RIVER





RIVER ELETEC CORPORATION

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Company Profile (as of Mar. 31. 2024)

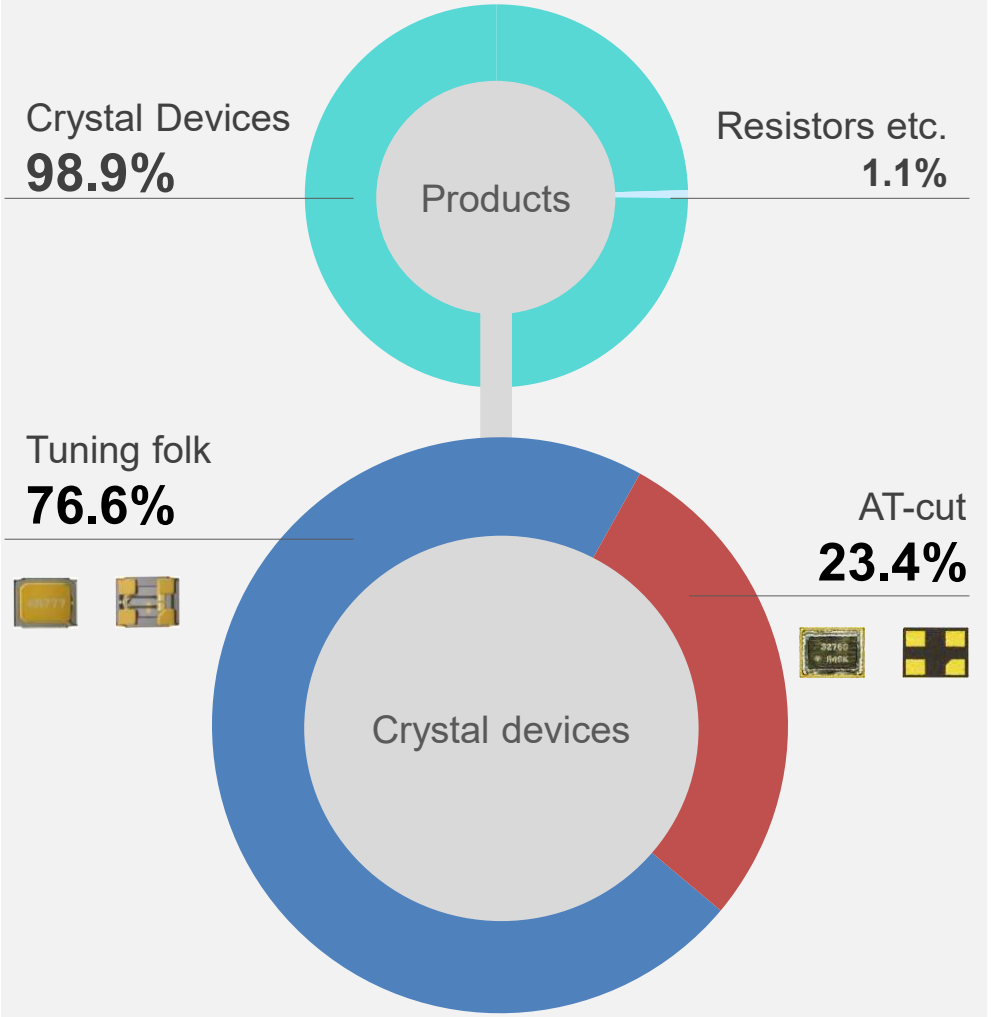
RIVER ELETEC is a manufacturer that develops, manufactures, and sells crystal devices used in all kinds of electronic devices such as smartphones.

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, Nisshinbo Micro Devices, 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

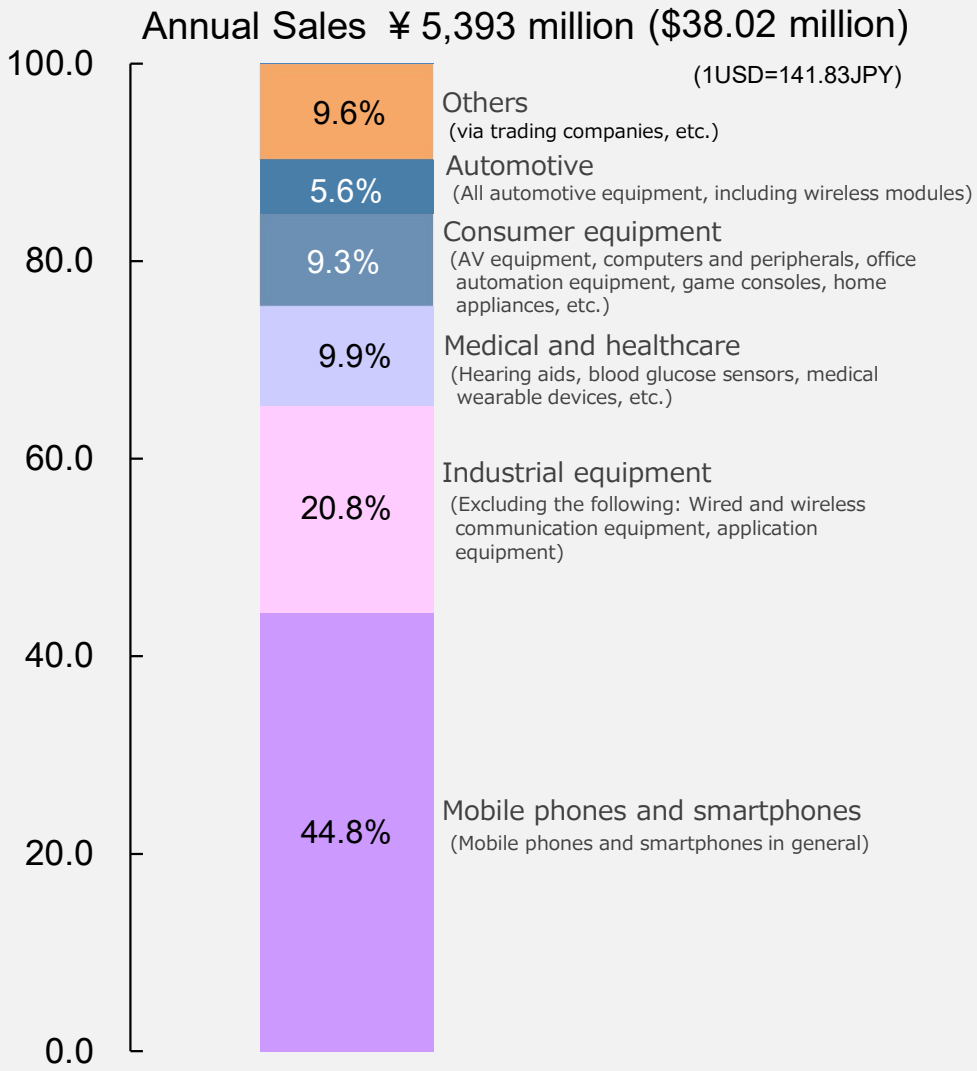
Our net sales in crystal devices account for over 90% of total net sales.

Sales composition by business segment



(As of March 2024, Consolidated)

Sales composition by application

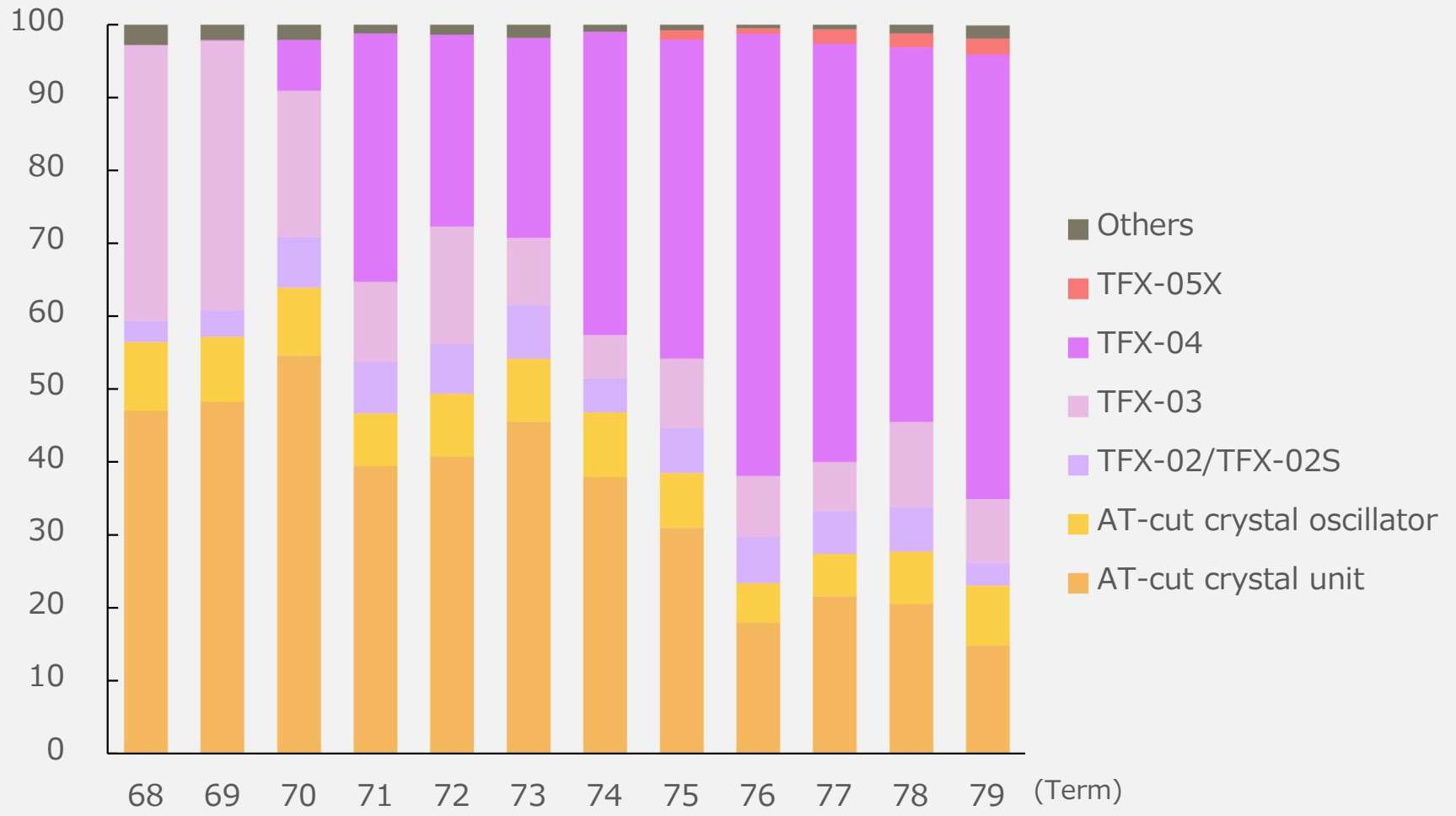


(As of March 2024, Consolidated)

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)

Group Companies (as of Mar. 2024)

Liaison Office
RIVER ELETEC CORPORATION
Korea Liaison Office

Factory
Aomori River Techno Corporation

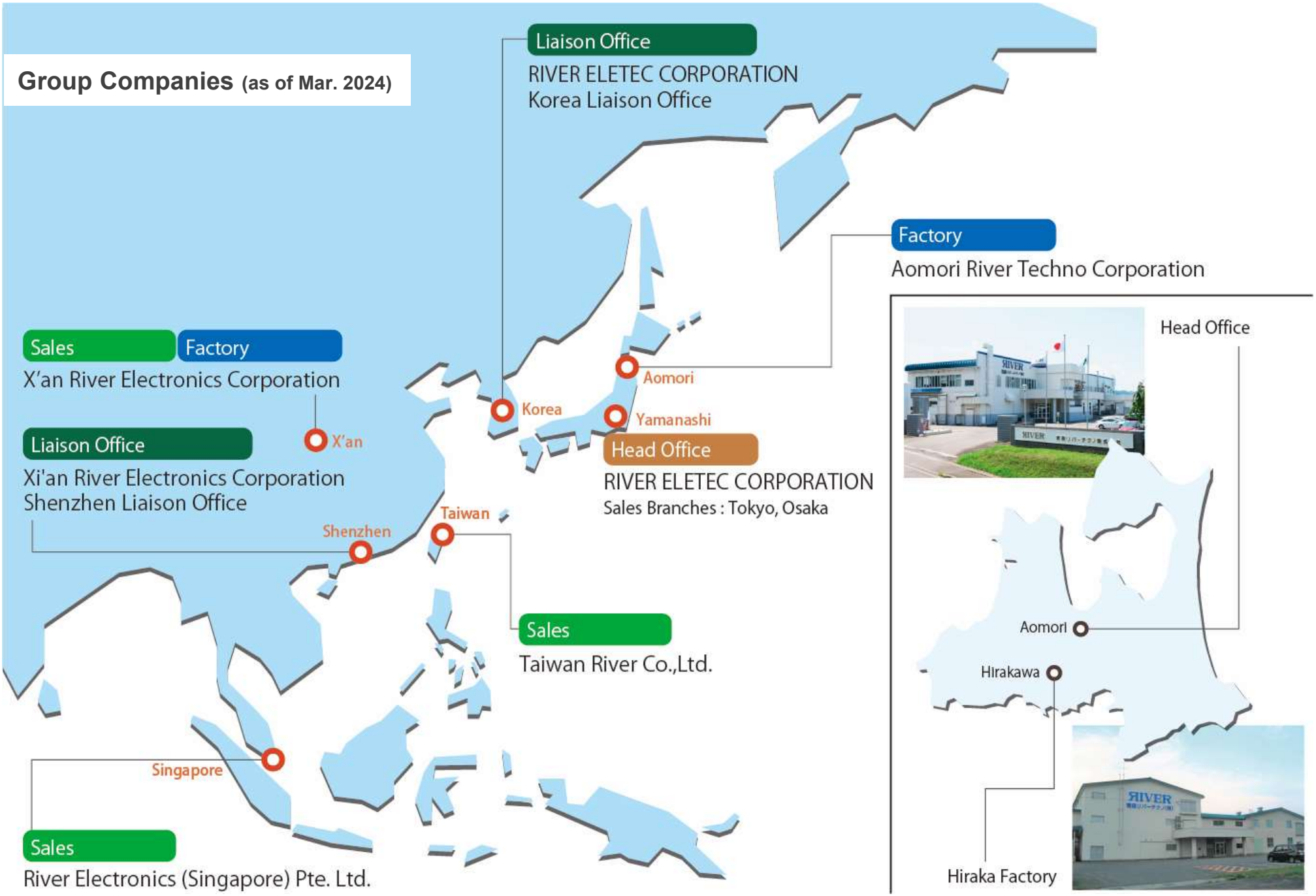
Sales **Factory**
X'an River Electronics Corporation

Liaison Office
Xi'an River Electronics Corporation
Shenzhen Liaison Office

Head Office
RIVER ELETEC CORPORATION
Sales Branches : Tokyo, Osaka

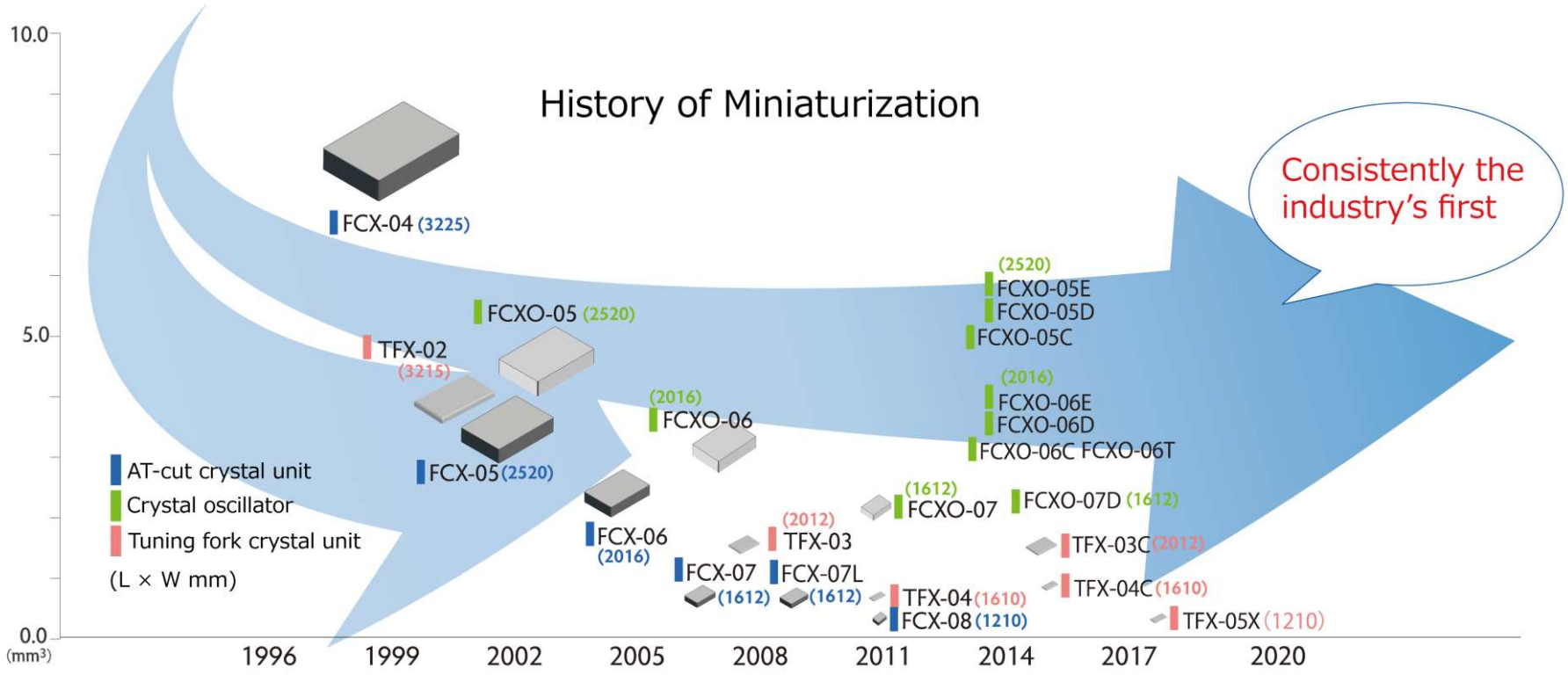
Sales
Taiwan River Co.,Ltd.

Sales
River Electronics (Singapore) Pte. Ltd.



Pioneer of ultra-compact crystal devices

RIVER ELETEC is a company that has always been leading the miniaturization of quartz crystal devices. By introducing ultra-compact crystal devices in the market ahead of other companies, we constantly gain early market share. This allowed us to develop our business through the brand strategy of “RIVER = ultra-compact crystal devices”.

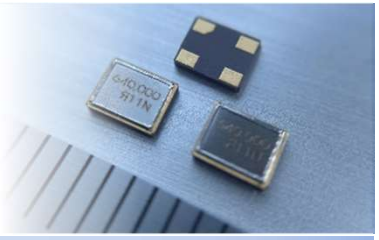


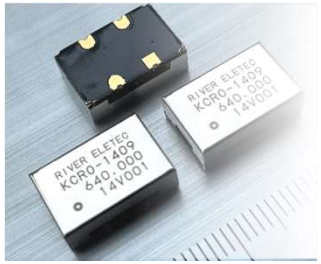
Advanced R&D Ability with Accumulated Expertise

While providing solutions for customers' needs for small and lightweight crystal devices, RIVER ELETEC has refined its proprietary technologies. The representatives of the technologies are “Electron Beam Sealing Method”, “Metal Diffusion Sealing Method”, and advanced quartz crystal photolithography. The outside-of-the-box thinking of their R&D team has improved the key technologies for crystal devices, such as microfabrication technology of crystal blanks and high-precision mounting technology, allowing them to provide high-performance and compact devices.

KCR-04

KoT cut OPAW Crystal unit



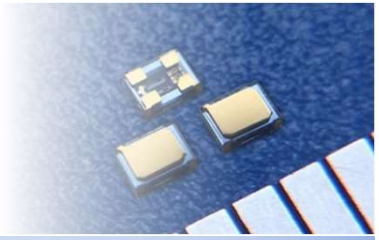


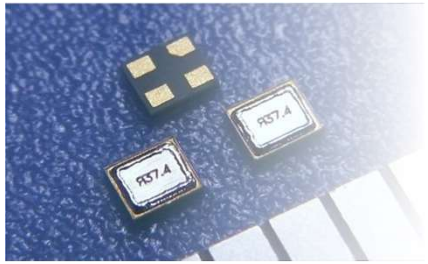
KCRO-1409

KoT cut OPAW Crystal oscillator

TFX-05X

Ultra-compact, Tuning fork crystal unit





FCX-08

Ultra-compact, AT-cut, MHz-Range Crystal Unit

※ "KoT Cut" and "OPAW" are registered trademarks by RIVER ELETEC CORPORATION.

Solution-Sales Powered by Strong Support System

The majority of RIVER products are custom-made for specifications customer required. Through the strong support system built by the Manufacturing, Sales, and R&D departments, we offer technical solutions to help our customers to enhance their value with the industry-leading support in quality, delivery time, and after-sales follow-up.



Manufacturing + Sales + R&D

Proposes custom products that meet customer's requirements

ISO9001: For Better Quality

RIVER ELETEC CORPORATION and Aomori River Techno Corporation are both certified to ISO 9001, the international standard for quality management systems. To meet the customer's needs and expectations, we continue to provide high quality products and good services.

Quality Policy of RIVER Group

The River Group proposes products to meet customer needs and provides products exceeding customer expectations. The satisfaction of the customer is the ultimate objective.

1. Designs in quality at the development phase and builds in quality during the manufacturing phase.
2. Strives to reduce product non-conformities and prevent their recurrence.
3. Is relentless in its pursuit of effectiveness and efficiency.
4. Continuously seeks to improve the quality management system and to strengthen the 'quality first' policy.

ISO9001 Certification



ISO14001: For Environmental Protection

RIVER ELETEC CORPORATION and Aomori River Techno Corporation are both certified to ISO 14001, the international standard for environmental management systems. To preserve the global environment and build a recycling-oriented society for sustainable development, we continue to develop our activities for environmental preservation.

Environmental Policy of RIVER Group

To contribute to a sustainable society, the River Group will continuously improve its environmental management system, reduce the environmental impact of its business activities, and lessen the environmental impact of its products throughout their lifecycles.

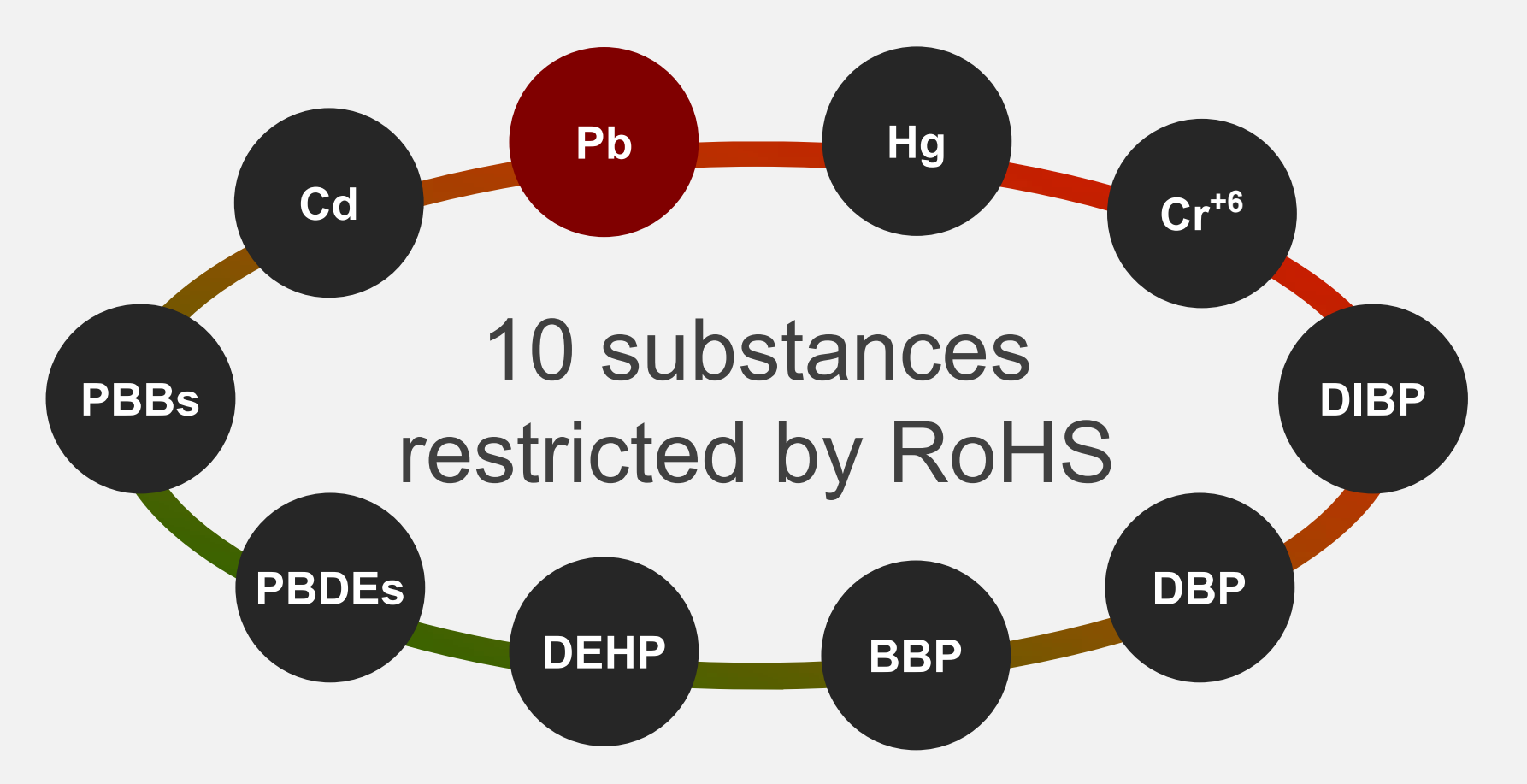
1. Will promote decarbonization whenever feasible.
2. Will promote the recycling of resources.
3. Will promote the development of environmentally friendly products, equipment and technologies related to manufacturing.
4. Will promote the prevention of pollution thorough careful management of chemical substances.
5. Will comply with applicable environmental laws, regulations, ordinances and other agreed upon requirements.
6. Will promote both biodiversity and environmental communications.

ISO14001 Certification



RoHS: For Environmental Protection

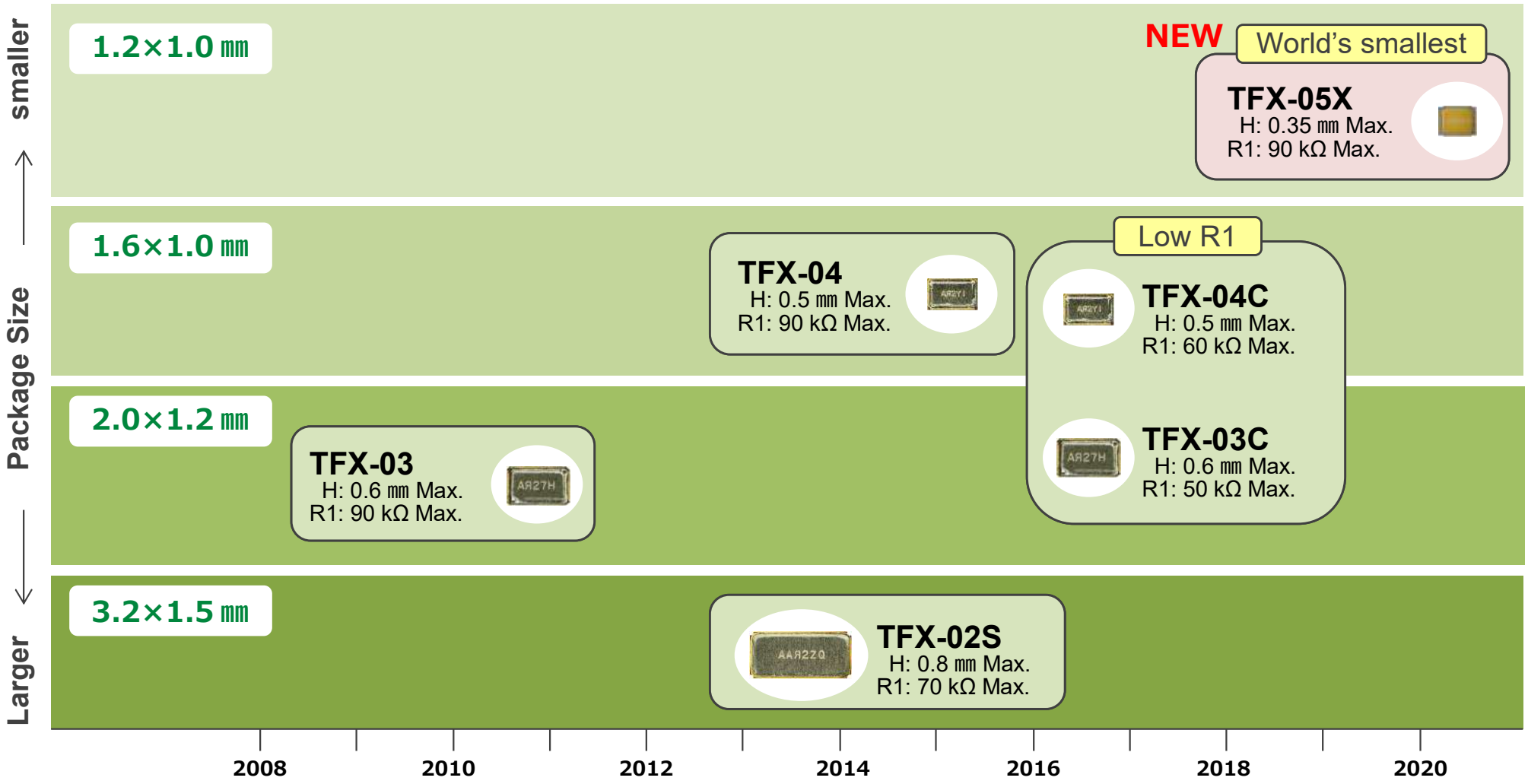
To reduce hazardous substances contained in electronic devices, RIVER ELETEC is actively working on reducing Lead, which is restricted by RoHS(2011/65/EU and (EU)2015/863), to provide products that can support RoHS-compliant, lead-free specifications.



*RoHS(Restriction of the use of certain Hazardous Substances in electrical and electric equipment): The restriction compliant with 2011/65 / EC and (EU) 2015/863 that prohibits the use of the following 10 substances** contained in electric appliances: **Lead (Pb), mercury (Hg), cadmium (Cd), Hexavalent chromium (Cd+6), Polybrominated biphenyl (PBB), Polybrominated diphenyl ether (PBDE), Bis phthalate (DEHP), Butyl benzyl phthalate (BBP), Dibutyl phthalate (DBP), and Diisobutyl phthalate (DIBP).

kHz Tuning-Fork Crystal Units

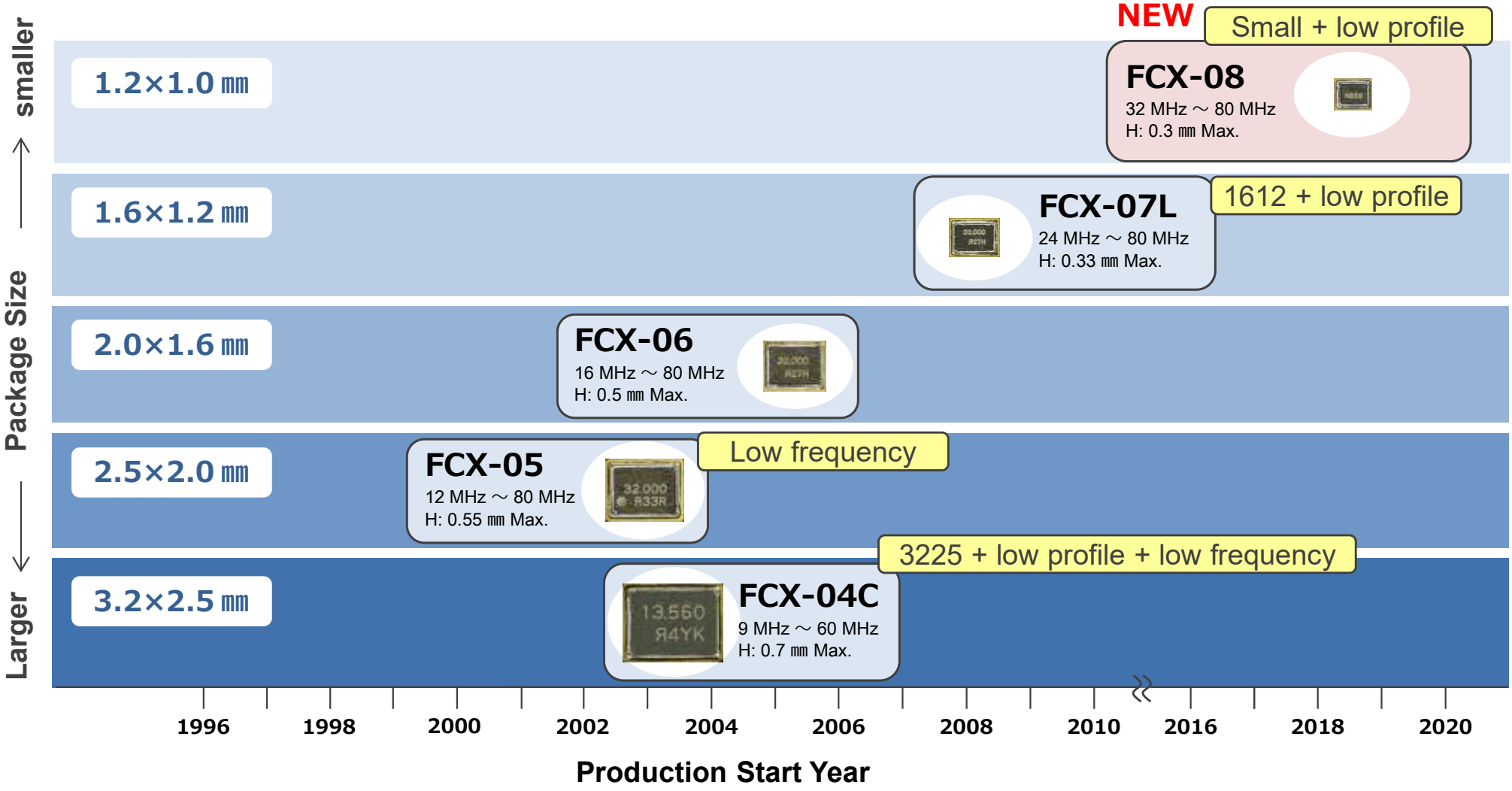
☑ Freq. tolerance: ±10 ppm*1
☑ CL: 5.0 pF~ available*2
☑ AEC-Q200 available
☑ RoHS-compliant, Lead-free available



*1: Except for TFX-05X
*2: Except for TFX-02S

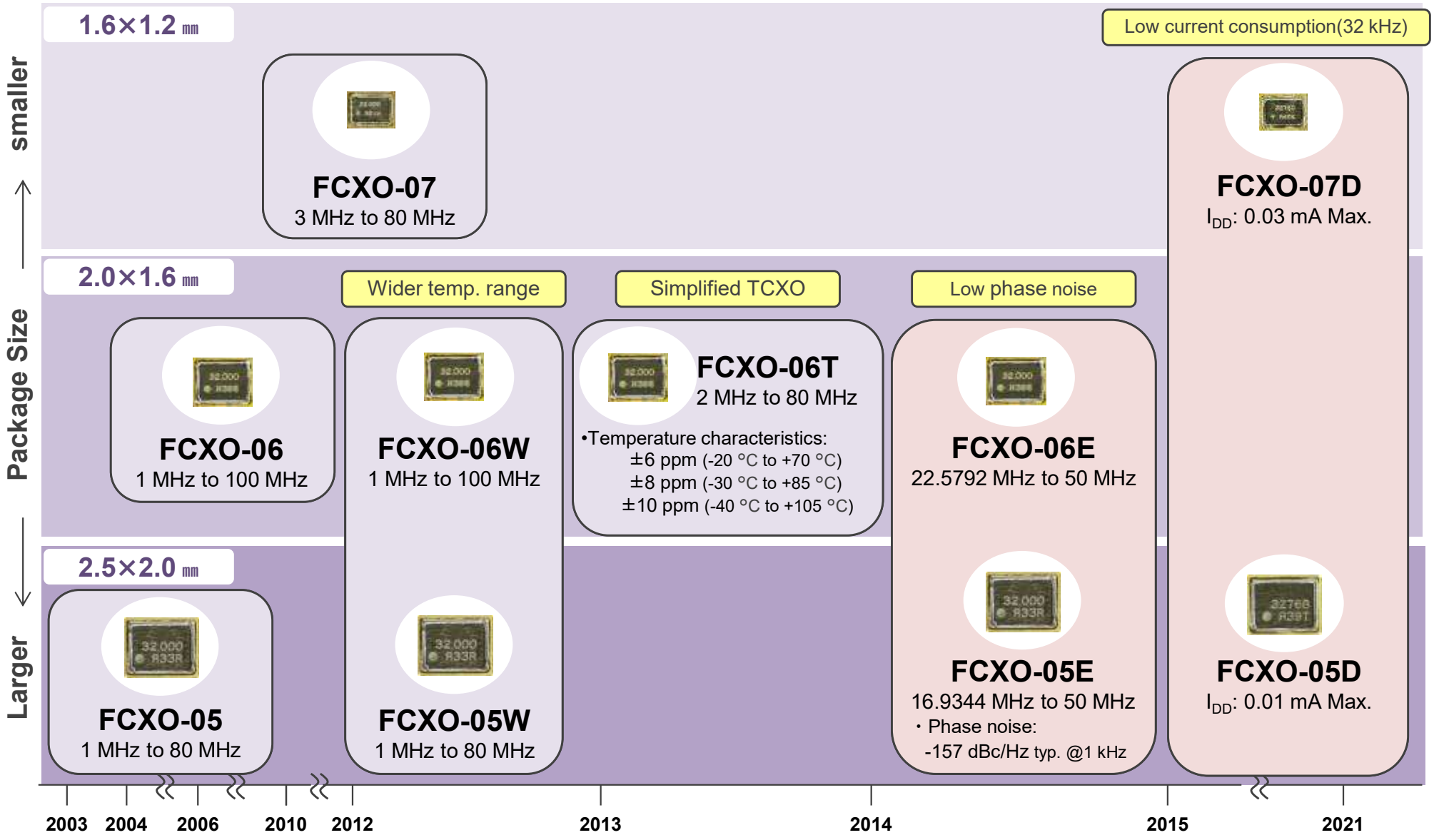
MHz AT-cut Crystal Units

☑ Freq. tolerance: ±7 ppm*1
☑ CL: Available from 5.0 pF *1
☑ AEC-Q200 available
☑ RoHS-compliant, Lead-free available



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



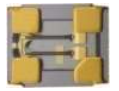
*1: Except for FCXO-05, FCXO-06, FCXO-07, FCXO-05D and FCXO-07D

kHz Tuning-Fork Crystal Units 1210
TFX-05X

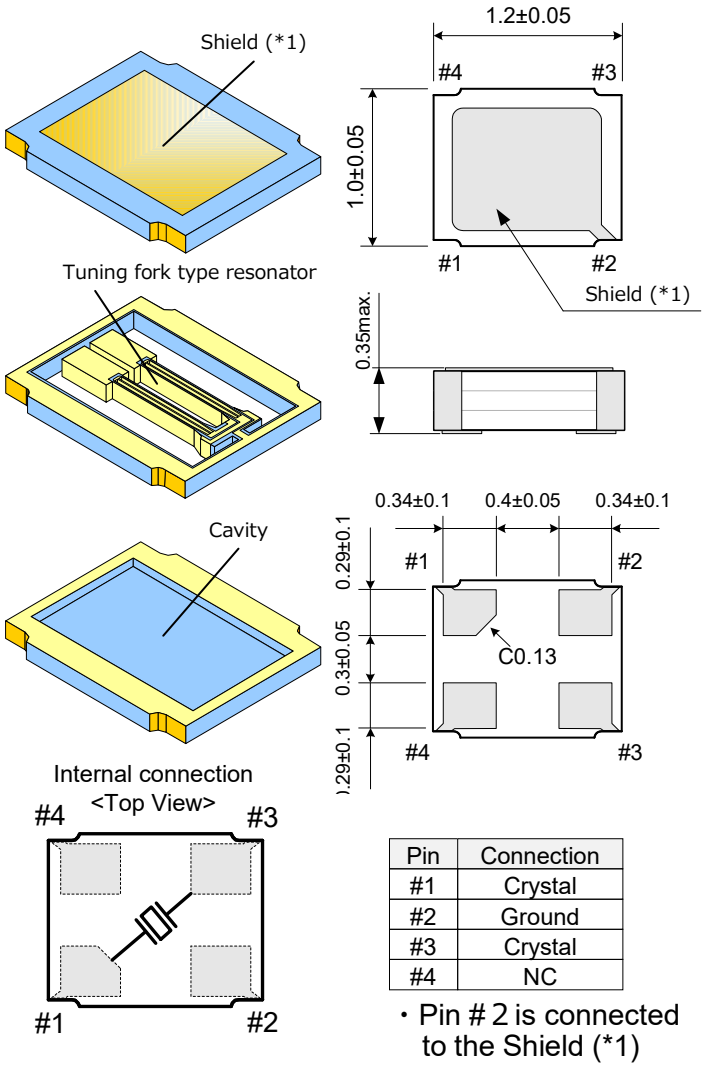
The world's smallest tuning fork crystal unit. Ultra-compact "Crystal Package" sealed by new sealing method "MDS" (Metal Diffusion Sealing).

Item	Specifications	Unit	Conditions / Remarks
Nominal frequency	32.768	kHz	-
Frequency tolerance	±20	ppm	@25 °C
Equivalent series resistance (Max.)	90	kΩ	-
Motional capacitance (Typ.)	7.0	fF	-
Shunt capacitance (Typ.)	1.5	pF	-
Storage temperature	-55 to +125	°C	-
Operating temperature	-40 to +85, -40 to +105	°C	-
Temperature coefficient	-0.03 ± 0.01	ppm/°C^2	-
Turnover temperature	25 ± 5	°C	-
Load capacitance	5.0, 7.0, 9.0, 12.5	pF	-
Drive level (Max.)	0.5	μW	-





1.2 × 1.0 × 0.35 mm Max.



Pin	Connection
#1	Crystal
#2	Ground
#3	Crystal
#4	NC

・Pin # 2 is connected to the Shield (*1)

(Unit: mm)

RoHS 2.0 Compliant 10 substances

Pb Free

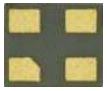
AEC-Q200 available

MHz AT-cut Crystal Unit 1210
FCX-08

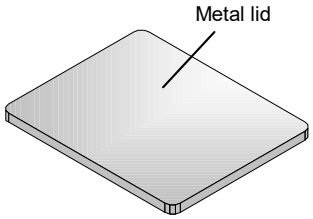
Ultra-compact AT crystal unit. Miniaturized to 54 % in volume and 63 % in footprint compared to the previous model (FCX-07L).

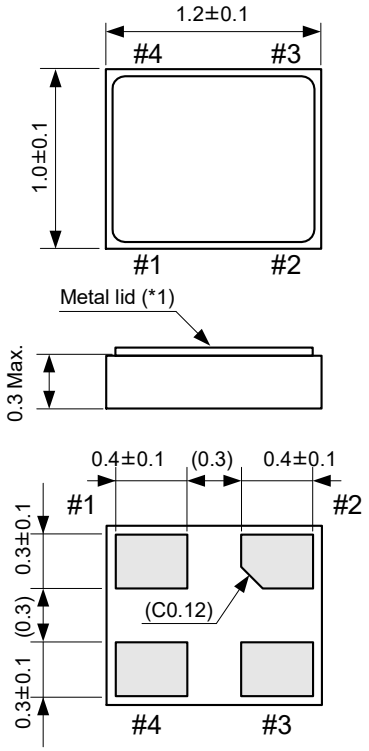
Item	Specifications	Unit	Conditions / Remarks
Nominal frequency	32 to 80	MHz	-
Overtone order	Fundamental	-	-
Frequency tolerance	±7	ppm	@25 °C
Equivalent series resistance (Max.)	100	Ω	32 MHz to 33 MHz
	80	Ω	33 MHz to 37 MHz
	60	Ω	37 MHz to 80 MHz
Storage temperature	-55 to +125	°C	-
Operating temperature	-40 to +85, -40 to +125	°C	-
Frequency / temperature characteristics	±10 (-30 °C to +85 °C)	ppm	Refer to 25 °C
	±50 (-40 °C to +125 °C)	ppm	Refer to 25 °C
Load capacitance	5.0 or Specify	pF	-
Drive level (Max.)	100	µW	-



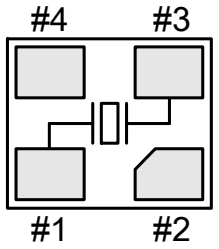


1.2 × 1.0 × 0.3 mm Max.





Internal Connection
<Top View>



Pin	Connection
#1	Crystal
#2	Ground
#3	Crystal
#4	NC

・Pin # 2 is connected to the Metal lid(*1)

(Unit: mm)

RoHS 2.0 Compliant 10 substances

Pb Free

AEC-Q200 available

LVDS/LVPECL Crystal Clock Oscillator

FCXO-04

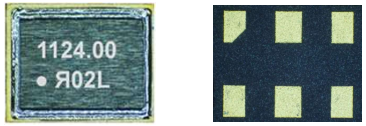
- Wide output frequency range 100 MHz to 1000 MHz
- LVDS or LVPECL output formats
- Low phase jitter 0.5 ps Typ.

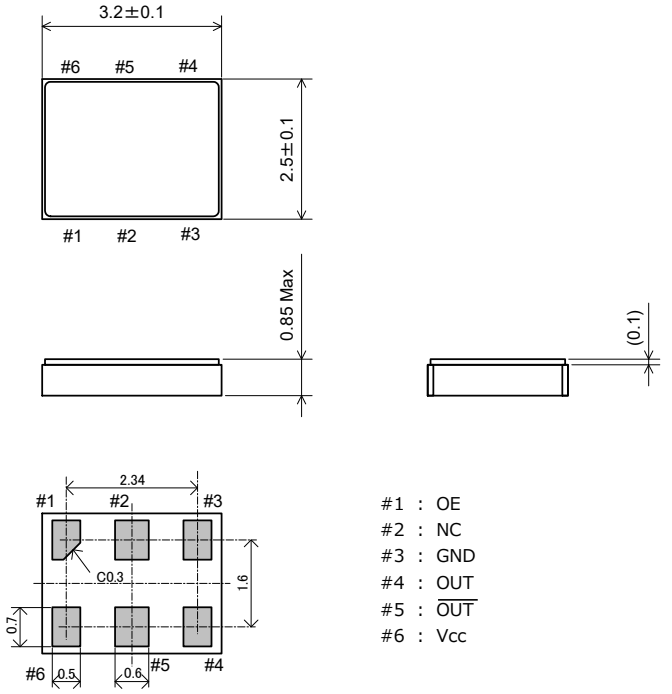
Item			Symbol	Conditions	Specifications			Unit
					Min	Typ	Max	
Output frequency			fo	-	100	-	1000	MHz
Storage temperature range			T_stg	-	-55	-	+125	°C
Operating temperature range			T_use	-	-40	-	+85	°C
Frequency tolerance			f_tol	-	-50	-	+50	ppm
Supply voltage		Type L	V_{CC}	-	2.97	3.3	3.63	V
		Type N	V_{CC}	-	2.375	2.5	2.625	V
LVDS	Current consumption		I_{CC}	-	-	23	-	mA
	Output voltage		V_{OD}	-	175	350	-	mV
	VOD change		ΔV_{OD}	-	-	-	50	mV
	Offset voltage		V_{OS}	-	-	1.25	-	V
	VOS change		ΔV_{OS}	-	-	-	50	mV
	LVDS load condition		L_LVDS	Between Outputs	-	100	-	Ω
	Rise time		tr	20 % to 80 %	-	350	500	ps
	Fall time		tf	80 % to 20 %	-	350	500	ps
	Symmetry		SYM	-	45	-	55	%
LVPECL	Current consumption		I_{CC}	-	-	54	-	mA
	Output voltage		V_{OH}	-	V_{CC} - 1.03	-	V_{CC} - 0.6	V
			V_{OL}	-	V_{CC} - 1.85	-	V_{CC} - 1.6	V
	ECL load condition		L_ECL	Terminated to V_{CC} – 2 V	-	50	-	Ω
	Rise time		tr	20 % to 80 %	-	-	250	ps
	Fall time		tf	80 % to 20 %	-	-	250	ps
	Symmetry		SYM	-	45	-	55	%
OE Function	Input voltage	Output Enable	V_{IH}	-	0.7V_{CC}	-	1.1V_{CC}	V
		Output Disable	V_{IL}	-	-	-	0.3V_{CC}	V
	Disable current		I_dis	OE = GND	-	16	-	mA
	Enable time		-	OE = GND → V_{CC}	-	-	100	ns
	Disable time		-	OE = V_{CC} → GND	-	-	50	ns
Start-up time			t_str	-	-	-	10	ms
Phase jitter			-	12kHz to 20MHz	-	0.5	1	ps

RoHS 2.0 Compliant 10 substances

Pb Free

AEC-Q200 available





#1 : OE
#2 : NC
#3 : GND
#4 : OUT
#5 : $\overline{OUT}$
#6 : Vcc

(Unit: mm)

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KoT cut OPAW crystal oscillator

High Frequency Crystal Oscillator with Excellent Phase Noise Performance

OPAW crystal oscillator is a high-frequency crystal oscillator utilizing OPAW, which can generate over 500 MHz at fundamental waves with high-precision. This provides not only excellent phase noise/jitter performance at the high frequency range of 500 MHz to 1.0 GHz, but also frequency stability and aging characteristics as good as AT-cut crystals. OPAW crystal oscillator will provide customers with powerful solutions in high frequency bands, such as millimeter wave bands, where further growth of market is expected.

Directly oscillates 500 MHz to 1.0 GHz

Ideal for high-end applications that requires high precision reference signals

→Ensure high communication quality for next-generation communication



For high-speed, large-capacity data communication

Low phase noise / jitter at 1 GHz

Provides good phase noise performance at high frequency bands, which had been very difficult to achieve

→Ideal for measurement applications requiring the lowest level of phase noise



For high precision measurement

Higher frequency stability than SAW

High frequency stability over a wide temperature range of Lamb-wave supports the needs that could not be met by SAW resonators

→Applicable to various industrial applications, such as Automotives, FA equipment, and robots.



For object detection systems

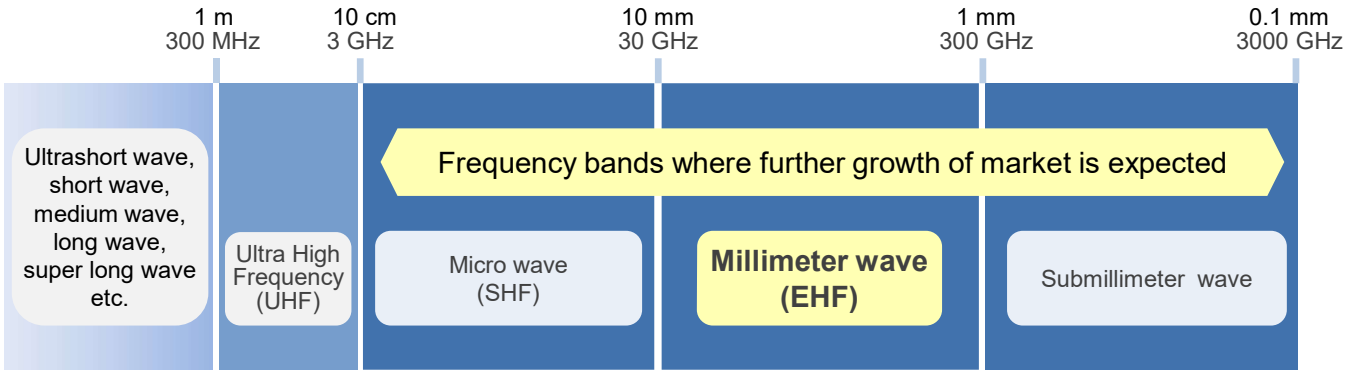
※ KoT : Kerfed orthogonal plate waves for zero Temperature coefficient
※ OPAW : Orthogonal Plate Acoustic Waves

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Positioning of KoT cut OPAW crystal oscillator

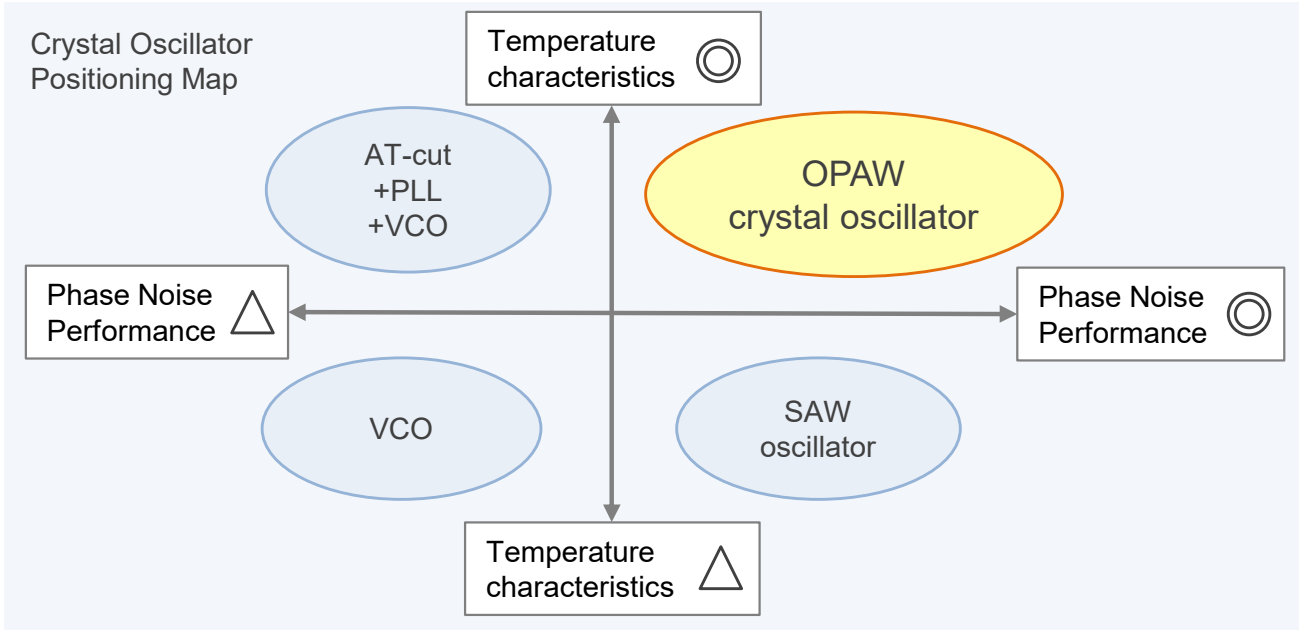
The target is high-frequency band

The target is high frequency bands, such as millimeter wave bands, where further growth of market is expected.



Lower phase noise & better temperature characteristics

OPAW crystal oscillator excels existing crystal oscillators in both phase noise performance and temperature characteristics.



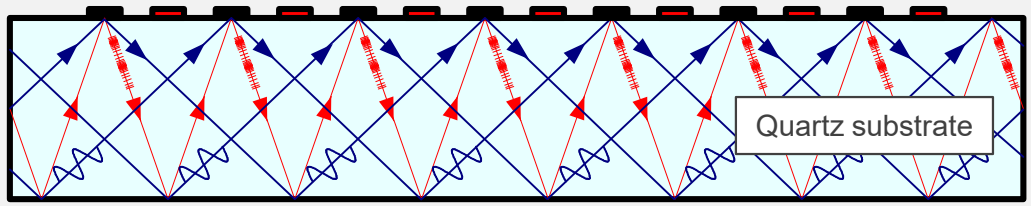
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What is OPAW?

Orthogonal Plate Acoustic Waves is a kind of bulk wave in which a longitudinal wave (P wave) and a transverse wave (SV wave) combined.

OPAW has a comb-shaped excitation electrode (IDT) consisting of multiple electrode fingers on the surface of the crystal substrate. It is a bulk wave that combines reflected waves of P wave and SV wave or P wave and SV wave in the crystal substrate by processing the substrate very thinly. Since the vibration mode is different from SAW (Surface Acoustic Wave), OPAW can exhibit much better frequency temperature characteristics than SAW.

OPAW propagation principle



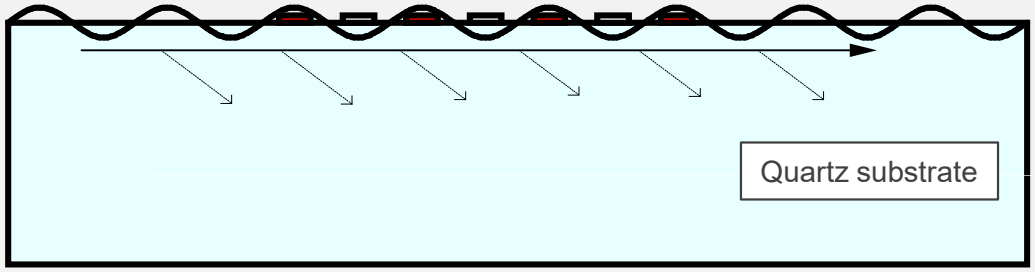
P and SV waves are reflected and combined across the entire substrate

↓

Good temperature characteristic

SAW has a comb-shaped excitation electrode consisting of multiple electrode fingers on the surface of the crystal substrate, it is a surface wave that concentrates P waves or SV waves solely on the surface.
Frequency can be predetermined and obtained by adjusting the pitch between the electrode fingers.

SAW propagation principle



P and SV waves are reflect and combine only on the surface of the substrate

↓

Poor temperature characteristic

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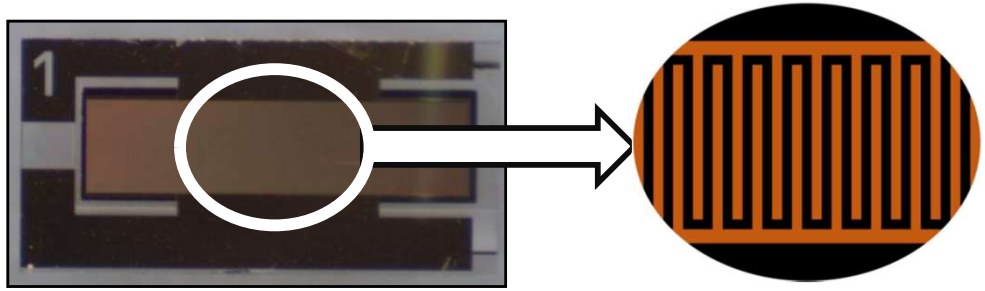
Strength of KoT cut OPAW crystal oscillator

Strength is realization of "High precision", "Low jitter" and "Good Temperature characteristics".

By using KoT cut mode of vibration pending patent in each country, RIVER ELETEC is capable to simultaneously provide "High precision high frequency", "Good phase noise and Jitter" and “Superior frequency versus temperature characteristics" that were difficult to achieve by conventional AT-cut oscillator, PLL oscillator and SAW oscillator.

IDT-electrode by unique photolithography technology

The IDT-electrode is processed very finely with RIVER’s unique photolithography technology. This enables the resonator to be thin and strong, achieving good frequency stability and temperature characteristics and enabling easy frequency adjustment.

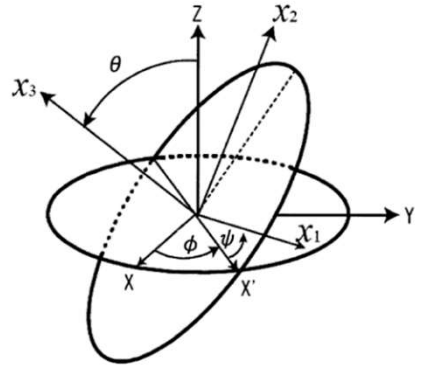


The actual photo of IDT from above

Enlarged image (drawing)

New cutting-angle of crystal

The quartz substrate is cut with new cutting angle, achieving high fundamental frequency and high accuracy of frequency.



High frequency accuracy, good phase noise/jitter performances, and good temperature characteristics at the same time

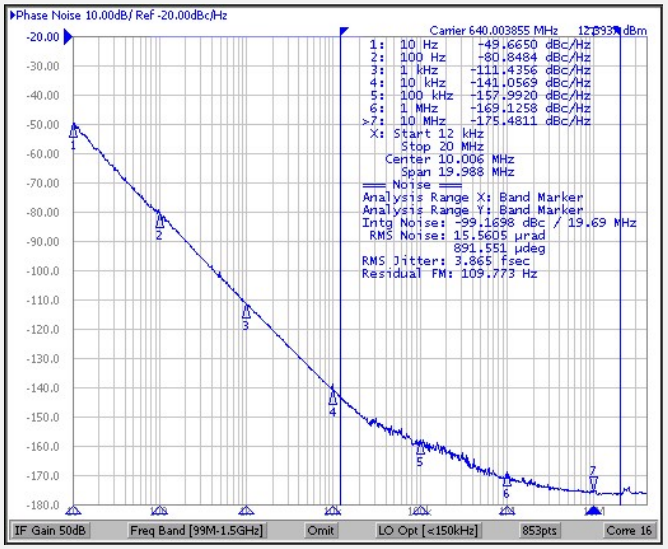
PRELIMINARY/CONFIDENTIAL

Characteristics of KoT cut OPAW crystal oscillator

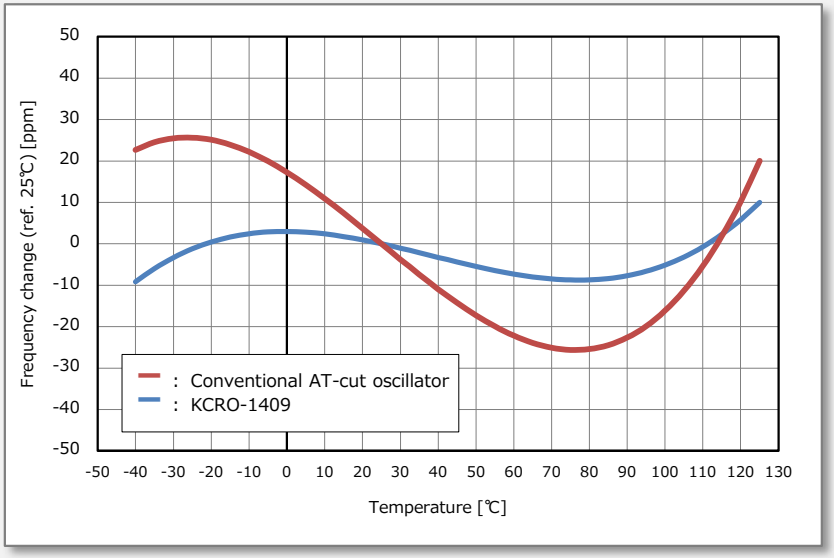
Comparison of Frequency Range and Tolerance (OPAW versus Others)

Type of oscillator	To High frequency	Frequency tolerance	Low jitter Low phase noise
KoT cut OPAW crystal oscillator	○	○	○
AT-cut oscillator	×	△	△
SAW oscillator	○	×	○
PLL oscillator	○	△	×

Phase noise



Comparison of Frequency versus temperature characteristics (KCRO-1409 vs Conventional AT-cut oscillator)

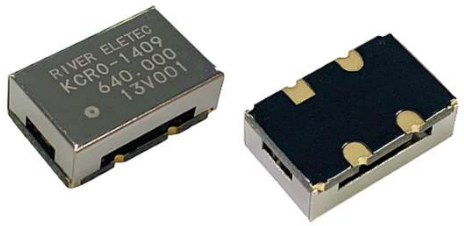


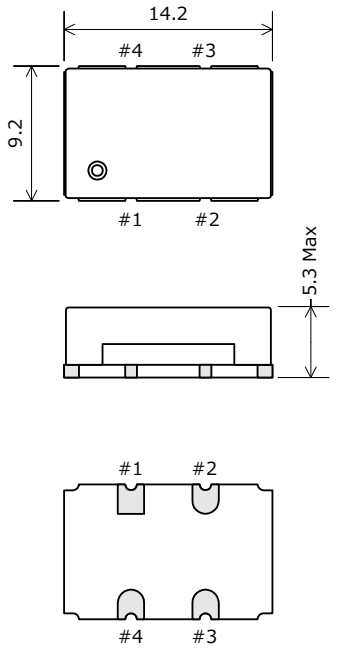
KoT cut OPAW crystal oscillator

KCRO-1409

- OPAW oscillator is using the new patent registered cut angle 'KoT cut'
- Frequency stability over temperature twice as good as AT-cut resonators
- Fundamental frequency available from 500 MHz to 1000 MHz
- Excellent phase noise characteristics → -140 dBc/Hz @10 kHz offset
- Two configurations: Fixed frequency (SPXO) and Voltage Controlled (VCXO)

Item		Specifications			Unit	Conditions / Remarks
		Min	Typ	Max		
Nominal frequency		500	640	1000	MHz	-
Storage temperature range		-40	-	+125	°C	-
Operating temperature range		-40	-	+125	°C	-
Frequency stability (Includes initial accuracy, frequency versus temperature characteristics and aging over ten years)	High precision	-20	-	+20	ppm	-40 °C to +85 °C
		-30	-	+30	ppm	-40 °C to +125 °C
	Standard	-50	-	+50	ppm	-40 °C to +125 °C
Supply voltage		4.75	5	5.25	V	-
Current consumtion		-	70	100	mA	-
Output waveform		Sine wave			-	-
Output level		3	-	-	dBm	50 Ω
Absolute pull range		-50	-	+50	ppm	VCXO, Vcontrol = 0 V to 5 V
Phase noise (10 kHz offset)		-	-140	-	dBc/Hz	SPXO, fo = 640 MHz
		-	-135	-	dBc/Hz	VCXO, fo = 640 MHz
Phase jitter (12 kHz to 20 MHz offset)		-	5	10	fs	SPXO, fo = 640 MHz
		-	7	14	fs	VCXO, fo = 640 MHz
g-sensitivity		-	-	2	ppb/g	-





Pin	Function	
	SPXO	VCXO
1	NC	Voltage Control
2	GND	GND
3	Output	Output
4	Vcc	Vcc

(Unit : mm)

RoHS 2.0 Compliant 10 substances

Pb Free

AEC-Q200 available

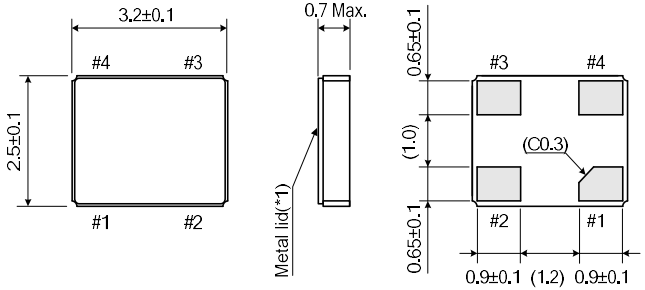
KoT cut OPAW crystal unit

KCR-04

- OPAW resonator is using the new patent registered cut angle 'KoT cut'
- High fundamental frequency between 500 MHz to 800 MHz
- Excellent frequency stability compared to AT-cut resonators and SAW resonators
  → Frequency tolerance +/- 10 ppm available
  → Stability over temperature is twice as good compared to AT-cut resonator
- KoT resonators lowers oscillator phase noise
  → -140 dBc/Hz @offset 10 kHz (Typ.)
- It can oscillate with a normal Colpitts oscillator circuit

Item	Specifications		Unit	Condition / Remark
	Standard	High precision		
Nominal frequency	500 to 800		MHz	-
Frequency tolerance	±20	±10	ppm	@25 °C
Equivalent series resistance (Max.)	30		Ω	640 MHz
Shunt capacitance (Max.)	6.0		pF	-
Storage temperature range	-55 to +125		°C	-
Operating temperature range	-40 to +85, -55 to +125		°C	-
Frequency / temperature characteristics	±20	±10	ppm	- 40 °C to + 85 °C (Ref. 25 °C)
	±50	±20	ppm	- 55 °C to + 125 °C (Ref. 25 °C)
Driver level (Max.)	500		μW	-





Pin	Connection
#1	Crystal
#2	Ground
#3	Crystal
#4	Ground

・Pin # 2 and #4 are connected to the metal lid (※1)

(Unit : mm)

RoHS 2.0 Compliant 10 substances

Pb Free

AEC-Q200 available

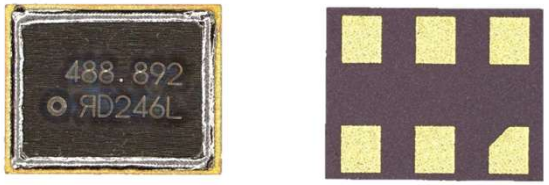
PRELIMINARY/CONFIDENTIAL

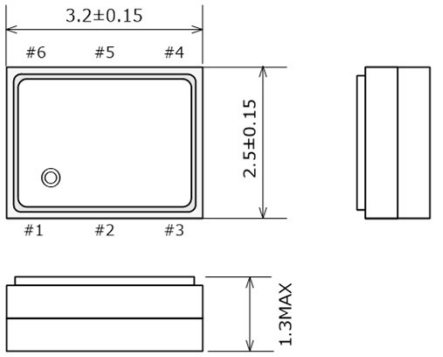
KoT cut OPAW crystal oscillator

KCRO-04

- OPAW oscillator is using the new patent registered cut angle 'KoT cut'
- Frequency stability over temperature is twice as good as AT-cut resonators
- Fundamental frequency of up to 1GHz is realized by using the new technology
- Unparalleled low jitter performance across all small size oscillators
- LVDS or LVPECL output formats

Item		Symbol	Specifications		Unit	Conditions / Remarks
Output frequency		fo	100≦fo＜800	800≦fo≦1000	MHz	
Storage temperature range		T_stg	-55～125		℃	
Operating temperature range		T_use	-40～125		℃	
Frequency stability ((Includes initial accuracy, frequency versus temperature characteristics and aging over ten years)		f_tol	±50 MAX. (-40～+125℃)		ppm	Standard
			±30 MAX. (-40～+125℃)		ppm	High precision option
			±20 MAX. (-40～+85℃)		ppm	High precision option
LVDS	Supply voltage	Vcc	1.8±0.09, 2.5±0.125, 3.3±0.165		V	
	Current consumtion(Max.)	Icc	40		mA	
	Output voltage(Typ.)	VOD	350		mV	2.5V～3.3V
			350	250	mV	1.8V
	Offset voltage (Typ.)	VOS	1.25		V	2.5V～3.3V
			0.9		V	1.8V
	LVDS load condition	L_LVDS	100		Ω	Between Outputs
	Rise time(Max.)	tr	500		ps	20% to 80%
	Fall time(Max.)	tf	500		ps	80% to 20%
	Symmetry	SYM	45～55		%	
LVPECL	Supply voltage	Vcc	2.5±0.125, 3.3±0.165		V	
	Current consumtion(Max.)	Icc	80		mA	
	Output voltage	VOH	Vcc-1.03 MIN.	—	V	
		VOL	Vcc-1.60 MAX.	—	V	
		VO	—	Vcc-1.25 TYP.	V	
		VOD(diff)	—	900 MIN.	mV	
	ECL load condition	L_ECL	50		Ω	Terminated to Vcc-2.0V
	Rise time(Max.)	tr	400		ps	20% to 80%
	Fall time(Max.)	tf	400		ps	80% to 20%
	Symmetry	SYM	45～55		%	
Input voltage		VIH	0.9Vcc MIN.		V	OEterminal
		VIL	0.1Vcc MAX.		V	OEterminal
Start-up time(Max.)		t_str	10		ms	
Phase jitter(Typ.) (12 kHz to 20 MHz offset)			70		fs	fo＜150MHz
			50			150MHz≦fo＜200MHz
			40			200MHz≦fo＜300MHz
			30			300MHz≦fo＜400MHz
			20			400MHz≦fo＜600MHz
			15			600MHz≦fo＜800MHz
			13			fo≧800MHz
g-sensitivity(Max.)			2		ppb/g	





Pin#	Description
1	OE
2	NC
3	GND
4	Output
5	Complementary output
6	Vcc

(Unit: mm)

RoHS 2.0 Compliant 10 substances

Pb Free

AEC-Q200 available

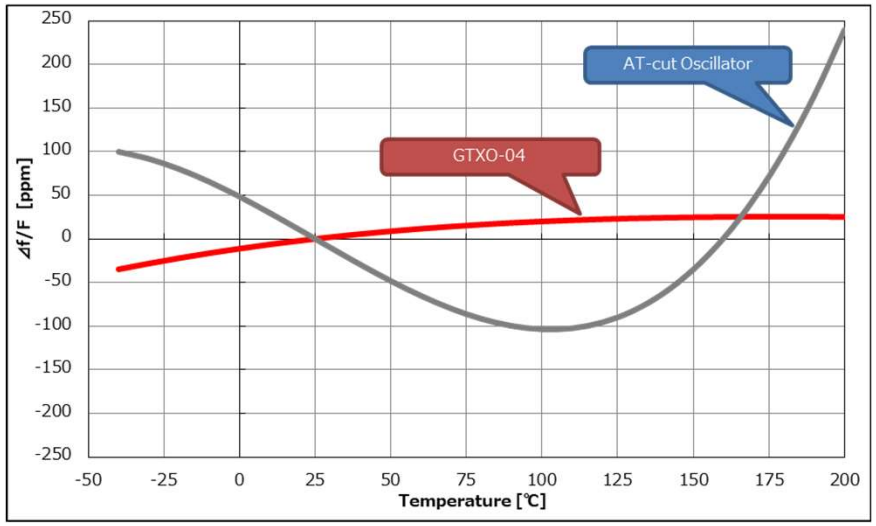
GT-cut Crystal oscillator

GT-cut crystal oscillator has Excellent Temperature Characteristics up to 200°C.

By applying GT-cut mode of vibration that have extremely good temperature characteristics at wide temperature range of -40 °C to +200 °C, crystal oscillator has achieved "High frequency accuracy on extremely wide temperature range" that conventional SPXO or TCXO were difficult to achieve. GT-cut oscillator supports frequency range from 1 MHz to 150 MHz in 3225 size, while retaining the excellent temperature characteristics of GT-cut mode. In addition, Output supports CMOS. It can be applied to clock applications of various devices that require "frequency stability over a wide temperature range", which is difficult to achieve with conventional AT-cut crystal units.

For special application that is difficult for AT

By applying GT-cut mode of vibration that have extremely good temperature characteristics, GTXO-04 has achieved extremely good temperature as “±50 ppm” at -40 °C to +200 °C.

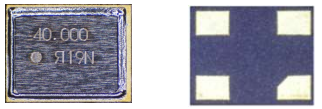


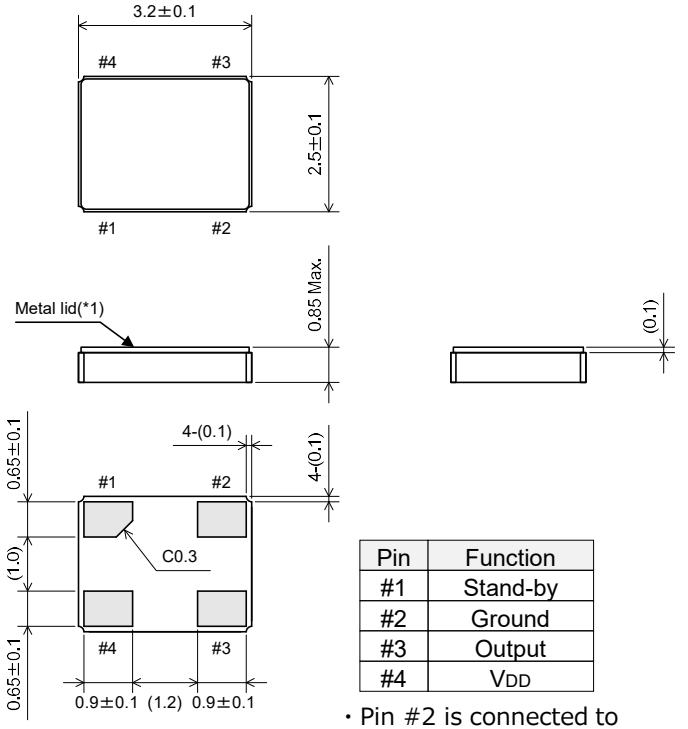
Excellent temperature characteristics of GT-cut

GT-CUT CRYSTAL OSCILLATOR（Programmable）
GTXO-04

- High stability over extended temperature ranges (±50 ppm over -40 °C to 200 °C)
- Broad choice of available frequencies (1 MHz to 150 MHz)
- Low current consumption, Typ. 8 mA (F = 150 MHz, VDD = 3.3 V, No load)

Item		Specifications			Unit	Conditions / Remarks
		Min	Typ	Max		
Nominal frequency		1	-	150	MHz	-
Storage temperature	Standard	-40	-	+125	°C	-
	High Temp	-40	-	+200	°C	-
Operating temperature	Standard	-40	-	+125	°C	-
	High Temp	-40	-	+200	°C	-
Frequency stability (*1)	Standard	-30	-	+30	ppm	-40 °C to +125 °C
		-100	-	+100	ppm	-40 °C to +200 °C
	High Precision	-20	-	+20	ppm	-40 °C to +125 °C
		-50	-	+50	ppm	-40 °C to +200 °C
Supply voltage (V_{DD})		-10%	1.8	+10%	V	-
		-10%	2.5	+10%	V	-
		-10%	3.3	+10%	V	-
Output			CMOS		-	-
Current consumption	Enable	5.8	8	10	mA	F: 1 MHz to 150 MHz, V_{DD} = 3.3 V, No load
	Standby	35	60	100	µA	-
Output voltage	V_{OH}	0.9V_{DD}	-	-	V	I_{OH} = 60 mA, V_{DD} = 3.3 V
	V_{OL}	-	-	0.1V_{DD}	V	I_{OL} = 1 mA, V_{DD} = 1.8 V
Standby function	V_{IH}	0.7V_{DD}	-	-	V	-
	V_{IL}	-	-	0.3V_{DD}	V	-
Output load		-	-	15	pF	-
Symmetry (Duty Cycle)		45	50	55	%	V_{TH} = 0.5V_{DD}
Rise time / Fall time		-	1.5	5	ns	0.1V_{DD} to 0.9V_{DD}
Start-up time		-	-	10	ms	-
Random jitter (RJ)		-	3.6	-	ps	V_{DD} = 3.3 V, BER = 10^{-12}
Total jitter (TJ)		-	51	-	ps	WAVECREST 3100C Instrument
Phase jitter		-	20	-	ps	Offset frequency: 12 kHz to 20 MHz





Pin	Function
#1	Stand-by
#2	Ground
#3	Output
#4	VDD

- Pin #2 is connected to the metal lid (*1)

(Unint : mm)

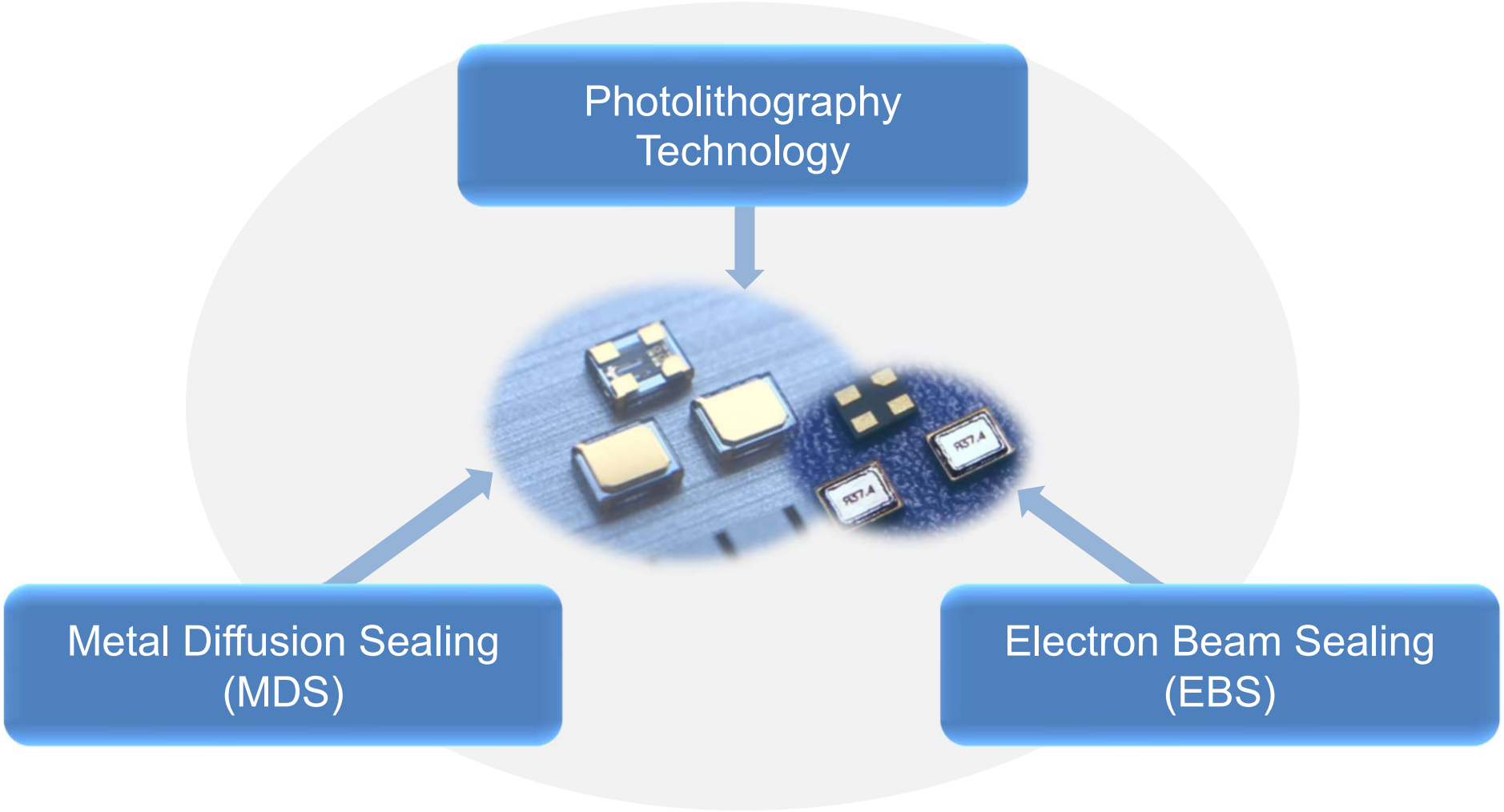
RoHS 2.0 Compliant 10 substances

Pb Free

AEC-Q200 available

RIVER's Unique, Cutting-Edge Technologies

RIVER's unique technologies have been improved by meeting customer's needs for miniaturization.
The representative are "Electron Beam Sealing" method and "Metal Diffusion Sealing" method, as well as sophisticated photolithography technology of quartz crystal.

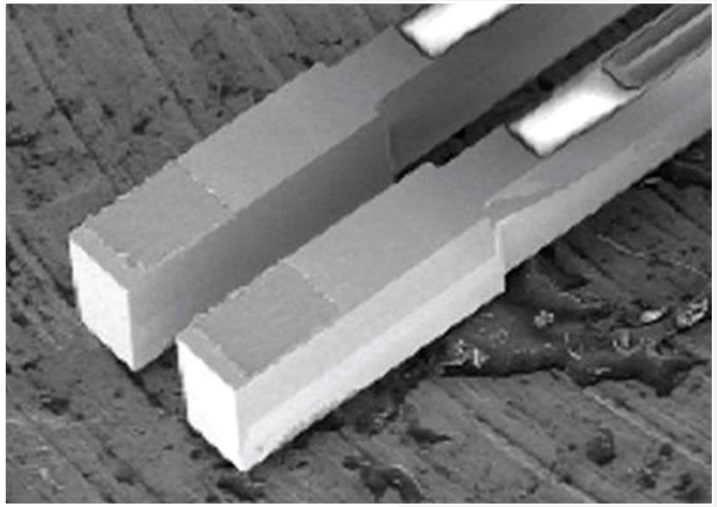


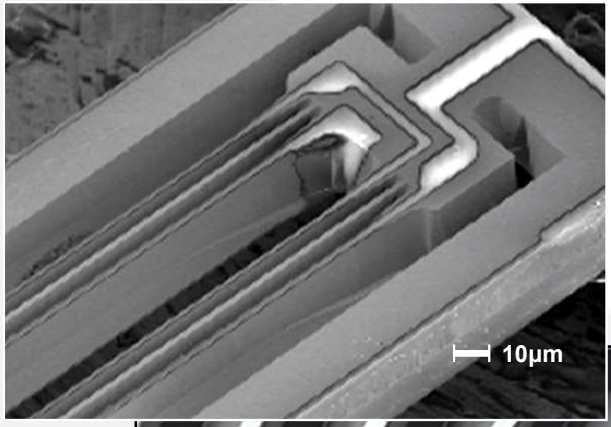
Sophisticated Photolithography Technology of Quartz Crystal

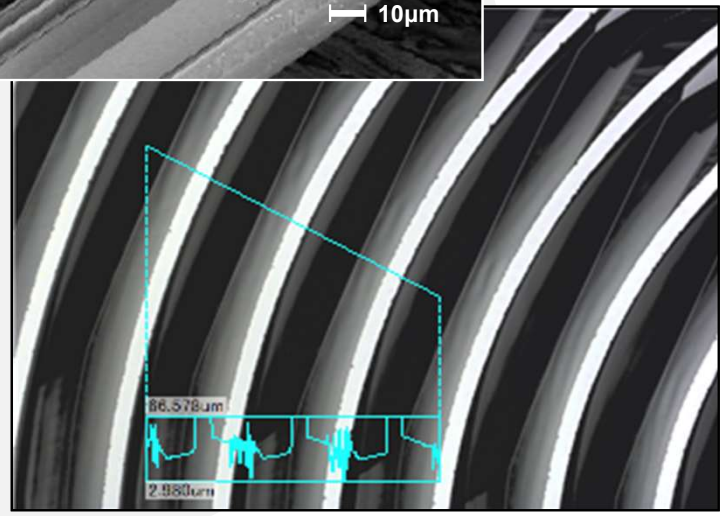
Photolithography technology of quartz crystal is a fine processing technology for quartz crystal utilizing the mechanism of photographic film development. Exposure technology of photograph is used to transfer a pattern onto a quartz substrate and form openings and recesses of the pattern by etching, applying micron-scale ultrafine patterns to the substrate.

Example of micro-scale pattern of TFX-05X

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







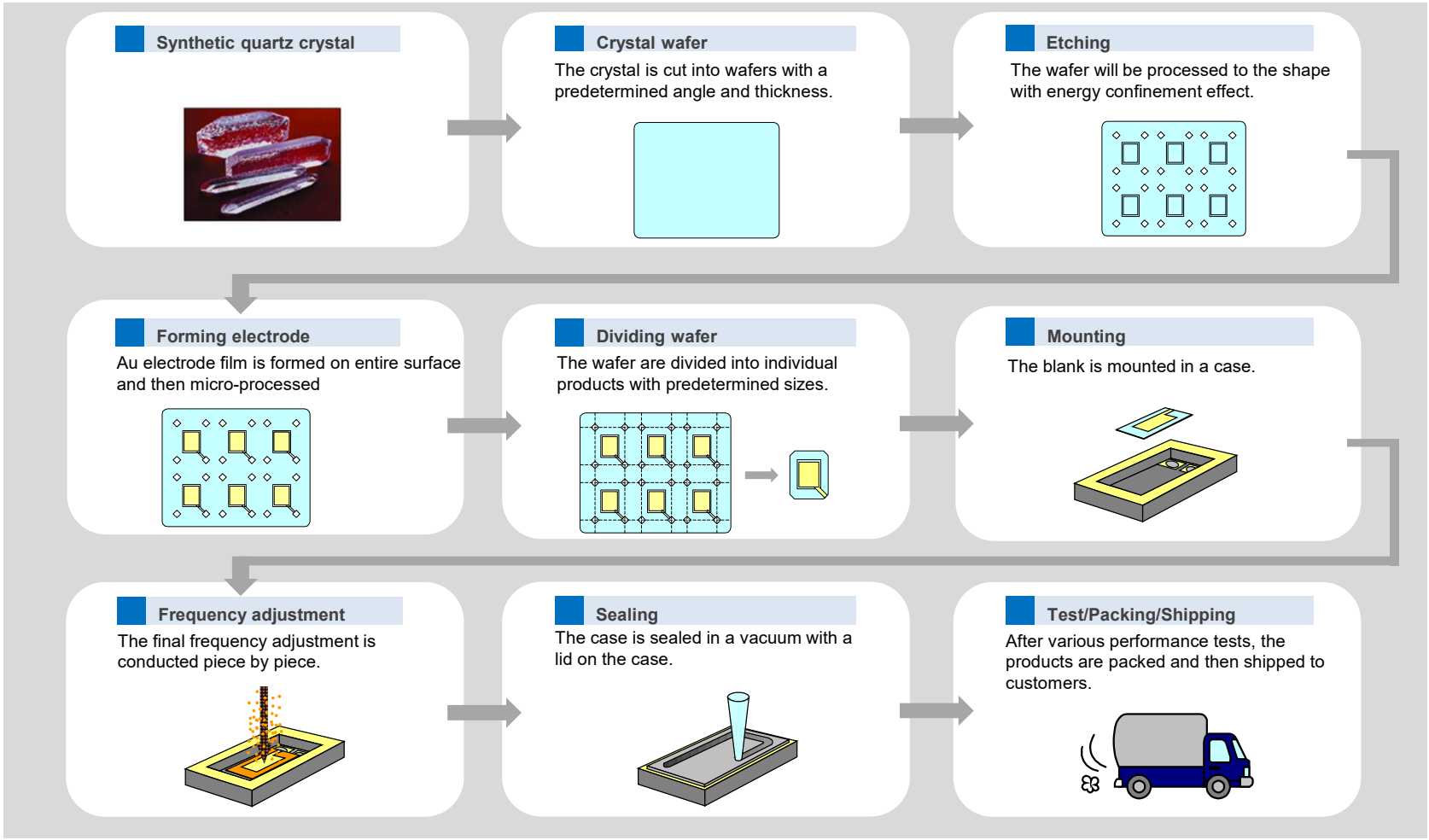
Advantages of Photolithography

☑ **Good Temperature Characteristics:** There are less variations in shapes because crystal blanks are processed at once on a wafer, not piece by piece. →Less variation in characteristics

☑ **Smaller Crystal:** Forming shapes by etching allows crystal blanks to be smaller and thinner.

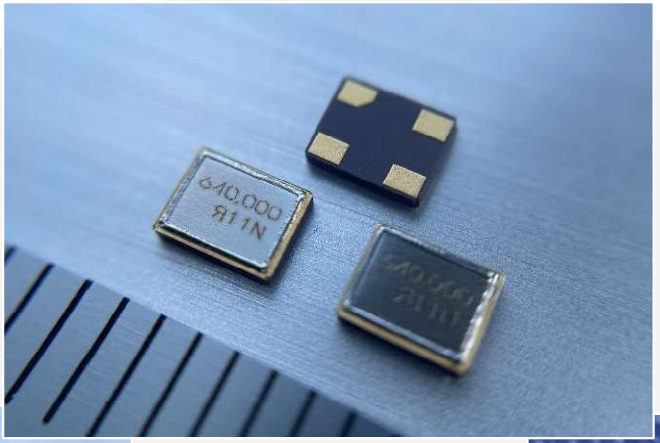
☑ **Better CI:** High accuracy of processing improves energy confinement effect (for AT) and electric field efficiency (for tuning fork).

Processing flow of crystal with photolithography



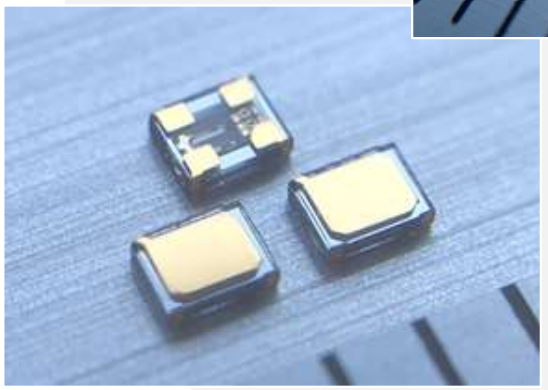
For the Finest Crystal Device in the World

Empowered by crystal processing technology experience accumulated over many years, RIVER ELETEC endeavors to improve its sophisticated photolithography technology of quartz crystal processing further to bring high-value products that cannot be imitated by anyone in the world.



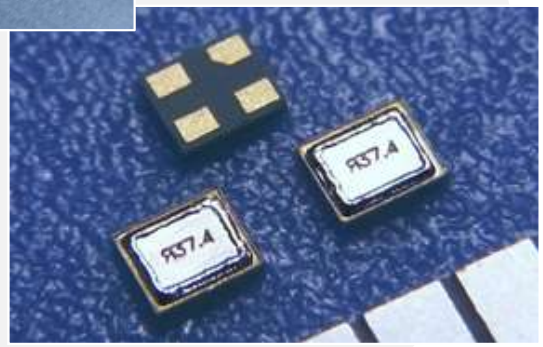
KCR-04

KoT cut OPAW Crystal unit



TFX-05X

Ultra-compact, Tuning fork crystal unit



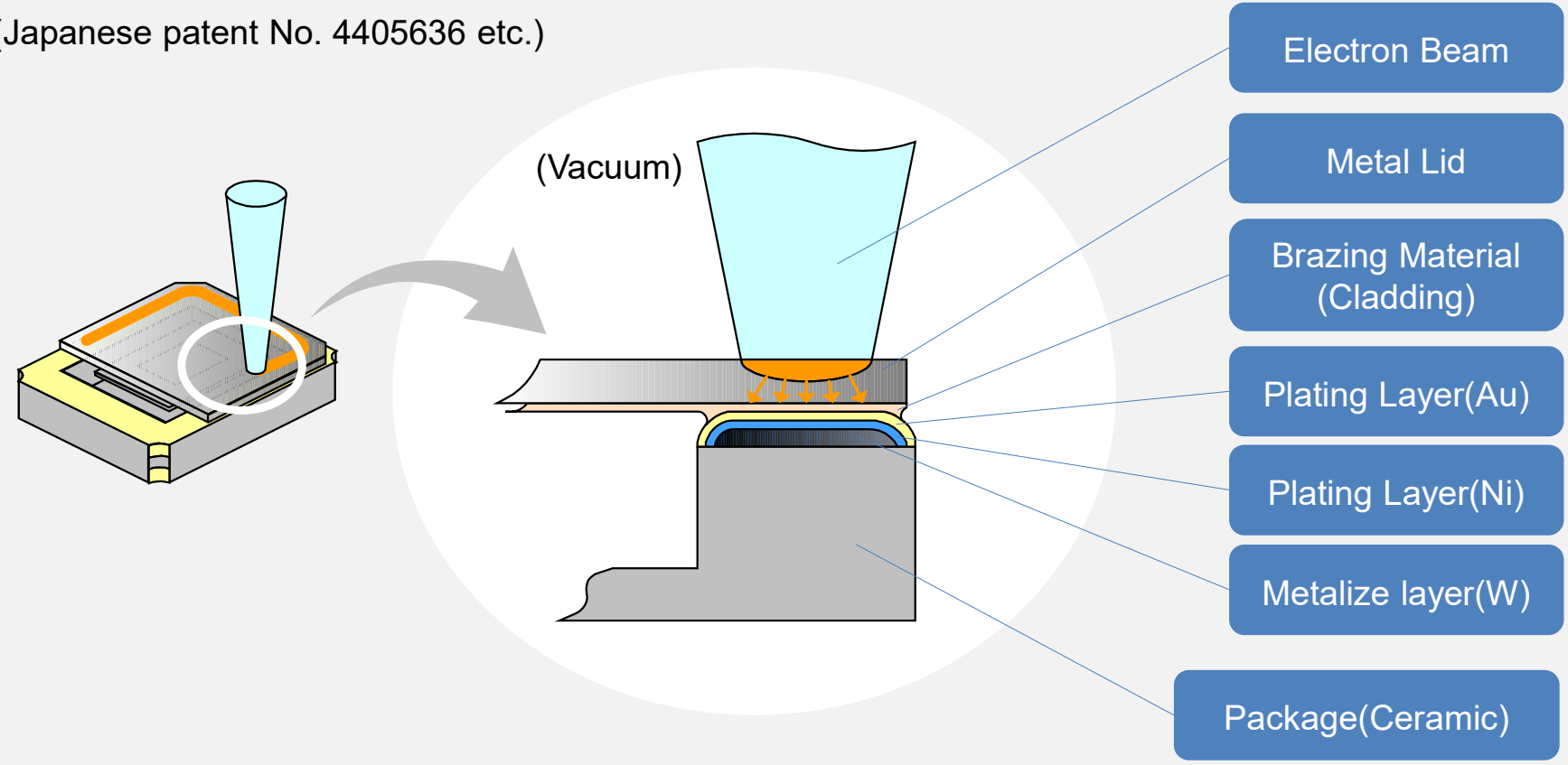
FCX-08

Ultra-compact, AT-cut, Crystal Unit

What is Electron Beam Sealing (EBS) Method?

Electron beam sealing method is RIVER's unique sealing technology using an electron beam to seal a metal lid to a ceramic package. In a vacuum, the electron beam is irradiated to the metal lid to melt brazing material (or cladding) under the lid by heat conduction and weld the lid to the ceramic package.

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



5 Advantages of EBS Method

1. Miniaturization

The electron beam irradiated is finely focused to control the melting width of the brazing material with high precision. This enabled a seal width to be smaller than seam welding, which is typical sealing method for crystal units.

2. Low ESR

There is no gas that disturb the vibration of a crystal blank because the inside of the package after sealing is kept at a high vacuum. This reduces the equivalent series resistance (ESR) of the crystal, and enables us to support lower frequencies.

3. High precision

The local heating of EBS causes lesser thermal damage to crystal. This reduces variation in frequency significantly and enables high precision of frequency (e.g. frequency tolerance of ±7ppm)

4. Less deterioration

The amount of gas remaining or generating over time (e.g. moisture, oxygen) inside is extremely small. This enables good aging characteristics and high reliability.

5. High productivity & low cost

The productivity of EBS is very high because the sealing time required for EBS is very short compared to the other sealing methods, such as seam welding. In addition, EBS is cost-effective because it needs no seam ring, which is used for seam welding, or expensive materials, which is required for Au-Sn soldering.

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	◎	○	○	◎	○

Electron Beam Sealing

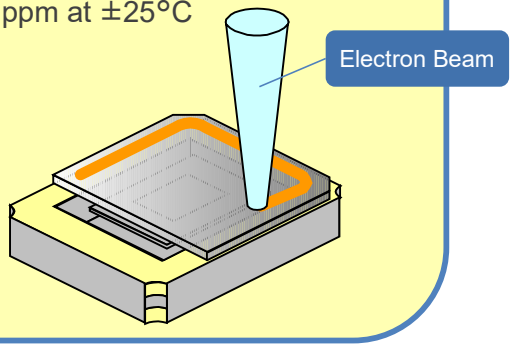
◎ Sealing with moving electrons is very quick (0.05 sec/pcs)

↓

◎ Less thermal damage

↓

◎ Achieves frequency deviation of ± 7 ppm at ±25°C



Seam Welding

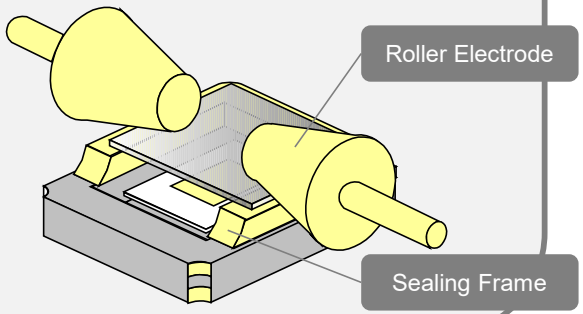
△ Sealing with motorized rollers is the slowest (0.25 sec/pcs)

↓

△ Higher thermal damage

↓

△ Frequency deviation of ±10 ppm at ±25°C



Au-Sn Soldering

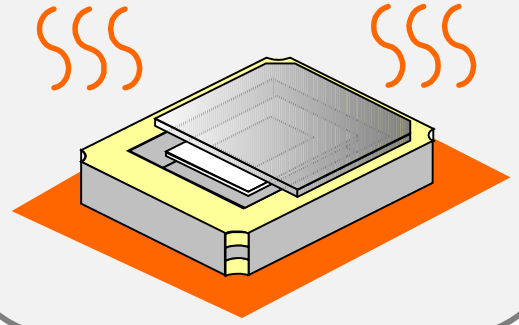
△ Sealing by heating all pieces at once is very quick, but costs too much because of the use of Au

↓

× Highest thermal damage

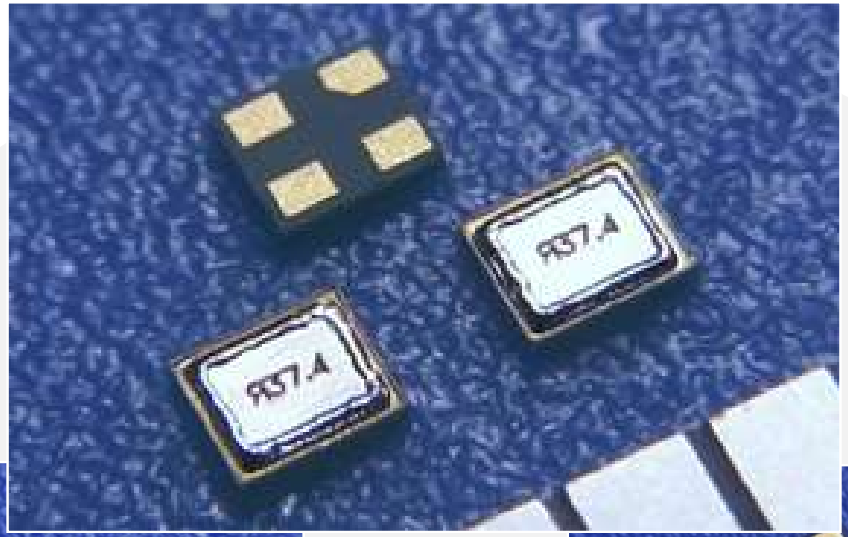
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△ Frequency deviation of ±10 ppm at ±25°C

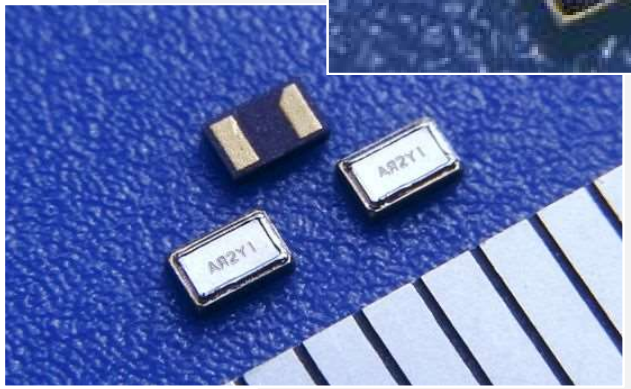


EBS Provides Stable High Quality

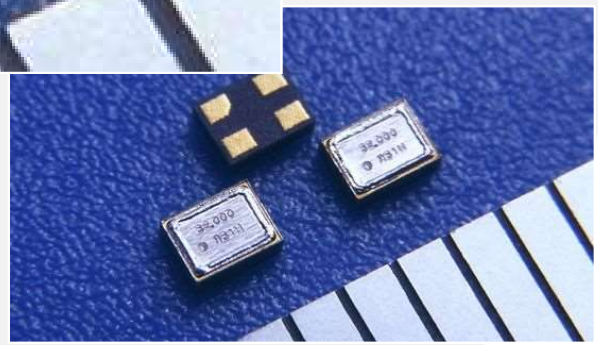
The Electron Beam Sealing method is used for the wide range of products of River ELETEC, and continues to provides stable high quality and reliability.



FCX-08
1210 AT Crystal Unit



TFX-04
1610 Tuning Fork Crystal Unit

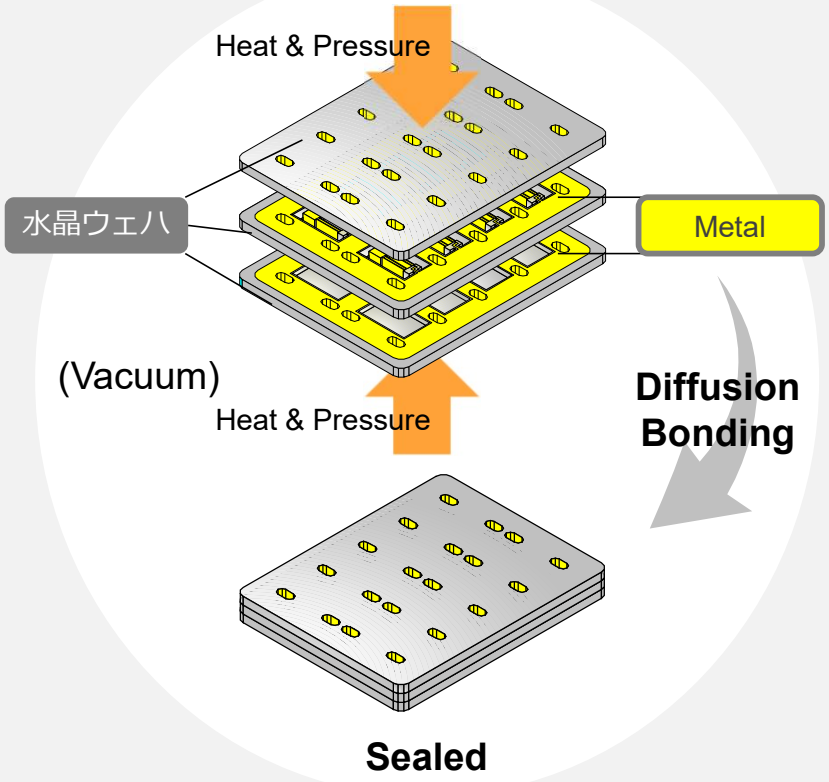


FCXO-07
1612 Crystal Oscillator

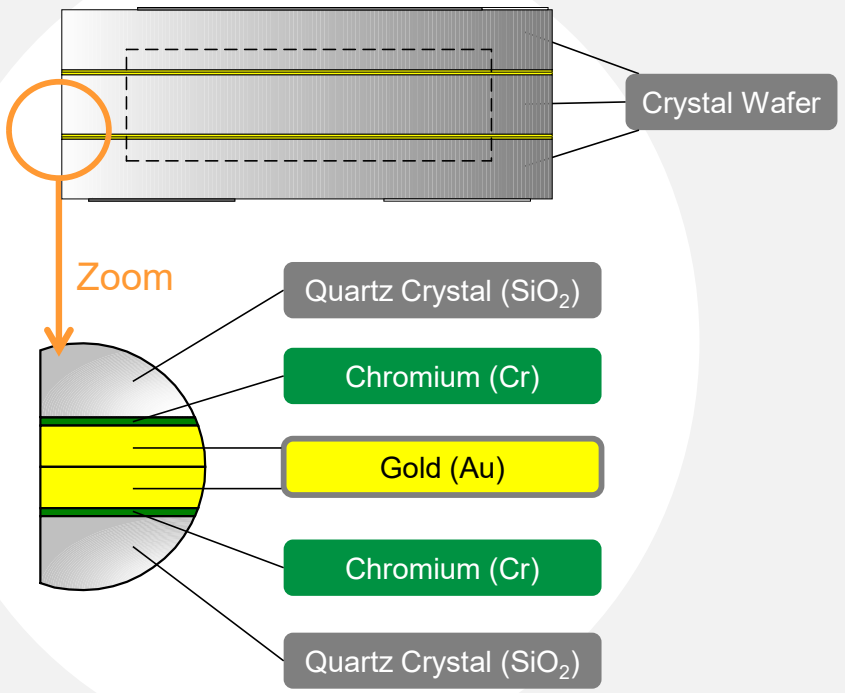
What is Metal Diffusion Sealing (MDS) Method?

The Metal Diffusion Sealing (MDS) method is unique advanced technology of RIVER's using direct metal-to-metal bonding caused by heat and pressure applied in a vacuum to seal three quartz crystal wafers with metal, such as gold, chromium and other metal) sandwiched between the wafers.

Mechanism of MDS



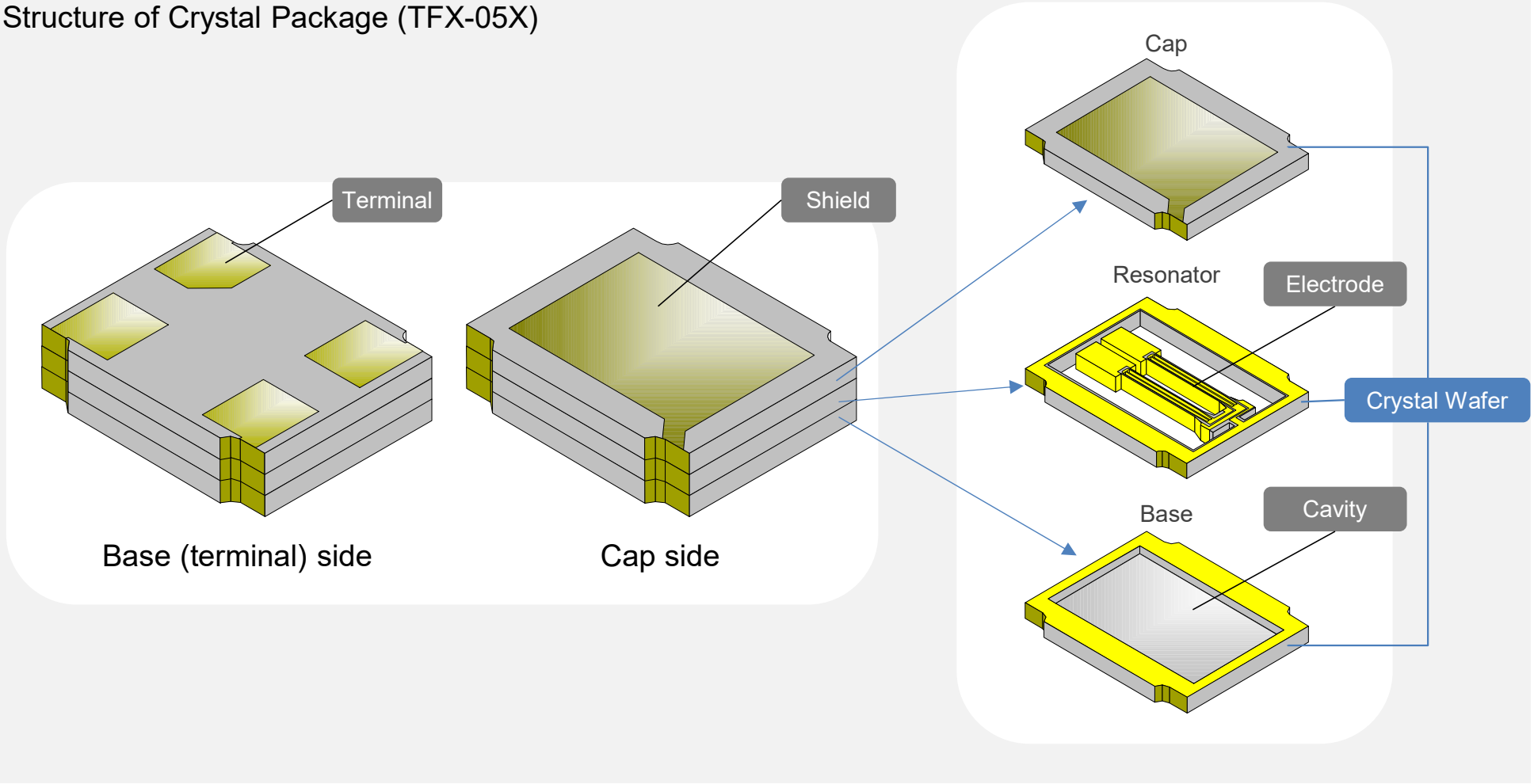
Cross-Sectional View of TFX-05X



Crystal Package with MDS Method

RIVER ELETEC has developed "Crystal Package" using Metal Diffusion Sealing method. Crystal Package is an innovative package combining a resonator and case made of quartz crystal. Three crystal wafers are formed into a cap, a resonator, a base respectively and sealed simultaneously by Metal Diffusion Sealing method.

Structure of Crystal Package (TFX-05X)



4 Advantages of Crystal Package by MDS Method

1. Significant size-reduction

Using ultra-thin quartz crystal wafers as a package enabled significant size and weight reduction. TFX-05X, the latest model, is miniaturized to 47.5 % in volume and 75 % in weight compared to the previous model (TFX-04).

2. Improved weather-ability

In MDS method, no conductive adhesive is required and the package is sealed right after wafers are processed. This eliminates the generation of gas and intrusion of foreign material, improving weather-ability such as aging and resistance to heat.

3. High precision of frequency

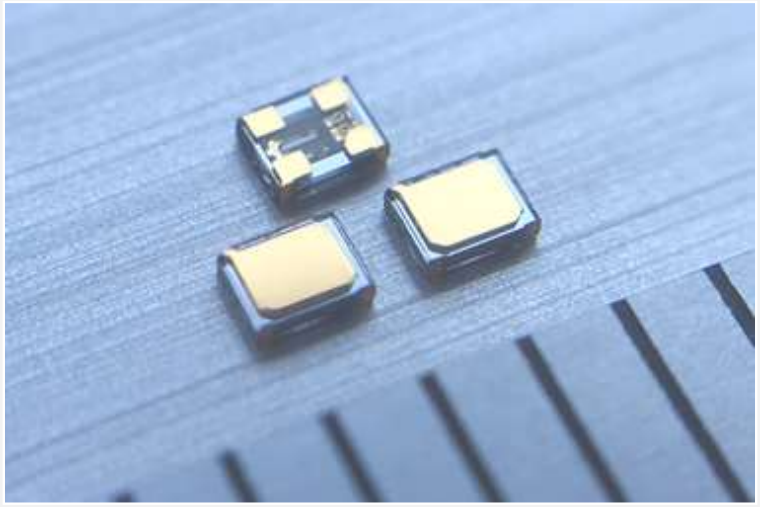
The transparent package made of crystal wafers enabled frequency adjustment after sealing with a laser irradiated from outside the package. This enabled more accurate frequency adjustment and support for narrow deviation spec.

4. Resource saving & eco-friendly

Compared to ceramic packages using ceramic, conductive adhesive, metal lids, and other various materials, the crystal package made of quartz crystal and only a small amount of metal is resource saving and eco-friendly. In addition, quartz (SiO_2) has higher strength, and thus higher potential as a material than alumina (Al_2O_3), which is used for ceramics.

The Newest Model "TFX-05X" Powered by MDS Method

With its ultra-compact size, high weather-ability, and high accuracy of frequency of the innovative crystal package powered by new sealing method MDS, TFX-05X support the ultra-compact, high-performance needs of next-generation mobile devices



TFX-05X

1210 Tuning Fork Crystal Unit

IC Matching Service (IC Evaluation)

Specialists for circuit evaluation of RIVER will present you optimum circuit constants.

We offer “IC Matching Service”, which proposes optimum circuit constant conditions for stable oscillation of crystal units. The report of the evaluation will be presented in about a week after our sales have received a circuit board and accompanying documents. (See the “Example of Evaluation Report” below) If you are in a hurry, please consult us as we accept express service, in which the report will be presented in 1 day after the receipt of the circuit.

On-site service is also available

If a circuit board is for internal use only, due to its confidentiality or software, our circuit evaluation engineer can visit to customers and conduct circuit evaluation there, or customers can visit us and be present to at the evaluation here.



Example of Evaluation Report (excerpted version)

RIVER ELETEC CORPORATION
ENGINEERING DEPARTMENT

Evaluation Report of the Crystal Oscillator

Crystal unit specifications

Nominal Frequency	37.400000MHz	Type	FCX-07L
Cut	AT(fundamental)		
Frequency Tolerance	±20ppm	Temperature characteristics	±20ppm (-20～+70℃)
ESR	60 ohm Max.		
Load Capacitance	5 pF		

Evaluation Board

Supplied Date	2019年3月1日
Oscillator Circuit	TC7SHU04FU

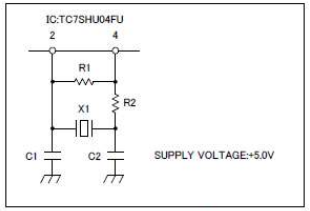


Figure.1 Circuit diagram of oscillator circuit

Criteria for Stable Oscillation (RIVER's recommendation)

Negative Resistance	300 ohm Min.
Drive Level	300μW Max.

Evaluation Result

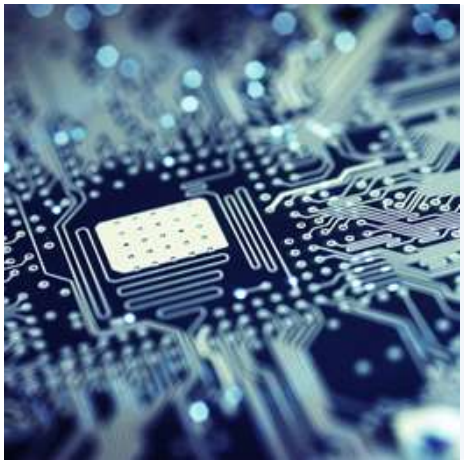
Please see Table.1 and 2 for the evaluation result of the oscillator circuit shown in Figure.1.

Pass: The criteria was satisfied.
Fail: The criteria was not satisfied.

Table. 1

	R1 [MΩ]	R2 [Ω]	C1 [pF]	C2 [pF]	Negative Resistance [Ω]	Drive Level [μW]	Oscillation Frequency [ppm]	Pass /Fail
Constant (1)	1	220	22	22	250	1540	-22.1	Fail
Constant (2)	1	1500	7	7	310	250	+3.3	Pass

Oscillation Frequency: Frequency deviation from the nominal frequency of the reference crystal manifactured on the load capacitance of 5 pF.



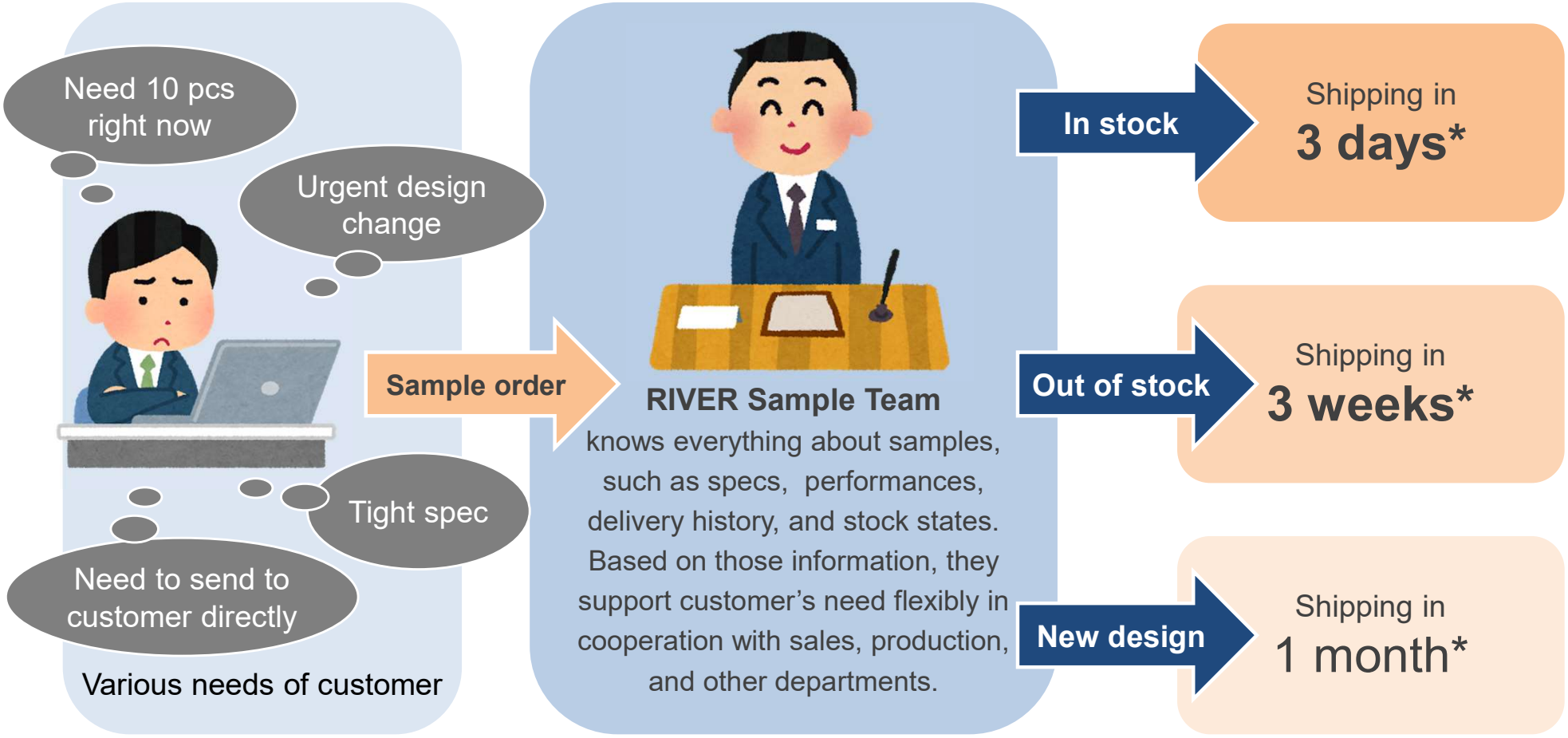
If there is a matching problem, we propose a change of circuit constants

If there is a problem with matching (such as unsatisfied criteria for stable oscillation), we propose a change of circuit constants. We can also measure additional data (such as start-up time, oscillation waveform, and others) on customer’s request.

*IC matching service is a free service for customers to use our crystal units safely. Please feel free to contact us.

Short Lead Time for Crystal Device Samples

Dedicated sample management team will meet various needs for samples in a short lead time.
With sharing information with sales, production, and other related departments, the sample management team promptly provides the samples of crystal devices according to customer's requests. The shipping lead-time is 3 days* if the samples are in stock, 3 weeks* if the samples are out of stock, and 1 month* if the samples are of new frequency and needs a new design of crystal blank.



*The shortest possible lead-time

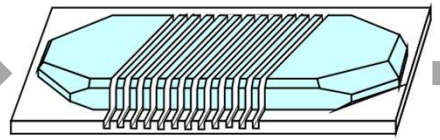
AT-cut Crystal Units (MHz-band)

Synthetic quartz crystal



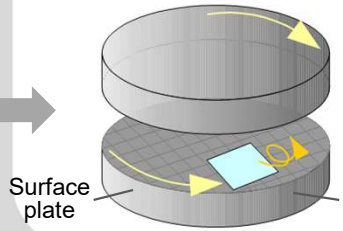
Cutting crystal

The crystal is cut into wafers with a predetermined angle and thickness.



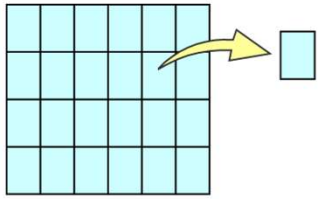
Lapping

A crystal piece is lapped into a predetermined thickness.



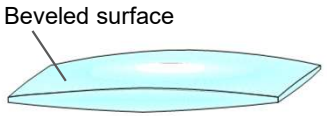
Cutting wafer

The crystal piece is cut into a predetermined blank-shape.



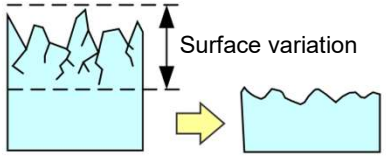
Beveling

The peripheral edges of the blank are beveled to improve CI (Crystal Impedance).



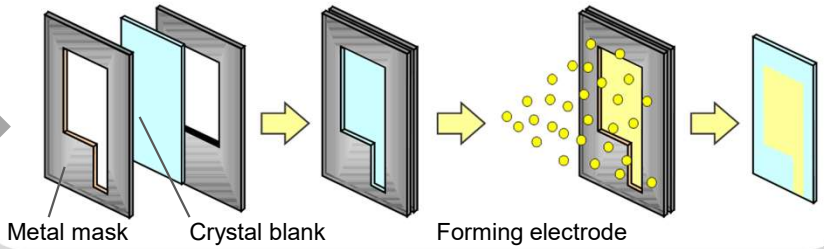
Etching

The surface of the blanks are smoothed in etching solution to even their frequencies.



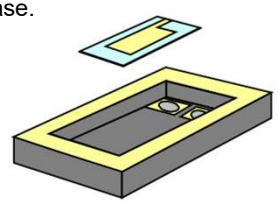
Forming electrode

metal materials, such as Au and Ag, are applied on the blank by spattering to form an electrode.



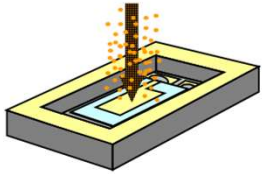
Mounting

The blank is mounted in a case.



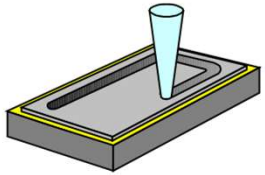
Frequency adjustment

The final frequency adjustment is conducted piece by piece.



Sealing

The case is sealed in a vacuum with a lid on the case.



Test/Packing/Shipping

After various performance tests, the products are packed and then shipped to customers.



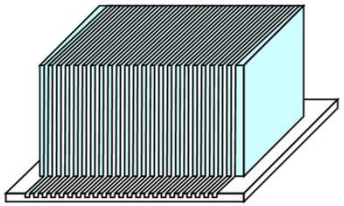
Tuning Fork Crystal Units (kHz-band)

Synthetic quartz crystal



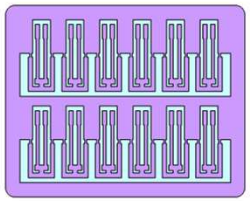
Cutting crystal

The crystal is cut into wafers with a predetermined angle and thickness.



Forming pattern

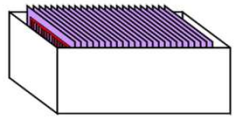
A resist-pattern is formed on the wafer for etching



※Blanks are not laid out here for simplicity

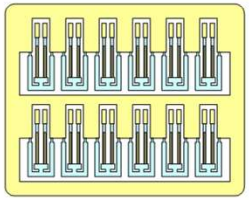
Etching

The openings of the pattern are formed by being dissolved in etching solution.



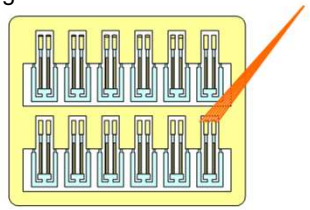
Forming electrode

Au electrode film is formed on entire surface and then micro-processed with photolithography.



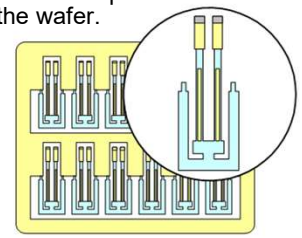
Frequency adjustment

Frequency is measured and adjusted to predetermined frequency by laser trimming.



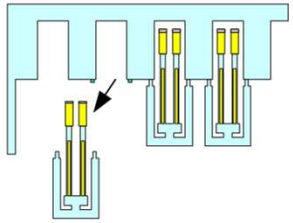
Wafer inspection

Exterior appearance of crystal blanks are inspected on the wafer.



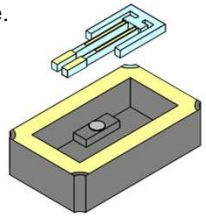
Detaching

The blanks are detached from the wafer.



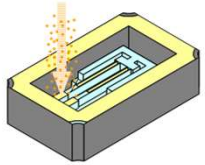
Mounting

The blank is mounted in a case.



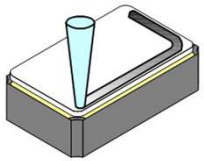
Frequency adjustment

The final frequency adjustment is conducted.



Sealing

The case is sealed in a vacuum with a lid on the case.



Test/Packing/Shipping

After various performance tests, the products are packed and then shipped to customers.



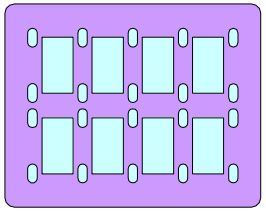
New Manufacturing Process for TFX-05X (Tuning Fork Crystal Units)

Process for Cap-wafer / Base-wafer

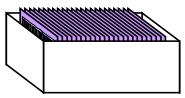
Crystal wafer
The crystal is cut into wafers with a predetermined angle and thickness.



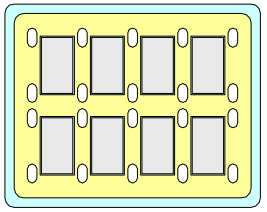
Forming pattern
A resist-pattern is formed on the wafer.



Etching
The openings and recesses of the pattern are formed by being dissolved in etching solution.

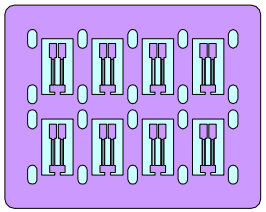


Forming electrode
Electrodes are formed with a predetermined pattern.

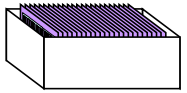


Process for resonator-wafer

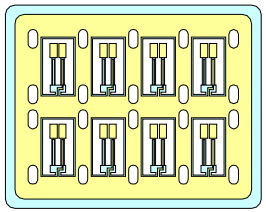
Forming pattern
A resist-pattern is formed on the wafer.



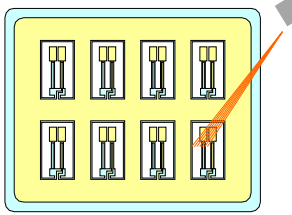
Etching
The openings and recesses of the pattern are formed by being dissolved in etching solution.



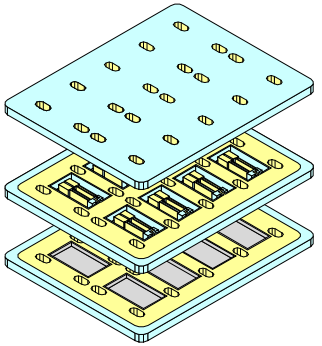
Forming electrode
Electrodes are formed with a predetermined pattern.



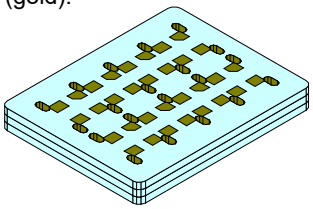
Frequency adjustment
Frequency is adjusted by lase-trimming.



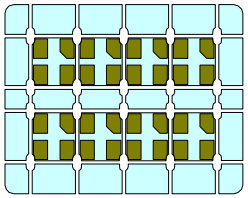
Sealing (MDS)
Pressure and heat is applied to seal a cap-wafer, a base-wafer, and a resonator-wafer.



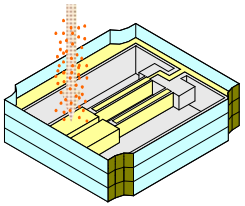
Plating terminal
Terminals are plated with Au (gold).



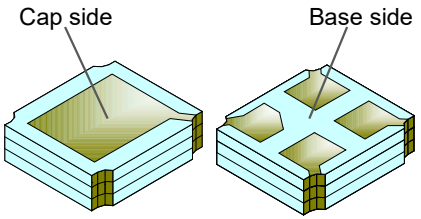
Dividing wafer
The sealed wafers are divided into individual products with predetermined sizes.

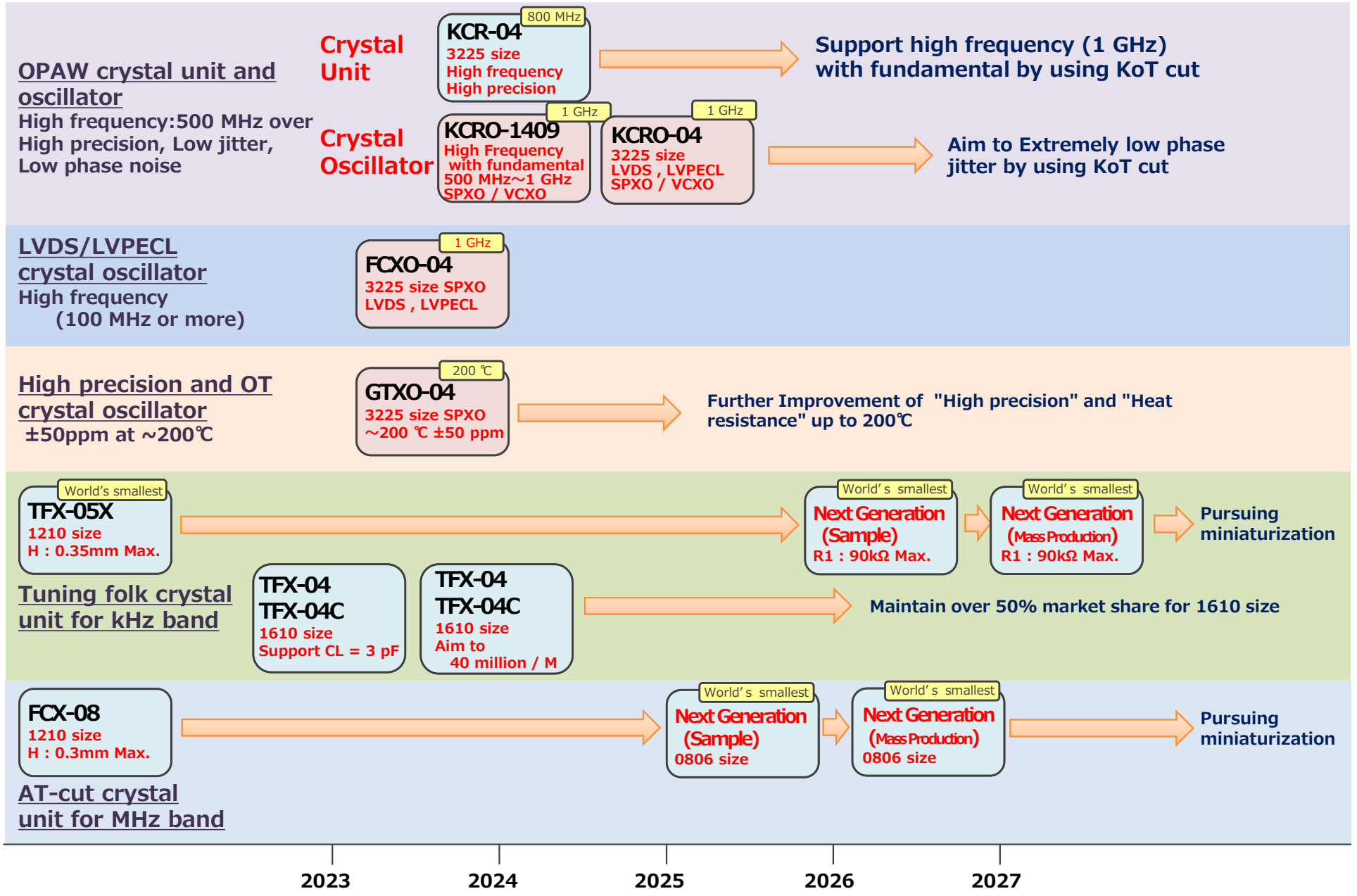


Frequency adjustment
The final frequency adjustment is conducted.



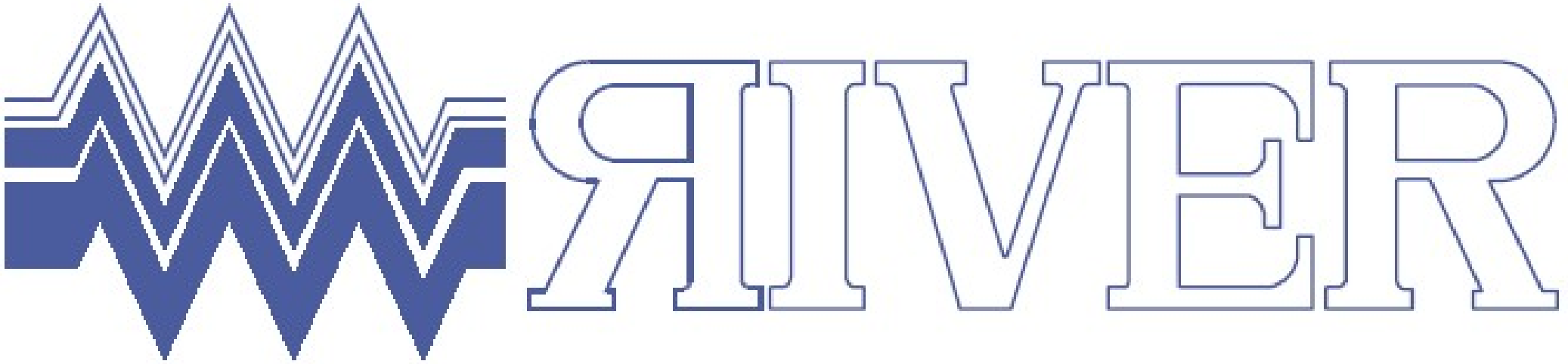
Finished





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RIVER ELETEC CORPORATION



Product Brochure