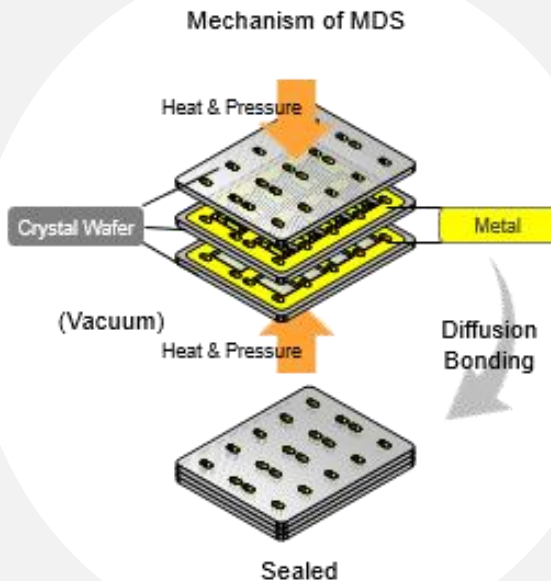
Method	EBS	Seam Welding	Au-Sn Soldering	Resin	Low Melting Glass
Miniaturization	◎	◎	◎	○	○
Cost	○	○	△	◎	◎
Inner Gas	Vacuum	N ² or Vacuum	Vacuum	N ²	N ²
Resistance to Humidity	◎	◎	◎	○	◎
Resistance to Shock	◎	◎	◎	◎	△
High Accuracy	◎	◎	○	◎	△
High Quality	◎	○	○	◎	○



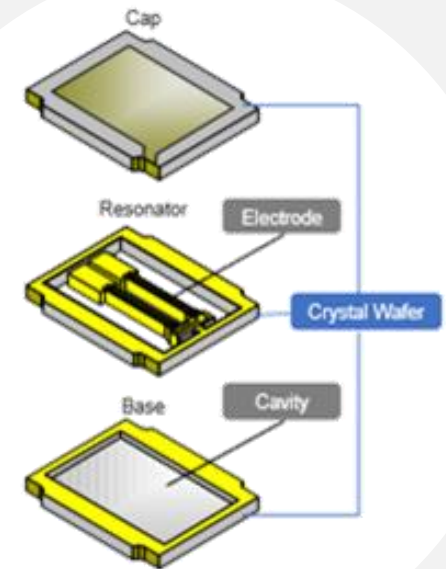
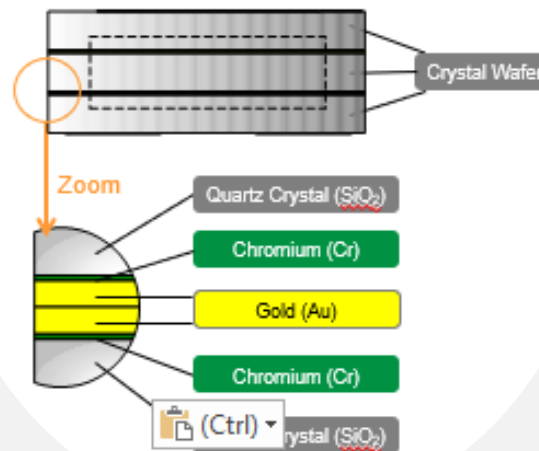
Metal Diffusion Sealing (MDS) for Crystal on Crystal

RIVER's 1210 32.768KHz crystal is not only the smallest but the lightest among all in the market. It's made possible by housing the Tuning Fork Crystal inside Cap and Base that are made of Crystals too.

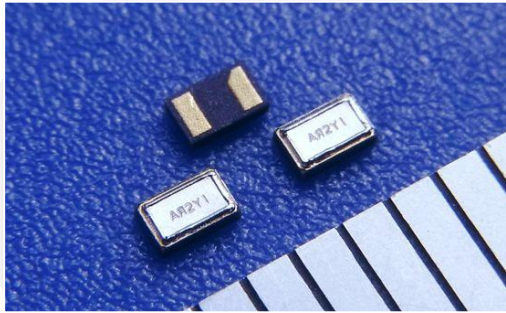
MDS is used to obtain direct metal-to-metal bonding to achieve:
High precision; Featherweight; Environmental friendly



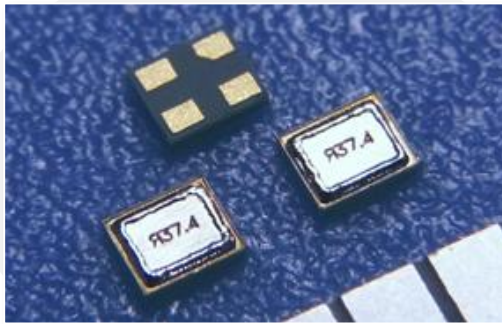
Cross-Sectional View of TFX-05X



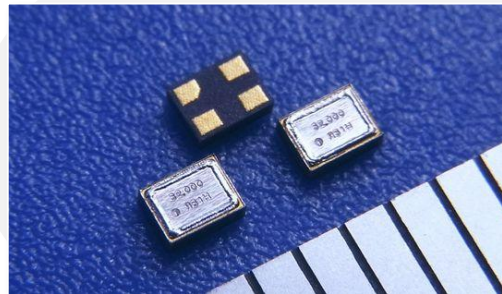
Photolithography + EBS



TFX-04
1610 Tuning Fork Crystal

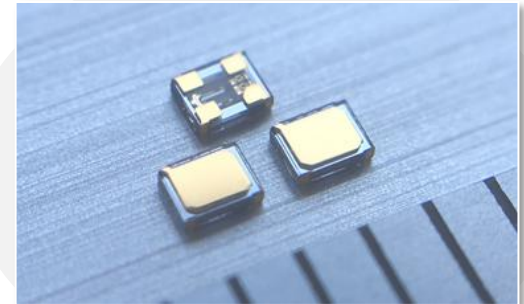


FCX-08
1210 AT Crystal



FCXO-07
1612 Crystal Oscillator

Photolithography + MDS



TFX-05X
1210 Tuning Fork Crystal

New Products Line-up



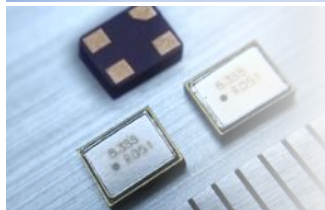
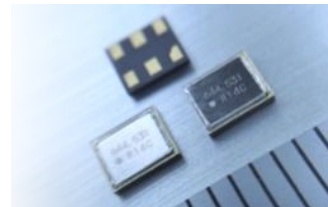
Advanced R&D Ability with Accumulated Know-how

RIVER's strength is not limited only to miniaturization of product sizes. With our 15% headcount in the company committed to product/process R&D, we have switch-gear to develop several niche products to fill the performance gaps in the current market application needs.

FCXO-04

AT-Cut Crystal Oscillator

- ❖ 100MHz~1GHz
- ❖ phase jitter 0.5ps



- ❖ 1MHz~150MHz
- ❖ $\pm 50\text{ppm}$ @40°C~200°C

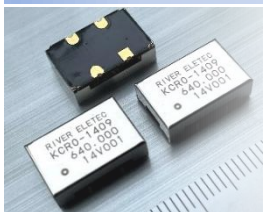
GTXO-04

GT-Cut Crystal Oscillator

KCR-04

KoT-Cut OPAW Crystal Resonator

- ❖ 500MHz~800MHz



- ❖ 500MHz~1GHz
- ❖ phase jitter 10fs
- ❖ Phase noise -140dBc/Hz

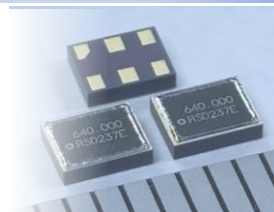
KCRO-1409

KoT-cut OPAW Crystal Oscillator

KCRO-04

KoT-Cut OPAW Crystal Oscillator with IC

- ❖ 100MHz~1GHz



3225 Size Oscillator with Wide Frequency Range

FCXO-04

AT-Cut Crystal Oscillator

Features:

- Wide output frequency range 100MHz to 1000MHz
- LVDS or LVPECL output formats
- Low phase jitter 0.5 ps Typ.
- $\pm 50\text{ppm}$ @ $-40\sim 85^{\circ}\text{C}$
- SPXO and VCXO Available

Cinema
Camcorder



148.351648MHz

Measuring
Instrument



864.000MHz

Ethernet Optical Module

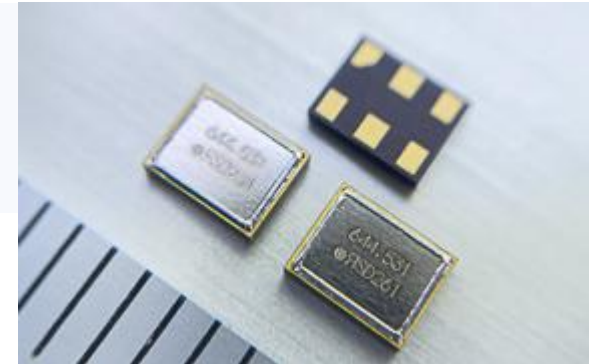


425.000MHz

HR Camera



526.864MHz



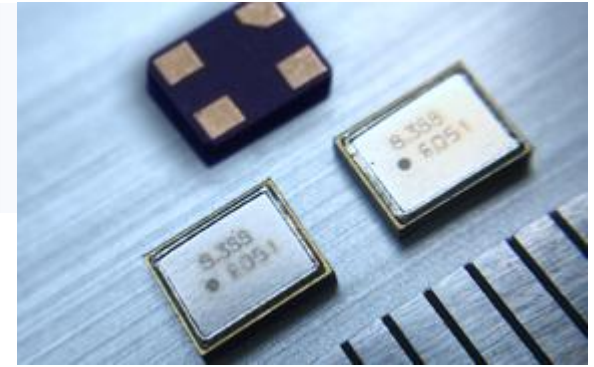
3225 Size Oscillator for High Temperature Application

GTXO-04

GT-Cut Crystal Oscillator

Features:

- High stability at wide temperature ($\pm 50\text{ppm}@-40/200^{\circ}\text{C}$)
- Low current consumption, Typ.
8 mA (F = 150 MHz, VDD = 3.3 V, No load)



High Temp Sensor



40.000MHz

EV Quick
Charger



25.000MHz

High Temp Optic Camera



12.000MHz

Mining
Equipment



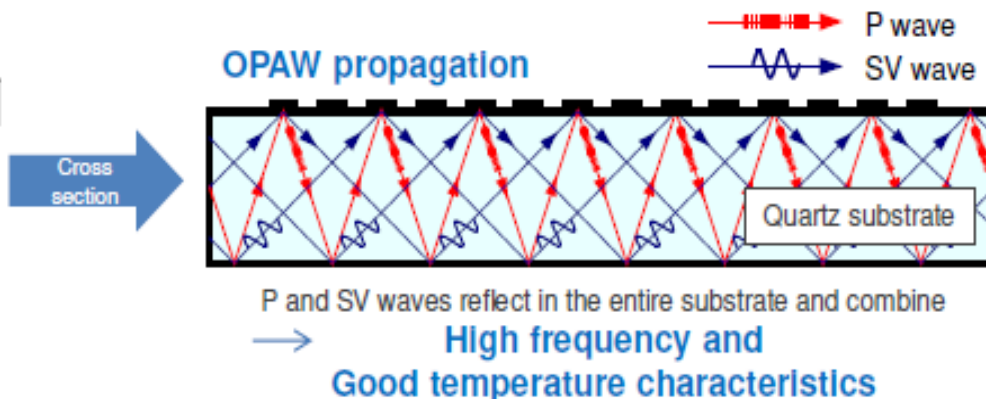
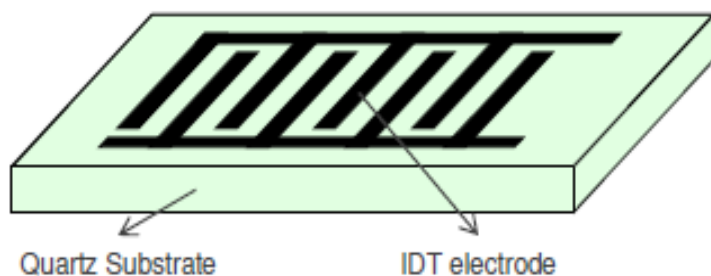
8.000~
30.000MHz

KoT Cut OPAW Product Design and Objectives



OPAW Operating Mechanism

Orthogonal Plate Acoustic Waves (OPAW) are a type of bulk wave that combines longitudinal waves (P waves) and transverse waves (SV waves).



KoT Cut OPAW Product Design and Objectives

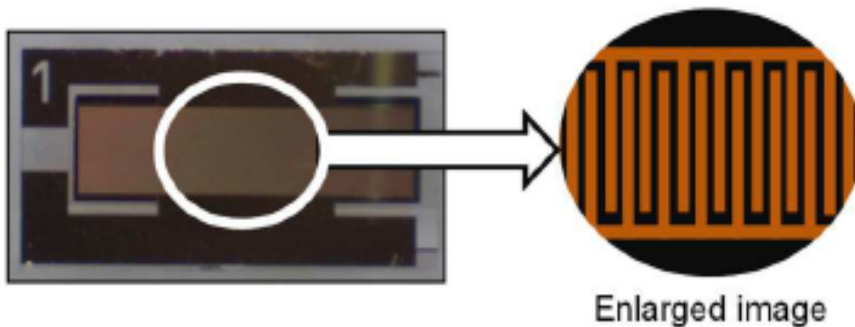


KoT Cut Principal

Kerfed orthogonal plate waves for zero Temperature coefficient (KoT-cut) is a new crystal cut angle on quartz that achieves low jitter, high frequency, and great stability over temperature characteristics.

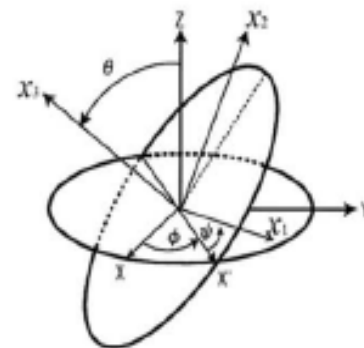
IDT-electrode by photolithography technology

Interdigitated electrodes (IDT) are processed with our unique photolithography technology, improving frequency characteristics and temperature characteristics, and enabling accurate frequency adjustment.



New cutting-angle

The new crystal cutting angle achieves both high-frequency oscillation in the fundamental wave and high frequency accuracy.



KoT Cut OPAW Product Design and Objectives

Features:

- High stability at wide temperature $\pm 30\text{ppm}@-40/125^{\circ}\text{C}$
- Very high frequency in High Fundamental Mode 100~1000MHz
- Superior in Phase Jitter 15fs Typ. ($600\text{ MHz} \leq f_o < 800\text{ MHz}$)

Applications and Usage














KCRO-1409 , KCRO-04 KoT - cut

- 491.52 MHz >>> Communication infrastructure related
- 500 MHz >>> Measuring instrument related
- 630 MHz >>> Ethernet
- Around 640 MHz >>> High performance video, medical imaging equipment
- Around 840 MHz >>> Optical communication
- 1 GHz >>> measuring instrument

KoT Cut OPAW Product Design and Objectives

Performance in Comparison

	 KoT	AT	SAW	PLL
To High frequency	 500~1GHz	 crystal thickness dwindles	 Beyond 300MHz	
Frequency temperature characteristics	 Twice as good as AT			
Low jitter / Low phase noise	 5 femtoseconds (KCRO-1409)			 100 femtoseconds

KoT Cut OPAW Product Design and Objectives

Patent Application and Approval

New cut angle (KoT-cut) patents have been established in major countries around the world.

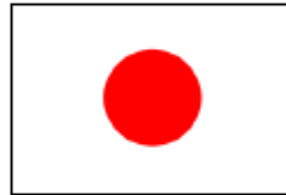


The US



No. US11,258,424

Japan



No. 7249055

China



Patent examination

Taiwan



No. I747636

The UK



No. GB2598165

RIVER ELETEC CORPORATION

<https://www.river-ele.co.jp/ja/>

