EPITAXIAL α QUARTZ THIN FILMS ON SILICON SUBSTRATES

SATT LUTECH — ITC

MARKET CHALLENGES

Highly processed monocrystalline quartz plates are desired for a **range of high-value applications** such as microelectronics and telecommunications. Owing to its **high quality factor piezoelectricity** , quartz is the material of choice for oscillators in electronic devices and transducers for mass sensors widely used in chemistry and biology. Quartz has other appealing properties, including **optical activity, birefringence, high hardness, remarkable chemical durability, and light transparency from the vacuum ultraviolet to near infrared and in the THz regions of the electromagnetic spectrum.**

Synthesis methods have been frustrated by the inhomogeneous crystal growth, crystal twinning, and loss of nanofeatures upon crystallization. Moreover, these methods **are complex, expensive, with a limited efficiency**, and impose a limit on the minimal thickness of the quartz layers around 50 microns.

INNOVATIVE SOLUTIONS

The novel developed process is the first controlled deposition process of α Quartz, transferable to the manufacturing scale and compatible with microelectronics processes. It opens the way to numerous potential applications of α Quartz.

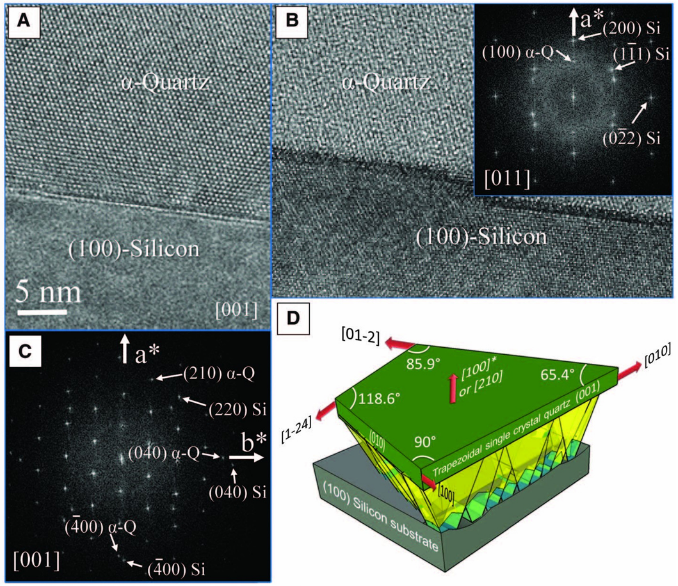
This process is based on **epitaxial growth of nanostructured polycrystalline quartz films on silicon** [Si(100)] substrates via the solution deposition and gelation of amorphous silica thin films, followed by thermal treatment. Key to the process is the combined use of either a strontium (Sr^{2+}) or barium (Ba^{2+1}) catalyst with an amphiphilic molecular template. The silica nanostructure constructed by cooperative self-assembly permits homogeneous distribution of the cations, which are responsible for the crystallization of quartz. The low mismatch between the silicon and α Quartz cell parameters selects this particular polymorph, inducing epitaxial growth.

SUGGESTED APPLICATIONS

- **Oscillators very stable in frequency**
- **High-density SAW Filter**
- **Accelerometers and gyrometers**
- **Mass sensors**
- **Lab-on-chip** (canals in quartz)
- **Optical Components** (transparency of α Quartz in visible and UV)
- **Substrate of α Quartz for epitaxial growth of crystals of biological interest**
- **Protective coating with Quartz** (friction, abrasion, chemical attacks, electric insulation)

DEVELOPMENT STATUS

The efficiency of the process has been demonstrated (several thicknesses 5nm, 40nm...). The resonance frequency of the layer is beyond the capacity of measure of the laboratory equipment (f > THz).



Fine structural characterization of quartz films. (A and B) HRTEM images of the α quartz-Si interface along [001] (A) and [011] (B) α quartz zone axis. FFTs of (A) and (B) are sown in (C) and the inset of (B), respectively. The film and substrate spots are set apart, confirming the relaxation of the film. (D) Schematic representation of a quartz habit, displaying the macroscopic measured angles between the planar edges of quartz crystals and crystallographic directions that define the trapezoidal (100)o facets.

COMPETITIVE ADVANTAGES

- **Faster process:** compatible with industrial constraints
  - no substrate preparation: no middle layer
  - no polishing (contrary to hydrothermal synthesis)
- **Low cost: standard silicon substrate**
- **Compatible with microelectronics** (pattern and CVD)
- **Control of the nanostructure:**
  - Layer thickness from 5 nm to 500 nm
  - Lateral dimensions of crystals
  - Crystals orientation from the crystalline orientation of the substrate
- **Possible incorporation of nanoparticles in the layer** (ex: surfactants, block polymers, ions, nano-objects)
- **Very high resonance frequency of the layer** (>THz)

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IP PROTECTION

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