point.one

MEMSLand

Cost Effective MEMS to Develop a Sustainable High Tech Business

MEMS oscillators for timing applications

NXP Semiconductors, Bruco, TUD, SAI\TUE

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Quartz resonators:
the "beating heart" of electronics

THE electronic timing reference for:

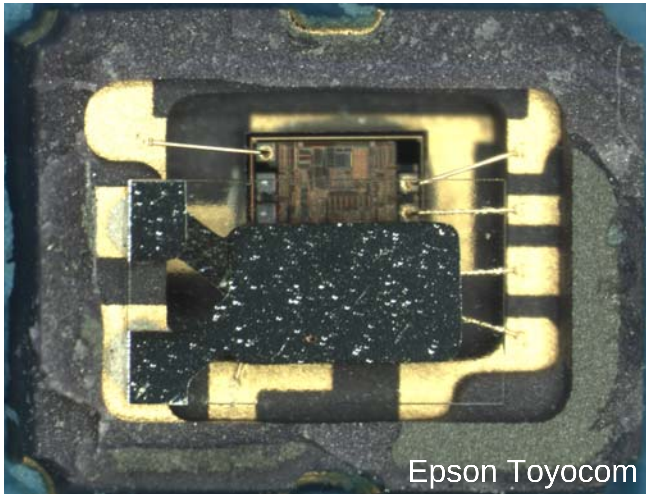
- Radio broadcasting (since 1926)
- Watches (since 1969)
- Clock signal for logic circuits

Pros

- Crystals can be cut to have (almost) zero temperature drift
- Very high Q-factor
- Piezoelectric

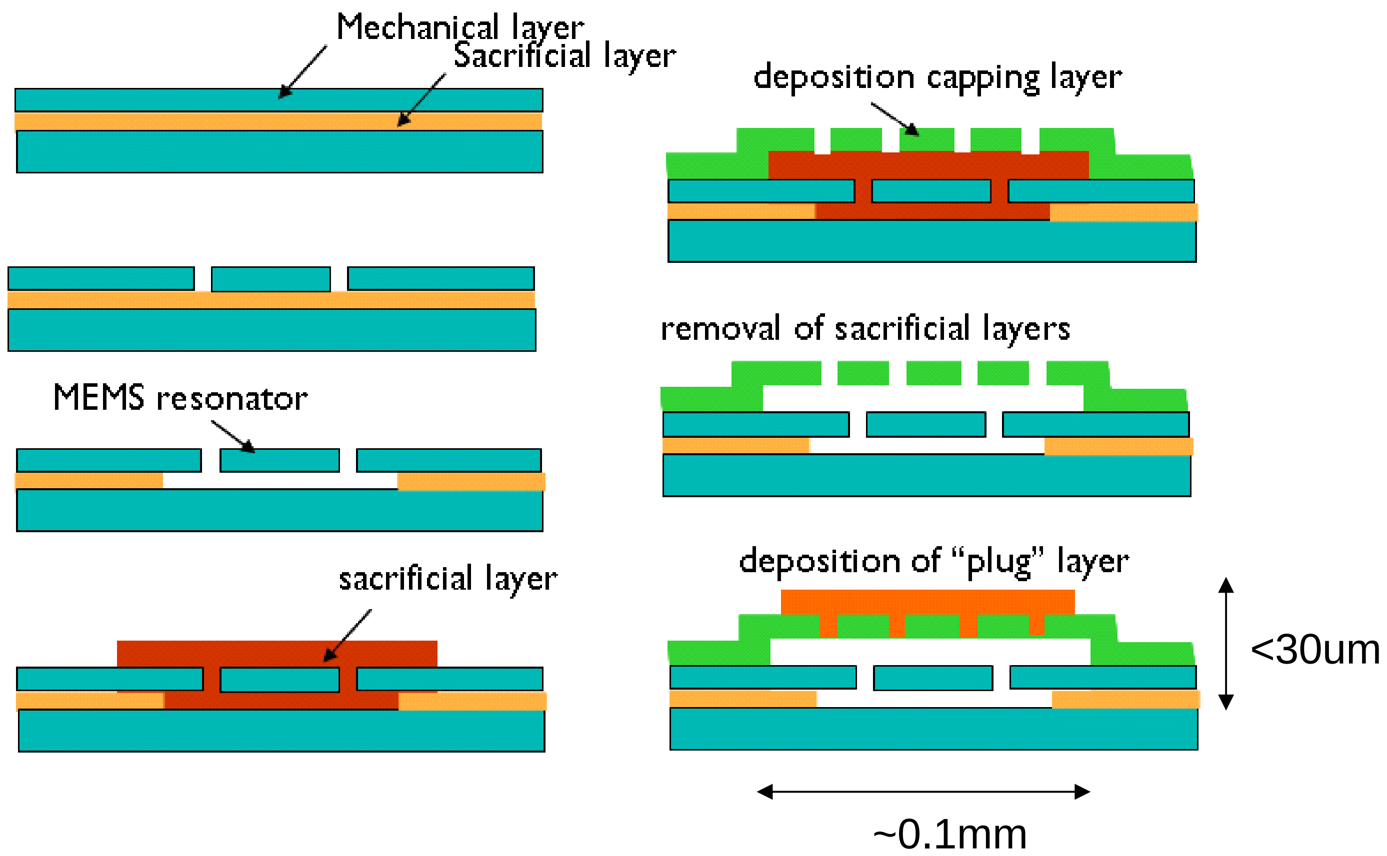
Cons:

- Relatively large due to crystal size and packaging
- Relatively expensive
- Problematic integration in SoC or SiP
- Single frequency
- Limited to ~100MHz



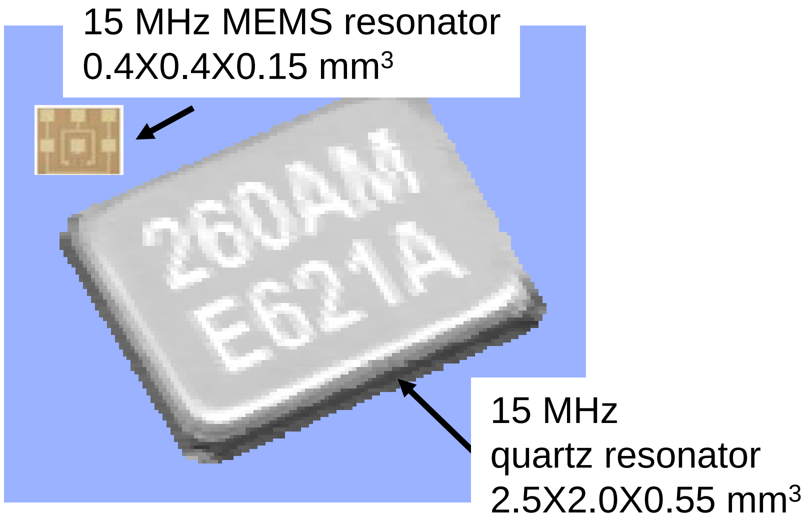
Epson Toyocom

How do you make a MEMS resonator?



A MEMS resonator is small, cheap, and silicon…

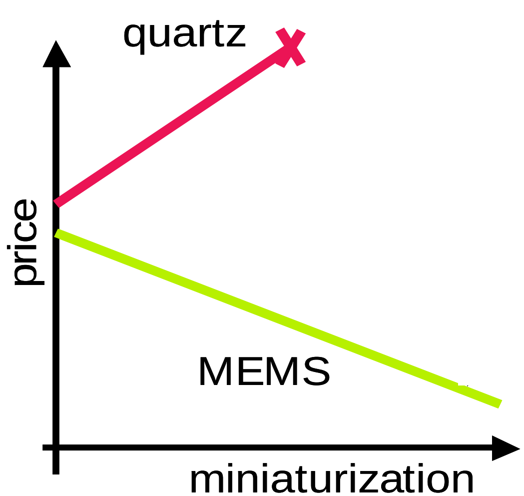
Small



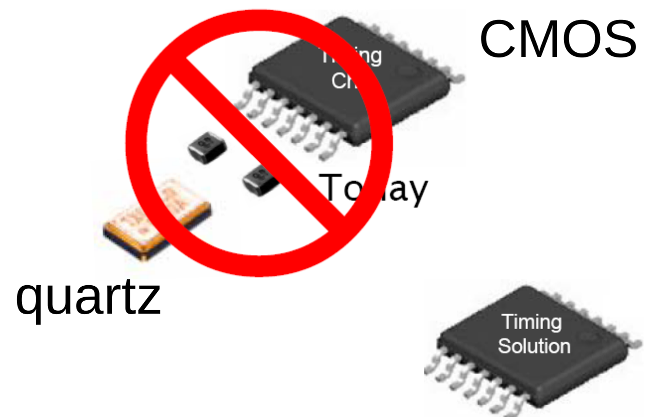
Cheap

- Processed 200 mm wafer contains > 100,000 devices

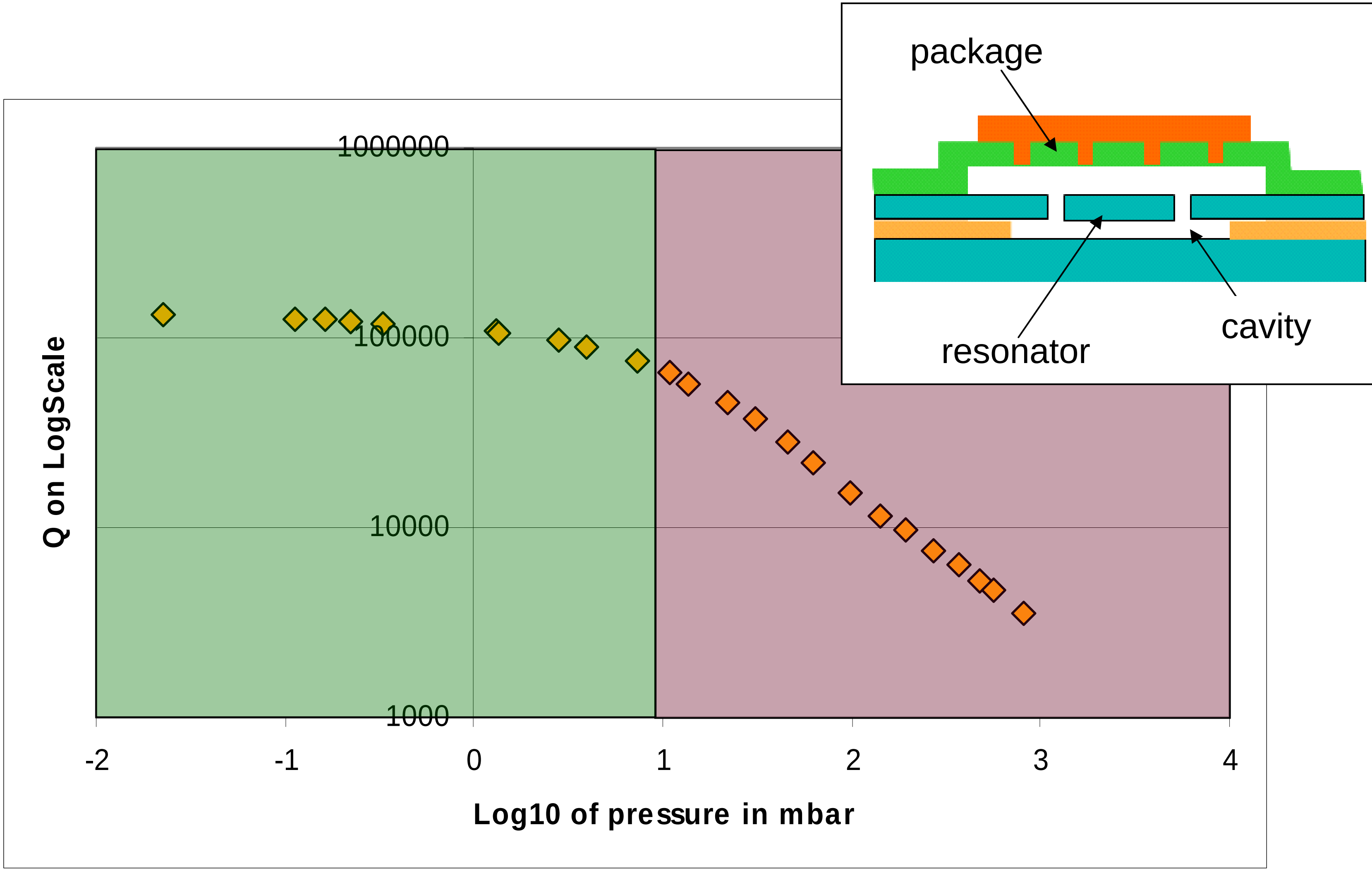
Scalable



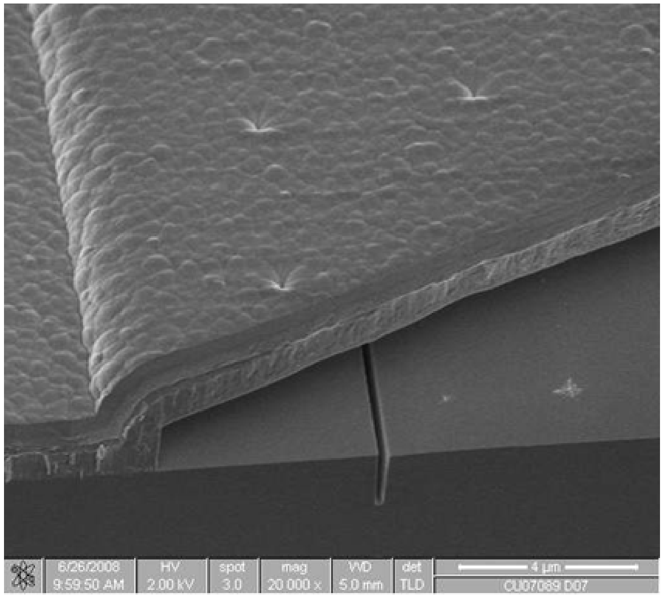
Allows integration

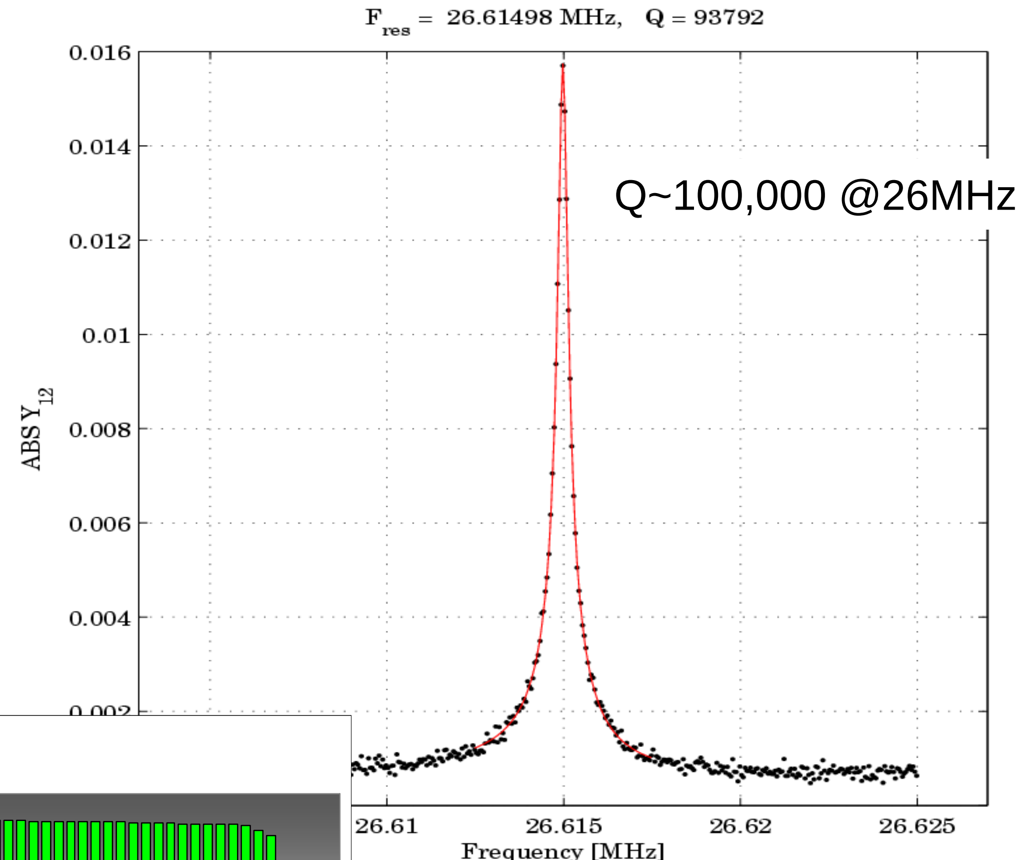


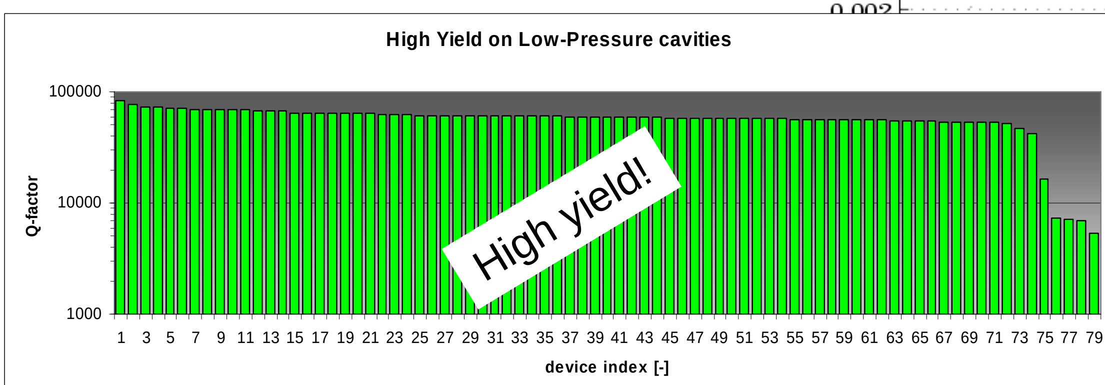
On-wafer, low-cost packaging



On-wafer packaged resonator with high-Q







- Pressure maintained in cavity is <10 mbar
- Resulting in very high Q

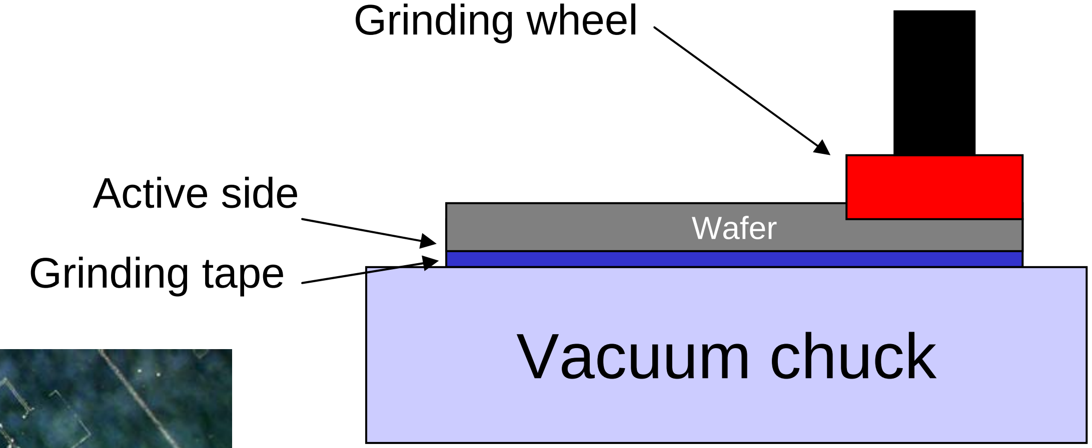
Back-end process development

1. device wafer (with TF caps)
2. testing
3. taping for grinding (face-down)
4. grinding
5. de-taping
6. taping for dicing (face-up)
7. dicing
8. testing
9. die pick-up (vacuum collet, top)
10. die placement and cure
11. wire bonding
12. plasma treatment
13. transfer moulding
14. post cure
15. package separation
16. final test

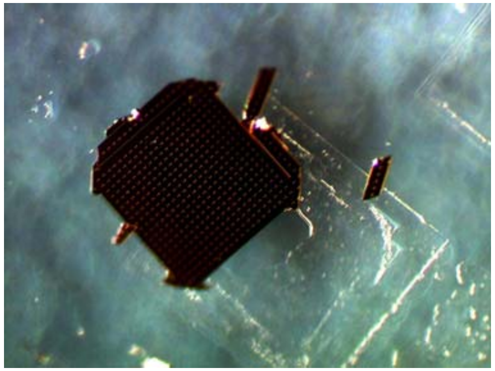
Example: Wafer back grinding

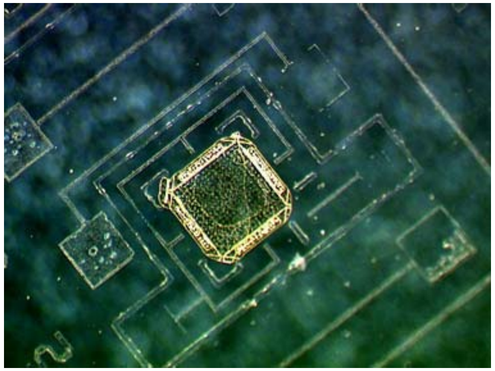
Grinding process

- Apply tape to the **active** side of the wafer
- Flip the wafer on the grinding vacuum chuck (tape side down)
- Grinding operation
- Remove tape



Damage due to taping and detaping:



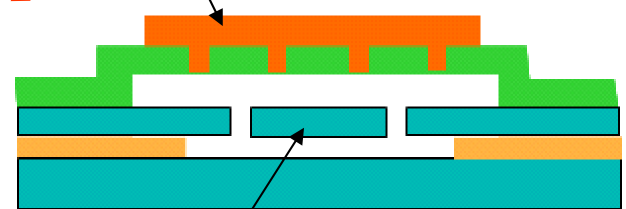


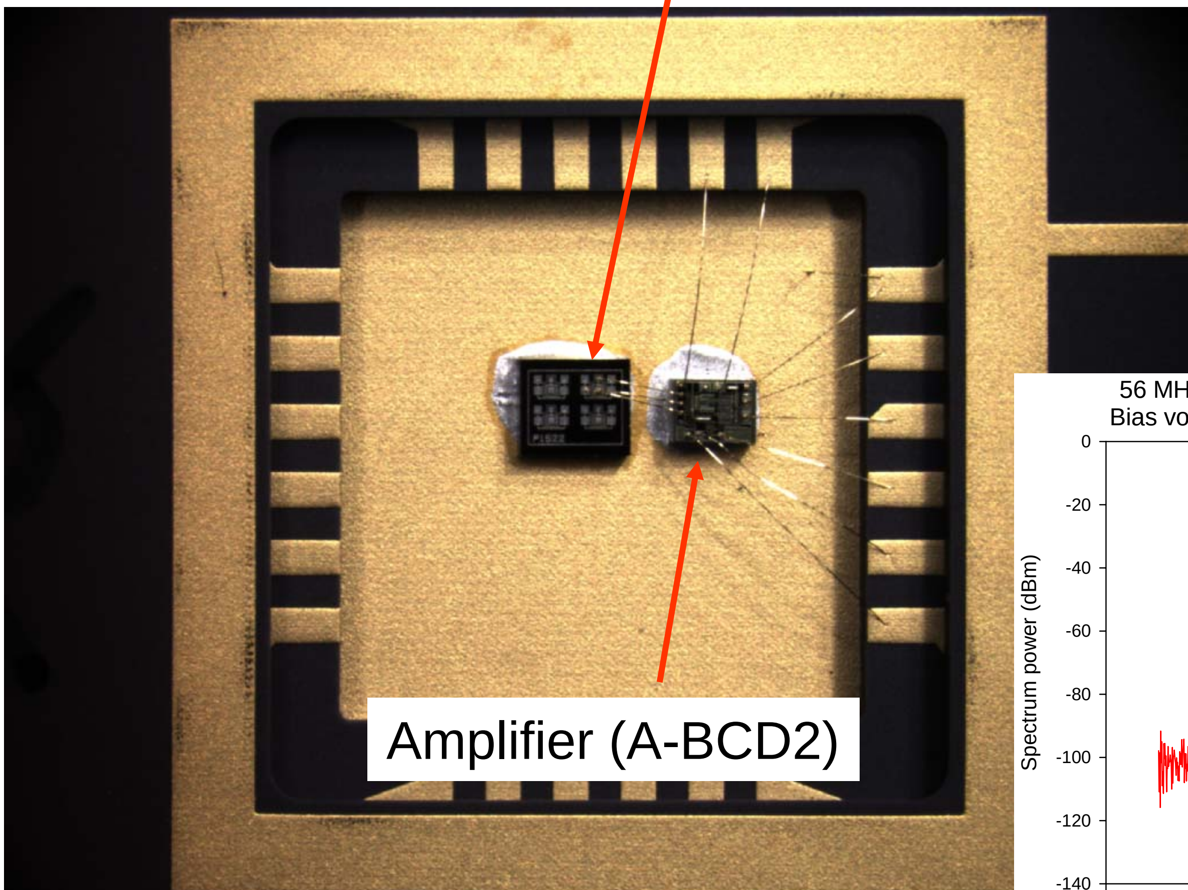
Pictures depict the grinding tape with pieces of resonator sticking to them

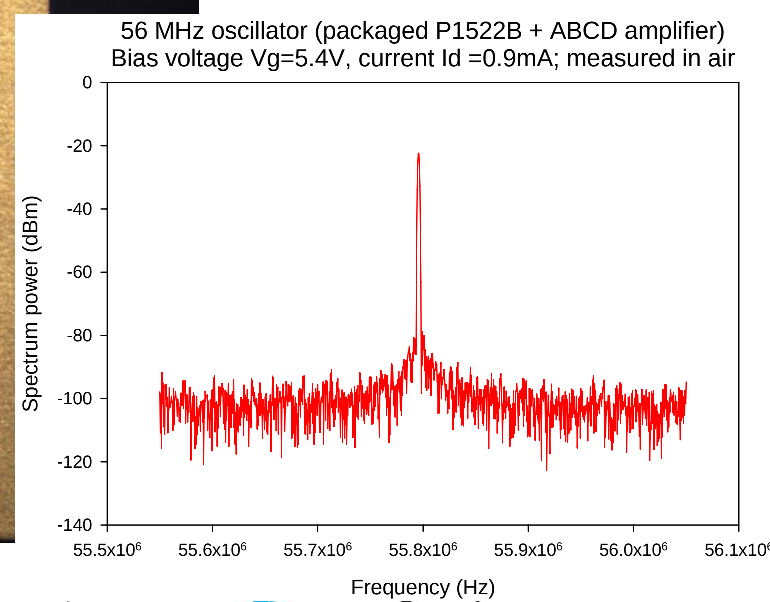
Source: Jeroen Zaal, TUD

56 MHz oscillator

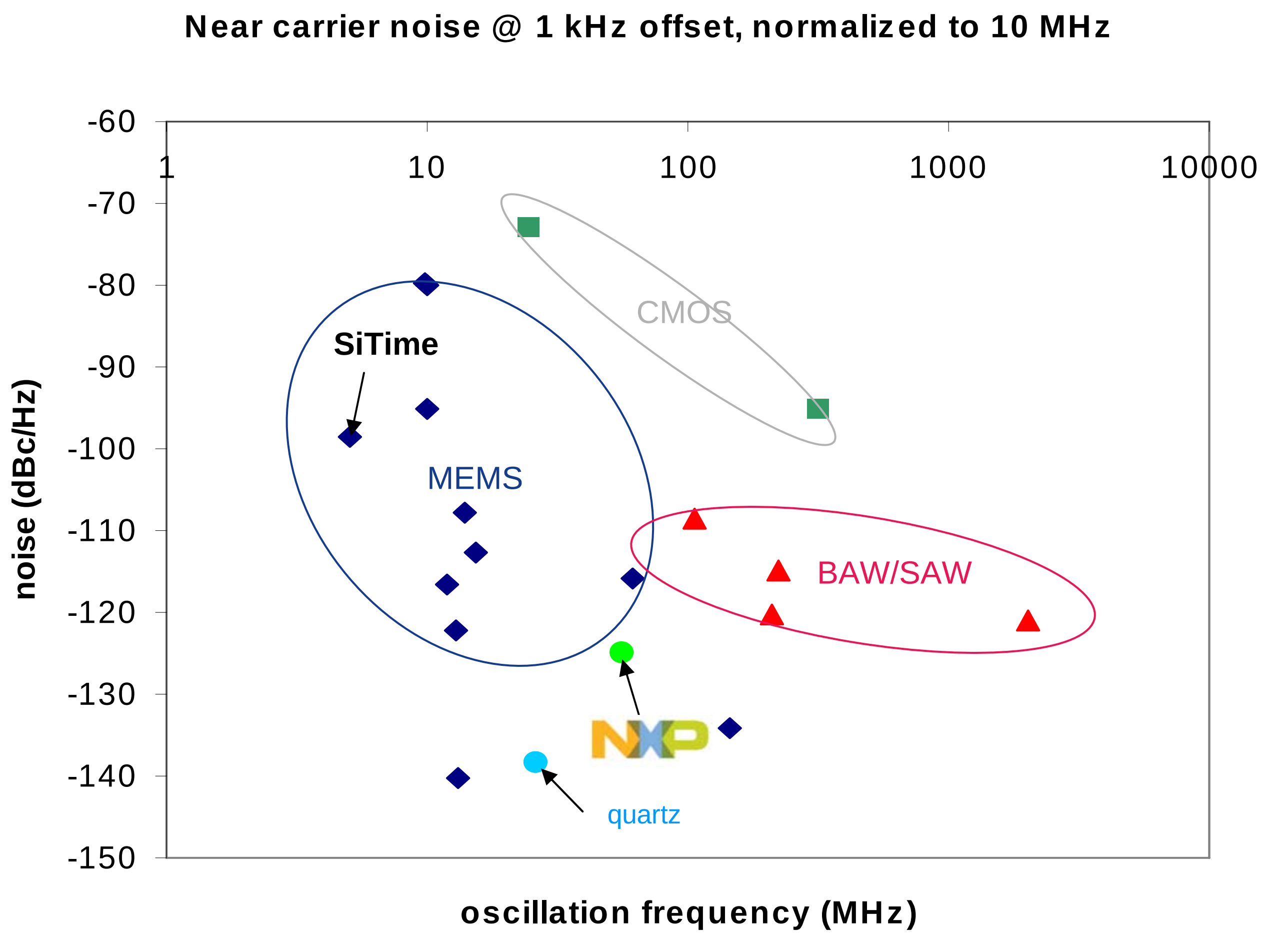
MEMS die with vacuum sealed resonator







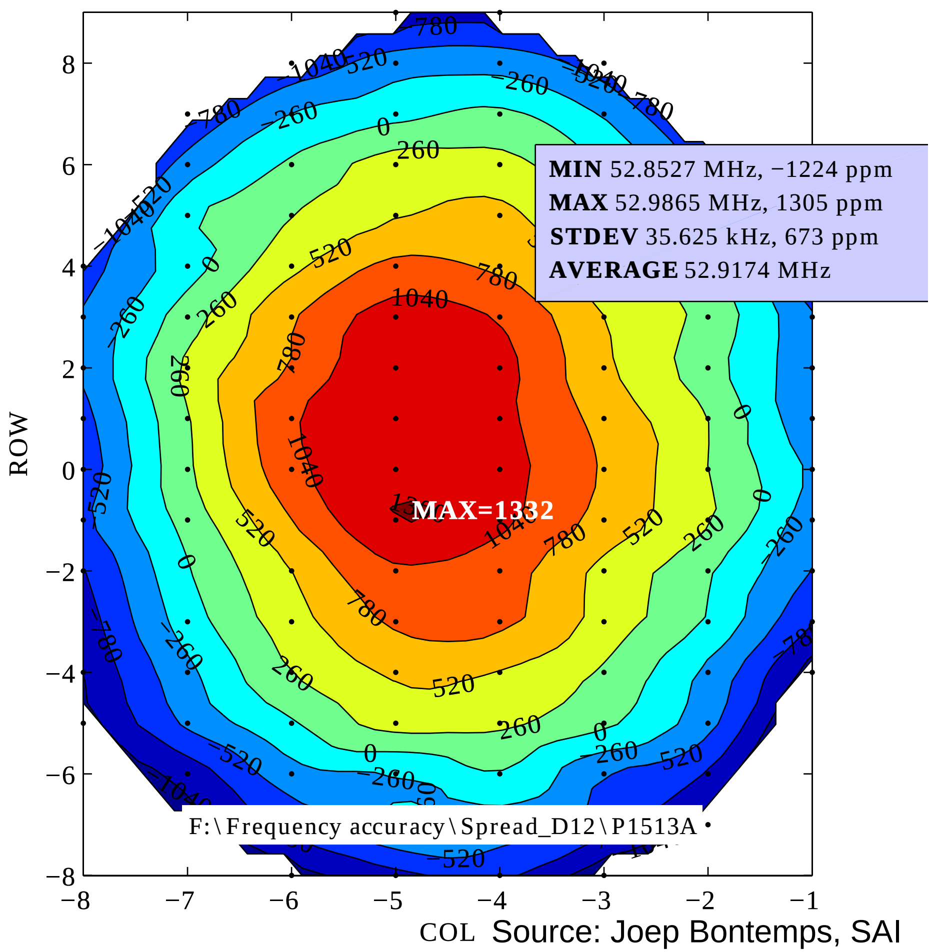
Side-band noise benchmark



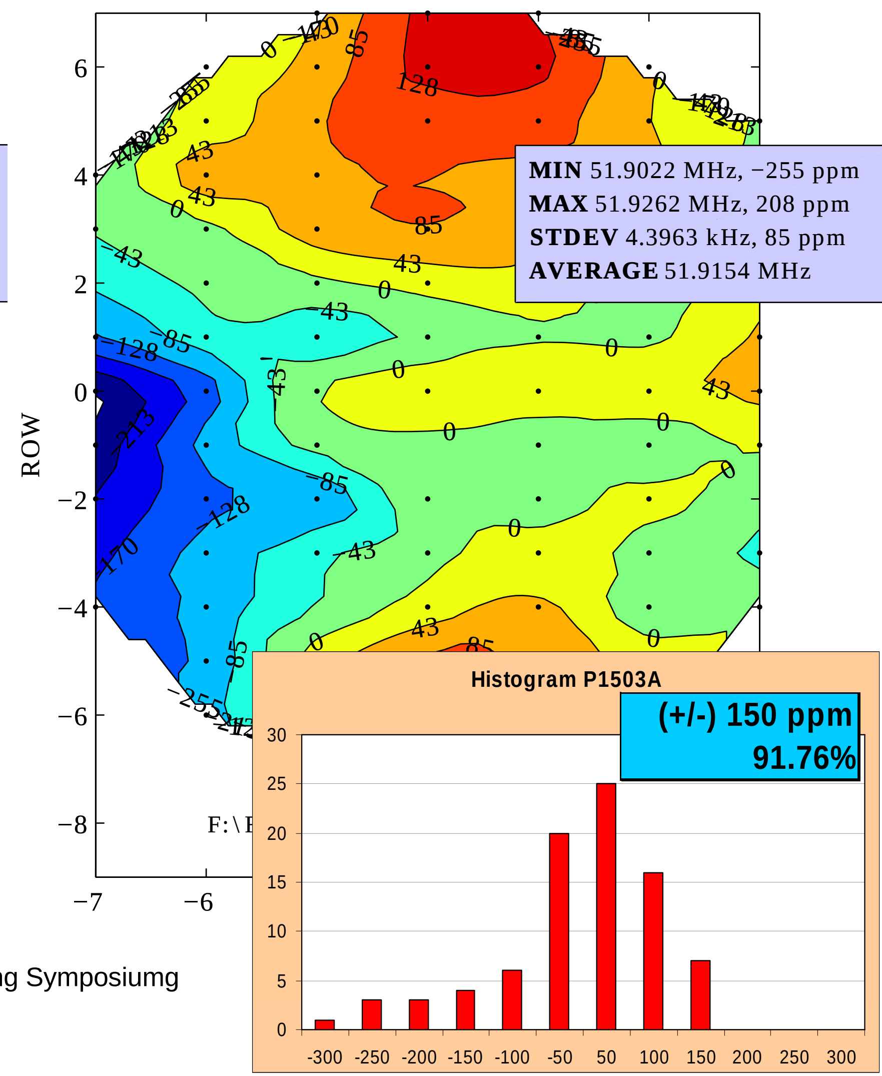
- Near carrier noise of NXP MEMS-XO is best in class

Process induced frequency spread

Uncompensated design

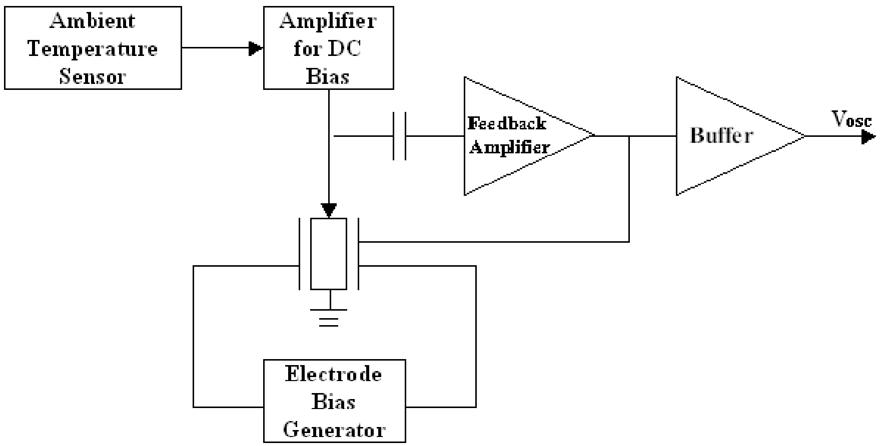


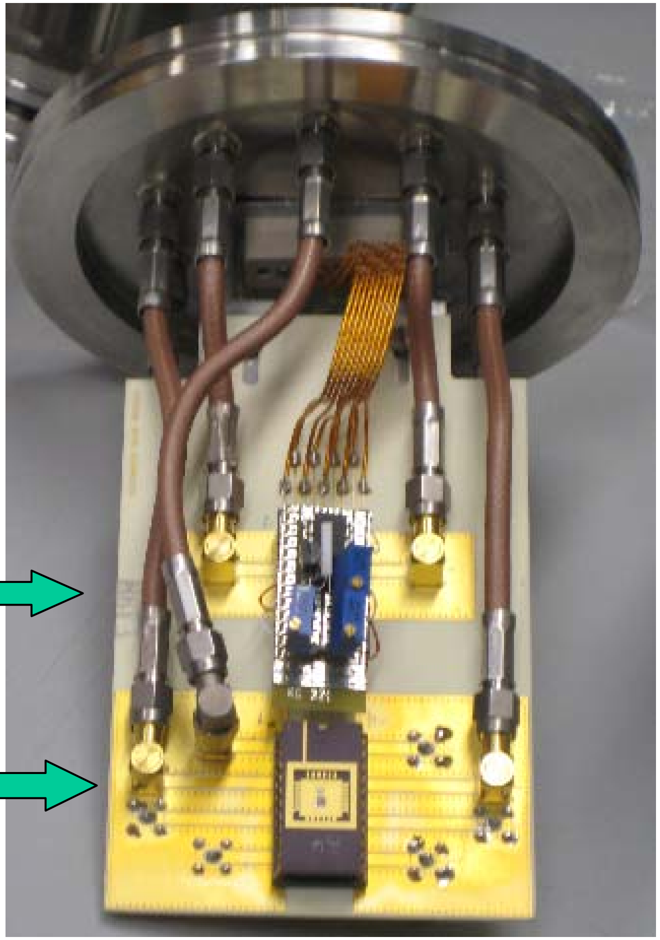
Compensated design



Source: Joep Bontemps, SAI

Temperature drift cancellation





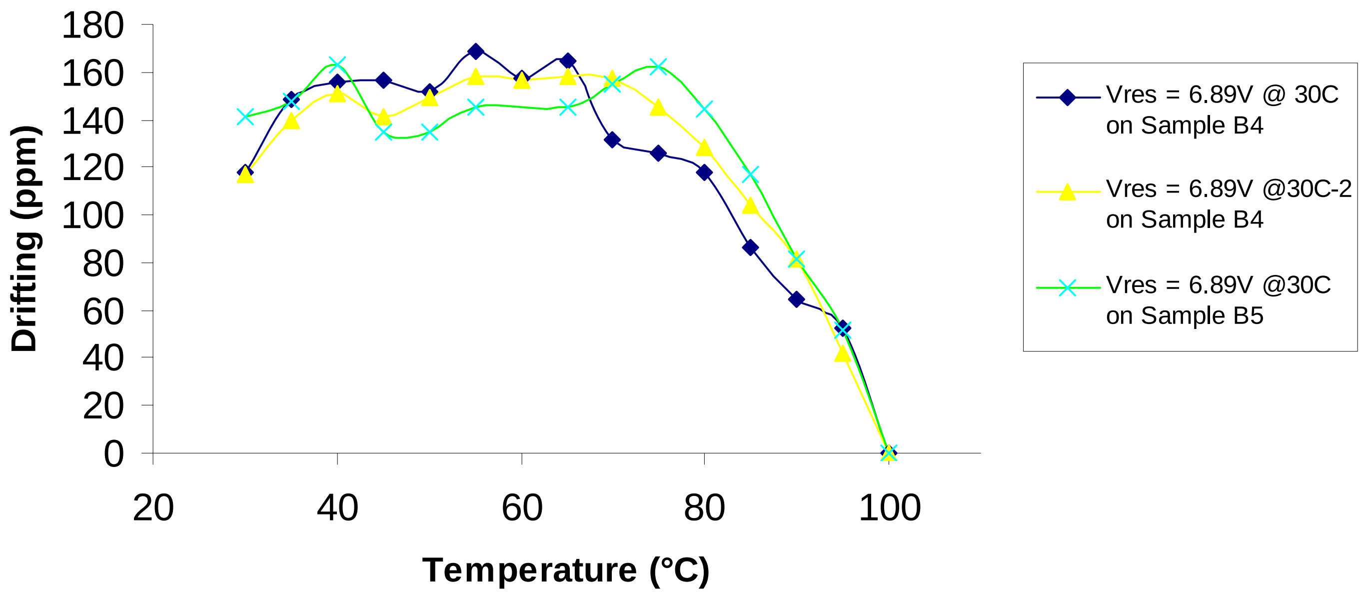
Temperature sensor &
Temperature controlled current source

Resonator

Source: Jan-Jaap Koning, Site Innovation Nijmegen

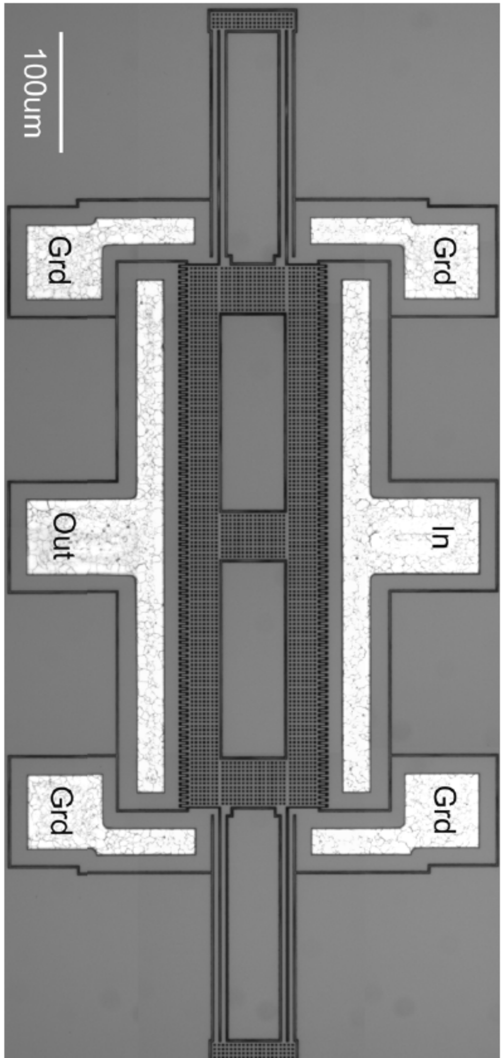
Low temperature drift…

- The drift from 30°C to 100°C has been decreased from 2200ppm to 170ppm

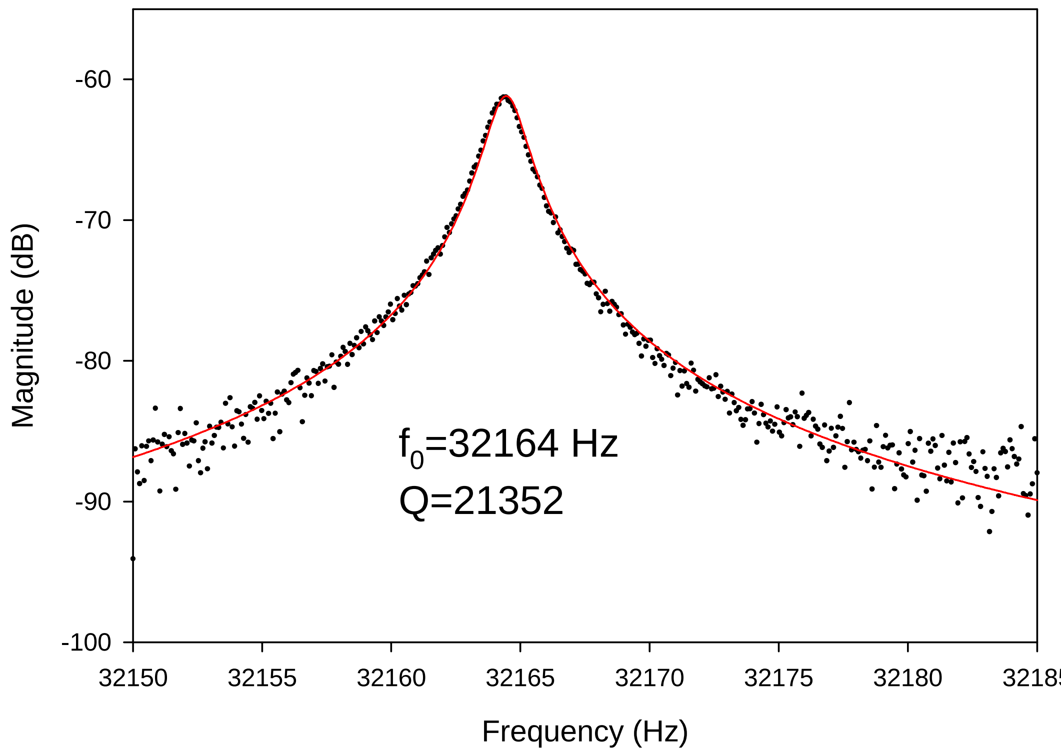


Source: Di Wu, Jan-Jaap Koning, Site Innovation Nijmegen

30 kHz resonator for real-time clock

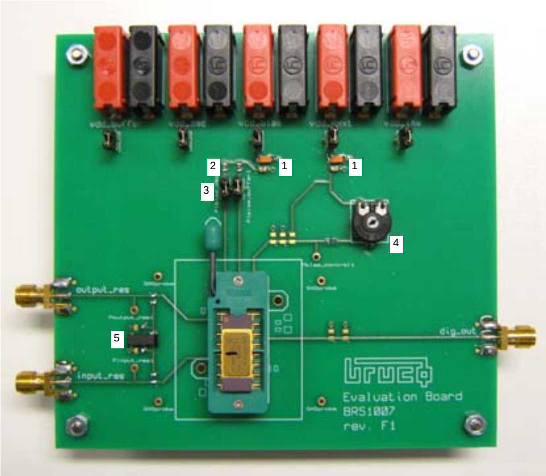


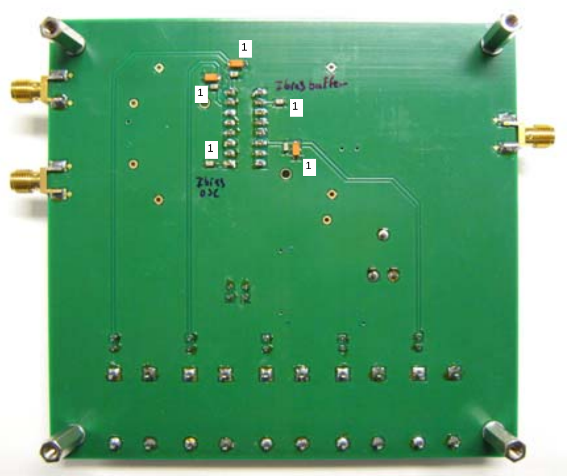
Shuttle 100 fingers, S100-15-10,
Vdc=1V, Vac=0.01V

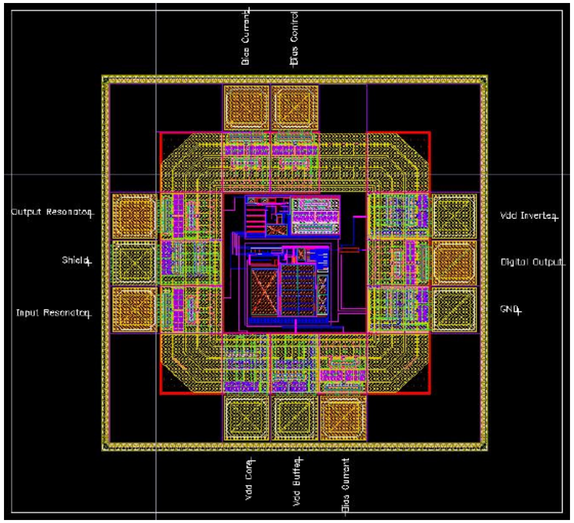


Real time clock demo

- Results of ASIC evaluation:
  - Power consumption: less than 1 uW.
  - Can handle resonators in a frequency range of 30 kHz up to 1 MHz.







Source: Jan-Wim Eikenbroek, Bruco

Conclusion

- MEMS is a disruptive technology in a well established and growing timing market
- MEMS allows for small and low cost thin-film package, replaces bulky metal can package
- MEMS offers low cost, small size, and SiP or SoC compatible quartz replacement opportunity
- MEMS phase-noise, manufacturing accuracy, and temperature drift are competitive with low- and mid-end quartz based oscillators

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