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**Topics:** Galinstan, Insertion loss, Coplanar waveguide, Liquid metal and Short circuit

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# Non-Toxic Liquid-Metal 2-100 GHz MEMS Switch

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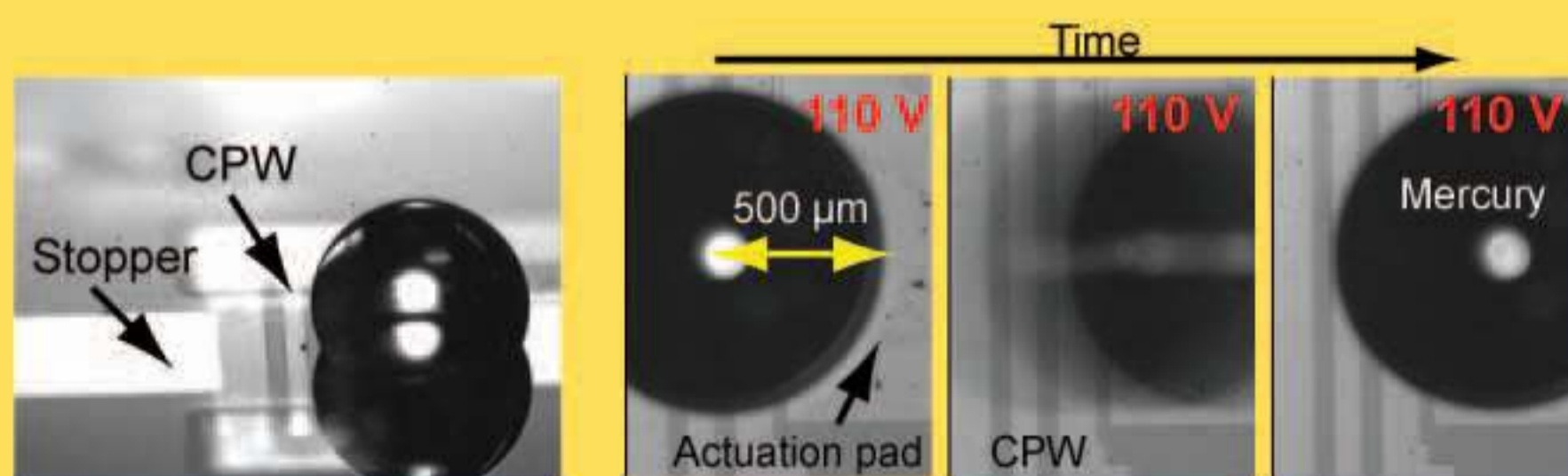
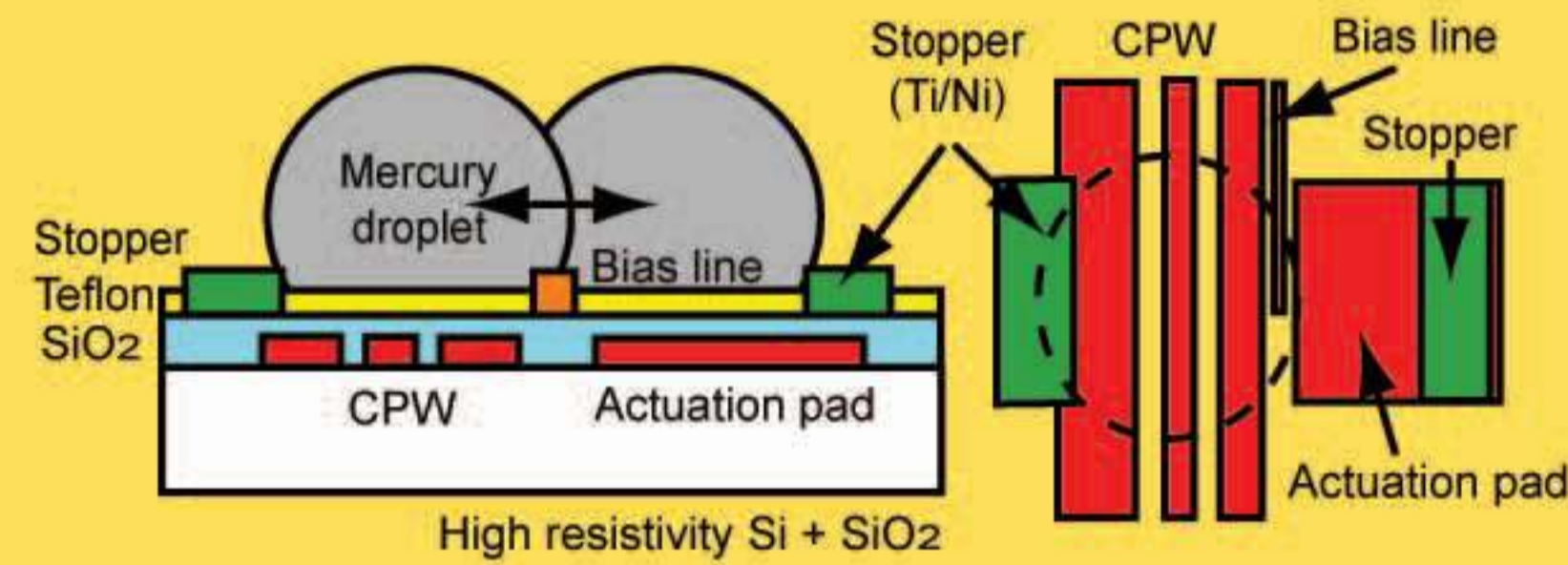
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# Non-Toxic Liquid-Metal 2-100 GHz MEMS Switch

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## 1. Motivation

- The first liquid-metal shunt capacitive switch has been demonstrated
- for high power applications
  - < 0.05 dB insertion loss at 2-20 GHz
  - >20 dB isolation at 20 GHz



However, the liquid metal used is mercury which is toxic and not environmental friendly

### Objective:

- Search potential substitutions for mercury
- Design switches with comparable RF performance

## 2. Design Idea

Replace mercury by non-toxic liquid metal — Galinstan (Ga/In/Sn)

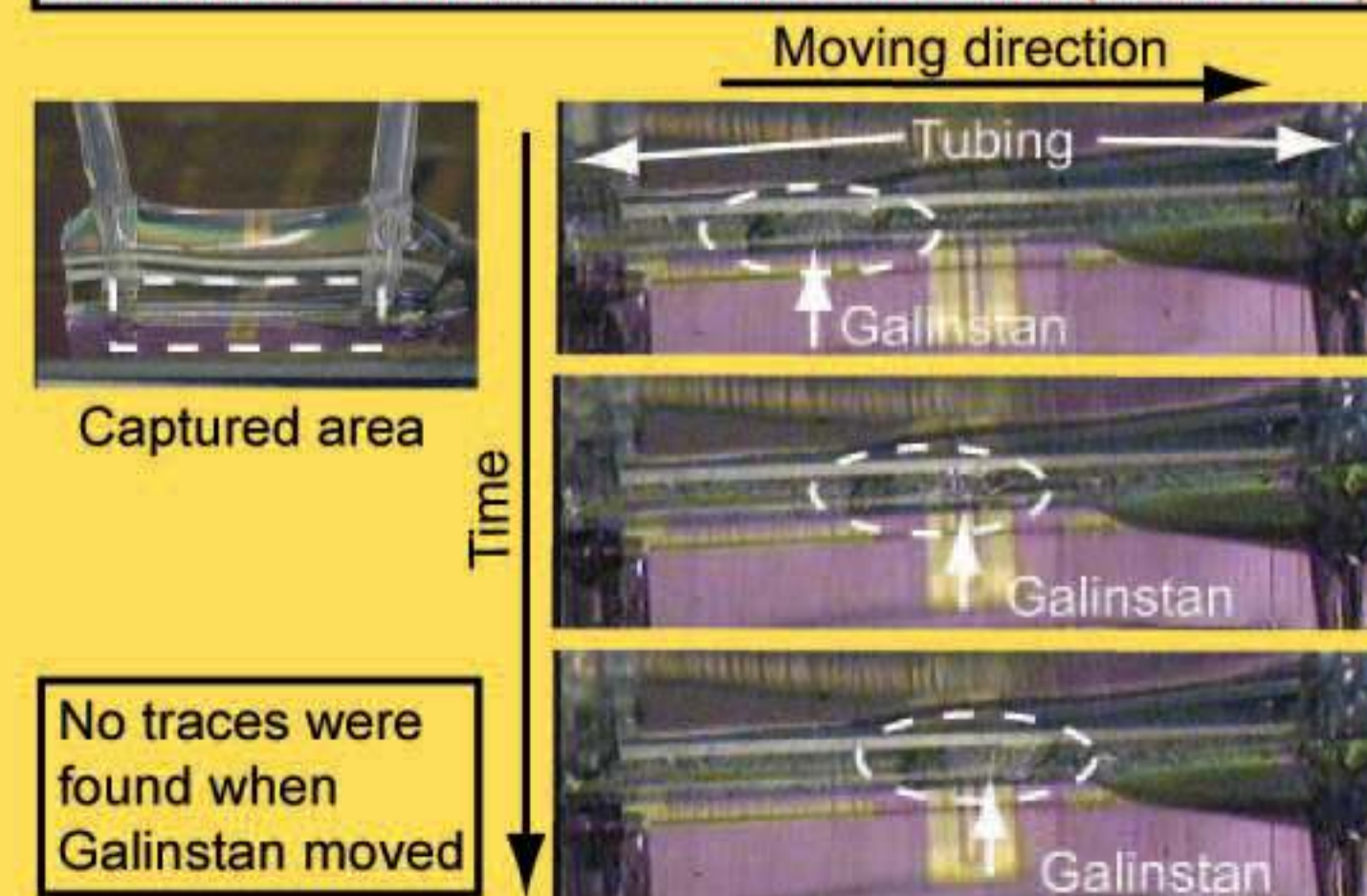
	Mercury	Galinstan
Conductivity (S/m)	$1.04 \times 10^6$	$2.3 \times 10^6$
Melting point (°C)	-38.83	-19
Boiling point (°C)	356.73	1300
Viscosity (Pa·s)	$1.53 \times 10^{-6}$	$2.4 \times 10^{-6}$
Density (g/cm <sup>3</sup> )	13.5	6.4

## 3. Galinstan Slug Movement

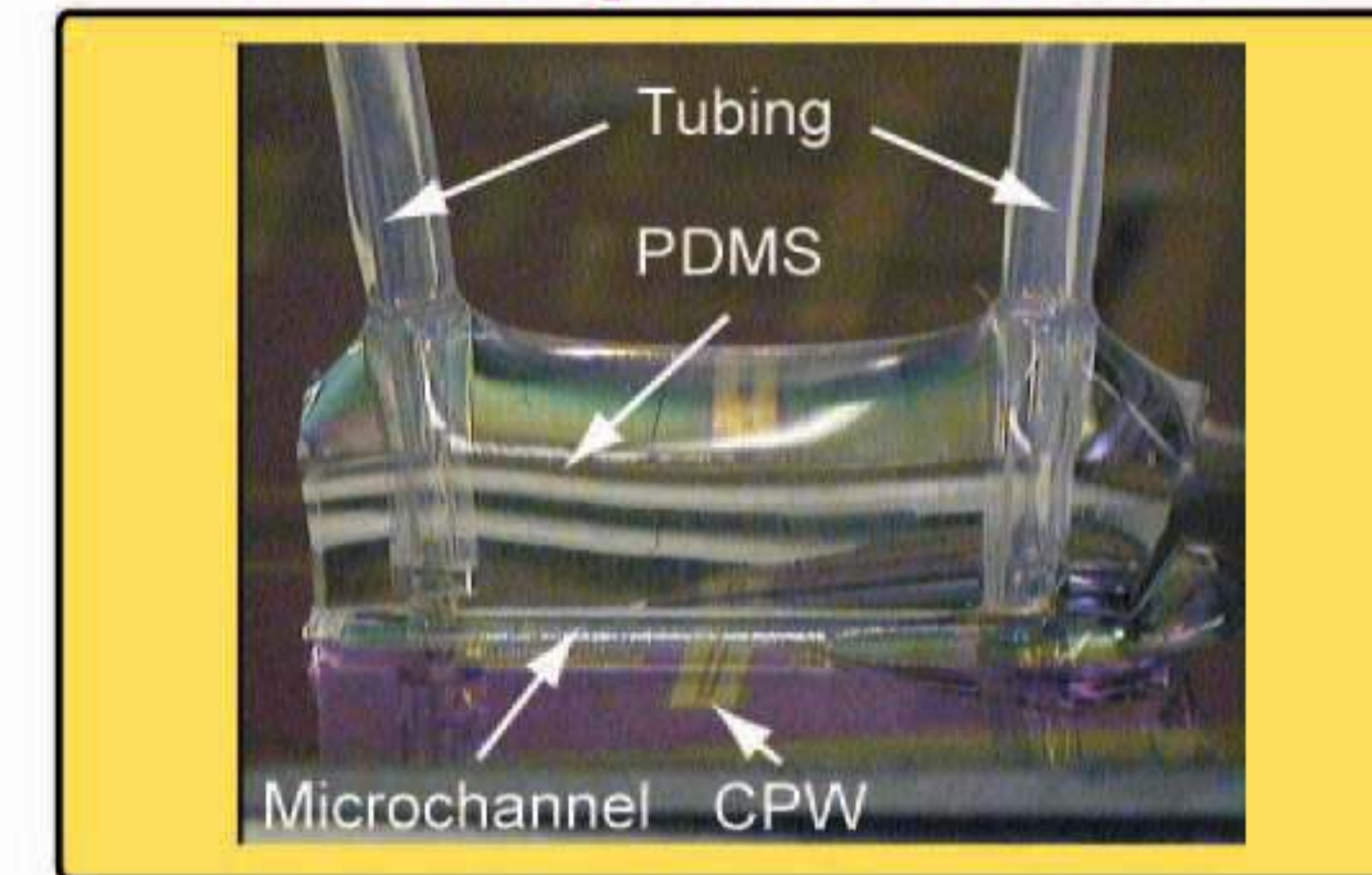
**Challenge:**  
Galinstan oxidizes quickly in air  
Its oxide adheres to almost every surface



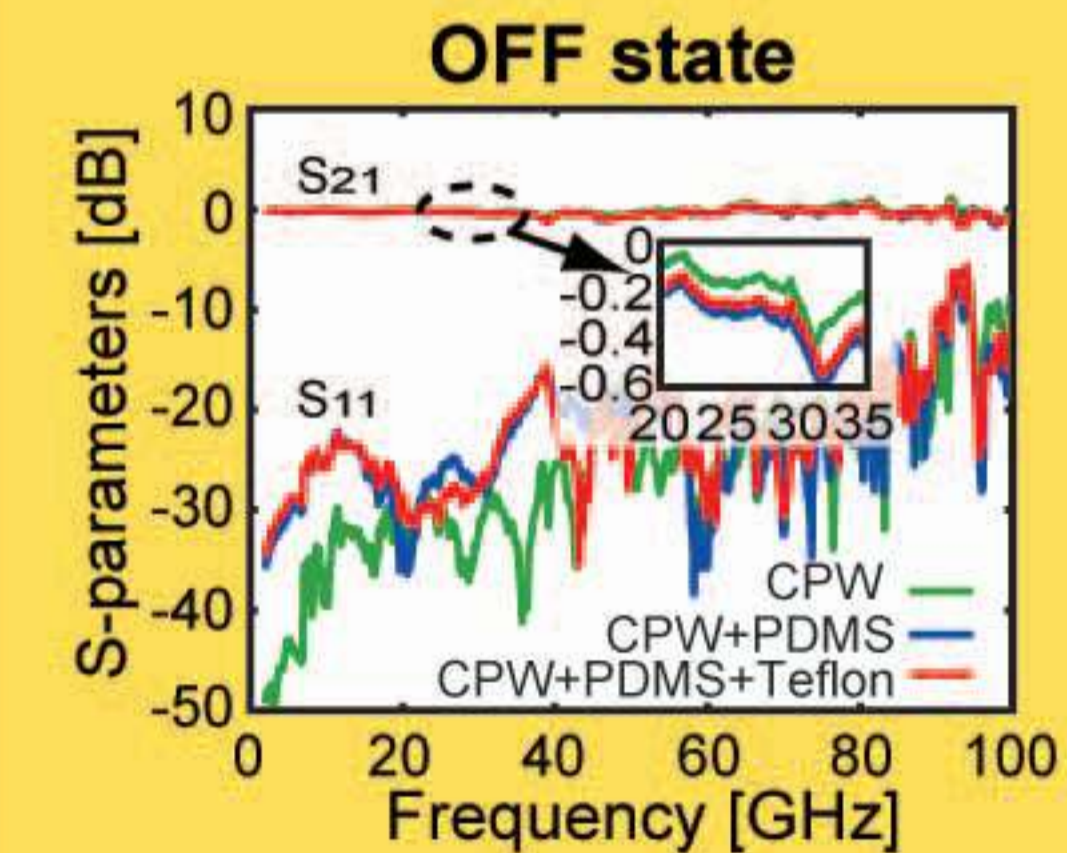
**Solution:**  
Immerse Galinstan in Teflon solution (Teflon AF)



## 4. Complete Device



## 5. RF Performance



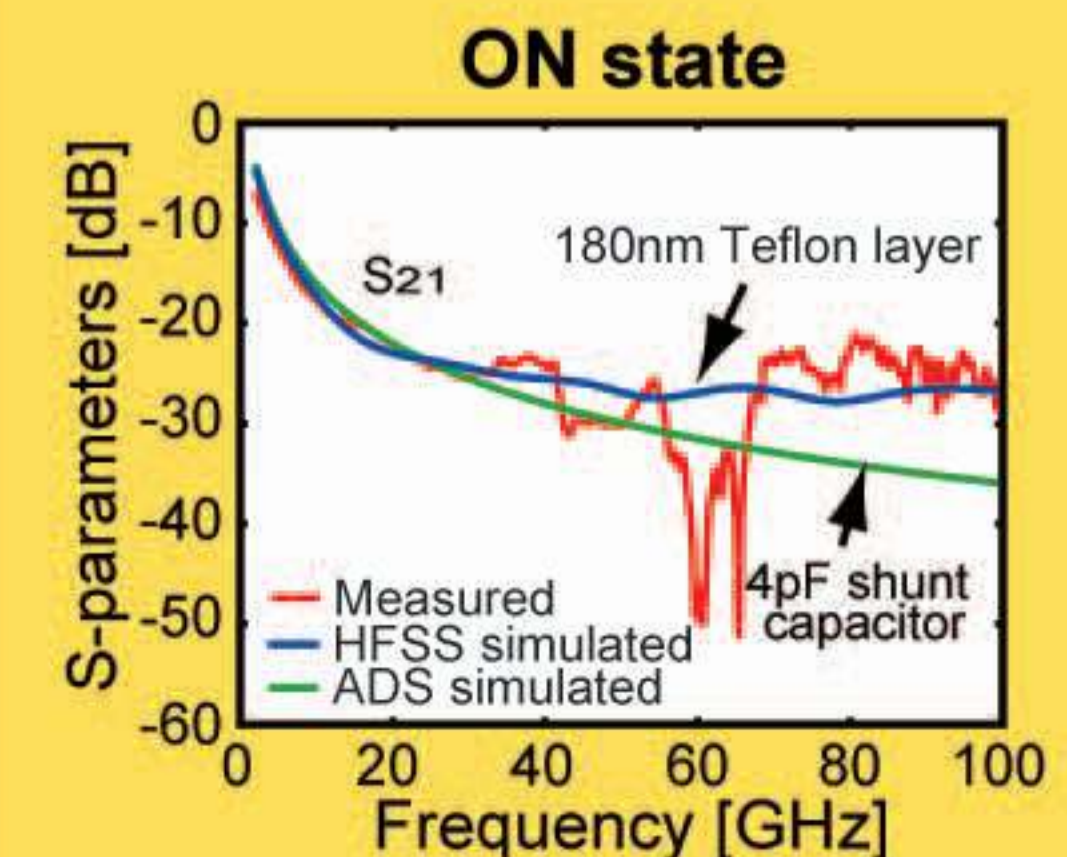
**Loss budget:**

	CPW+	PDMS+	switch	Extracted loss
20GHz	0.12	0.23	0.2	0.08
40GHz	0.51	0.71	0.66	0.15
100GHz	0.81	1.7	1.28	0.47

unit: dB

**Insertion loss:**  
<0.5 dB up to 100 GHz including packaging

Teflon solution is transparent in the microwave region



**Isolation:**  
>20 dB at 20-100 GHz

~180-nm Teflon solution layer between Galinstan and CPW