Development of MEMS microrelays

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Outline

- Introduction
- Microrelay architecture
- Process flow description
- WL-CSP
- Critical Success Elements
- Reliability benchmarking
- Summary

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Conventional relays vs. MEMS microrelays

Application	Requirements	E-M	Solid State	MEMS
Automatic Test Equipment (ATE)	Low cost	X		X
	High bandwidth			X
	Small size		X	X
	Lifetime		X	X
	High Power	X	X	X
Telecom	Low cost	X		X
	Small size		X	X
	Low power consumption			X
Industrial/ Automation	Low cost	X		X
	Small size		X	X
PC Peripherals	Switch speed		X	X
	Low power			X
	Small size		X	X

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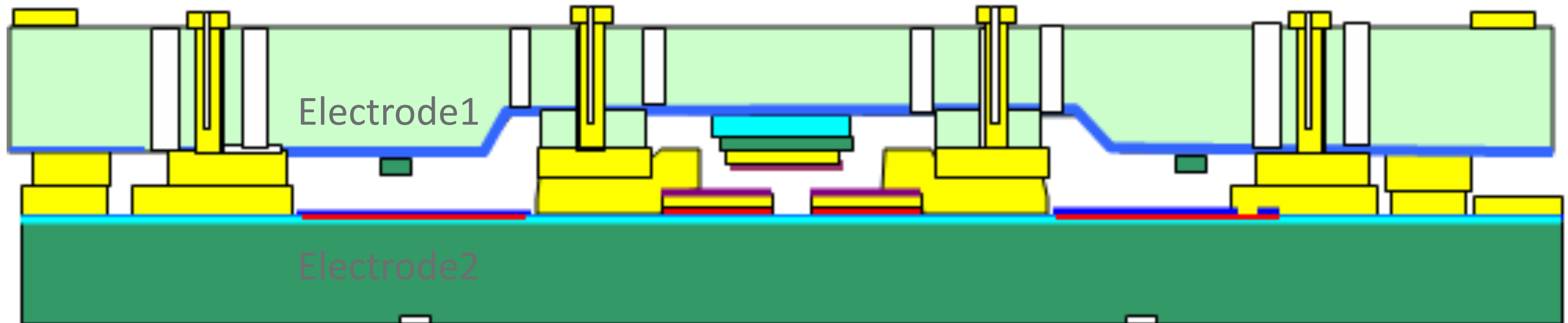
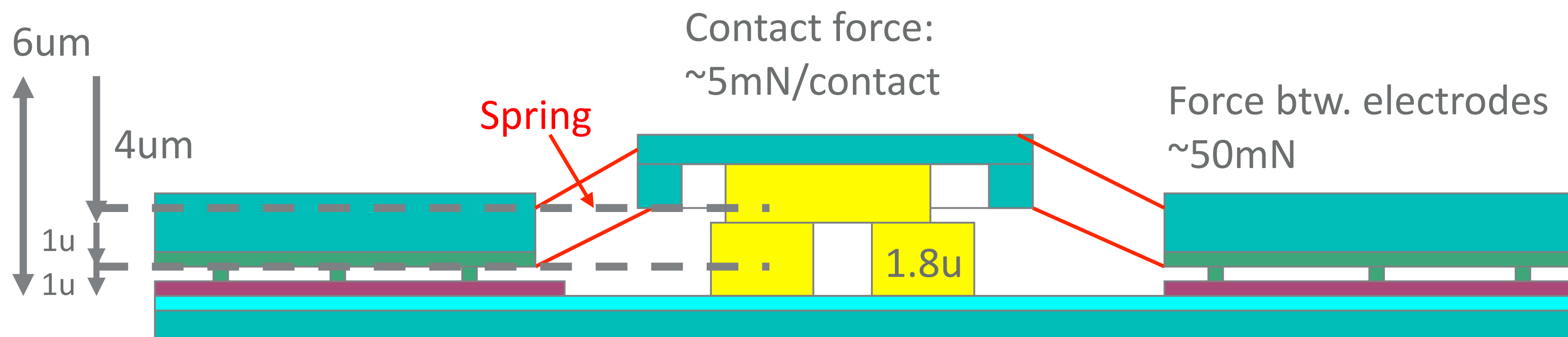
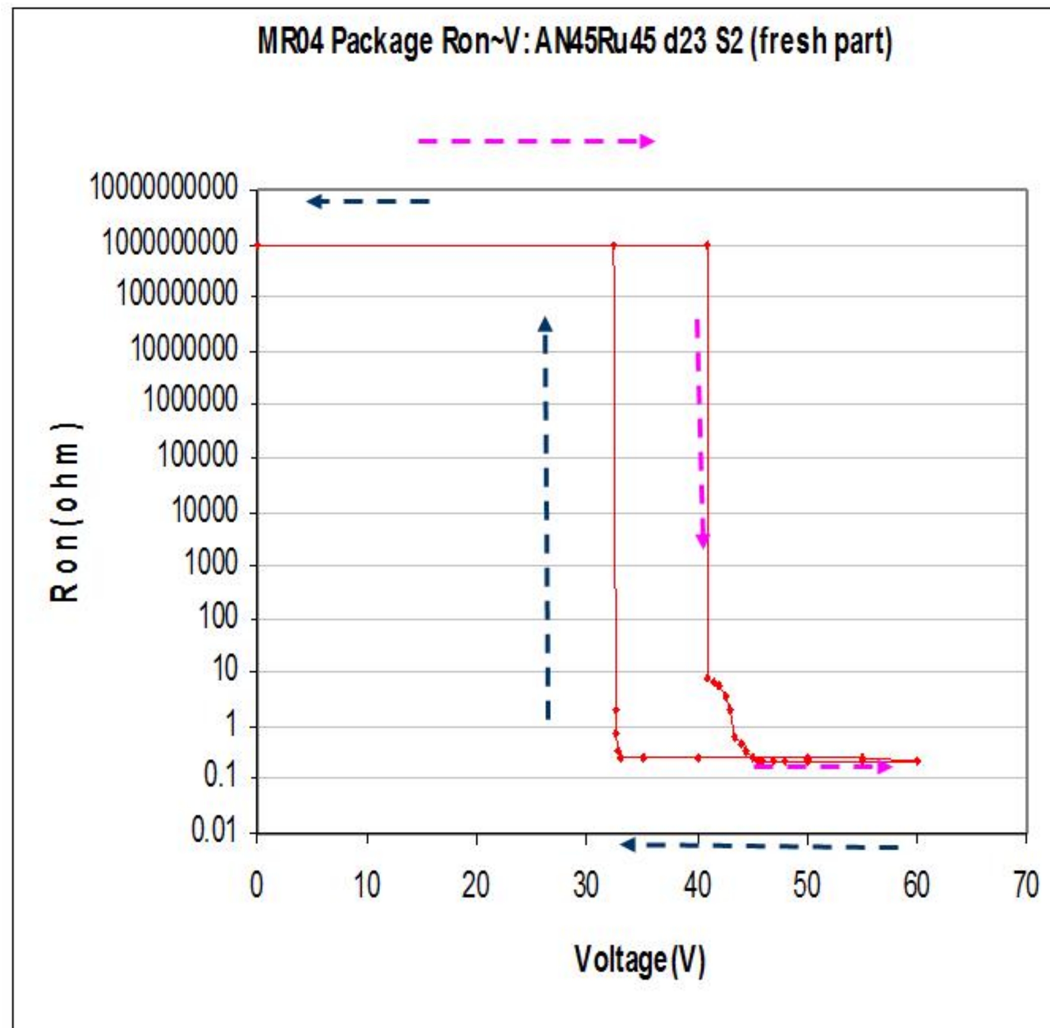
Microrelay: Basic structure





Microrelay Ron-V Curve



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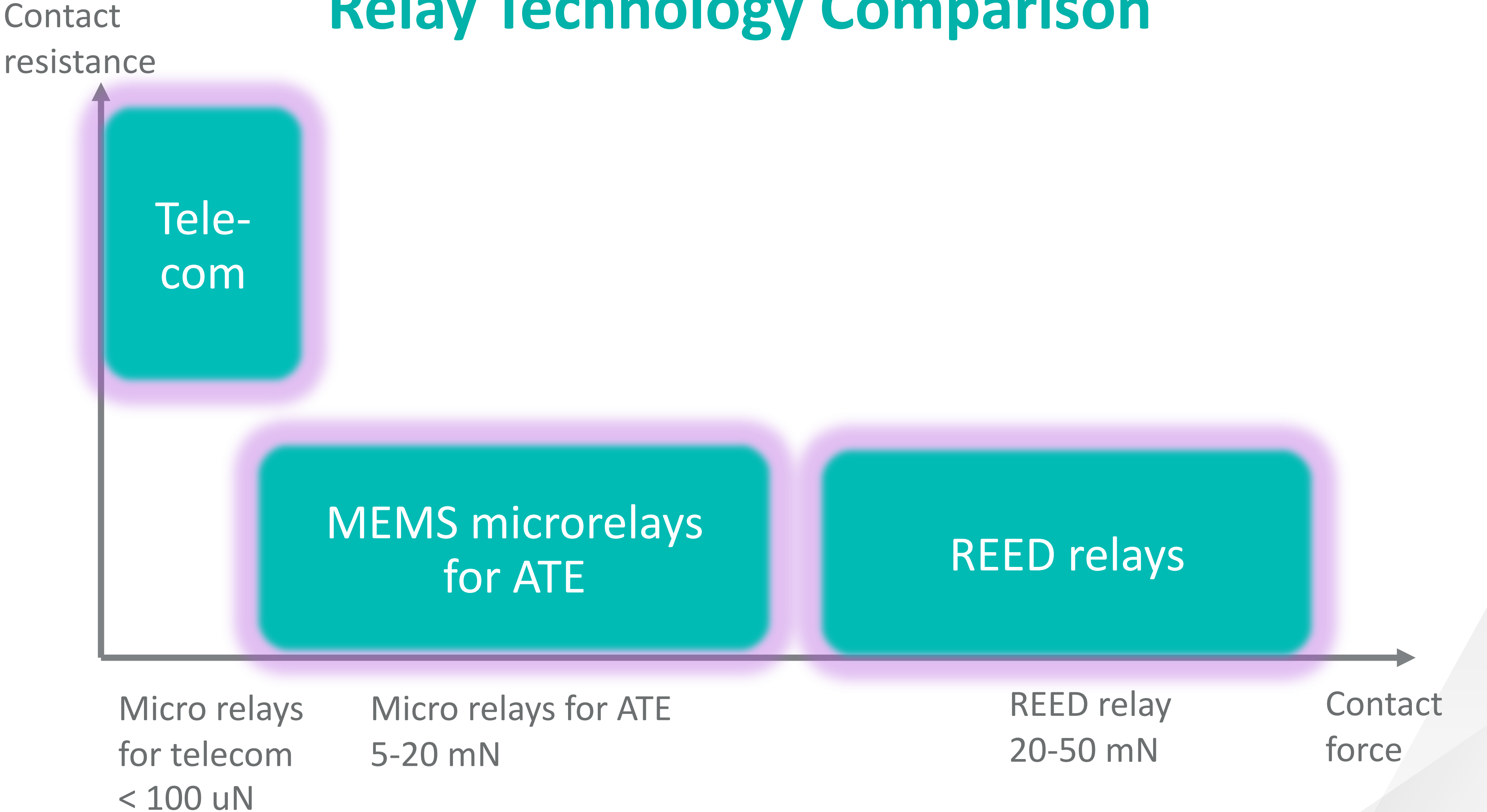
Relay Technology Comparison



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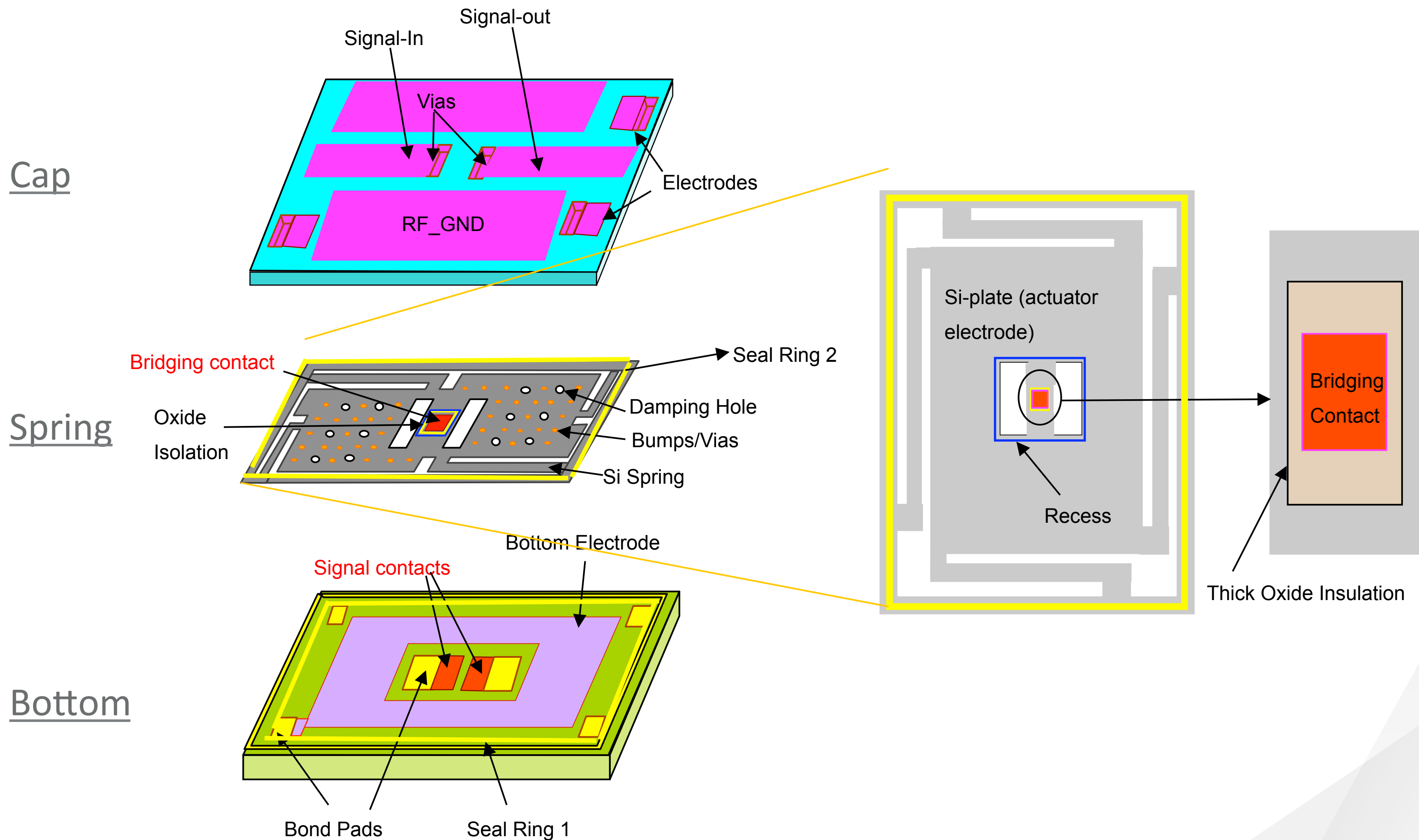
MEMS microrelay architecture



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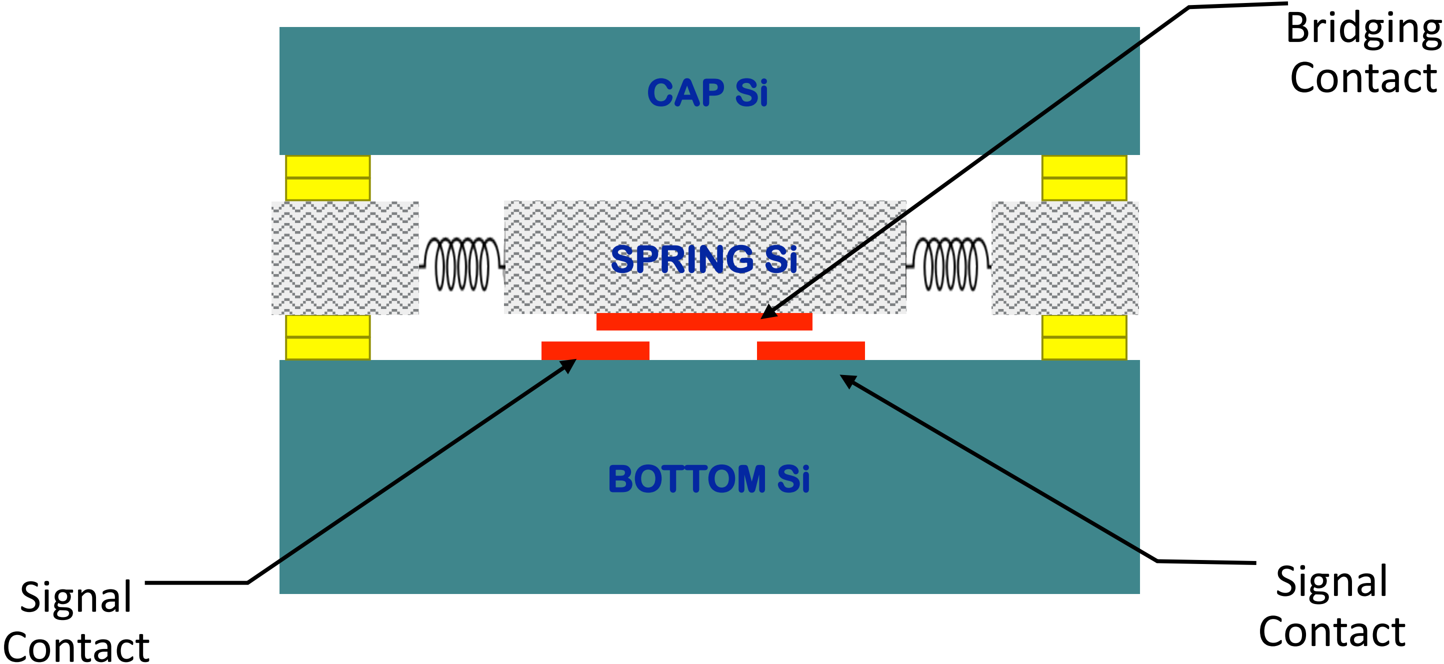
MEMS microrelay architecture



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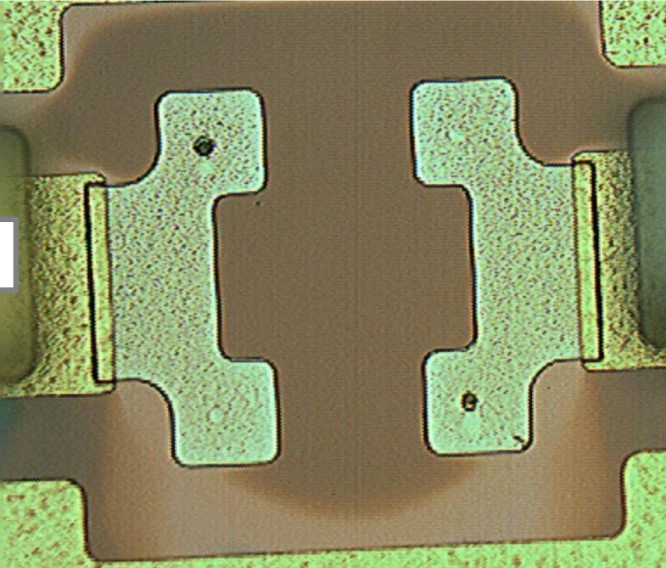
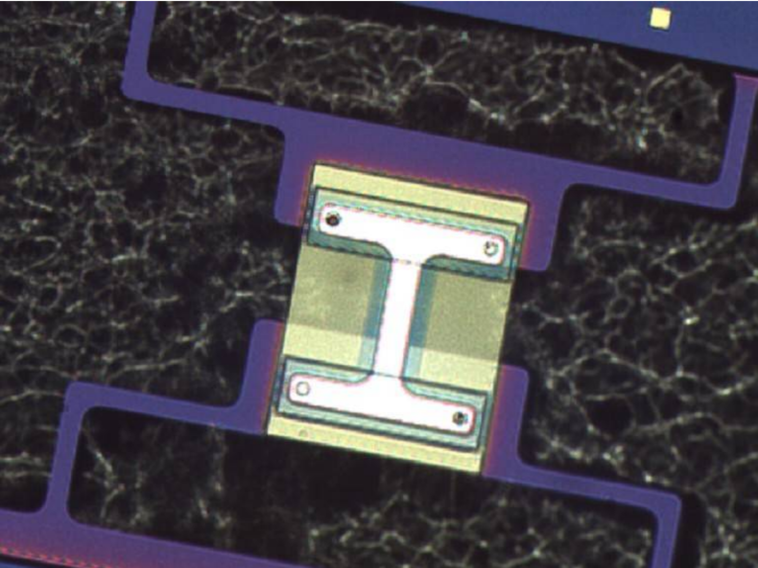
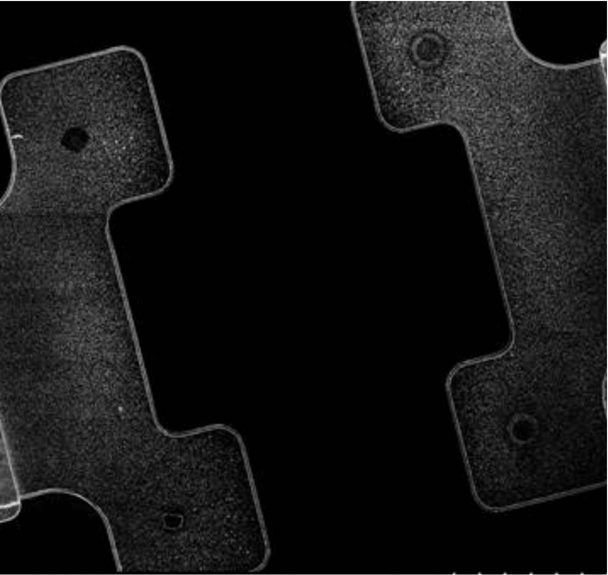
Microrelay Contact Images

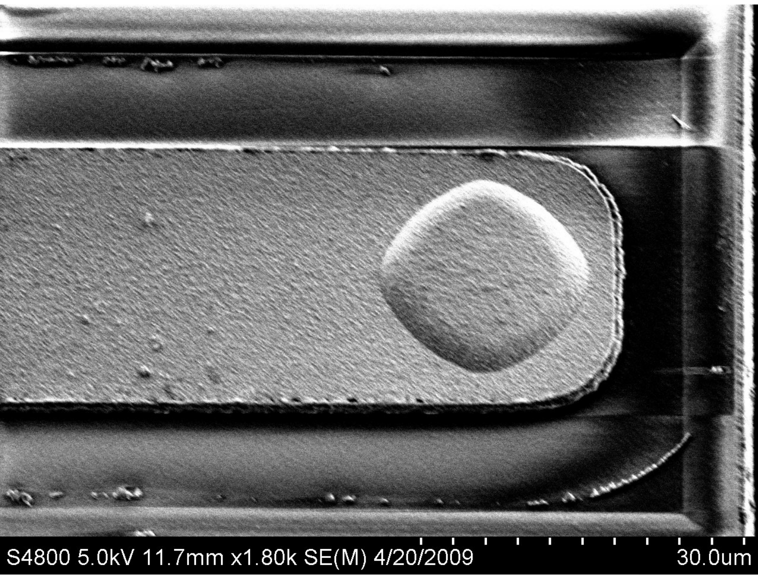
Bottom



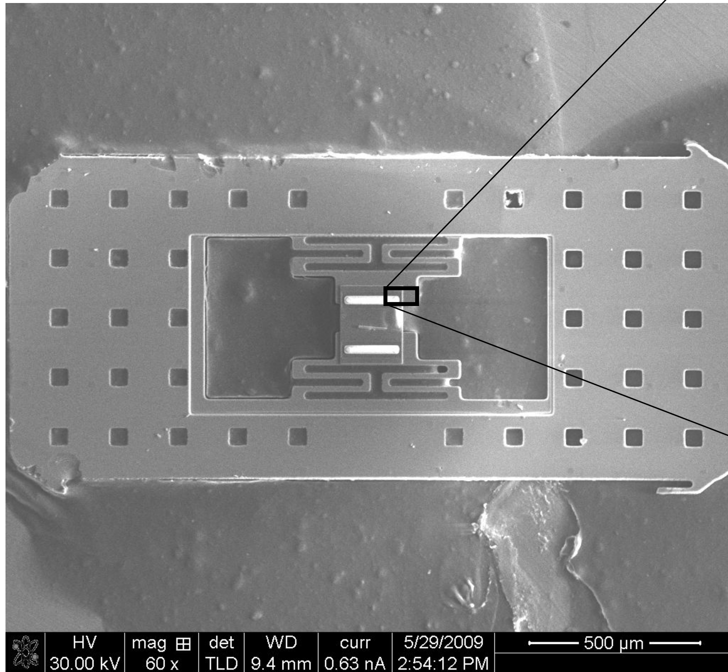


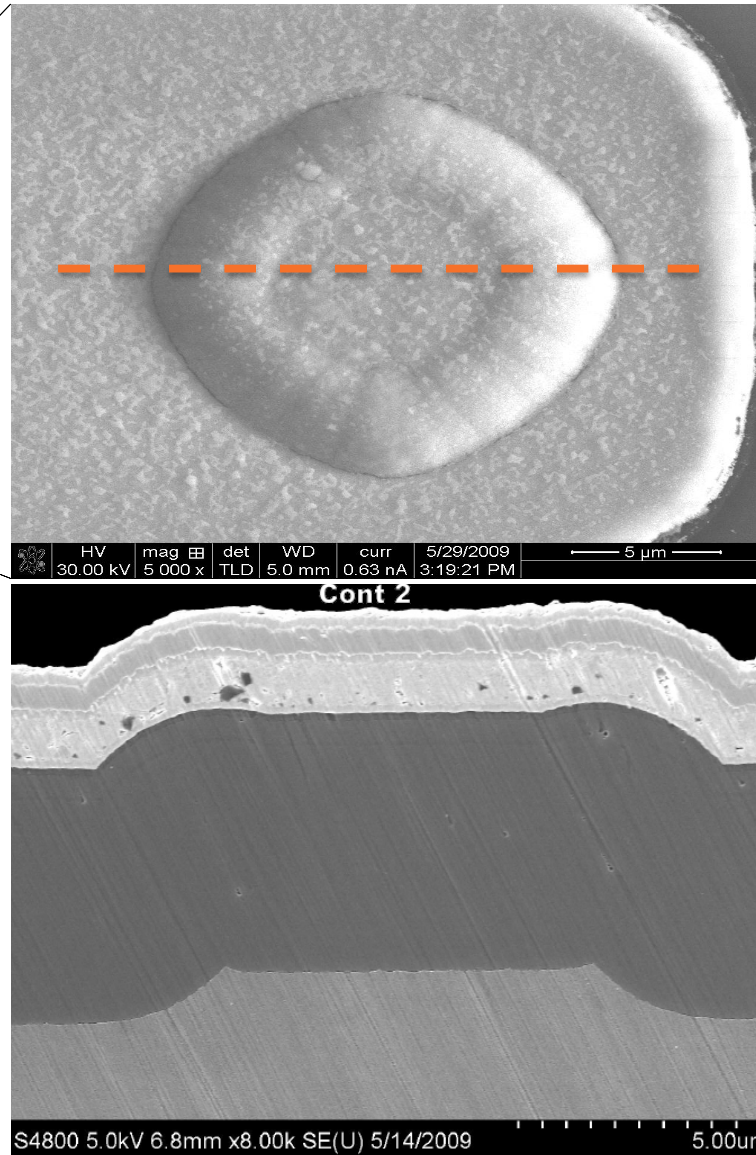
Spring





Contact SEMs





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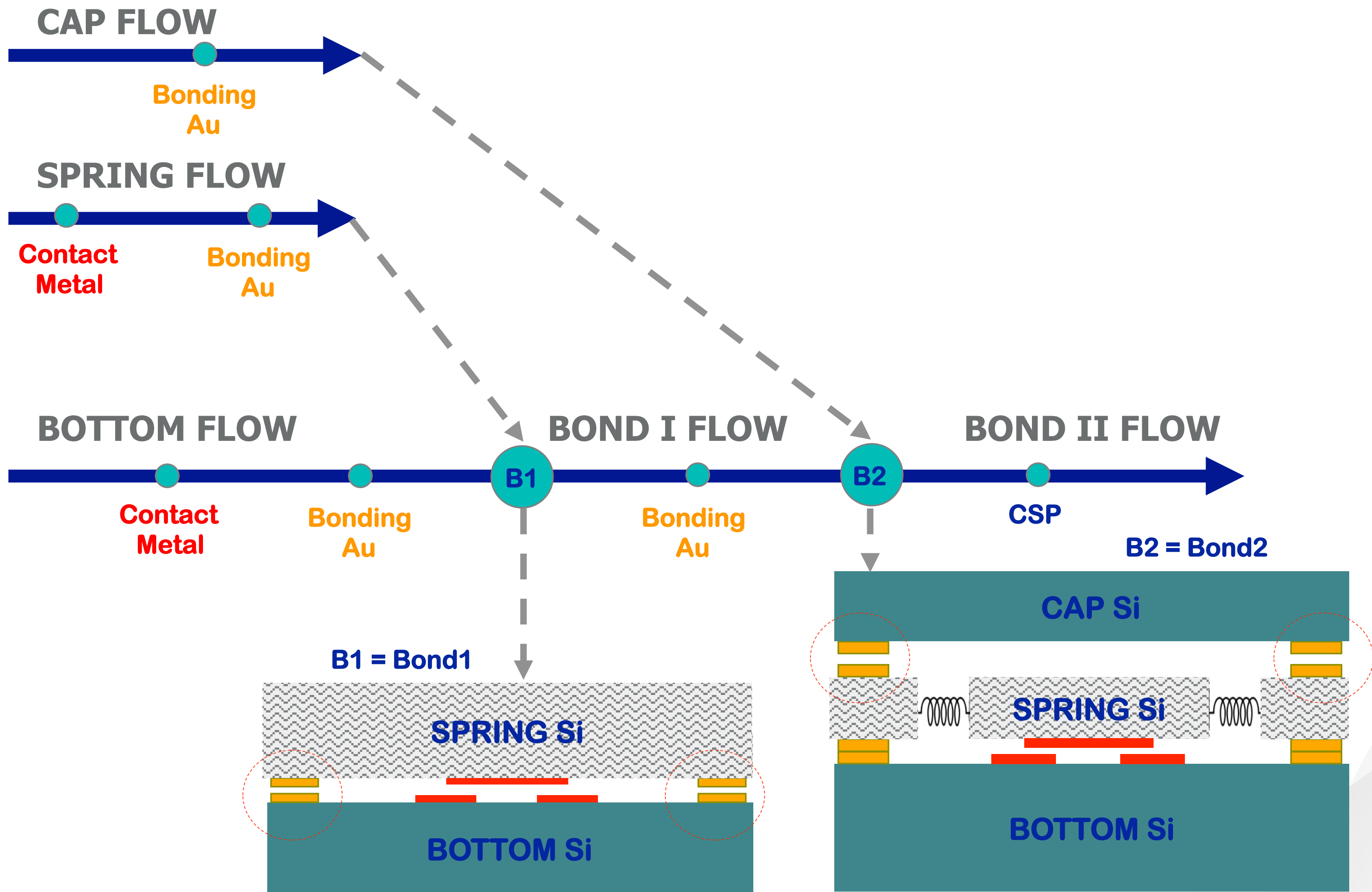
Microrelay process flow schematic



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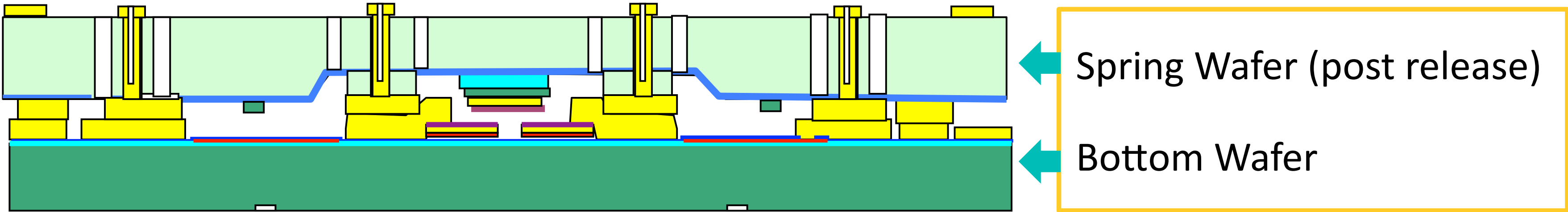
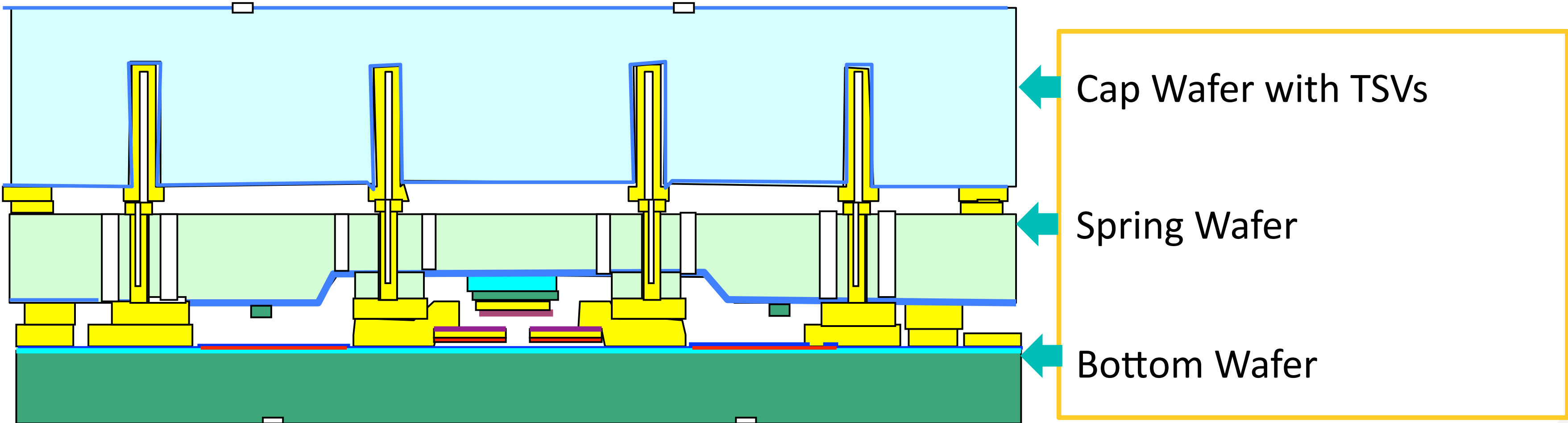
WL-CSP package integration flow (1/2)





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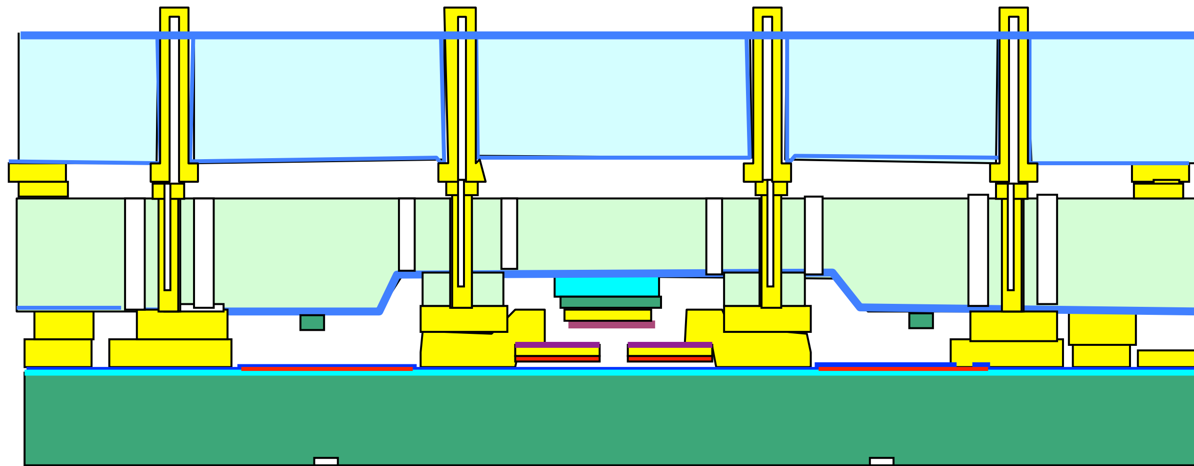
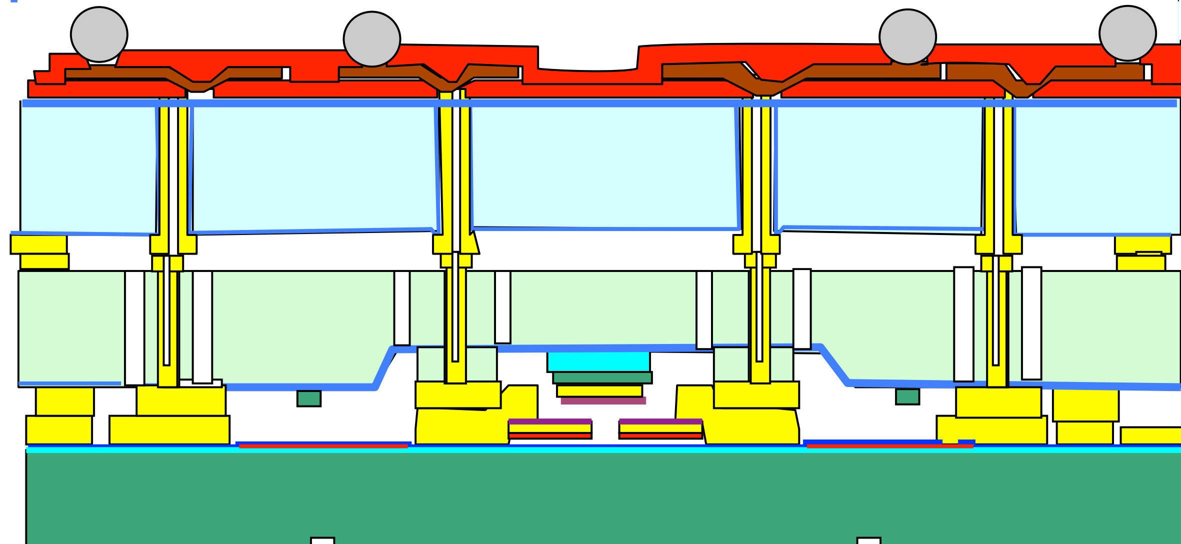
WL-CSP package integration flow (2/2)



Cap Wafer TSV Reveal



WLP process flow
(polymer encapsulation, Cu re-distribution, solder ball placement and reflow)

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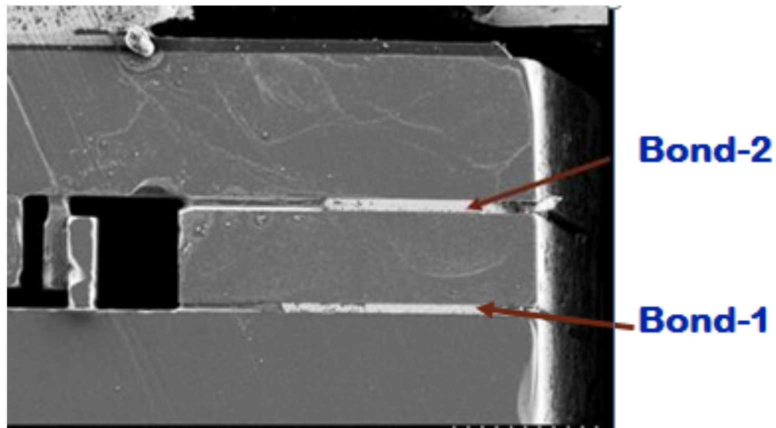
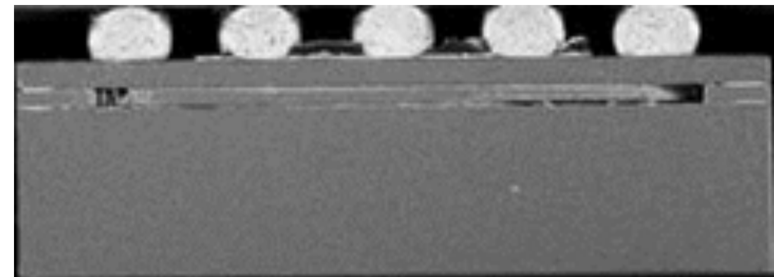
WL-CSP Details

- Au:Au thermo-compression bonding (Bond-1 & Bond-2)
- Lead-free CSP





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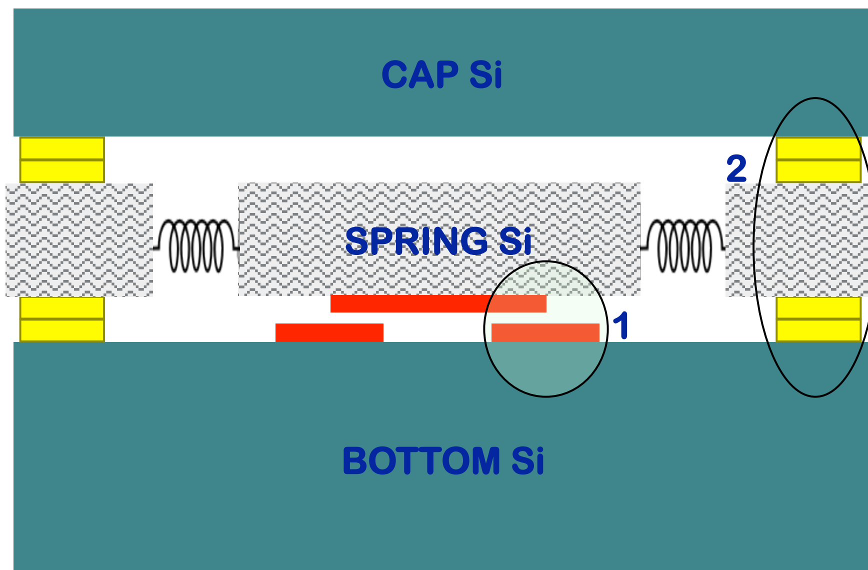
Critical success elements of microrelay

Two main requirements:

- **Low Stiction** (1)
- **Stable R_{ON}** (2)



1. Material selection and surface engineering.

2. Hermetic seal to maintain stable on-resistance.

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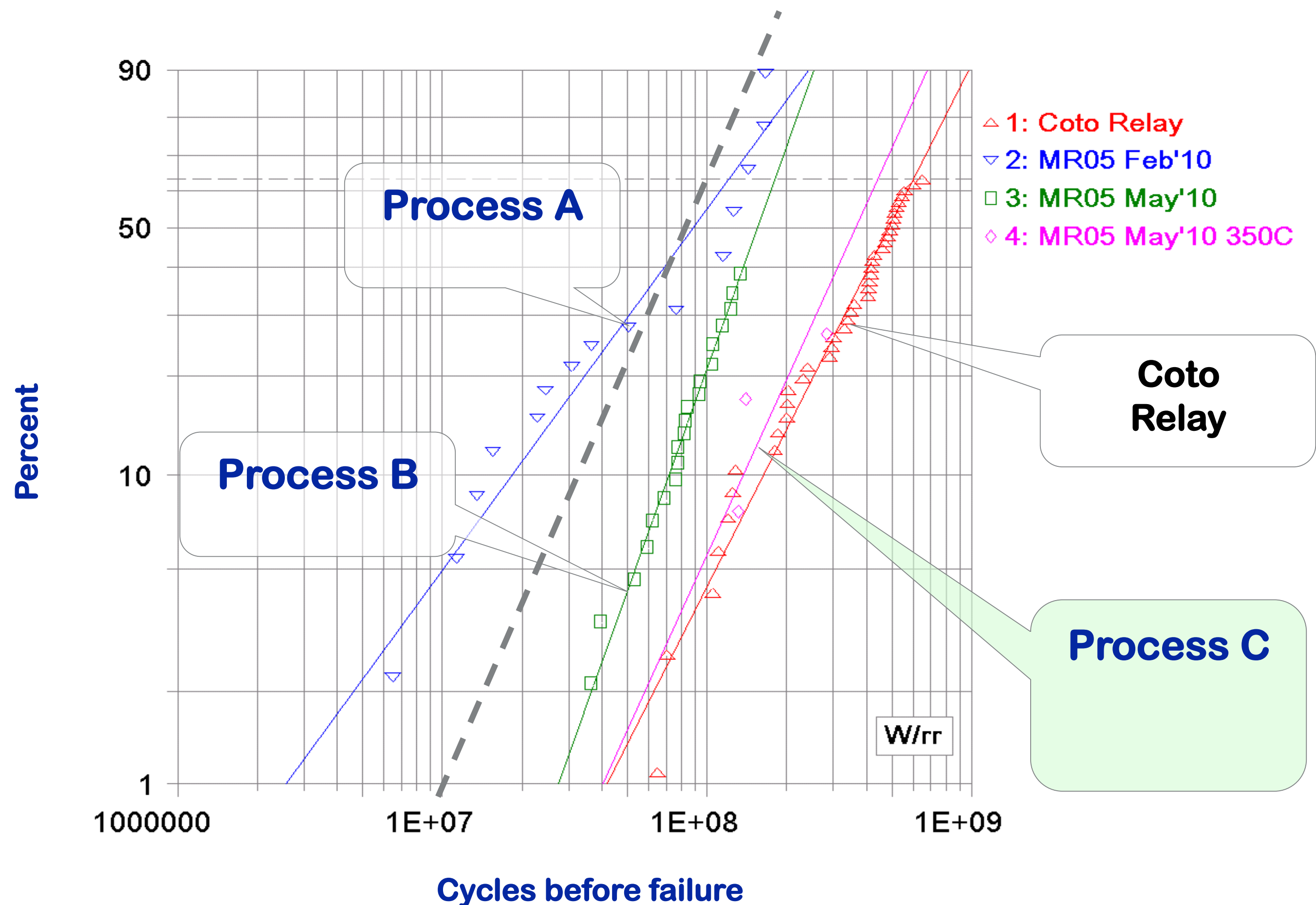
Cycling Reliability Benchmarking



Process C exceeded reliability specs (dashed line) and showed benchmark performance.

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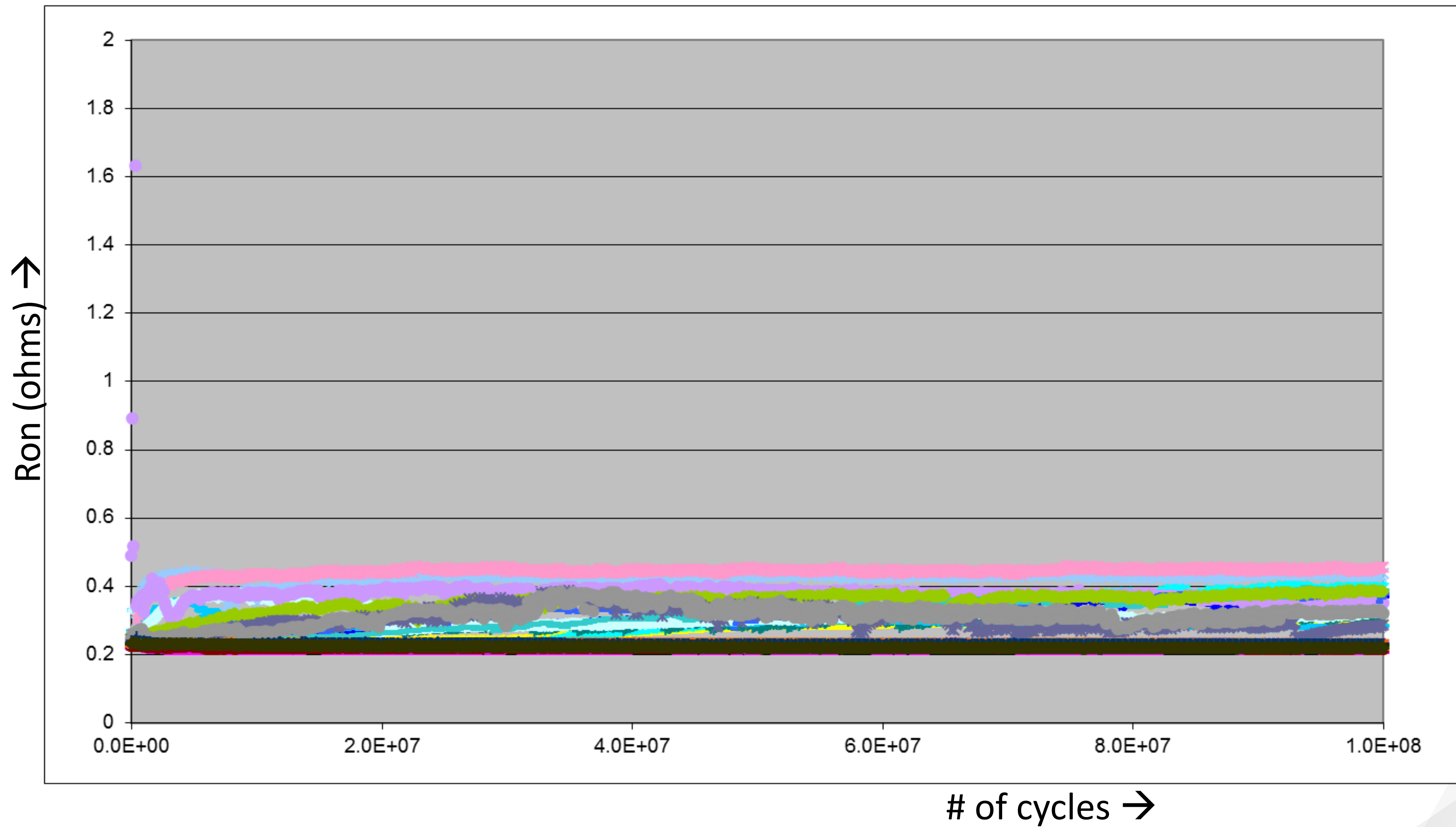
"Hot Switch" Ron stability



Ron (hot switching @ 100mA) is stable up to 100 million cycles on new process

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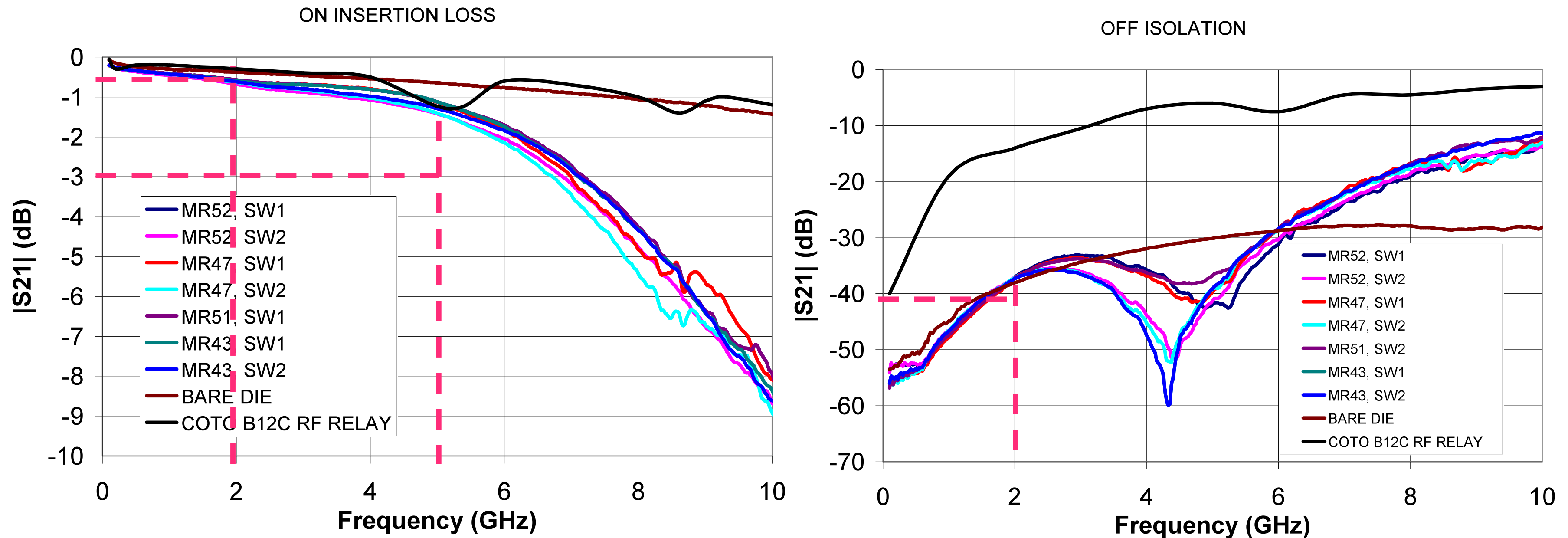
RF Performance of Microrelay LGA package parts, bare die and COTO relay



- LGA packaged SPDT parts- pass specifications for Insertion Loss and isolation
- Reed relay B12C is Coto's recommended SPDT RF relay for ATE applications
- Bare die performance is far superior to Coto relay in isolation
- Bare die is similar to Coto relay in insertion loss
- Ceramic substrate package degrades RF performance insertion loss

- - Specification limit

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Overall MEMS microrelay performance

	Status	Comments
Device size	About half of REED relays	Die size: 3x3mm^2 (CSP) Package: 5x5mm^2 (can be smaller).
RF performance	Better than REED relays for isolation	RF on bare die is good. Limited package data, need improvement for insertion loss.
Yield	High Yield demonstrated	Continuous improvement
CRS	Benchmark performance (Hot switch)	Compatible with ATE application
Reliability	Comparable to Coto.	Compatible with ATE application

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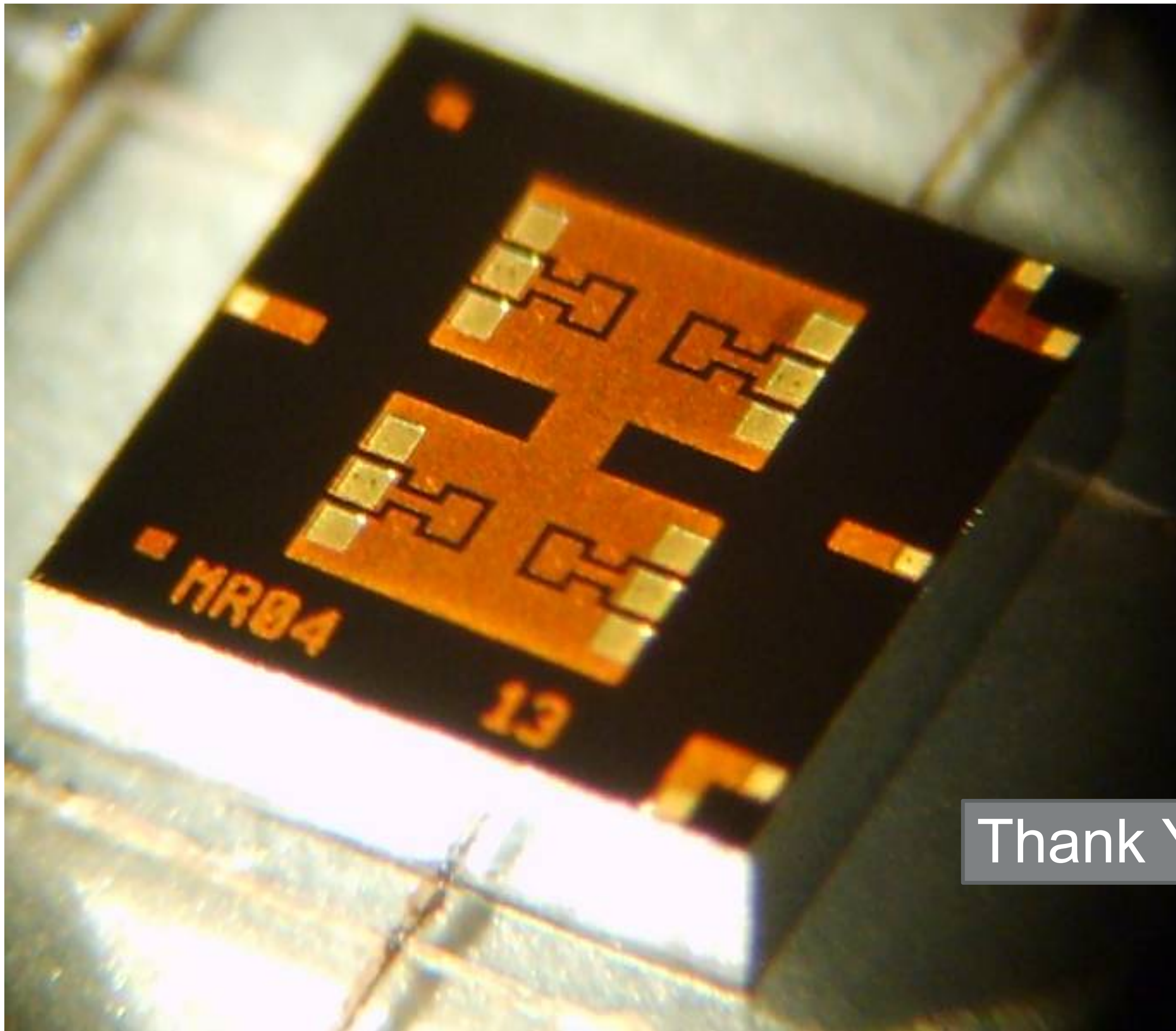

Thank You

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