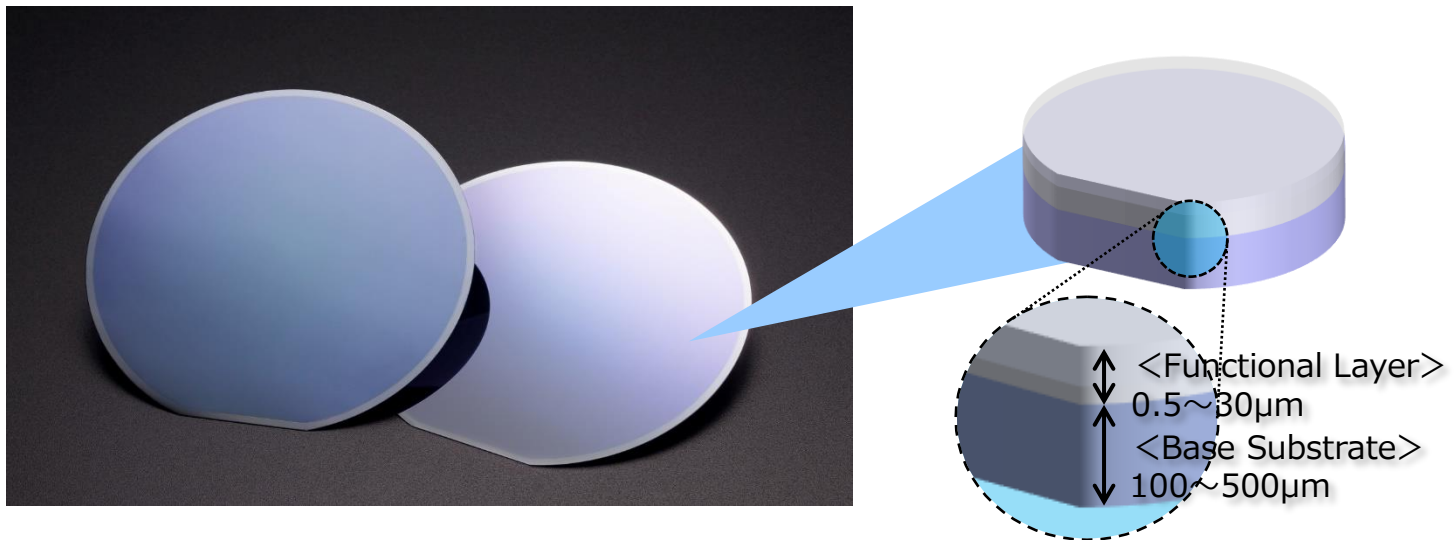


Source: NGK Insulators HP
<https://www.ngkinsulators.com/en/product/wafer.html>

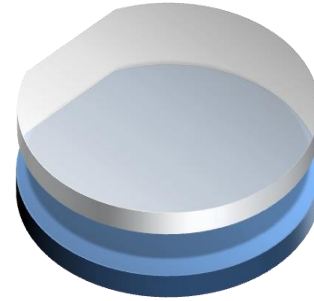
NGK Insulators, LTD
Corporate NV Creation

- NGK offers “Bonded wafer” combined with different materials.
- Bonded wafer by NGK’s proprietary technologies* can improve various characteristics **.
 - * Direct bonding of 2 types materials without adhesive and film-thinning of functional layer by polishing.
 - ** High-Insulation, High-Thermal Conductivity, Low-Thermal Expansion, High-Rigidity etc.
- We have started commercialization for SAW Filter Application in 2014.
Our wafer has been adopted for High performance filter which is essential for 4G LTE.
- It is possible to achieve various combinations of materials (functional layer and base substrate).

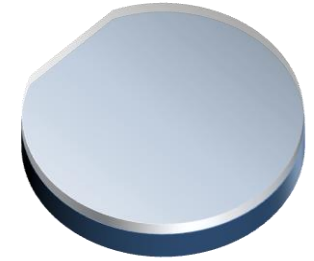


- Wide range of combinations of materials
 - Any material and crystal orientation are available.
 - When using single crystal, high physical properties and crystal orientation control are available, which is not possible by deposition.
- Ultra thin functional layer
 - No degradation of crystallinity due to ultra thin polishing of functional layers by NGK's precision polishing technology.
 - Thin thickness (Min. 0.2 μm) is available.
 - High precision with ultra low variation ($\pm 0.05 \mu\text{m}$).
- Direct bonding without adhesive
 - Heat stress-free by room temperature bonding.
 - High thermal resistance.
 - High chemical resistance.

Direct Bonding



Precision Polishing



Typical Specification

Wafer Size	4 inch : standard 6 inch : option	
Functional Layer	Material	Please see p.4 of the attached
	Thickness	0.2~100 μm
Base Substrate	Material	Please see p.4 of the attached
	Thickness	100~500 μm
Bonding	Direct bonding	

Examples of bonded wafer combinations

- Bonded wafer can improve High-Insulation, High-Thermal Conductivity, Low-Thermal Expansion, and High-Rigidity by combinations of functional layer and base substrate.
- Bonded wafers can be used as substrates for “MEMS”·“Power Devices”·“RF Devices” ·“Optics”.
- Other materials may also be available. (Please contact us at any time!)

Functional Layer

Functional Layer										
Semiconductor						Piezoelectric Material				Amorphous
Si	GaAs	SiC	GaN	ZnO	InP	LiTaO ₃	LiNbO ₃	PZT	Quartz	Glass

Base Substrate

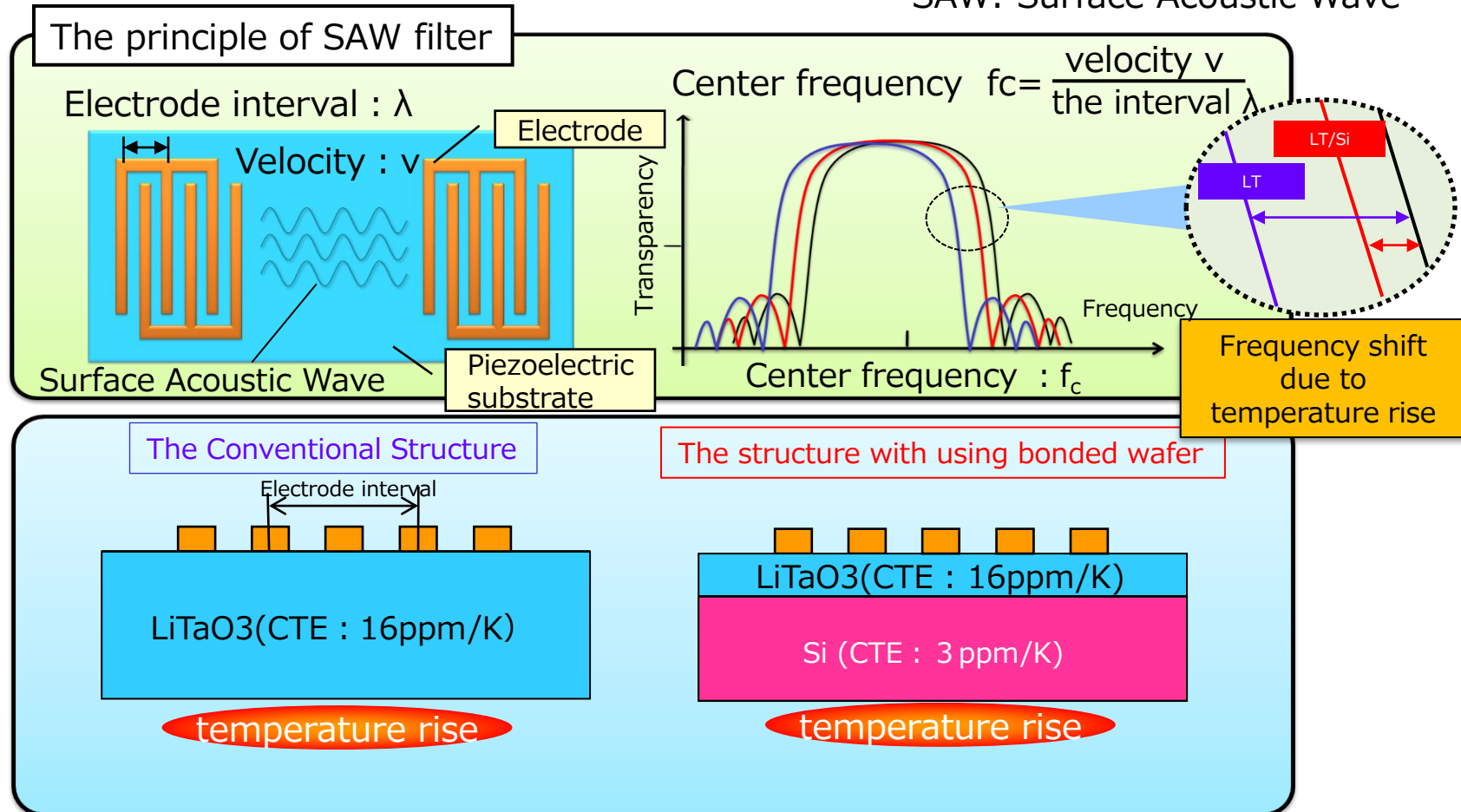
Base Substrate									
Single Crystal				Poly Crystal Ceramics					Amorphous
Si	LiTaO ₃ / LiNbO ₃	Quartz	Sapphire	Al ₂ O ₃ (HICERAM)	AlN	Si ₃ N ₄	SiC	ZrO ₂	Glass
Low CTE High TC	Co-material	High Insulation High Rigidity	High Insulation High Rigidity	High Insulation High Rigidity	High Insulation High TC	High TC High Rigidity	High TC High Rigidity	High Rigidity	Low CTE

CTE : Coefficient of Thermal Expansion TC : Thermal Conductivity

Example) LiTaO₃ bonded wafer for SAW filter

The improvement of the temperature characteristics

SAW: Surface Acoustic Wave

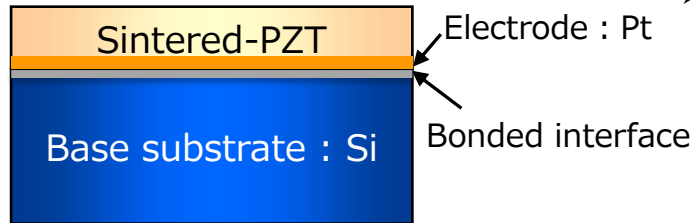


Restraining the expansion/contraction of substrate ⇒ Improving temperature characteristics

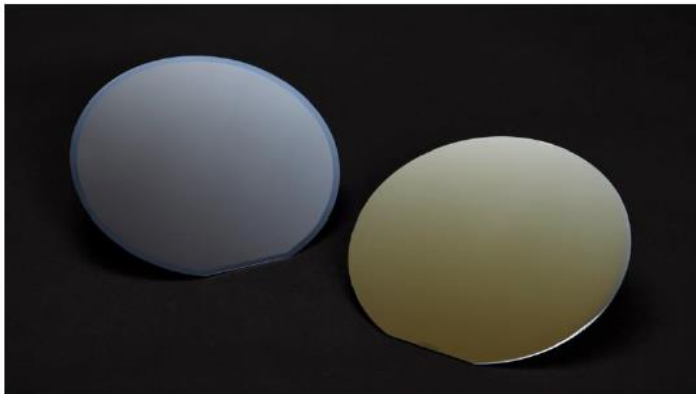
Example) Sintered-PZT bonded wafer (for MEMS)

Prototype) Sintered-PZT (10 μ m)/Pt(0.1 μ m)/Si(500 μ m)

■ Structure

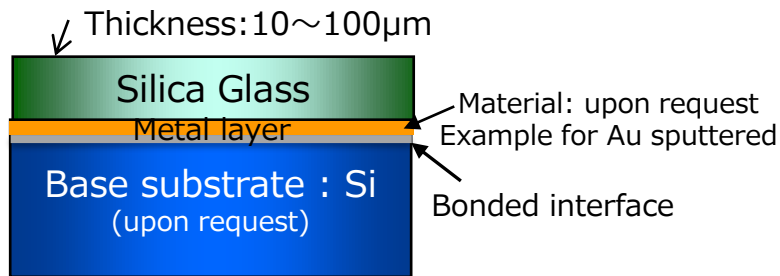


■ Product appearance



- **Sintered-PZT is available for functional layer.**
 - High-Piezoelectric constant (250pC/N @1 k V/mm) under weak electric fields.
 - The thickness of PZT layer(1~100 μ m) is available.
 - **Direct bonding at room temperature.**
 - Low-internal stress and Low warp of wafer.
 - High thermal resistance by bonding without adhesive.
 - Materials for electrodes and the base substrate can be freely selected.
- ⇒ **High rigidity, high power, and high reliability actuators are realized.**

Example) Silica glass bonded wafer



Silica Glass	NGK Wafer
Dielectric Loss : $\tan\delta$	0.001
Dielectric Constant : ϵ	3.8

The above results were measured at 300 GHz.

- It is a wafer that is bonded silica glass to the base substrate which has high thermal conductivity.
- Millimeter wave and sub-terahertz circuits made with NGK's bonded wafer can realize low transmission loss, low latency and high thermal conductivity.
- We can fabricate via hole and transmission line such as CPW and MSL on the wafer upon request.

CPW : Coplanar Waveguide

MSL : Microstrip Line

【 Application Example 】

- Next generation Wi-Fi router
- Sub-THz base station
- Download terminal of super high-definition image



NGK INSULATORS