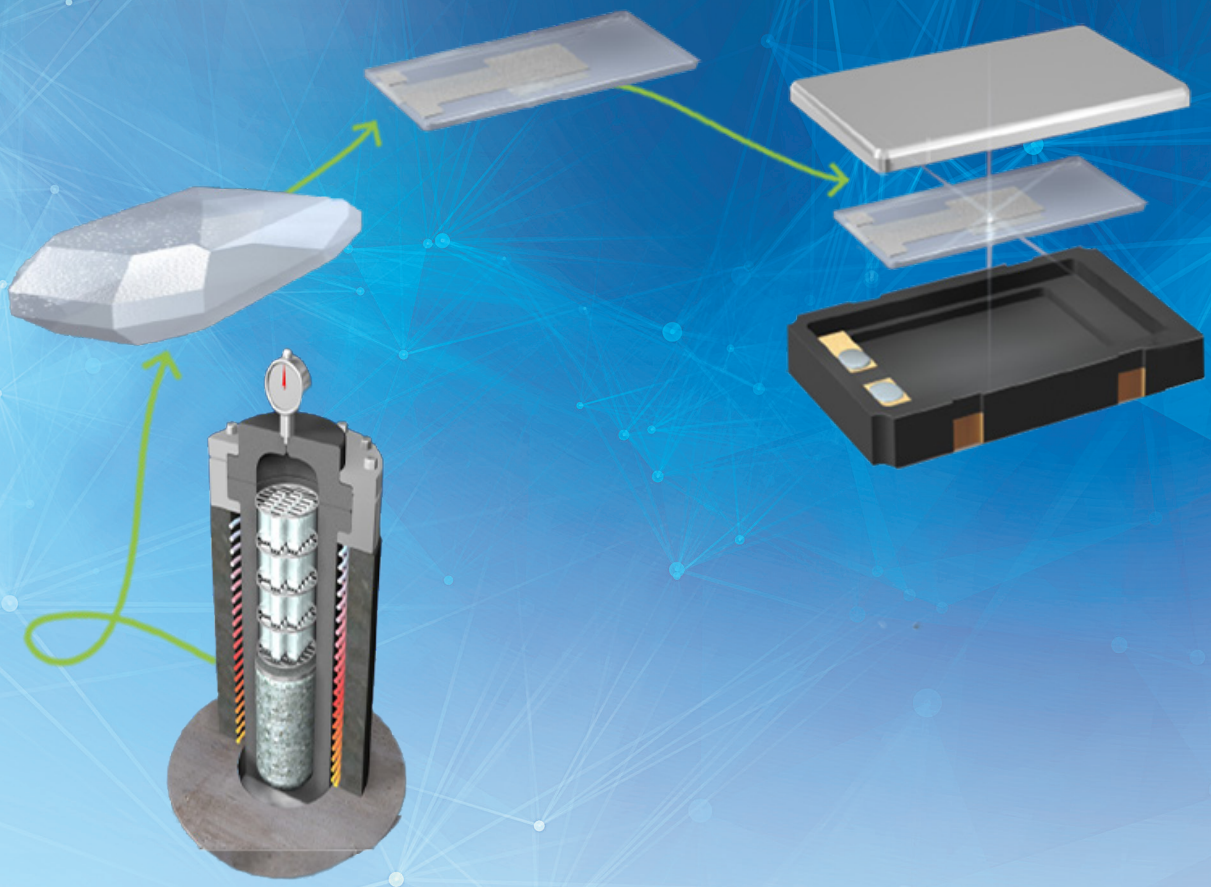
Jauch
THE PULSE OF PROGRESS

QUARTZ CRYSTAL MANUFACTURING PROCESS



DOCUMENT

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INTRODUCTION

What is the crystal made of?

Quartz crystals are used in electronic devices because they maintain precise frequencies. Most quartz crys¬tals for electronics are made synthetically using the hydrothermal process.
Quartz is a mineral made of silicon and oxygen (SiO_2). It forms under high pressure and temperature over many years. Natural quartz often has imperfections, making it unsuitable for technological applications.

To produce high-quality quartz crystals, stable conditions are needed. This is achieved using an autoclave, a pressure vessel that turns natural quartz into pure SiO_2. Synthetic quartz production has been around since the 1950s.

Synthetic quartz offers several advantages. The purity of the crystal can be controlled, which is important for its quali¬ty and frequency stability. Additives can be precisely added to improve growth and performance.

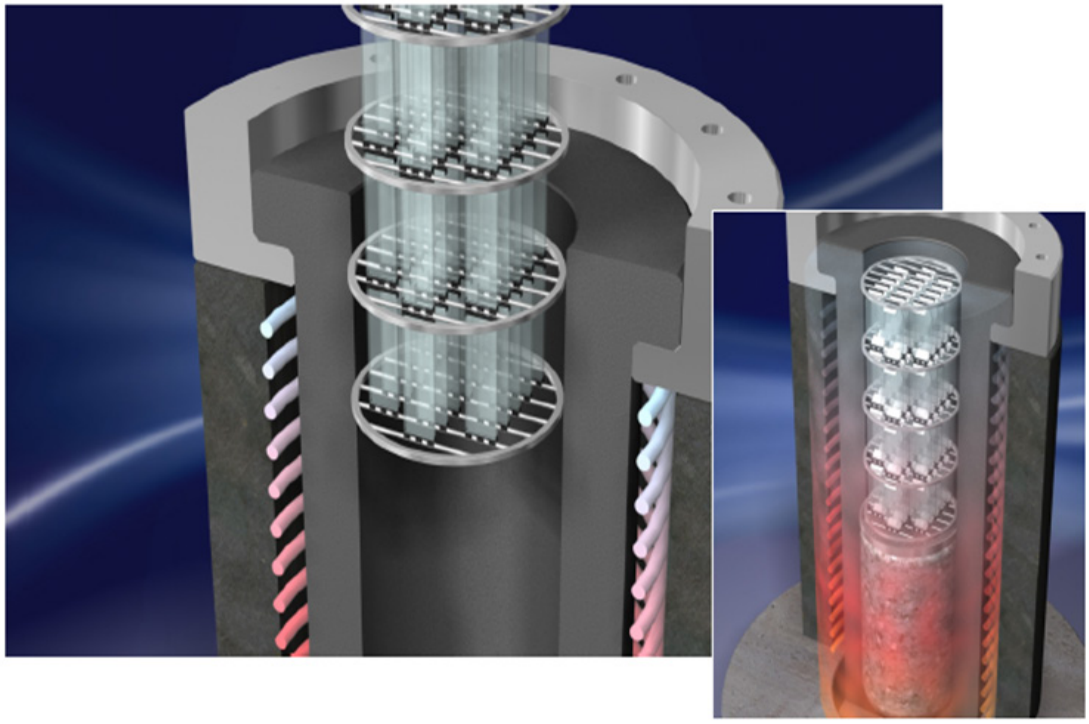
PRODUCTION STEPS

1. Autoclave is filled with broken crystal and crystal seeds

- Broken crystal fragments SiO2 (bottom part) are dissolved in alkaline solvent
- Crystal seeds are fixed in a carrier in the upper part
- Autoclave is sealed hermetically

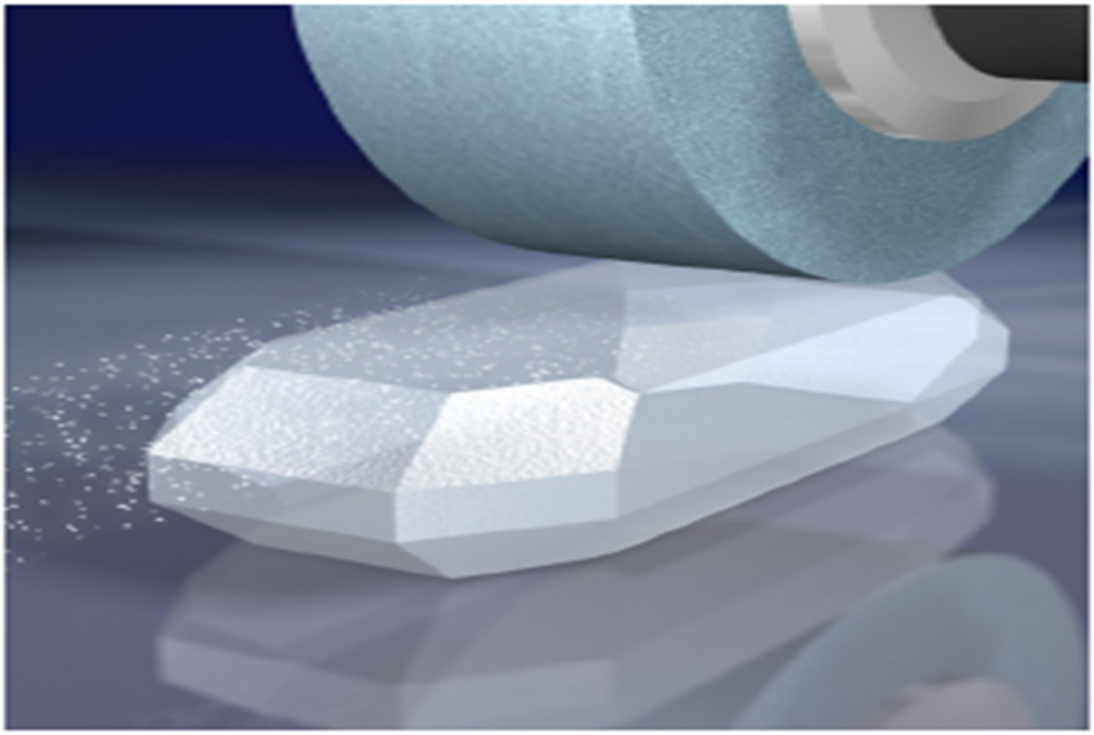
2. Growth of crystal bar

- Temperature 300 °C ~ 400 °C
- Pressure 130 MPa ~ 150 MPa (1300 bar ~ 1500 bar)
- Crystal fragments are dissolved
- Convection of SiO2 solution due to temperature profile
- Controlled crystallization at surface of the seed
- Temperature gradient controls crystal growth (about 0.5 mm / day)
- Crystal Growth takes about 40 ~ 80 days
- Growth rate has impact on quality (lattice perturbations)



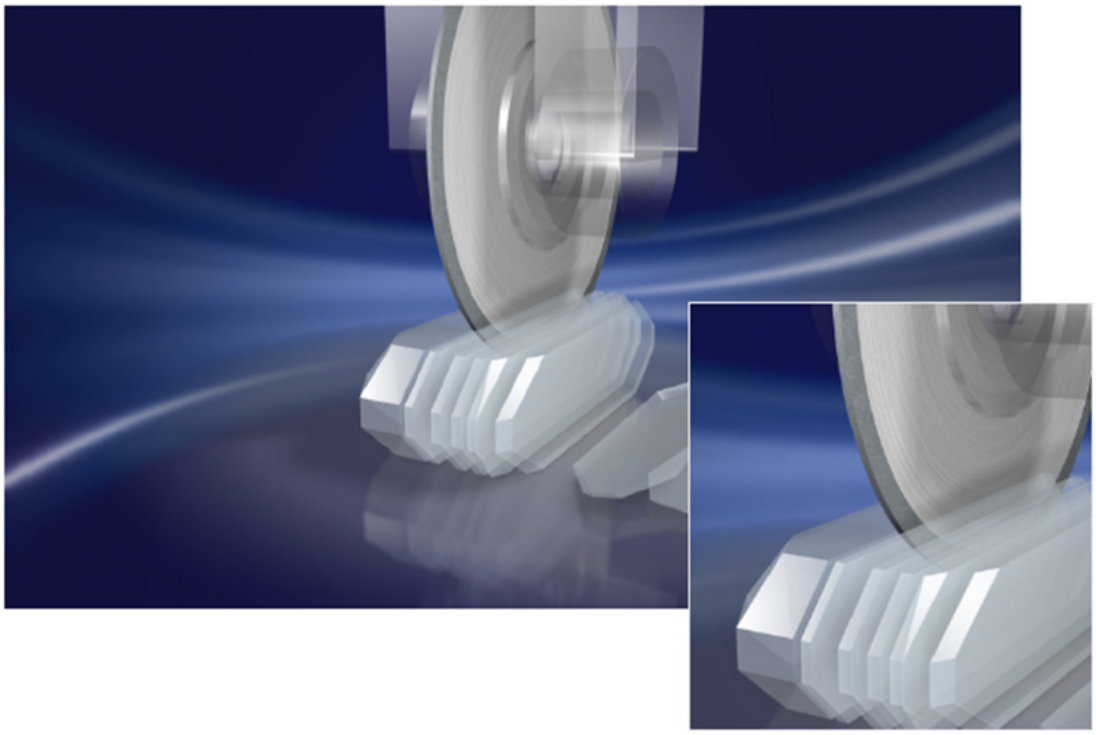
3. Surface grinding of reference plane Z

- Identification of correct grinding angle by X-ray inspection
- The Z-plane of the quartz bar is defined by accurate grinding
- Required accuracy 2 minutes



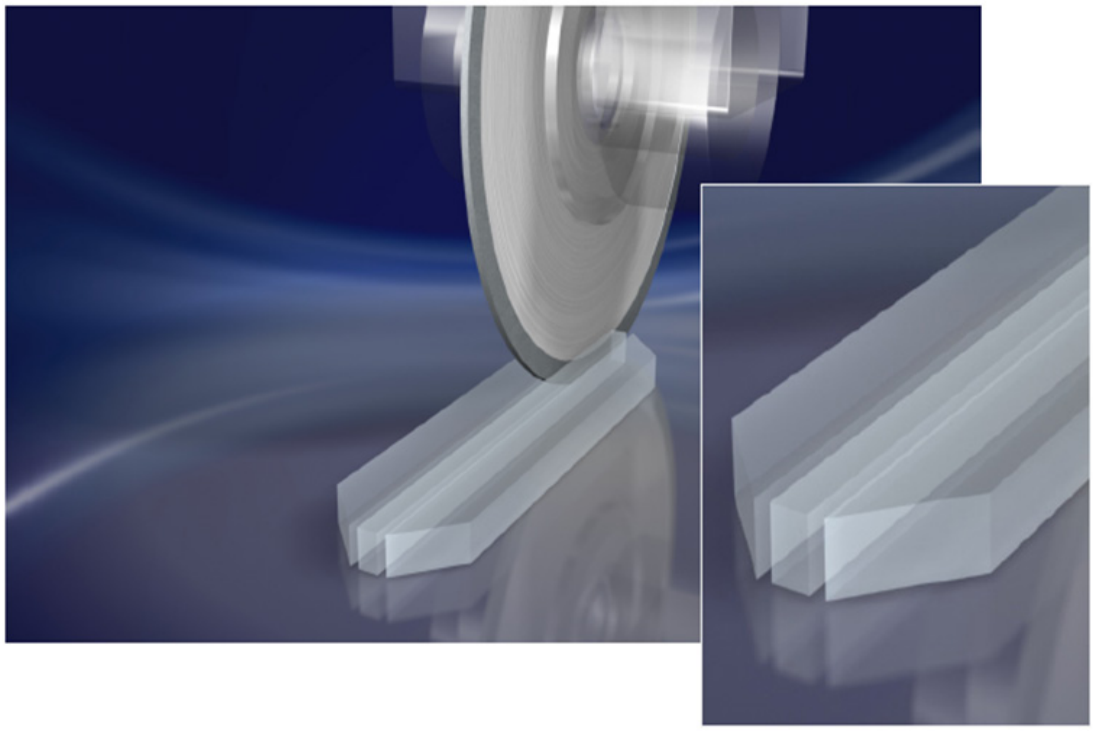
4. Sawing of crystal bar

- Quartz crystal bars are cut into lumbers
- Sawing orientation along X-axis



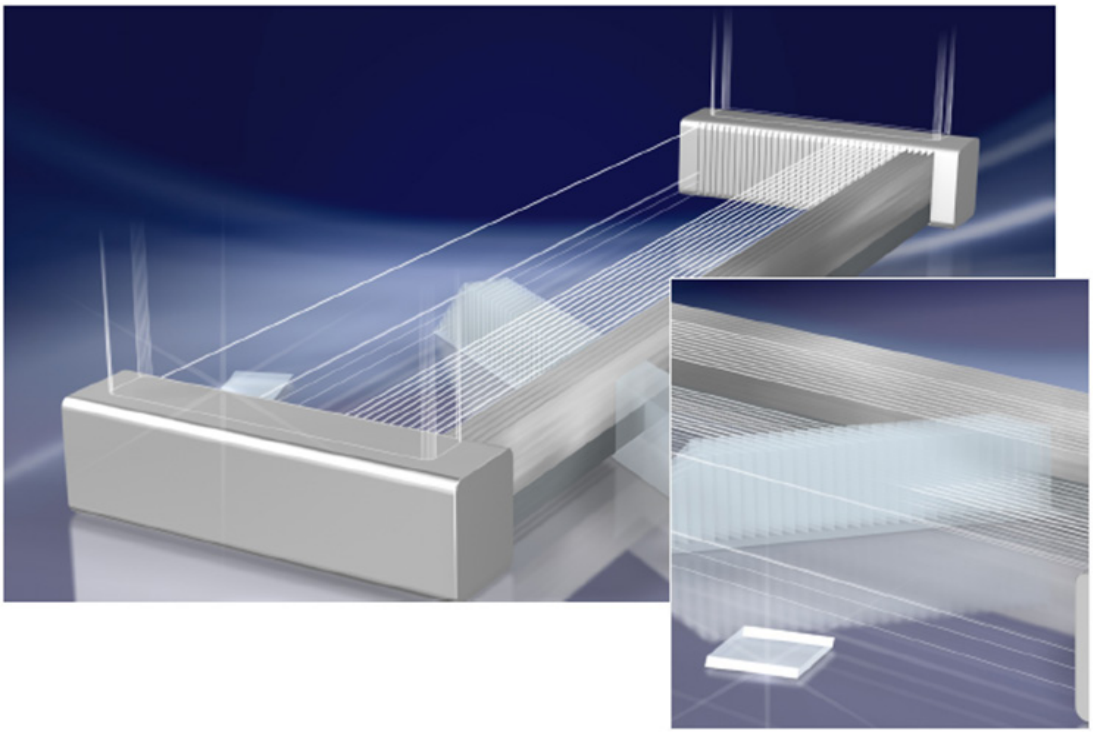
5. Separation of the crystal seed

- Seed is not used for crystal plates
- Boundary areas are not usable for further processing



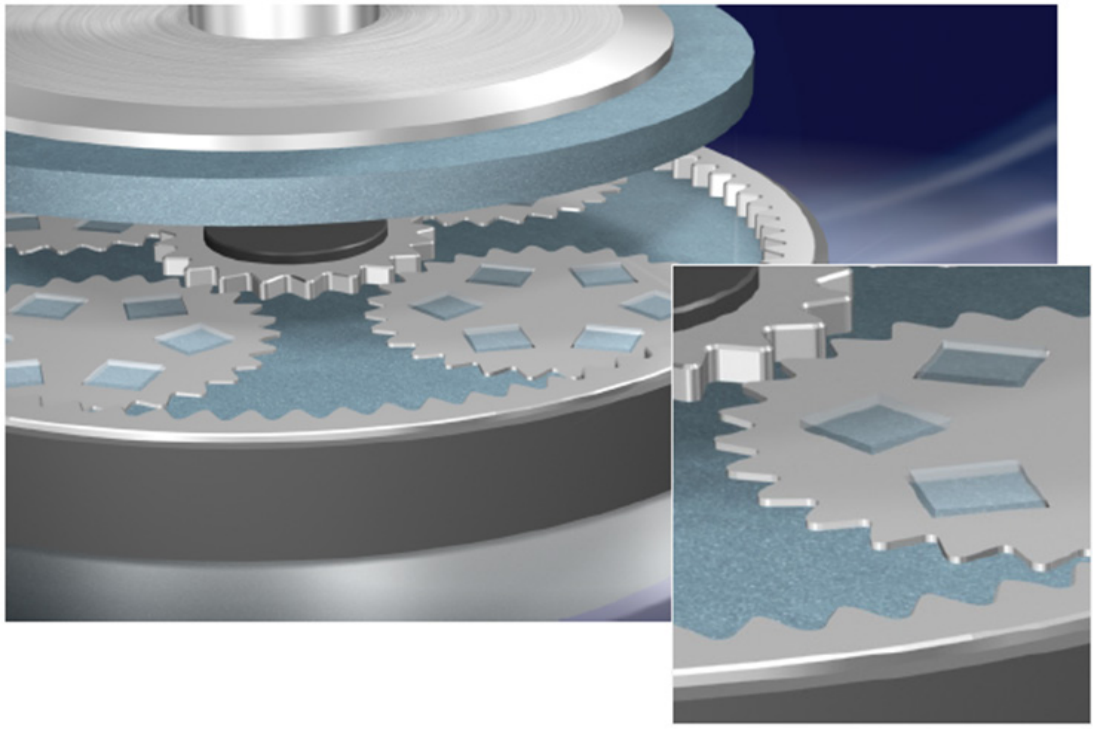
6. Sawing of lumbers into crystal wafers

- Sawing by wire saw or frame saw
- Lumbers are sawn at predefined angle
- Cutting angle selected according to specification for temperature range and frequency stability
- Dedicated angle is so called AT-cut



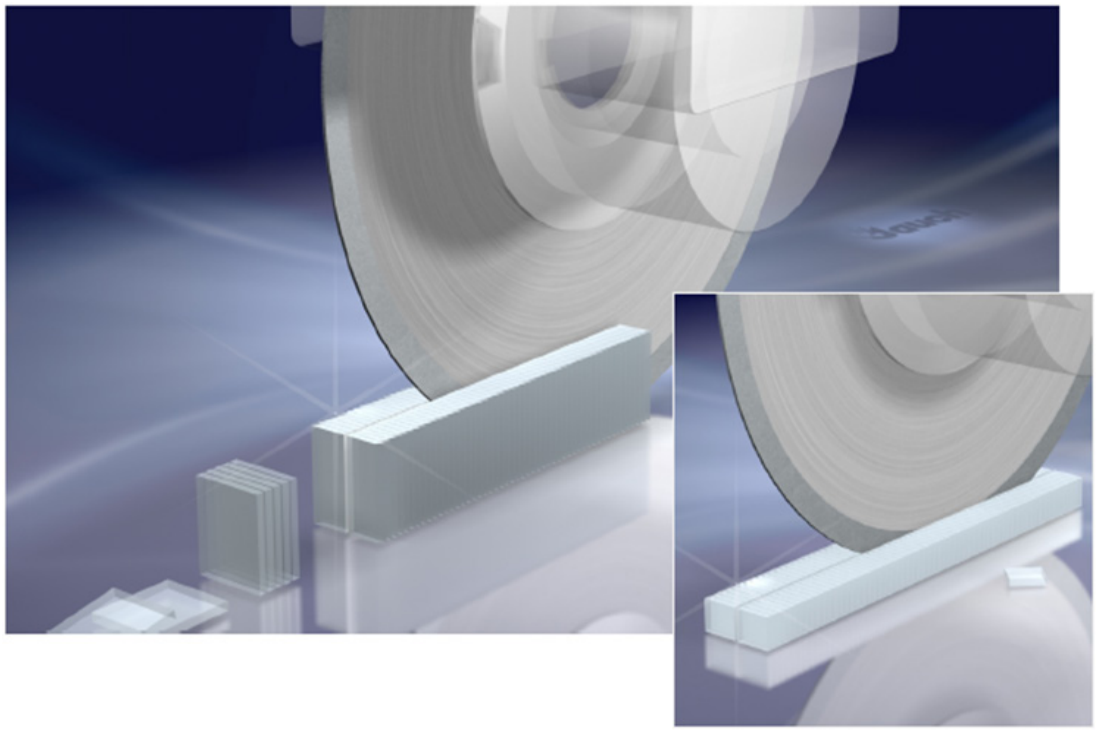
7. 1st lapping process

- Plane-parallel lapping
- Target thickness is defined by specified frequency
- Target frequency is slightly below specified final frequency



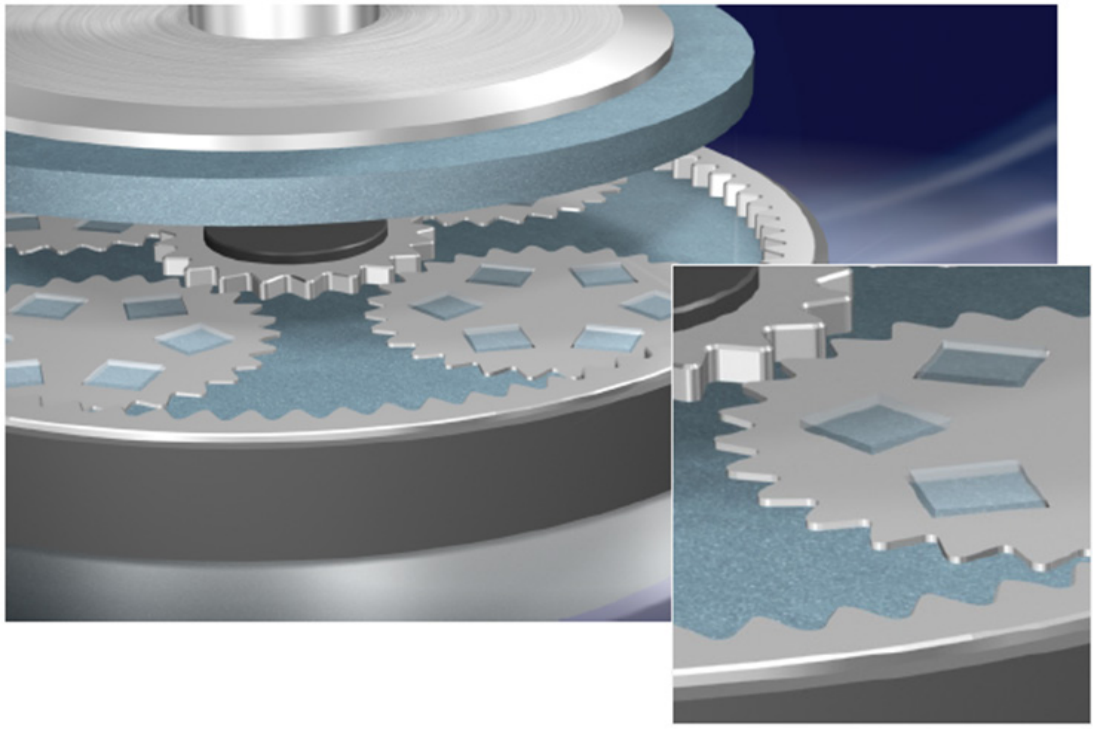
8. Sawing wafers into crystal plates (“blanks”)

- Lapped wafers bonded into blocks
- Wafer blocks cut into raw blanks
- Dimensions of raw blanks defined by crystal package
- Wafers are separated into blanks



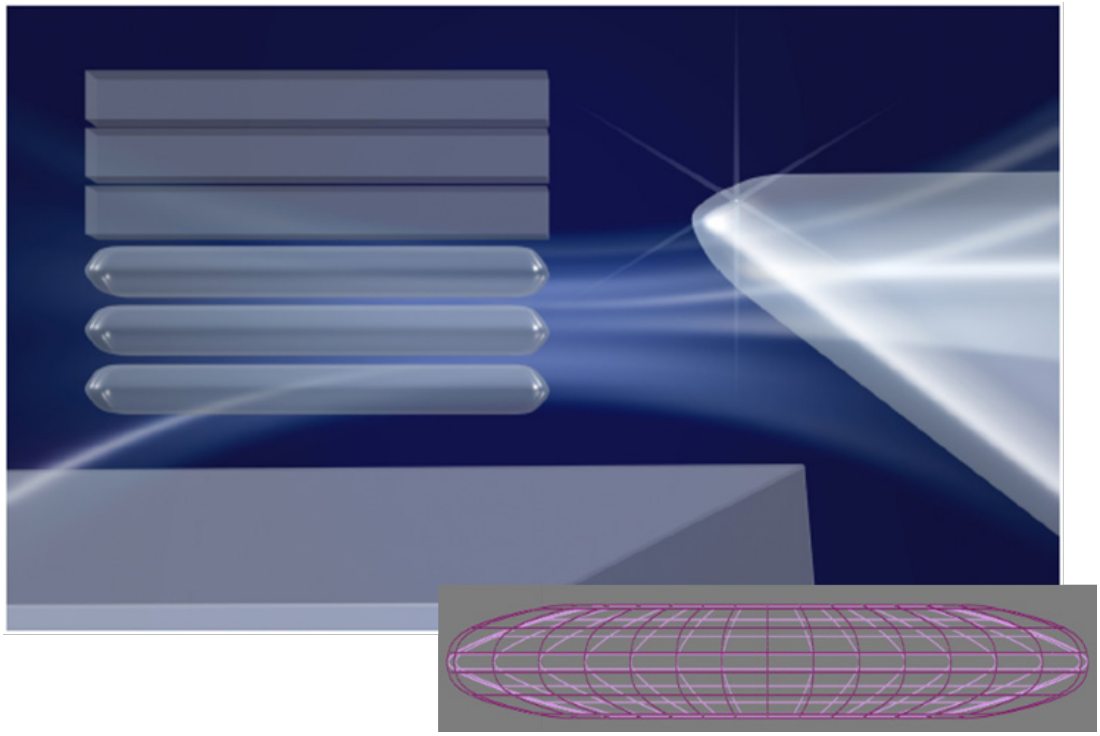
9. Lapping to target frequency

- Plane-parallel lapping, until target frequency is reached
- Target thickness is defined by target frequency
- Target frequency is slightly below the specified final frequency



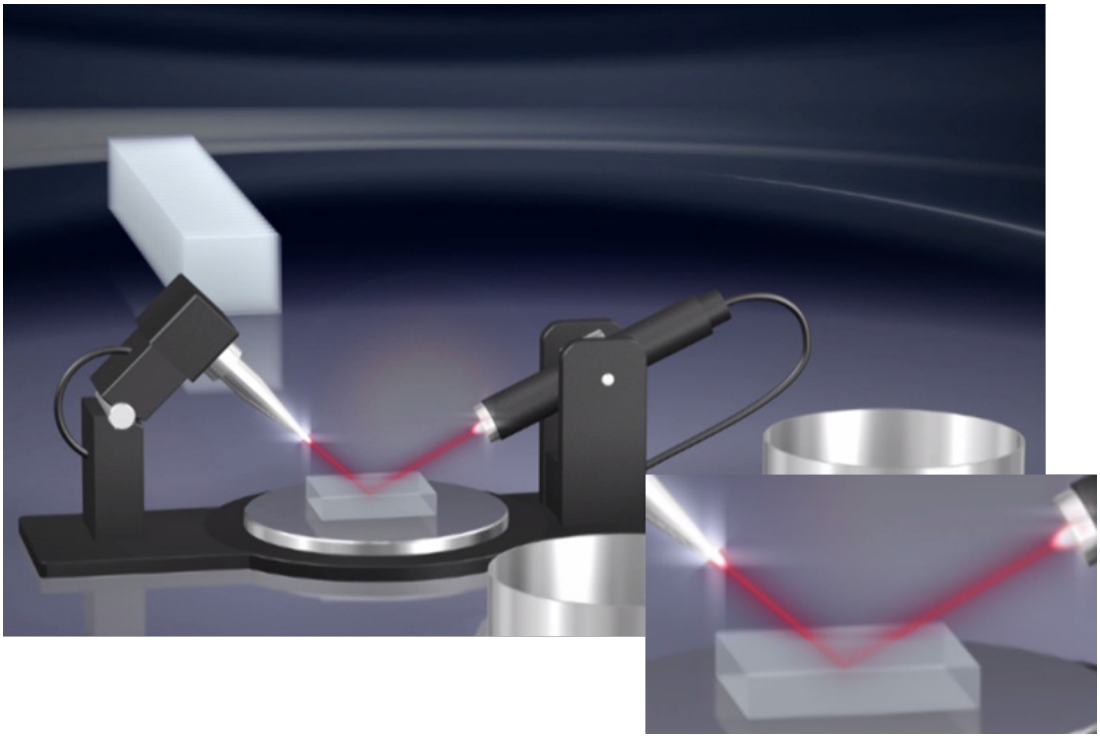
10. Beveling of blanks

- By a grinding (beveling) process, blank edges are
  - → resonant energy is kept in the center of the blank
  - → resonant losses can be kept low, series resistance
  - → unwanted resonant modes can be reduced



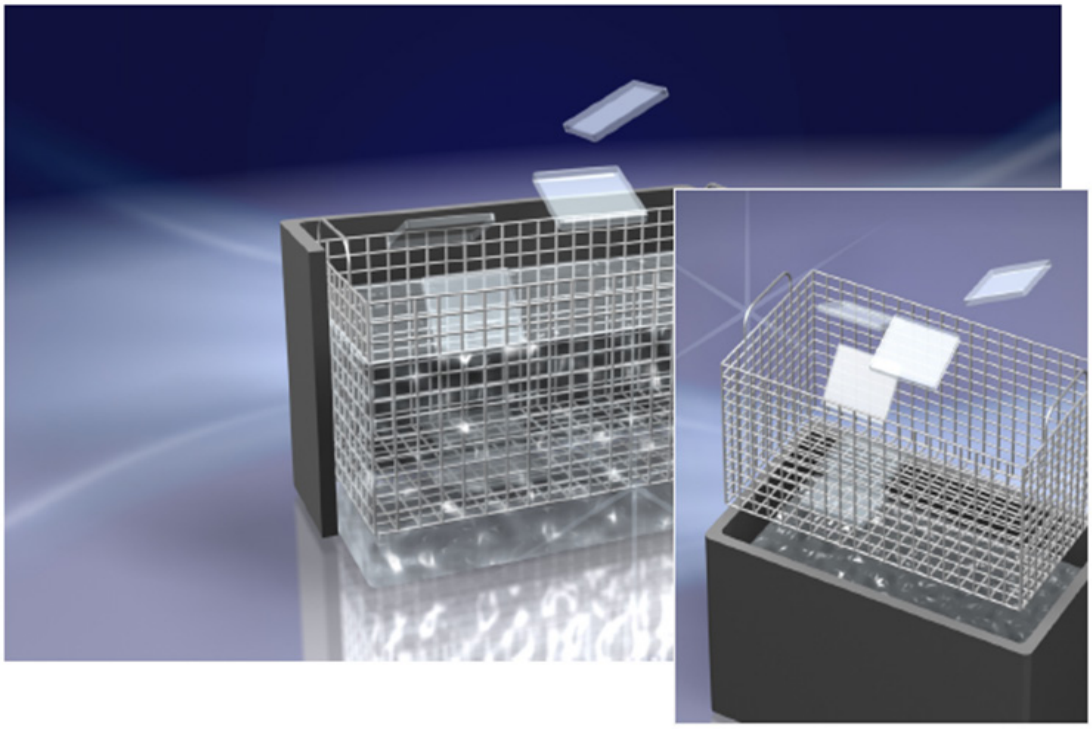
11. Sorting of the cutting angle

- Sorting of cutting angle by X
- X-ray Goniometer measures
- Lattice angle defines the temperature
- Preferred angle: AT-cut



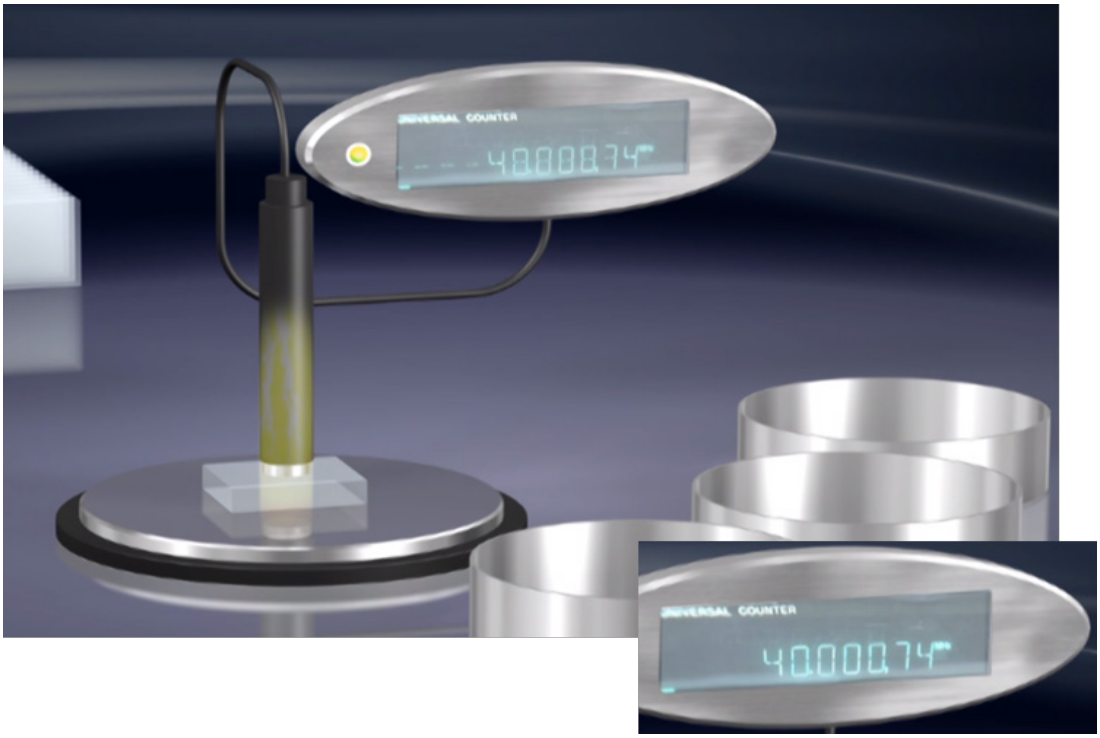
12. Washing and etching of blanks

- Blank washing and etching to prepare blank surface for electrode deposition
- Cleaning process improves cohesiveness of electrode
- Etching process improves surface finish and keeps series resonant resistance low



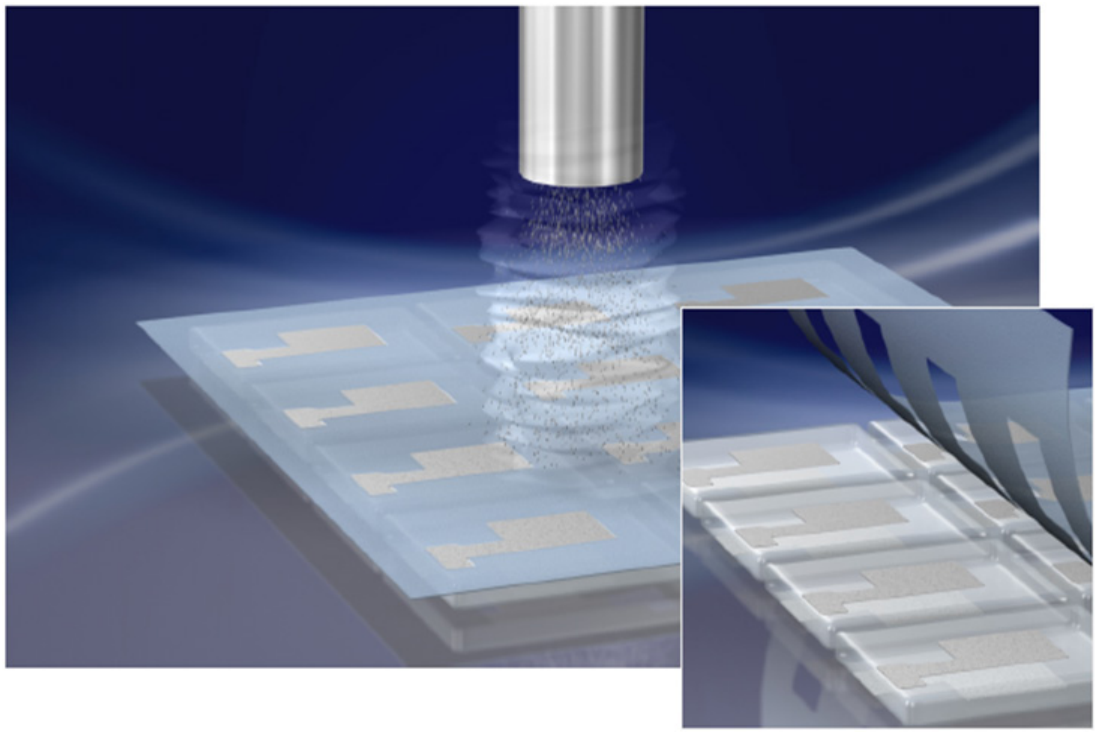
13. Frequency sorting of the blanks

- Frequency should be slightly above specified final frequency
- Added mass of electrodes on blank decreases resonant frequency



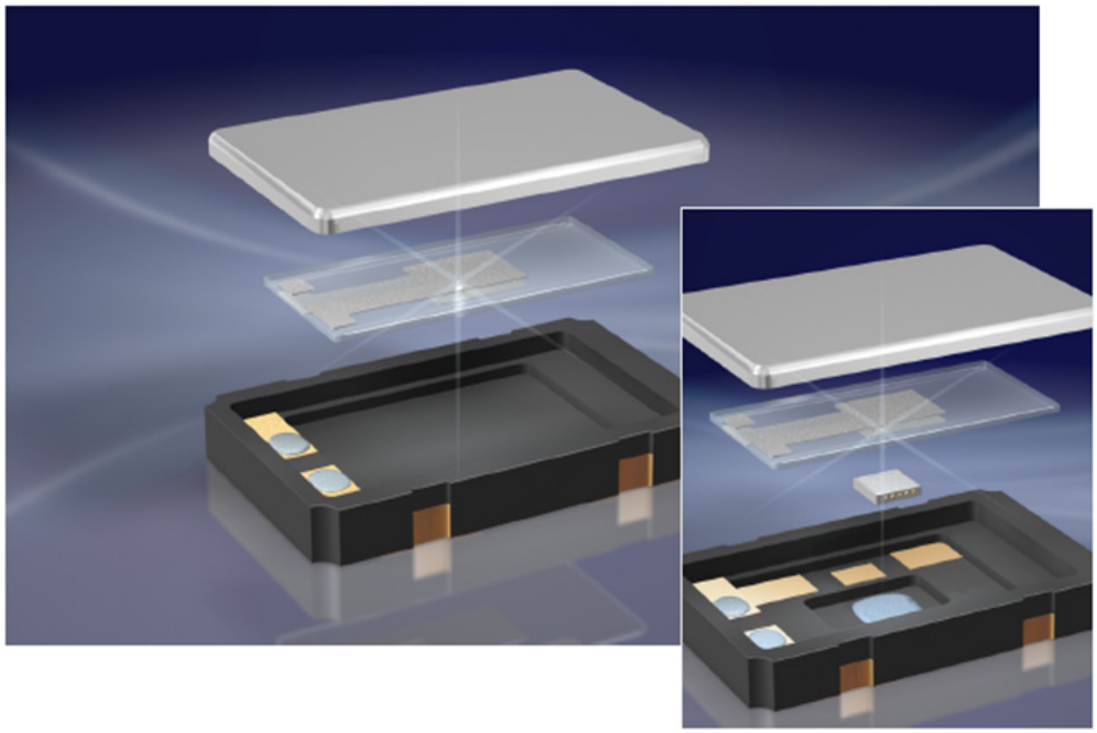
14. Evaporation of electrodes

- Evaporation or sputtering of electrodes in vacuum
- Dimensions of electrodes defined by a mask / stencil
- Dimensions of electrodes depending on specified frequency
- Surface of electrodes defines resonant area inside the blank
- Additional mass of electrodes slightly decreases resonant frequency



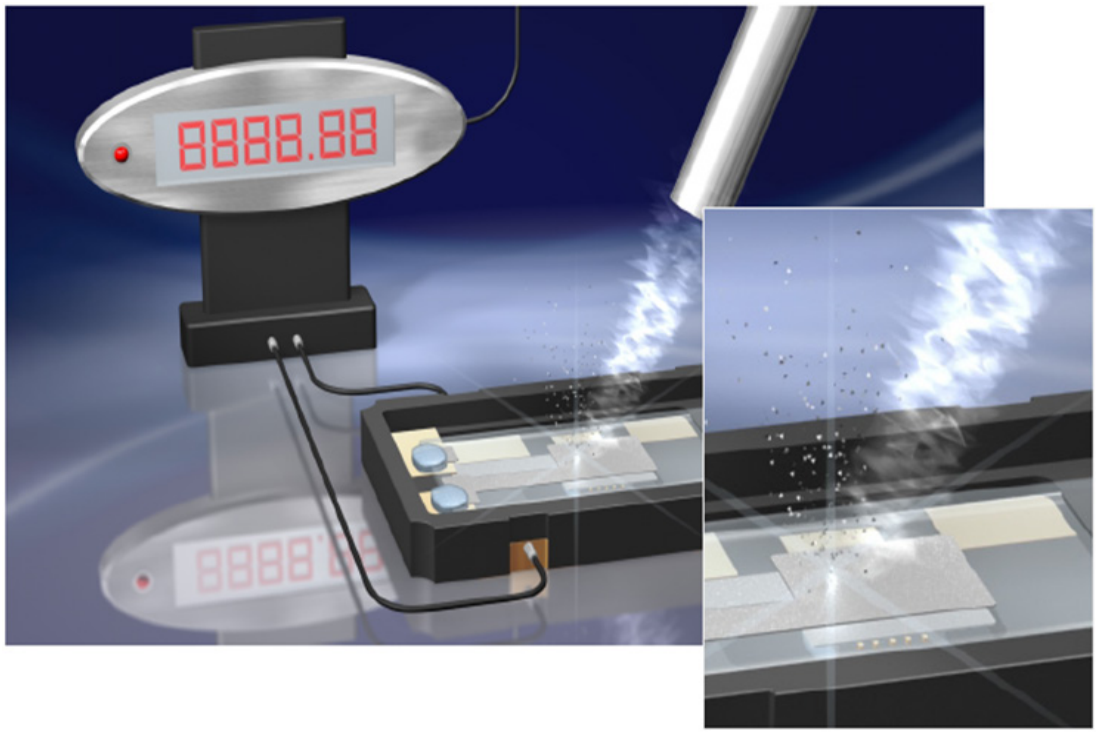
15. Mounting of blanks

- Cementing points of conductive adhesive are placed in the package base
- Conductive adhesive contains silver particles
- During the oscillator production process, a chip is fixed and bonded



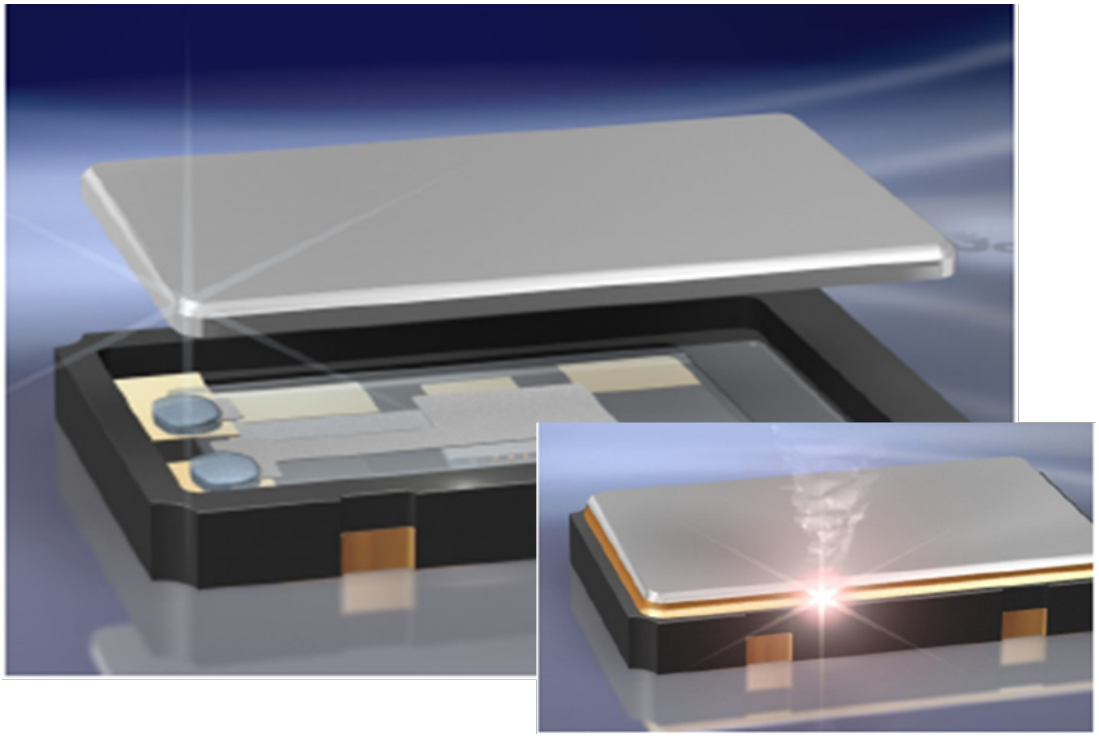
16. Final frequency adjustment

- 2 different methods of frequency adjustment possible:
  - additional evaporation of electrode material (→ frequency decreases
  - partial removal of electrode material using plasma (→ frequency increases
- Final frequency adjustment is performed at specified load capacitance!



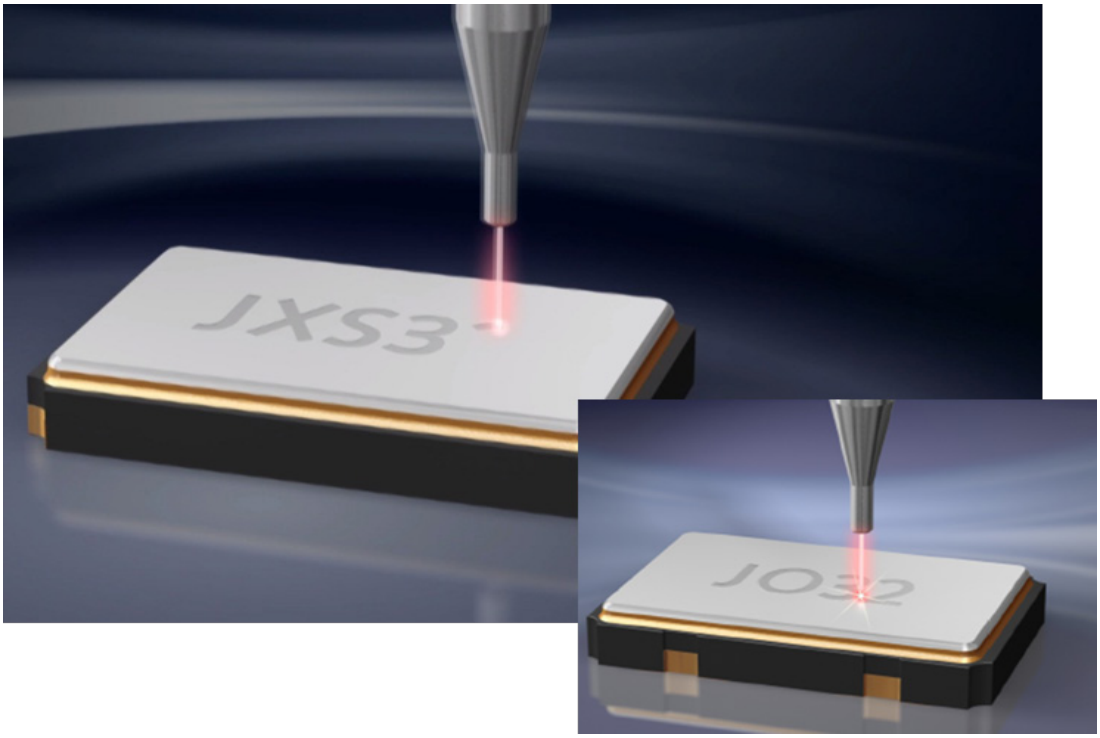
17. Package sealing

- Different methods are possible:
  - electrode welding of metal lid to package (Seam Seal)
  - glass melting process, glass frit melted to bond lid to bottom (Glass Seal)
- Sealing process is performed in a Nitrogenous atmosphere (N)
- Nitrogen prevents electrodes from corrosion



18. Product marking

- Laser marking
- Ink marking



19. Final-Testing / Packaging

- 100 % final testing according
- Packaging (taping, ...)
- Packaging, shipment

Overview

1. Autoclave is filled with natural quartz SiO2 and alkaline solvent
2. Quartz seeds are fixed in a carrier in upper part of autoclave
3. Saturated solvent of SiO2 crystallizes on the surface of the quartz seeds
4. Growth of the crystal is controlled by temperature gradient
5. The growing process duration is 40 and 60 days
6. Z-plane of the quartz bar is grinded
7. Quartz bars are cut into lumbers
8. Quartz crystal seed is removed
9. Lumbered bars are cut into wafers
10. Wafers are separated into blanks
11. Cutting blanks to final size
12. Sorting of cutting angle by X-ray inspection
13. Lapping, polishing, beveling of blanks
14. Blank washing and cleaning
15. Electrode evaporation with silver or gold in vacuum chamber (sputtering)
16. Blanks are positioned and contacted
17. Final frequency adjustment at specified load capacitance
18. Package sealing under nitrogen atmosphere
19. Marking
20. 100% final test, packaging

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Jauch Quartz GmbH
In der Lache 24
78056 Villingen-Schwenningen
Germany

frequencyproducts@jauch.com
+49 7720 945-0
www.jauch.com