Experimental demonstration of Surface Acoustic Wave propagation on α-GeO_2 for wireless, passive sensor design

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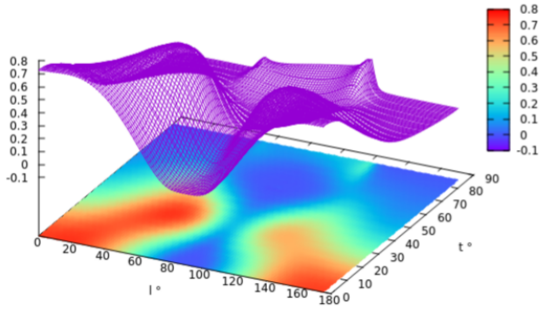
α-GeO_2: from material to sensor to measurement

- **Surface acoustic wave** (SAW) transducer for wireless sensing of a passive sensor at high temperature (>800°C)
- α-GeO_2: **no phase transition** up to its melting temperature (1116°C)
- α-GeO_2: high temperature growth for **stable** and stoechiometric material
- α-GeO_2: quartz-like substrate (point group 32)
- α-GeO_2: low electromechanical coupling coefficient ⇒ **resonator** architecture
- **Question:** ability to generate and propagate a surface acoustic wave in a high-quality factor design compatible with wireless sensing?



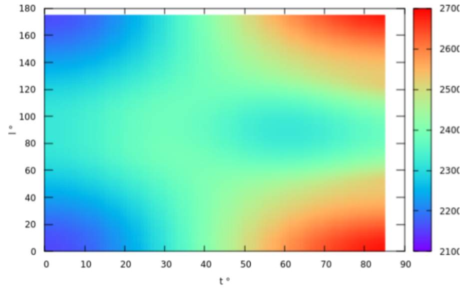
Electromechanical coupling coefficient v.s orientation

GeO_2 surface acoustic wave generation

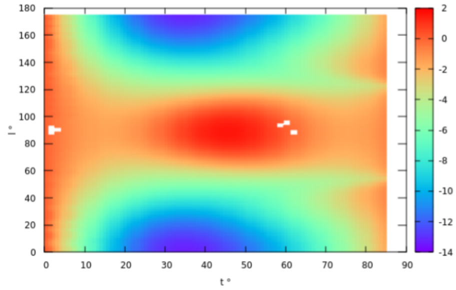
Mixed matrix simulation based on published[a,b] piezoelectric constants to identify favorable α-GeO_2 cut, propagation direction, beamsteering, and temperature turnover.

[a] R.M. Taziev, *SAW properties in quartz-like α-GeO₂ single crystal*, J. of Physics: Conference Series, **1015**(3) 032142 (2018)

[b] A. Lignie, P. Armand, P. Papet, *Growth of piezoelectric water-free GeO₂ and SiO₂-substituted GeO₂ single-crystals*, Inorganic chemistry **50**(19) 9311–9317 (2011)



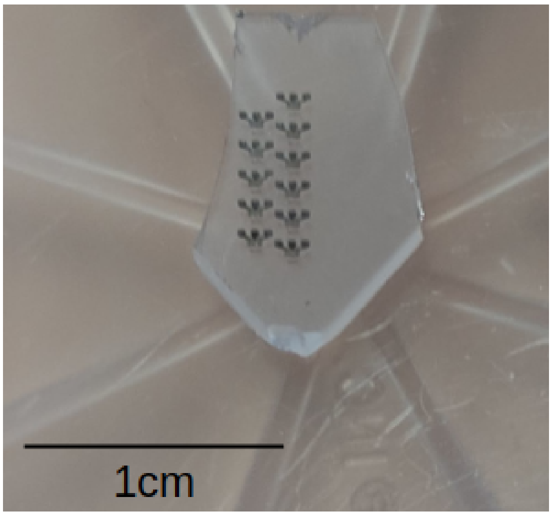
Velocity v.s orientation



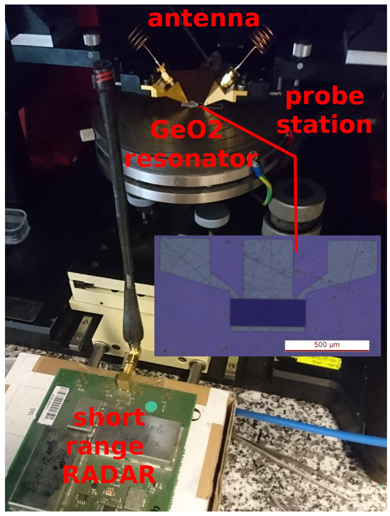
Beam steering v.s orientation

Wireless interrogation of the passive transducer

- Design of a **reflective, single port resonator** operating in ...
- ... the **434** ±1 MHz Industrial, Scientific, and Medical (ISM) band.
- Varying wavelength λ for varying h/λ (h electrode thickness) and metallization ratio to adjust reflection and propagation coefficient of mixed matrix model.
- Quality factor ($Q > 1000$) sufficient to **differentiate** sensor response from **clutter**
- Aluminum electrodes patterned using **e-beam lithography** on cm^2 scale substrates
- ⚠ GeO_2 surface **damaged by Al etchant**, limited reuses of the substrate before requiring renewed polishing.



Patterned crystal



Experimental demonstration of passive sensor wireless measurement

Conclusions and perspectives

- **Experimental wireless** measurement of the temperature dependance of frequency using a probe station fitted with a temperature controlled chuck
- **Demonstrated with Al electrodes up to 200°C** to be ... ⟶
- ... replaced with **Pt electrodes** for high temperature wireless sensing (leading to high mass loading and **excessive sensitivity** of the frequency to metallization thickness).
- Problem of **antenna** integration: nature and bonding to antenna?

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