Design of Asynchronous STW Resonators for Filters and High Stability Source Applications

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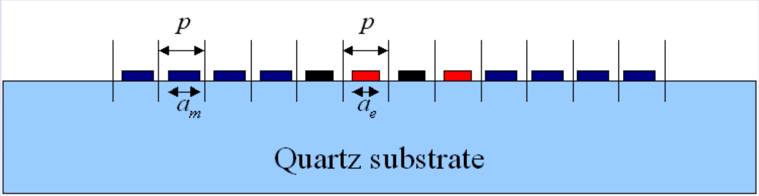
STW resonators

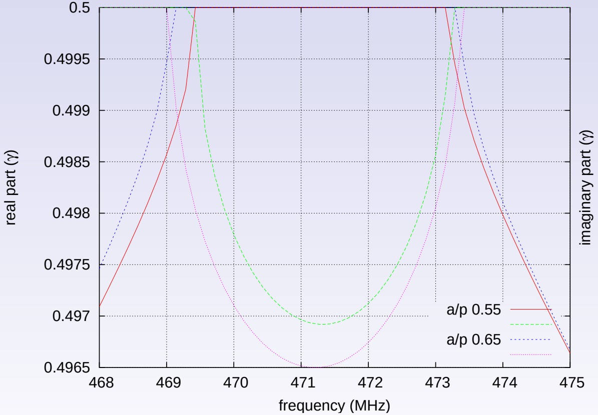
STW display highest QF product (compared to Rayleigh for example).



Can the quality factor Q be improved with an optimized geometry ?

p : period=constant over the whole device (cavity, transducers and mirrors)
a : finger width

Asynchronous design for stop-band tuning

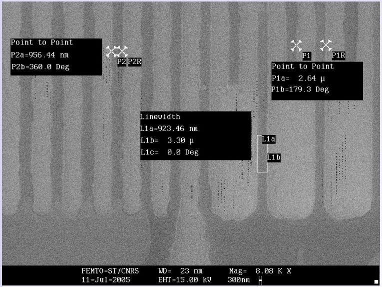


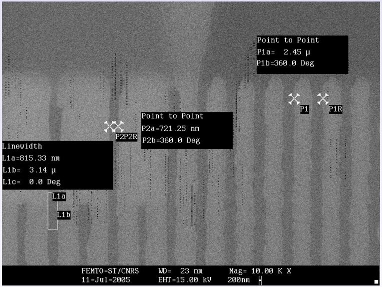
Increasing the finger width in the mirror enhances the reflection coefficient

Realization of the resonators

Dipole and quandripoles designed for resonance at 750 and 1015 MHz were designed and fabricated (FEMTO-ST/LPMO cleanroom : 2.5 μm and 3.38 μm fingers).

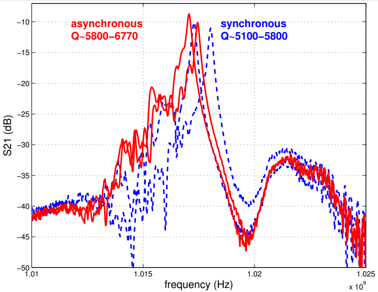
700 to 1000 Å thick *Al* sputtered on AT quartz (3" wafers).

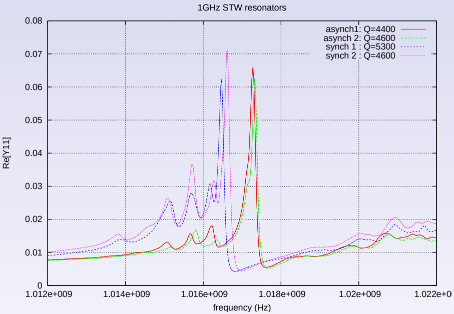




Measurements

Measurements : reflected admittance $Y_{11}(f)$ for dipoles, and $S_{21}(f)$ transmission coefficient for the quadrupoles





$\Rightarrow$ asynch. devices display reduced ripples but also lowered Q factor
$\Rightarrow$ asynch. devices appear best suited for filter applications while synchronous devices are better suited for frequency source applications (high Q needed)

Modelling

Simplified mixed matrix based model

- for simulating the response of dipoles and quadrupoles
- including geometrical effects and mass loading but
- excluding bulk modes.

$$\begin{pmatrix} S_1 \\ S_2 \\ I \end{pmatrix} = \begin{pmatrix} r_1 & t & \alpha_1 \\ t & r_2 & \alpha_2 \\ -\alpha_1 & -\alpha_2 & G + jB \end{pmatrix} \begin{pmatrix} E_1 \\ E_2 \\ V \end{pmatrix}$$

$$r_1 = r_2 = -j \sin(\Delta) \exp(-j\varphi)$$

$$t = \cos(\Delta) \exp(-j\varphi)$$

$$\alpha_1 = \alpha_2 = j\sqrt{G} \exp\left(-j\frac{\varphi + \Delta}{2}\right)$$

$$B = G\frac{\sin(\varphi) - \sin(\Delta)}{\cos(\Delta) - \cos(\varphi)}$$

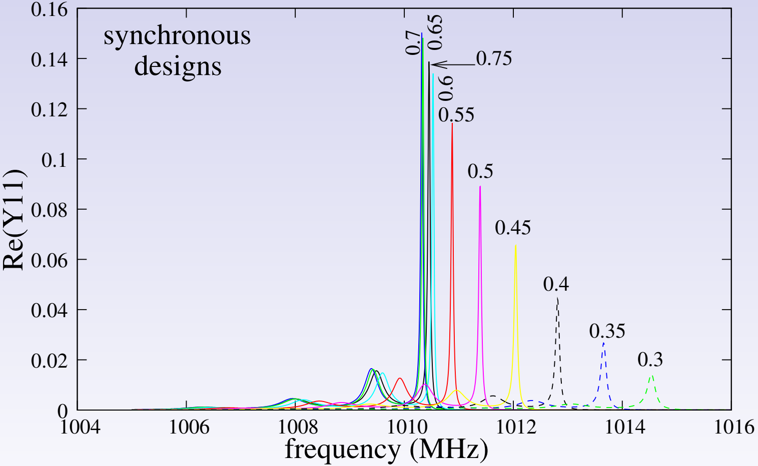
and

$$|\Delta| = \pi\frac{f_e - f_s}{f_e + f_s}$$

$$\varphi = 2\pi\frac{f}{f_e + f_s}$$

$$G = \frac{y_s - y_e}{\tan(|\Delta|)}$$

Synchronous dipole resonators

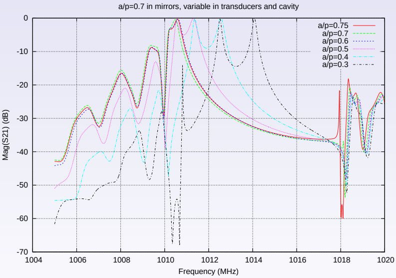


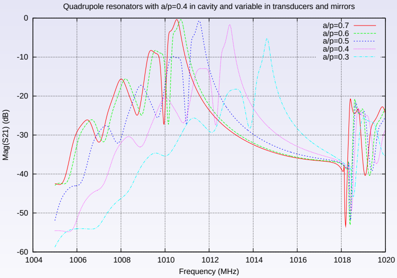
An optimum a/p appears to be around 0.7 for which insertion loss are lowest and Q highest.

Quadrupoles

Modelling of

- asynchronous devices (a/p mirror constant at 0.7, varying a/p in transducers+cavity)
- sychronous configurations (negligible effect of the cavity)





Conclusion

- Synchronous and asynchronous STW resonators have been modelled and fabricated
- sideband ripples are strongly attenuated in the asynchronous design $\Rightarrow$ filters
- the quality factor is degraded in the asynchronous design compared to synchronous $\Rightarrow$ source
- strong sensitivity to the mass of the fingers (metal thickness). Not systematically investigated here.
- optimum a/p values are in the 0.7 range for synchronous dipoles and 0.3 for synchronous quadrupoles $\Rightarrow$ spectral purity.
- greatest difference between a/p of mirrors and transducers leads to sharpest resonances (greatest efficiency of mirrors) in asynchronous quadrupoles.