

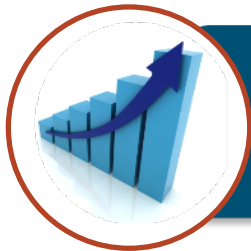
World's Smallest MEMS CSP TCXO for Mobile Applications

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Manager, Systems Design
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SiTime – Leader in MEMS Timing



**\$5 Billion
Timing Market**

Market CAGR – 5%
MEMS CAGR – 65%



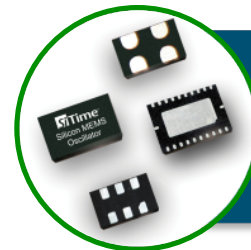
**MEMS, Analog,
Systems Leader**

100 Patents; 2-Year Lead



Market Leader

200MU Shipped, 100 Major OEMs
80% Share of MEMS Timing



Product Leader

Programmable – 200K Part Numbers
ASP from \$0.30 – \$15

High-Volume Markets Using SiTime



Consumer



**Mobility +
Wearables + IoT**



Computing-Storage



Industrial



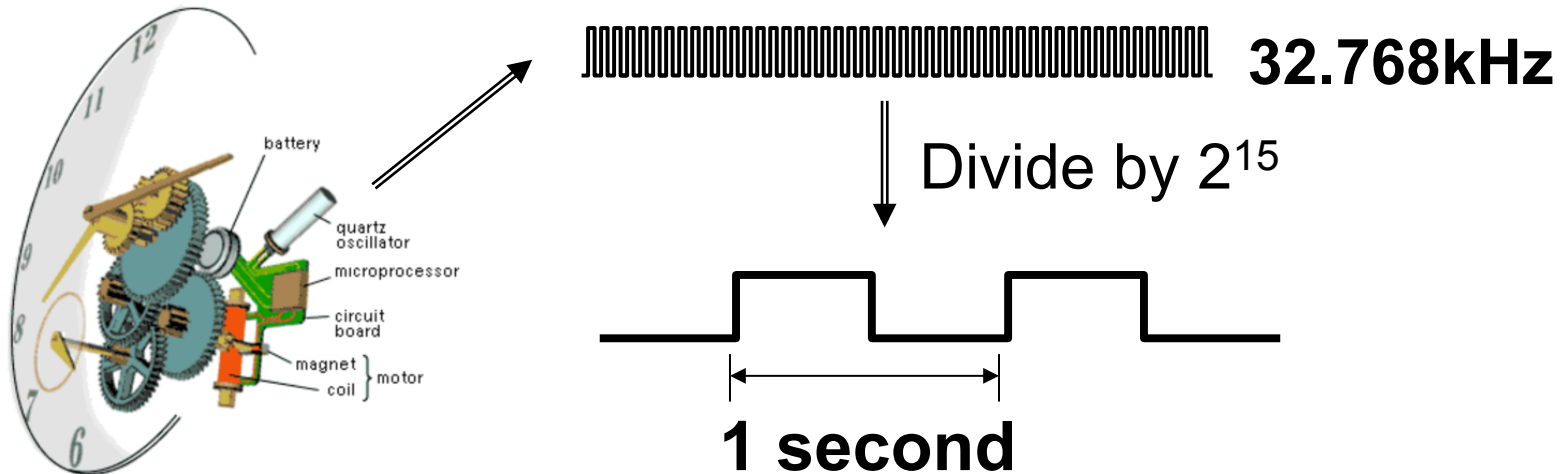
Wireless Telecom



Networking

32kHz Clocks are Ubiquitous

- 32.768kHz clock for time keeping; 6B units used per year



Requirements

Solution

Small Size

→ MEMS Technology

Low Power

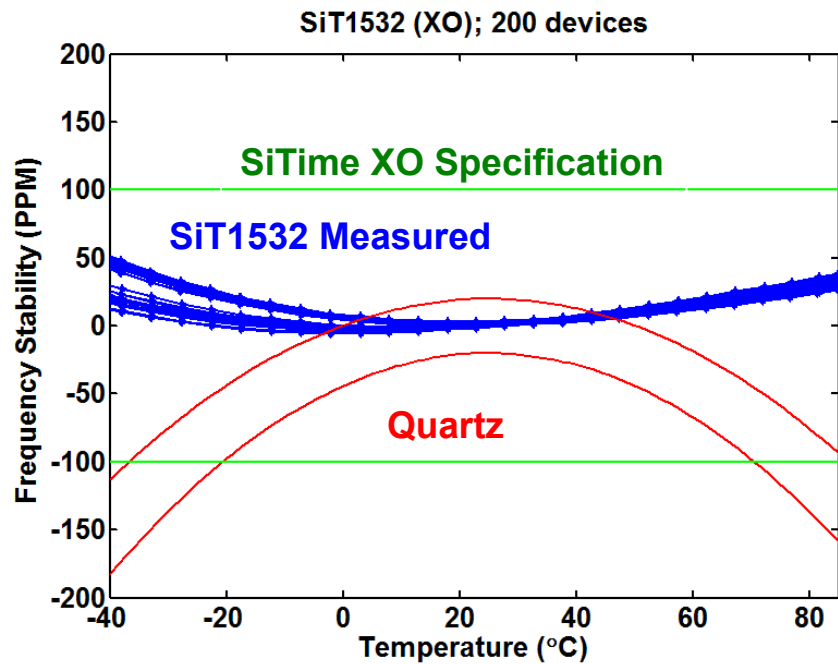
→ + CMOS Techniques

High Accuracy

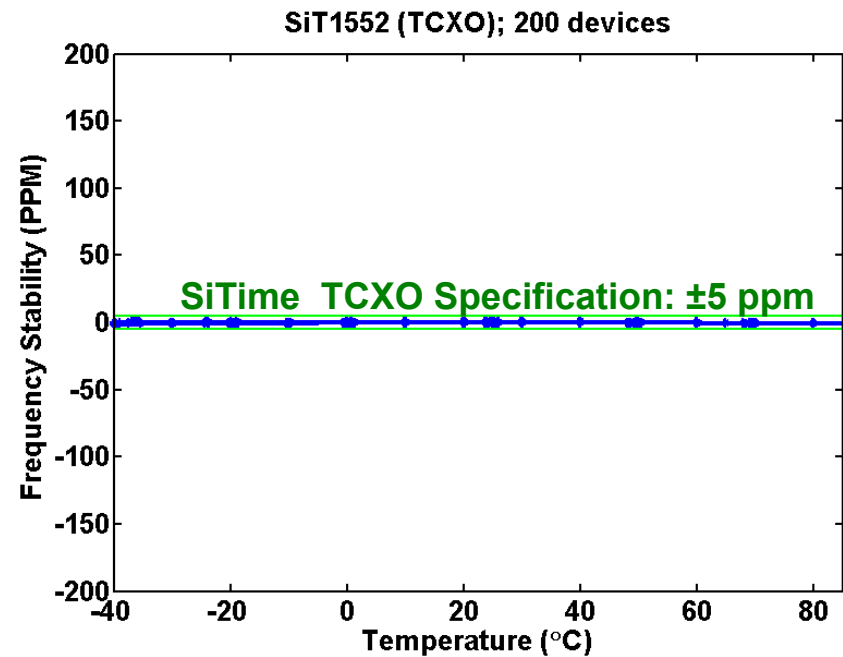
→ + Temp Compensation Engine

SiTime Delivers Best-in-Class Stability

SiT153x 32kHz XO (± 100 ppm)



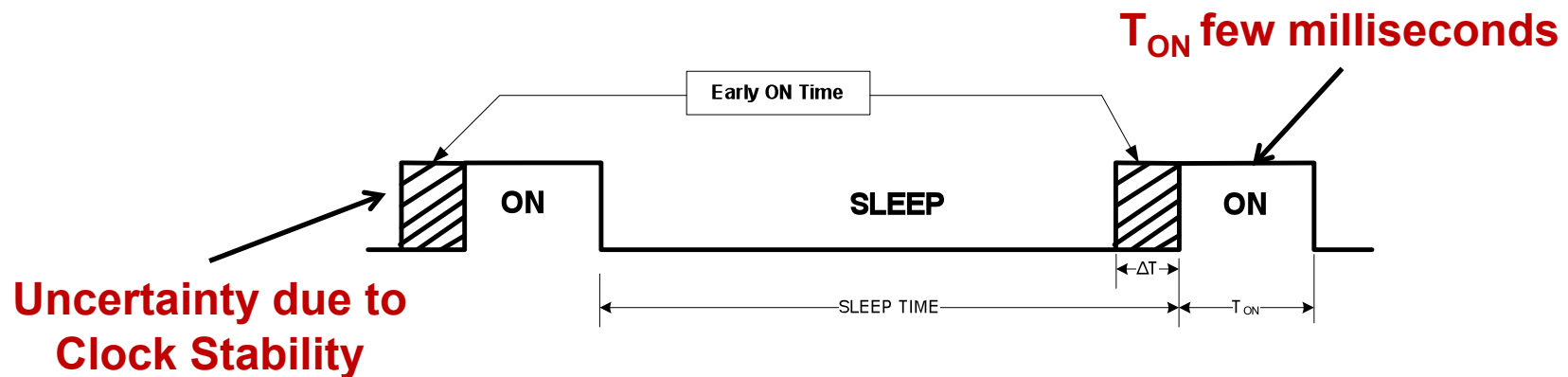
SiT1552 32kHz TCXO (± 5 ppm)



5 ppm TCXO Extends Battery Life

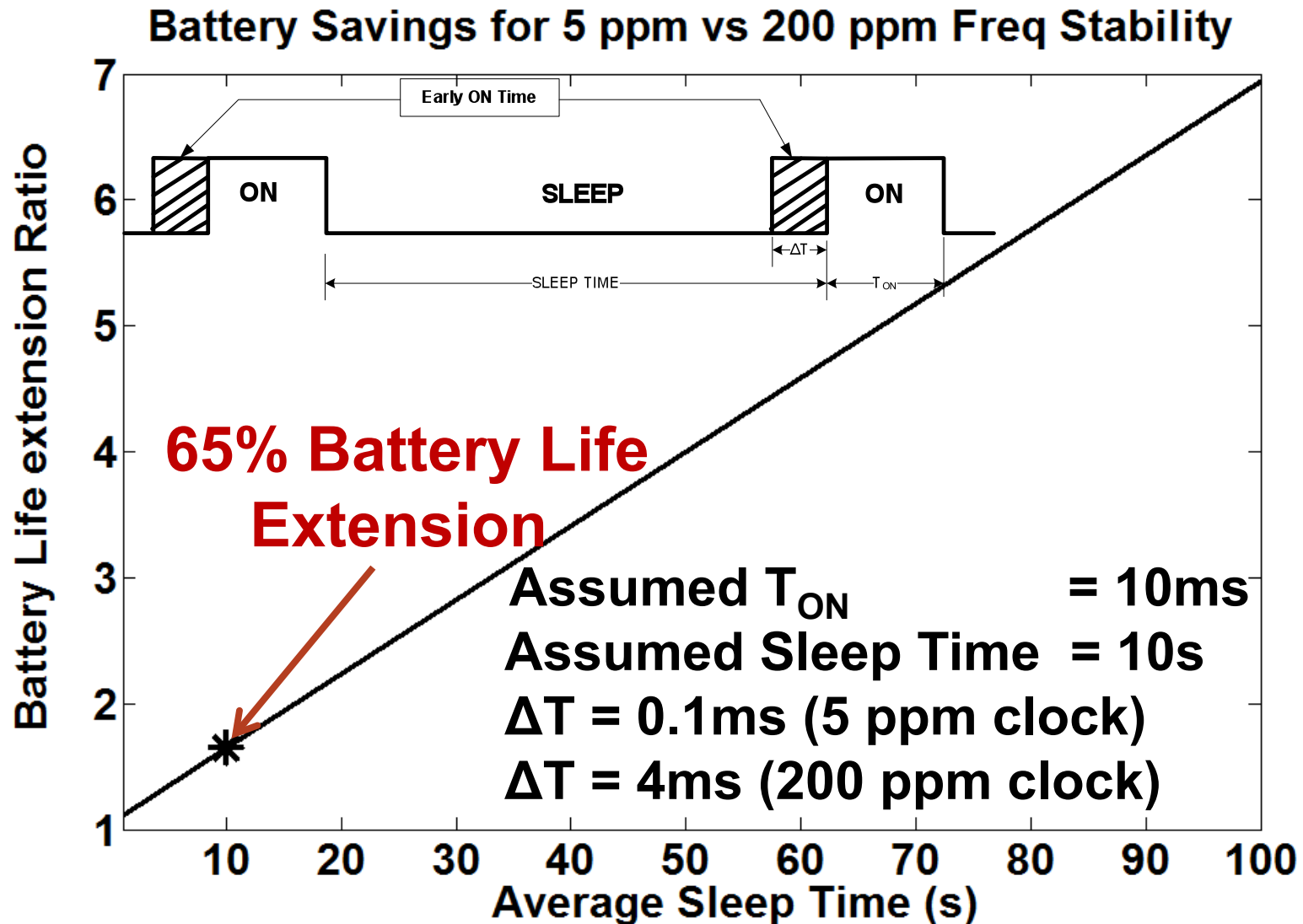


- Clock Stability affects Early ON (ΔT)
 - $\Delta T = (\text{Clock Stability}) * (\text{Sleep Time})$
- Early ON time (ΔT) causes power penalty
- 5 ppm 32kHz sleep-clock enables longer sleep duration and maximizes battery life
- Tighter Stability \rightarrow Longer Sleep Time \rightarrow Lower Power

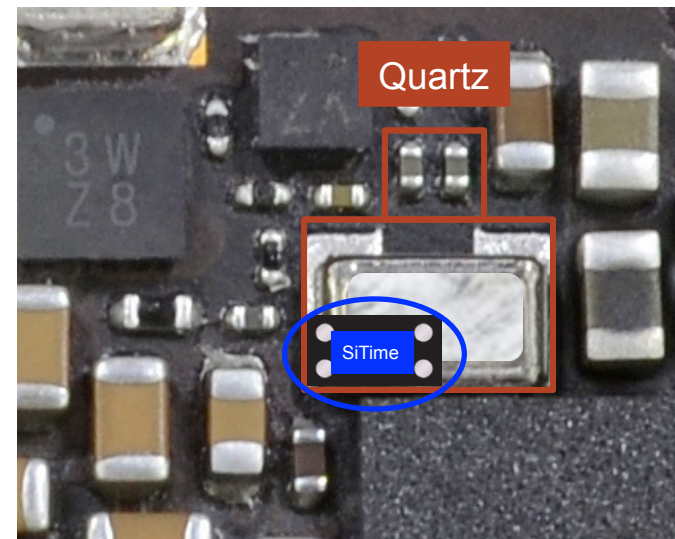


**Average Power is proportional to the ratio of
"ON" time to "Sleep" time**

5 ppm TCXO Extends Battery Life

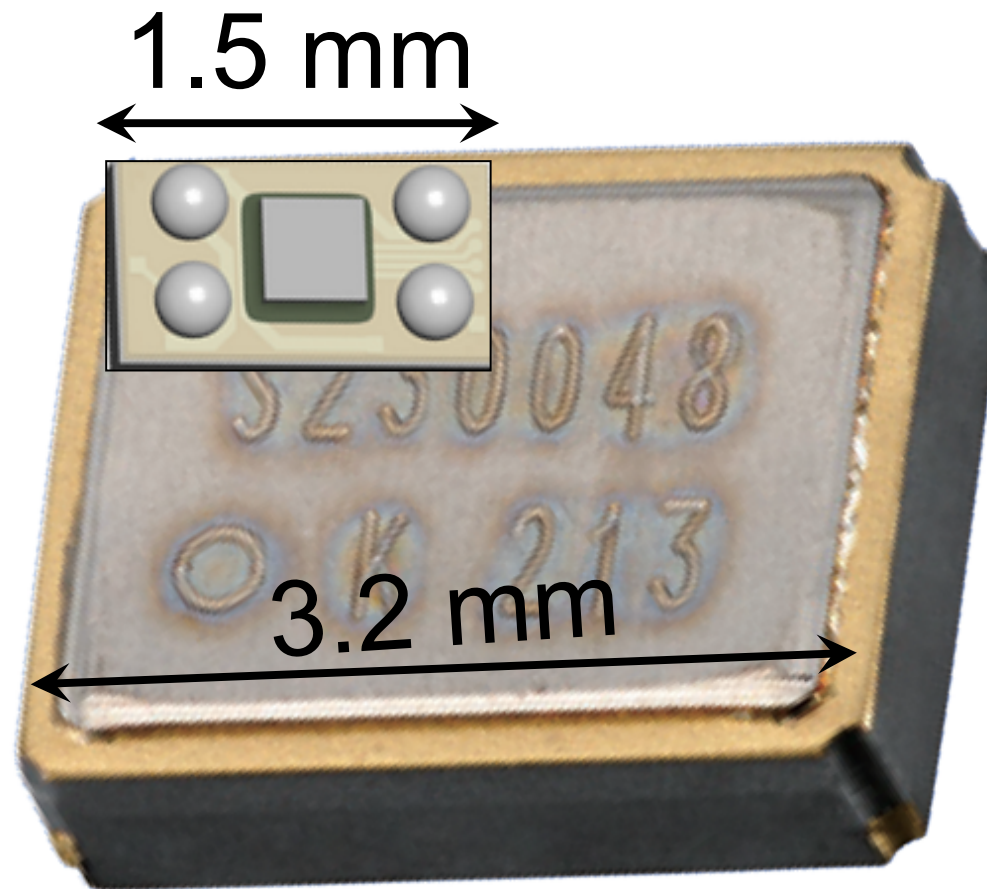


Smallest 32kHz XO in Production



3.8x smaller
than smallest
XO!

Smallest 32kHz TCXO in Production



6x smaller than smallest 5ppm TCXO!

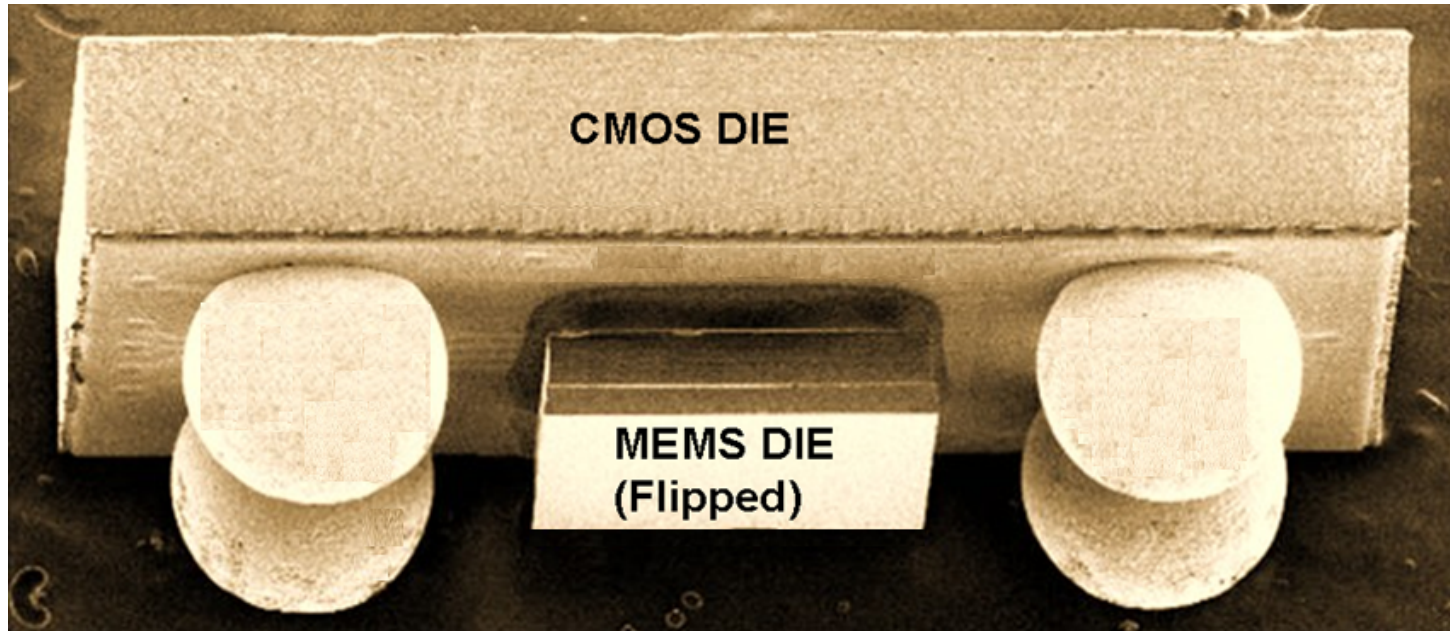
Size Comparison to Quartz Solutions



32kHz Clocking Solutions in Production

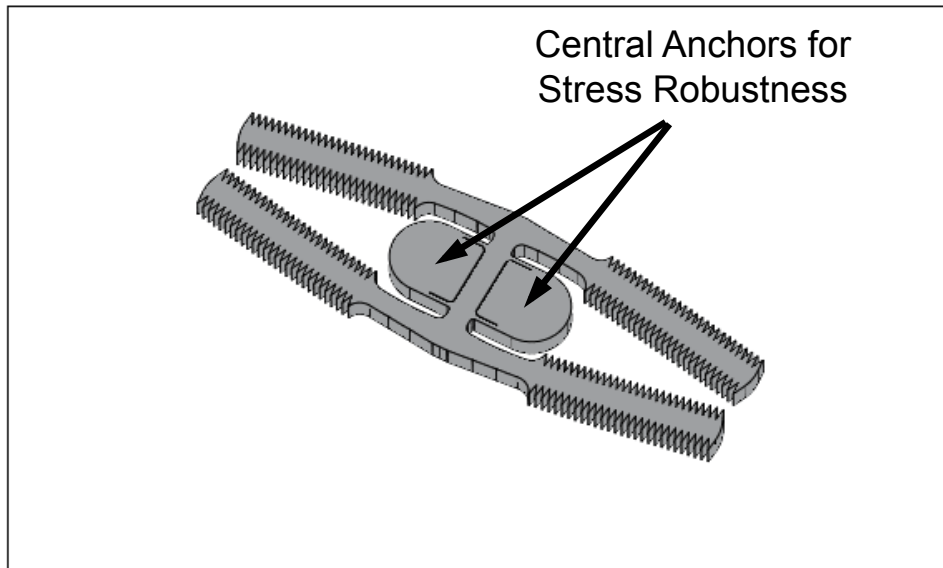
	SiTime TCXO	Smallest Quartz XO XTAL	Smallest Quartz TCXO
Package Footprint w/ Caps	1.3mm ²	5mm ²	10mm ²
Load Capacitors	No	Yes	No
Load Dependent Start-up	No	Yes	No
Bypass Caps	No	No	Yes

Inside the Smallest 32kHz TCXO

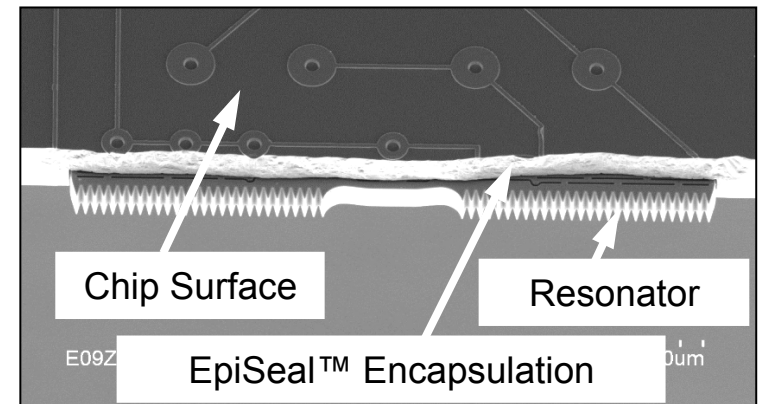
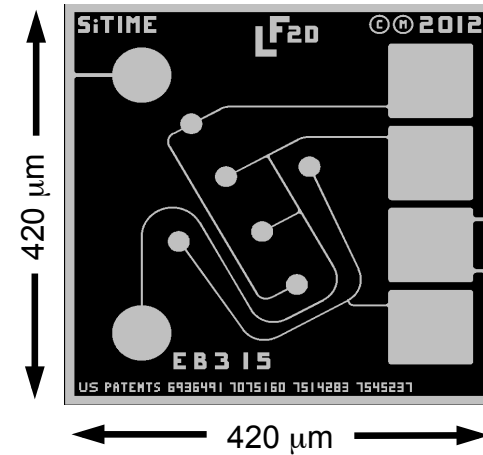


1.55mm x 0.85mm x 0.55mm
length x width x height

524kHz TempFlat™ MEMS Resonator **SiTime**

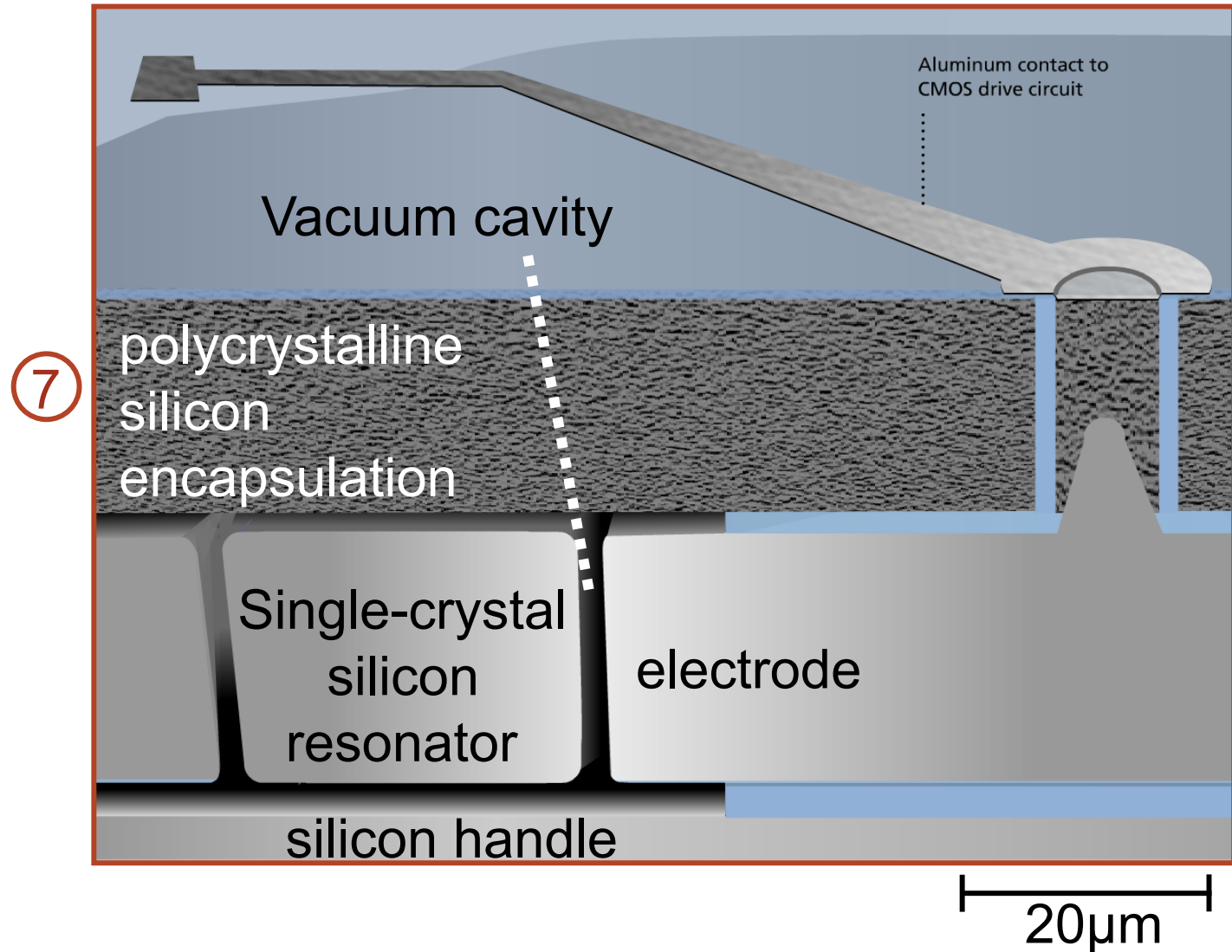
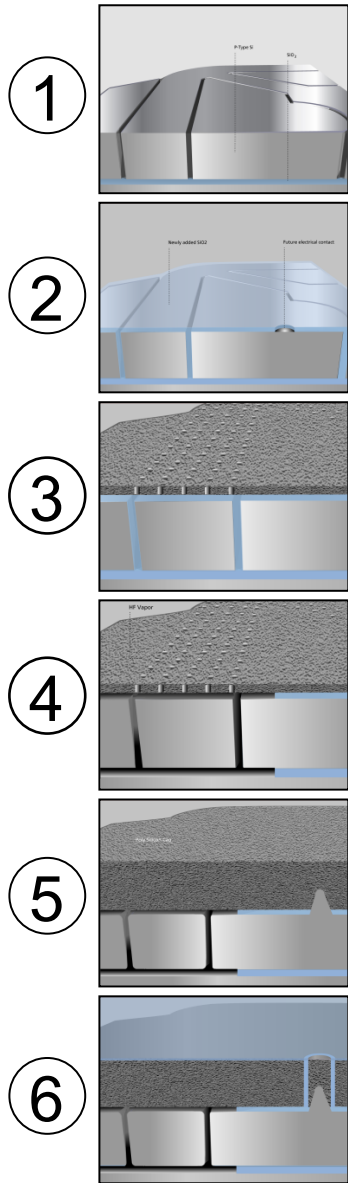


524kHz TempFlat™ MEMS Resonator

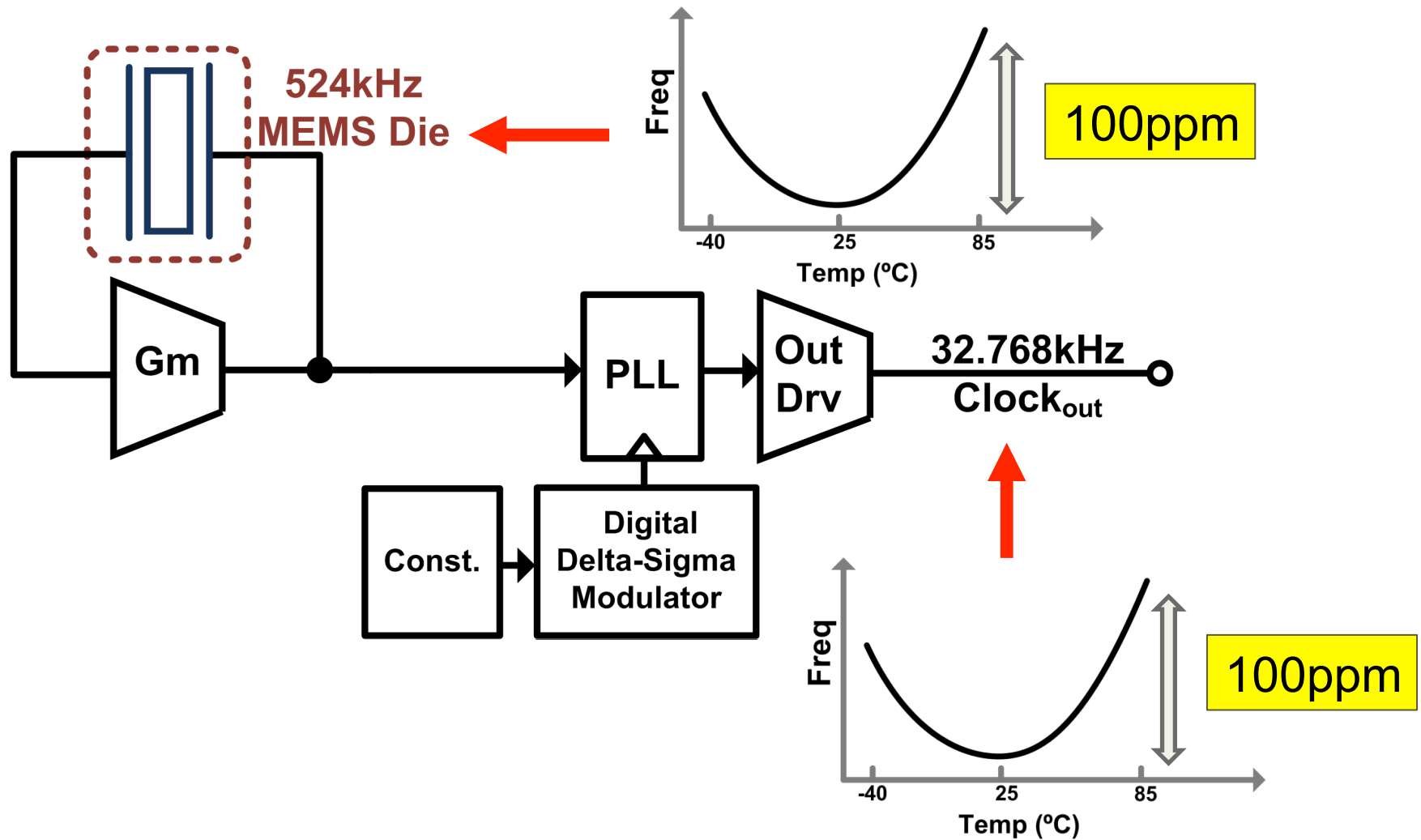


- Stable: Frequency within 100 ppm without temp sensor
- Reliable: No aging, no fatigue
- Manufacturable: Standard 200 mm CMOS fab

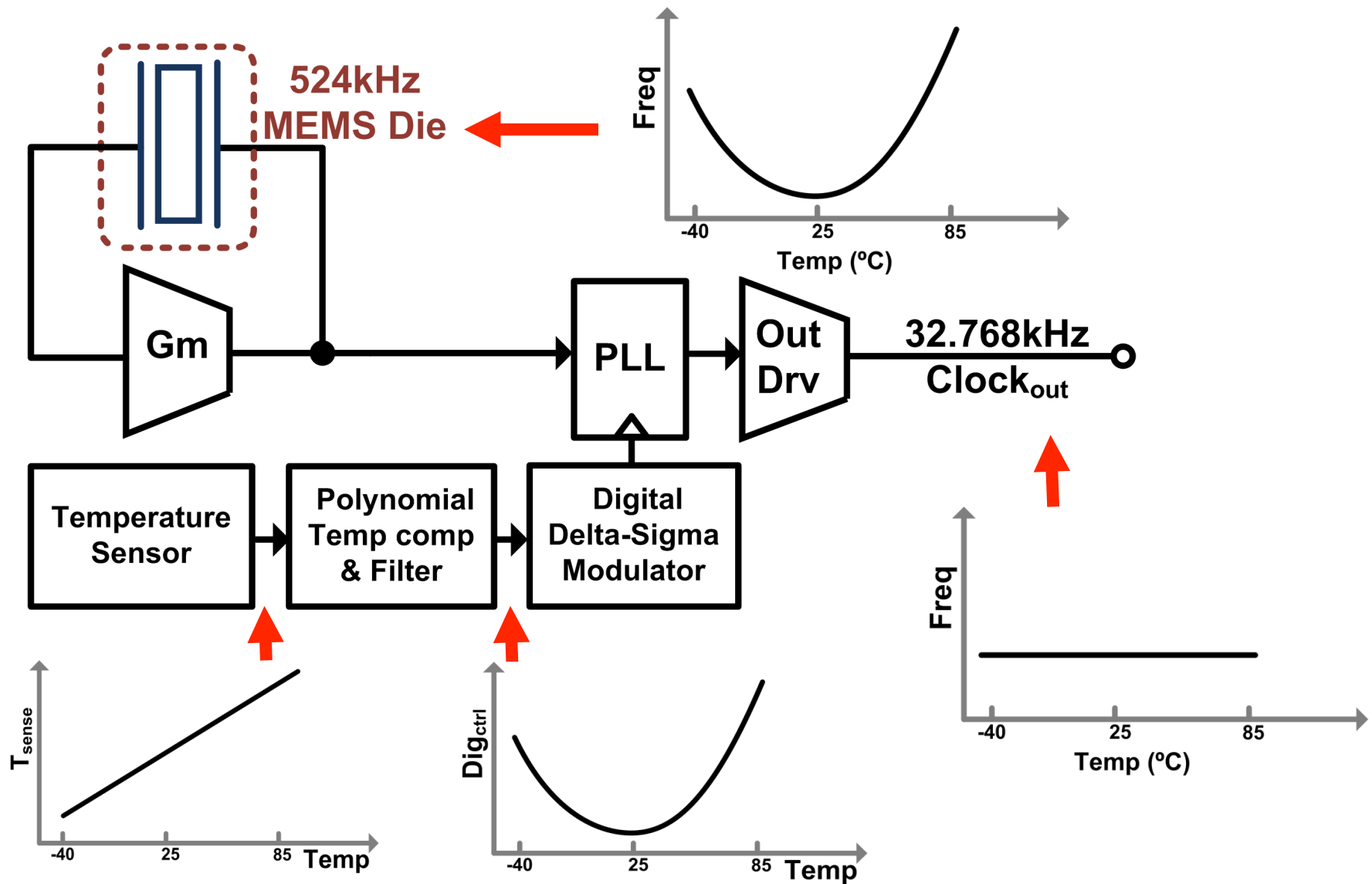
SiTime Episeal™ Encapsulation



32kHz XO Architecture

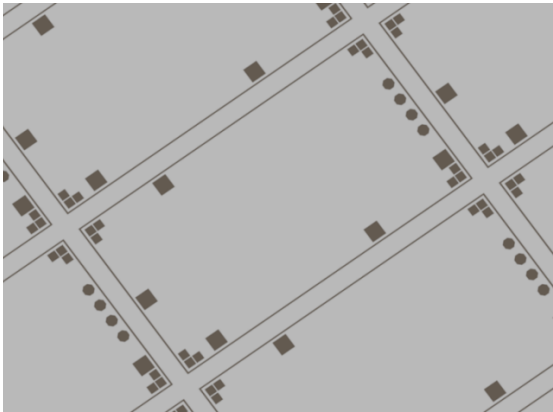


32kHz TCXO Architecture

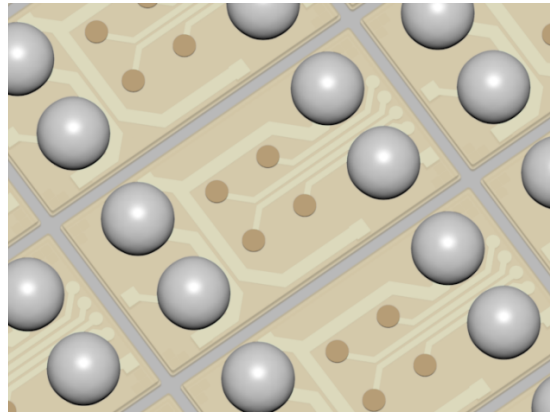


2-die CSP Packaging Flow

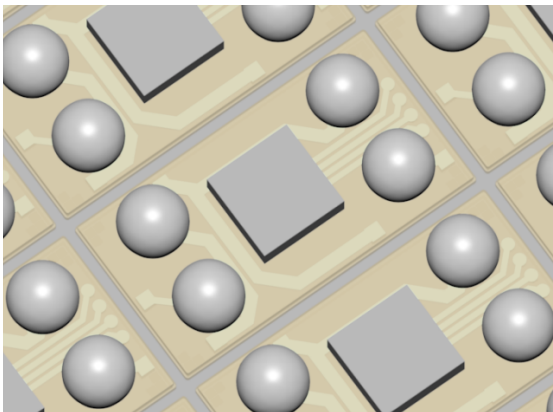
- All packaging steps are done at wafer level
- High die count per wafer enables high volume production



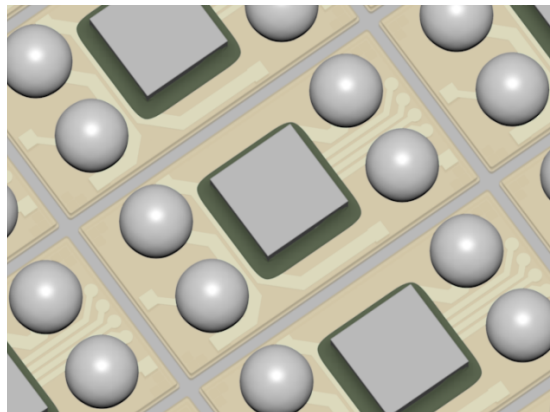
1. CMOS wafer



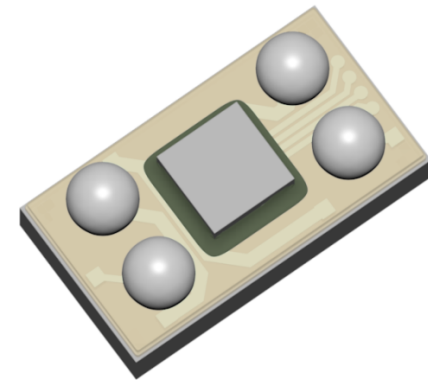
2. Solder ball mounting



3. Flip-chip attach MEMS die



4. Underfill application



5. Final test and singulation

CSP Construction Analysis

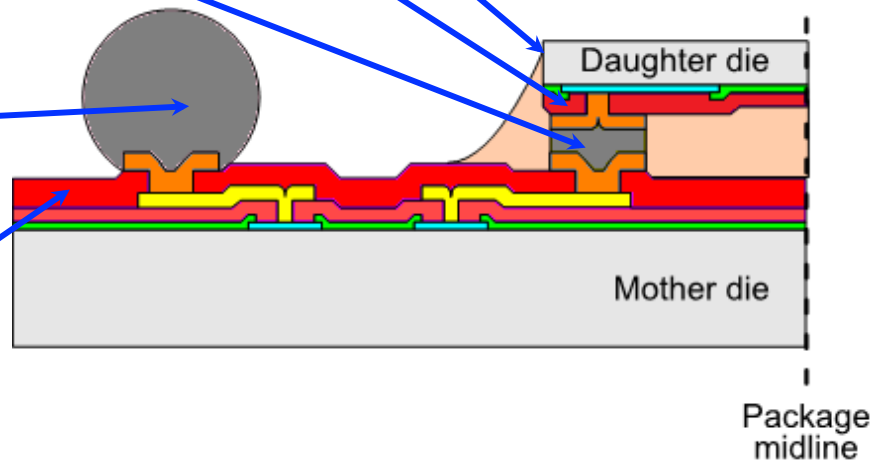
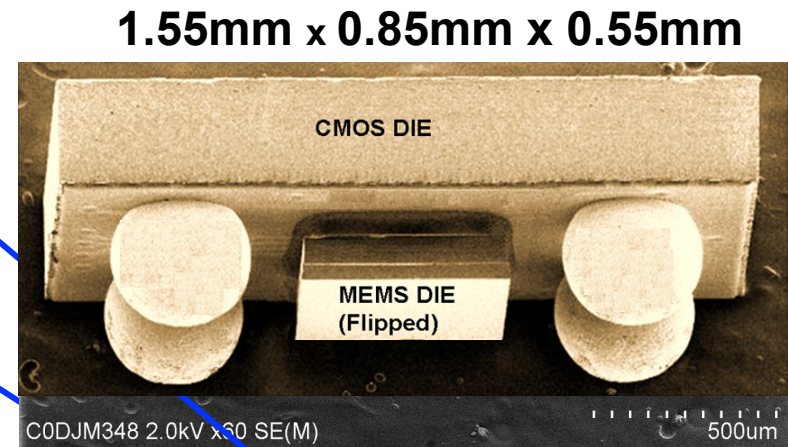
Flip-chip :
Shear strength: Cpk > 10

Daughter die repassivation:
CD tolerance: Cpk = 3.0

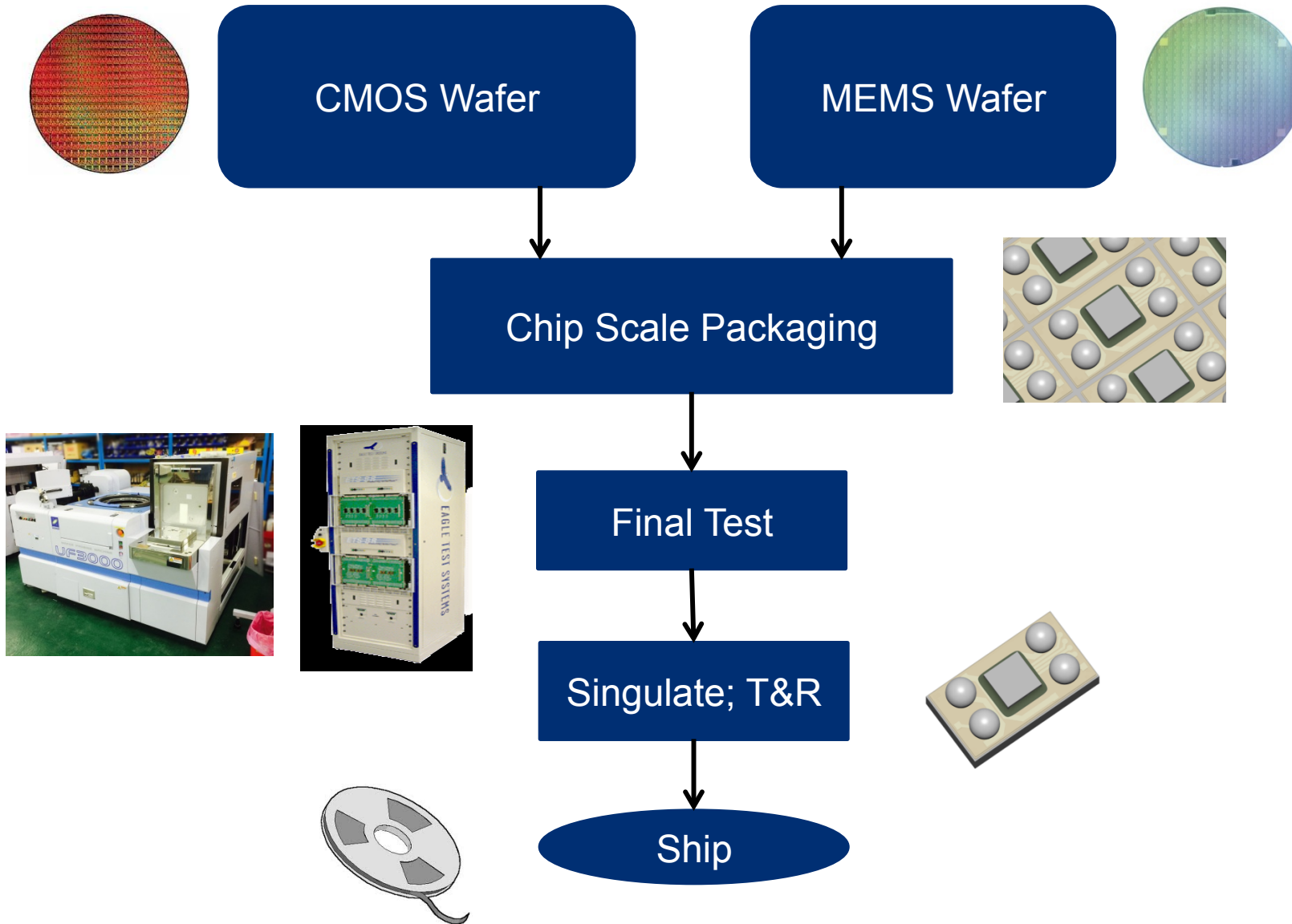
Flip-chip solder ball:
Height: Cpk = 2.75
Width: Cpk = 2.04
Shear: Cpk = 2.08

Package solder ball:
Height: Cpk = 2.96
Width: Cpk = 2.41
Shear: Cpk = 2.06

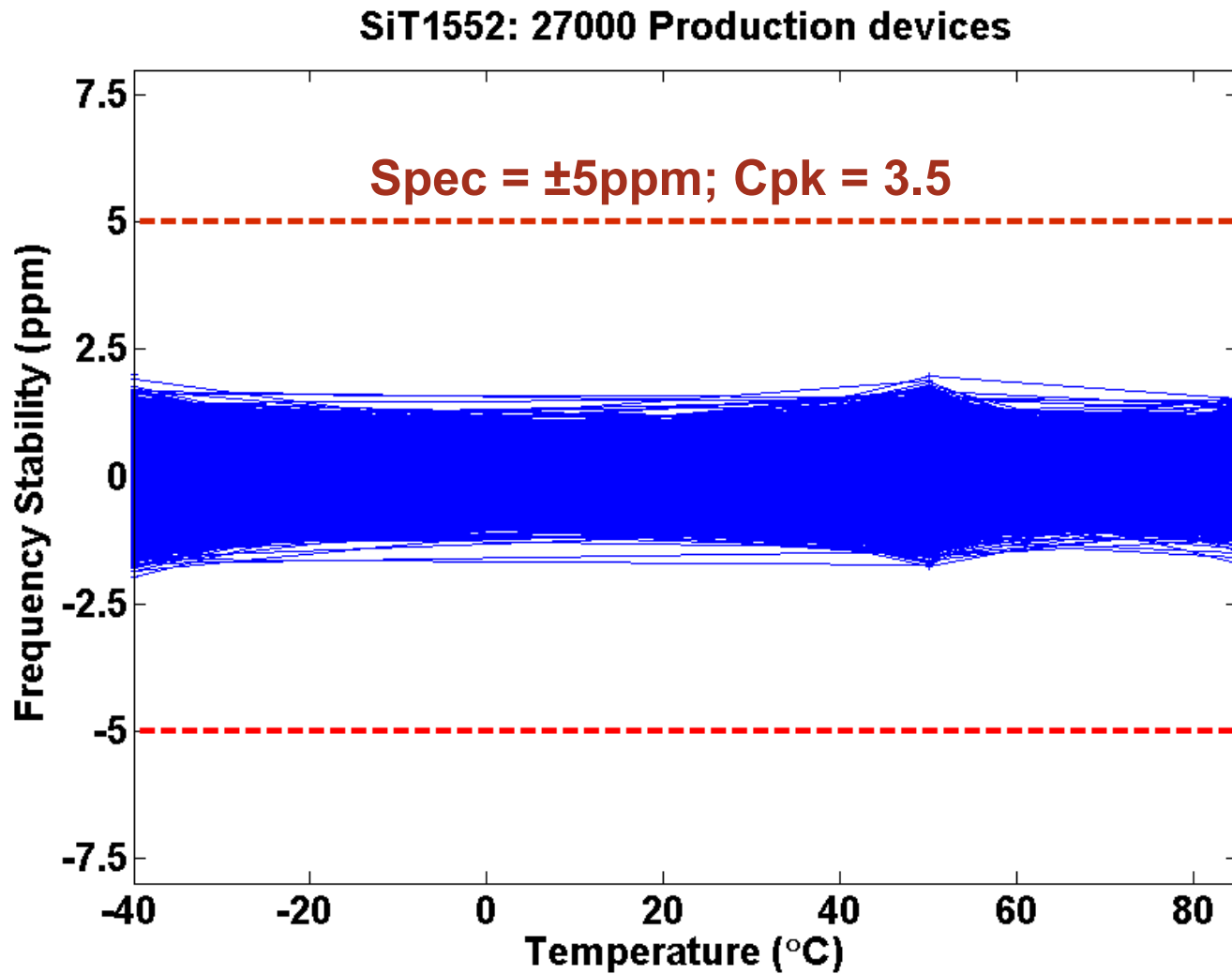
Mother die repassivation:
CD tolerance: Cpk = 4.5 min



Production Flow



Production Results: Frequency Stability



SiTime TCXO Specifications



Parameter	SiTime SiT1552	Kyocera KT3225T	Epson TG-3530
Frequency Stability (ppm)	± 5	± 5	± 5
Temperature Range (°C)	-40 to 85	-40 to 85	-20 to 70
Area (mm ²)	1.3	8	50.5
Current (µA)	1 typ 1.5 max	1.5 typ 4 max	1.7 typ 4 max
Start up Time (s)	0.3	3	3
Supply Sensitivity (ppm/V)	± 0.25	± 1	± 1

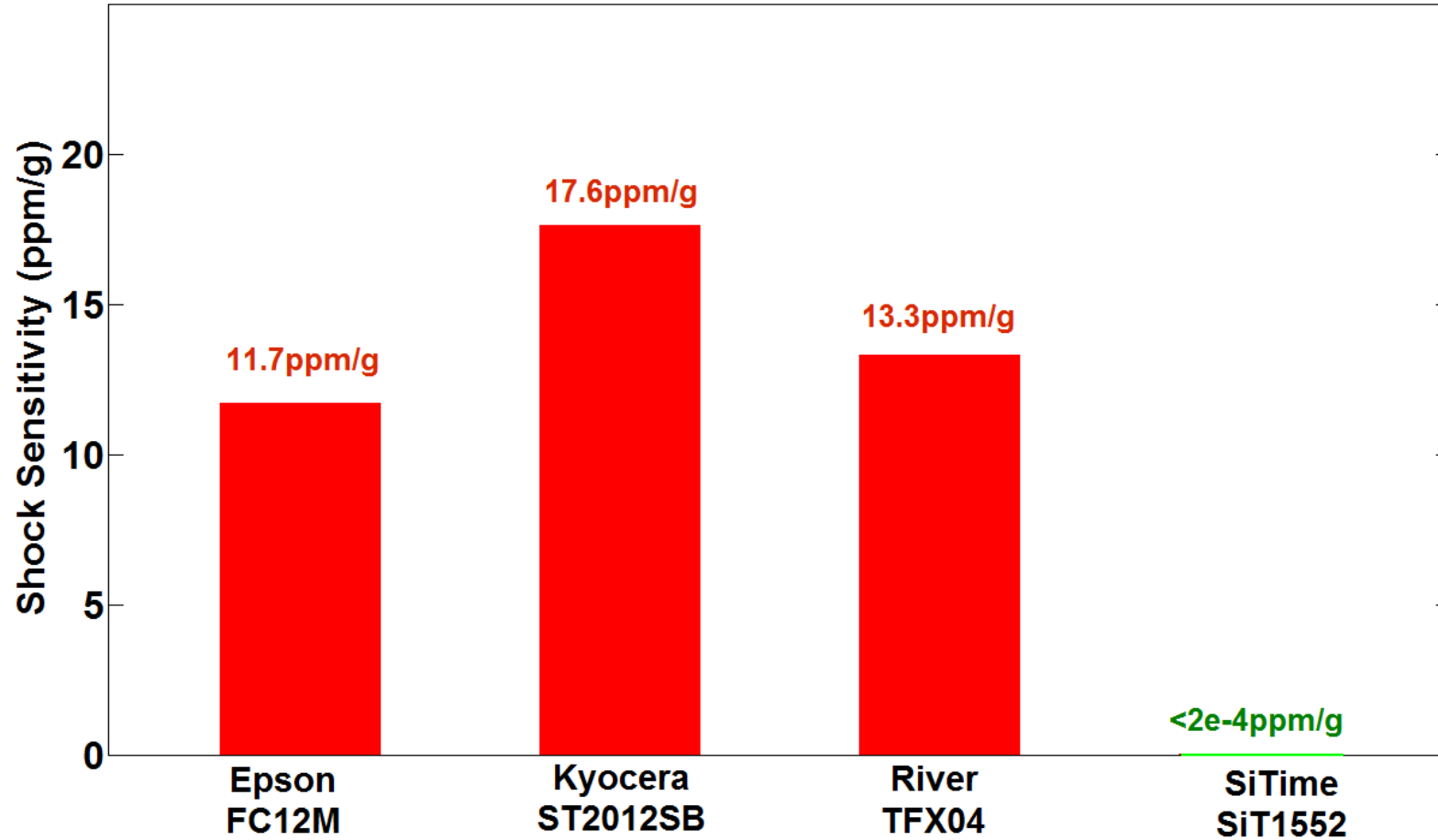
Reliability



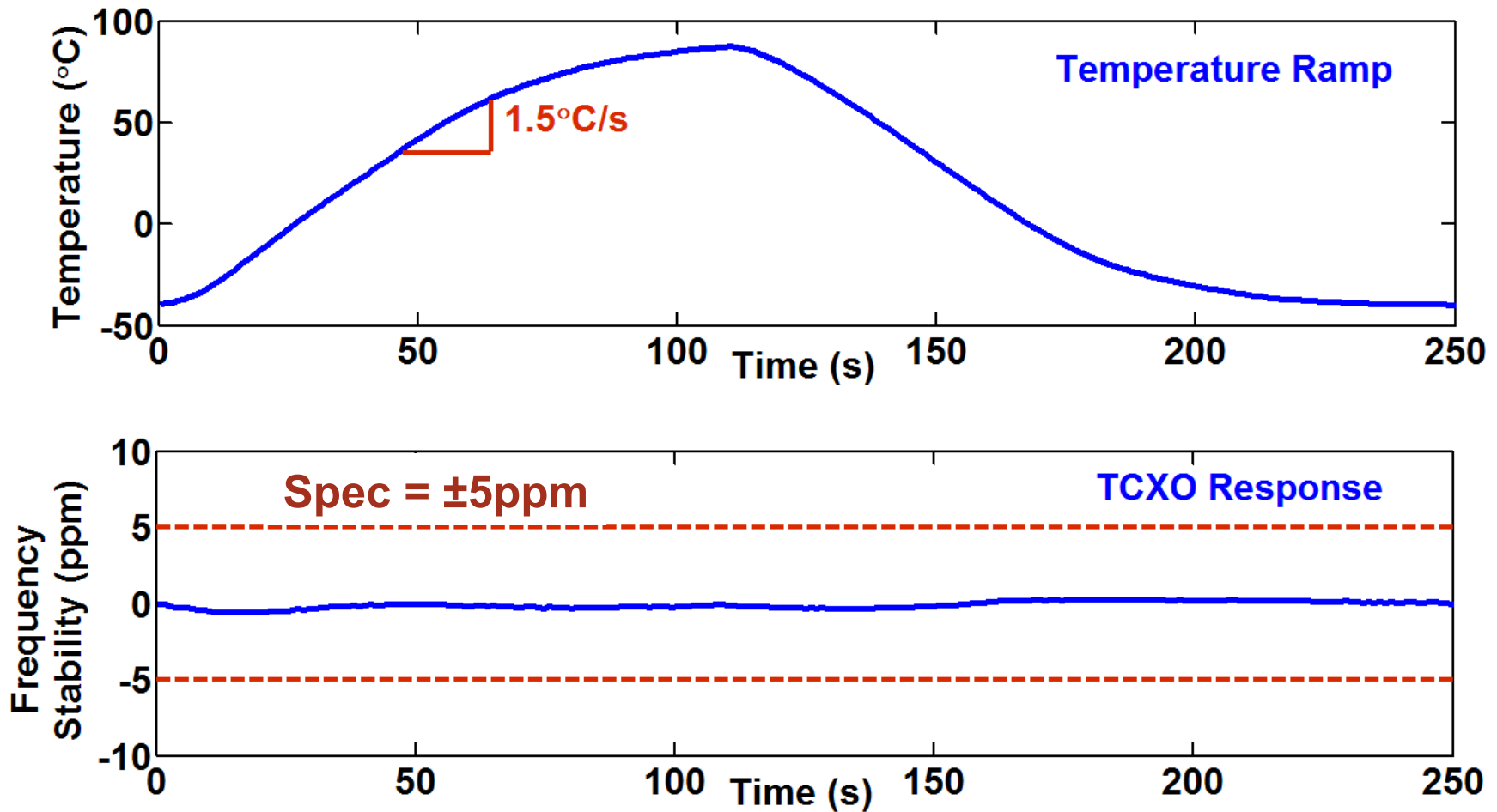
Shock Robustness



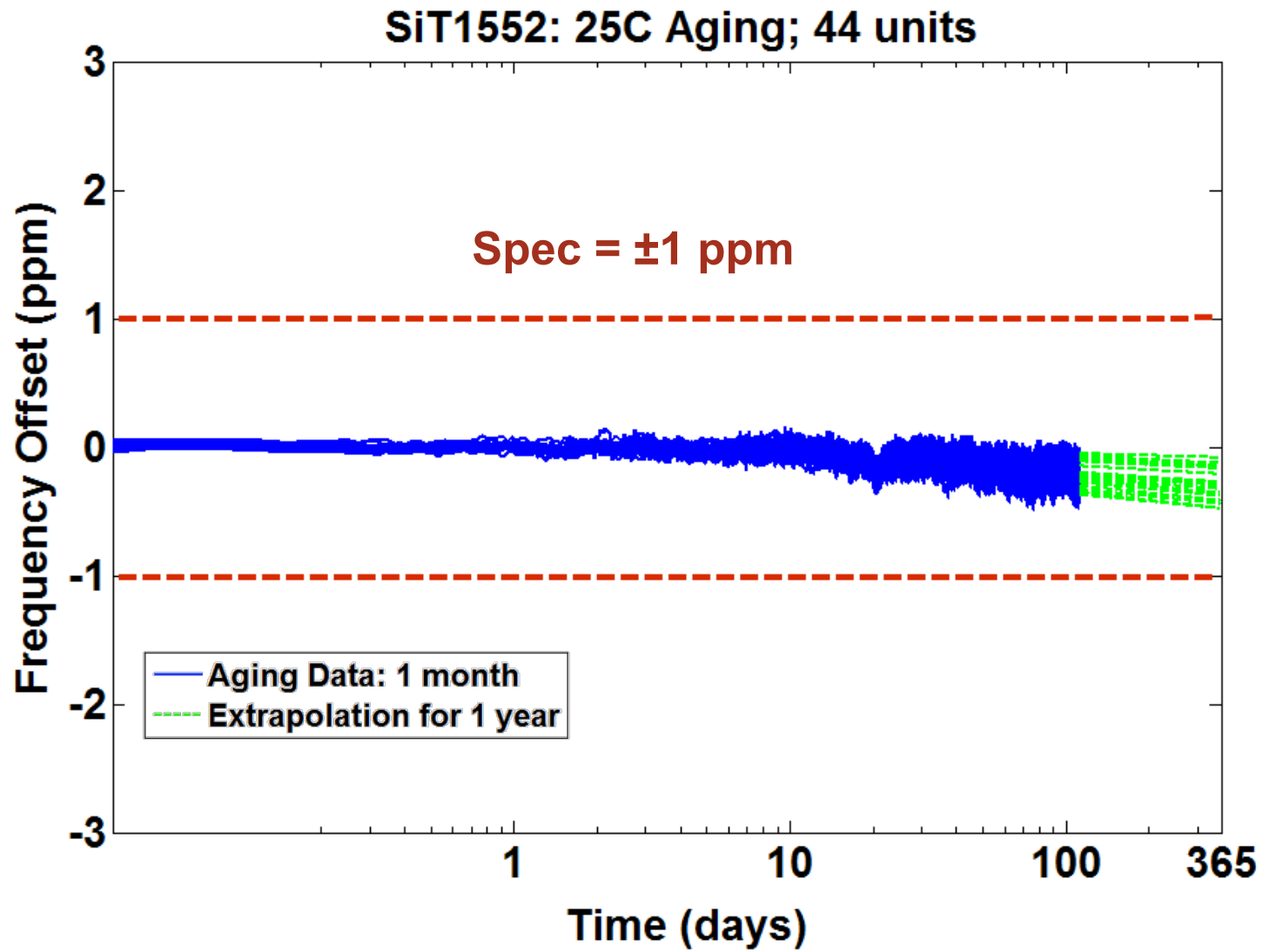
SiT1552 Shock Sensitivity Compared to Quartz



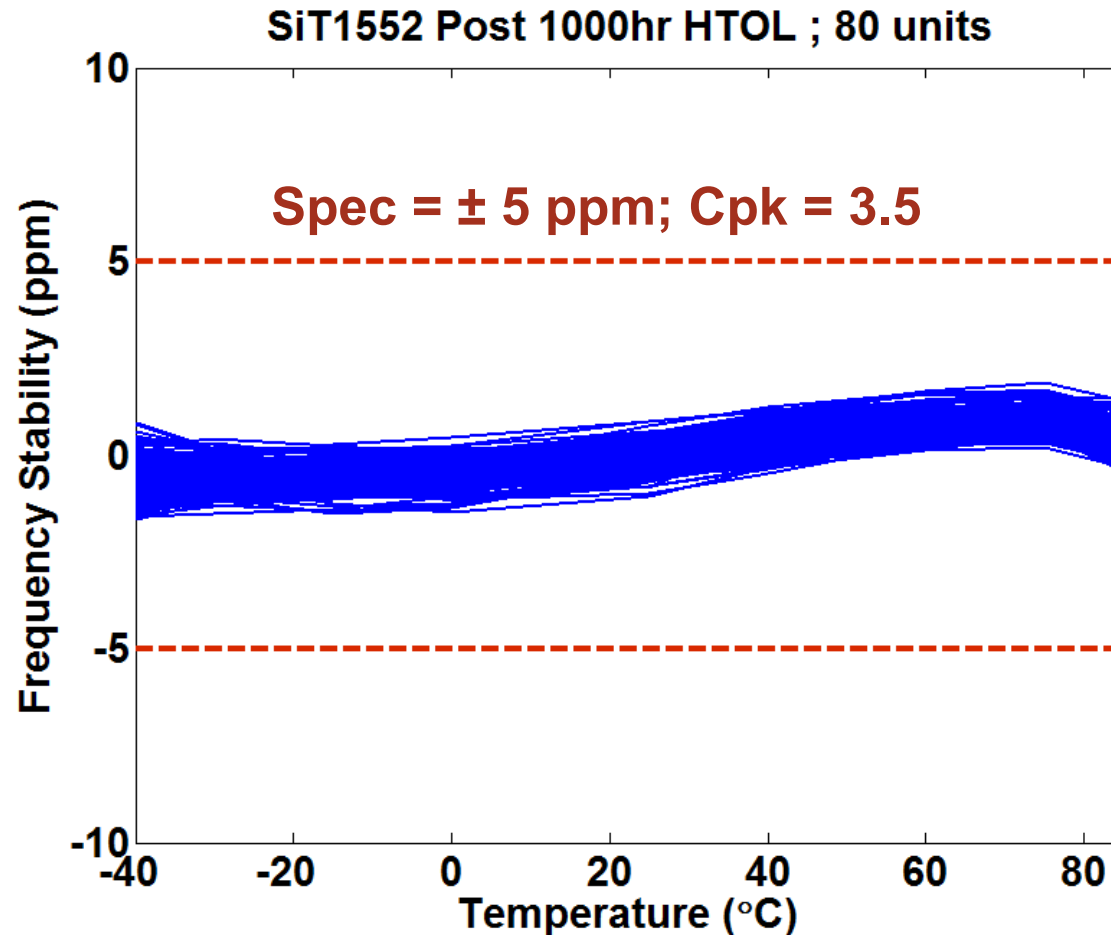
Fast Temperature Ramp Response



1-year Aging

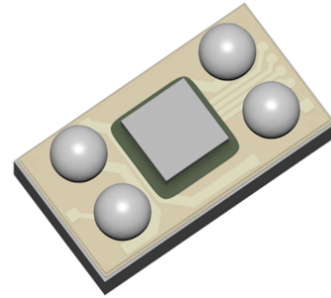


High Temp Operating Life



**$<\pm 5$ ppm after 1000 hours of
High Temperature Operating Life (125°C)**

In Conclusion...



- SiT1552 is the world's smallest and best-in-class production 32 kHz TCXO
- Enables increased functionality, smaller size and longer battery life in wearables, smartphones and other mobile devices

