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THERMAL CHARACTERISATION OF POLYMER FILMS BY 3ω METHOD AND SCANNING THERMAL MICROSCOPY

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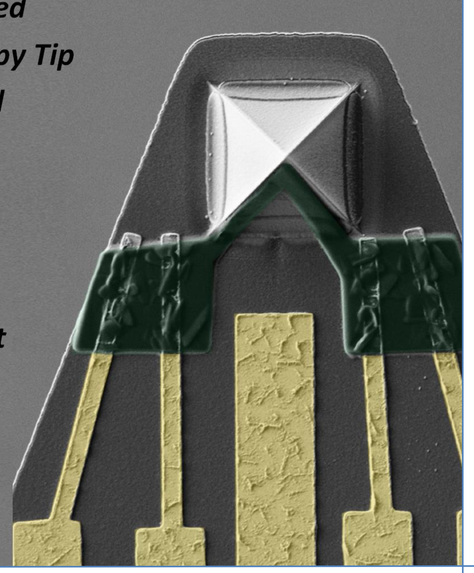
The Goal

Testing a newly developed Scanning Thermal Microscopy Tip for high-resolution and high-sensitivity Thermal Conductivity measurements

Testing SU8 photoresist thermal conductivity as a function of temperature

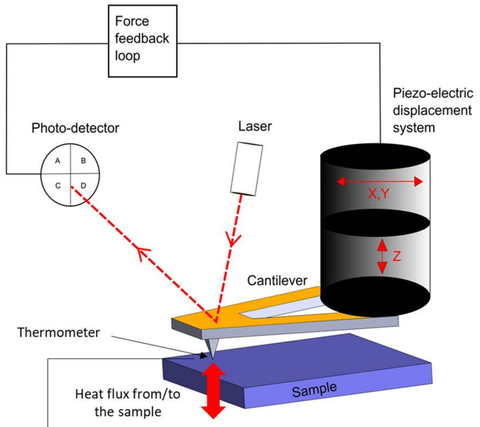


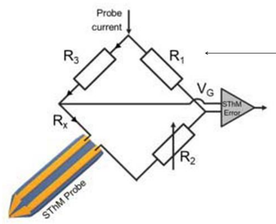
Scanning Thermal Microscopy (SThM)

Temperature and thermal conductivity mapping

High spatial resolution (order of 10 nm)

High temperature sensitivity (up to 10 mK)





Thermo-resistive tip

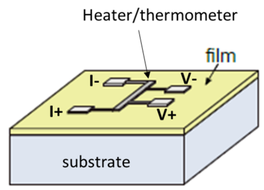
Both passive and active mode

The measurement process

The 3ω method…

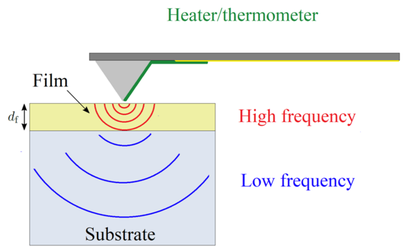
Electrothermal approach

Frequency-based



$$\Delta T = \frac{2V_{3\omega,\mathrm{rms}}}{R_{e,0} I_{1\omega,\mathrm{rms}} \beta}$$

$$\beta = \frac{1}{R_{e,0}} \frac{dR}{dT} \sim 0{,}01$$



… Combined with SThM

k_{th} at different depths and spatial locations

Suited for nanostructured and heterogeneous samples

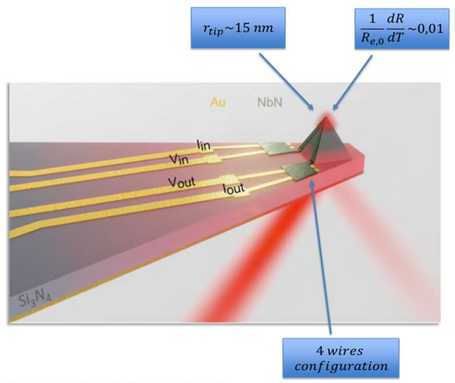
The newly developed SThM tip

Commercial probes have low thermal sensitivities

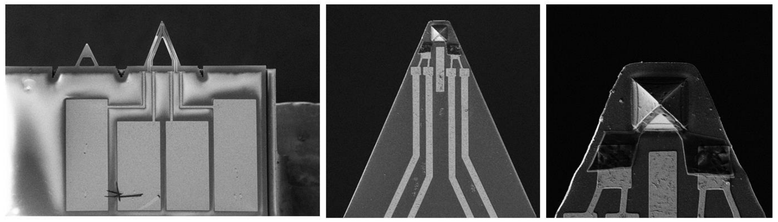
- High temperature differences required
- High radiation losses

A new Niobium Nitride tip was designed at Institute NEEL

- high temperature sensitivity and spatial resolution
- 4 wires configuration
- Ideal for low k_{th} samples



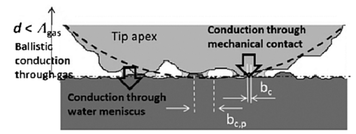
But… extremely complex fabrication!



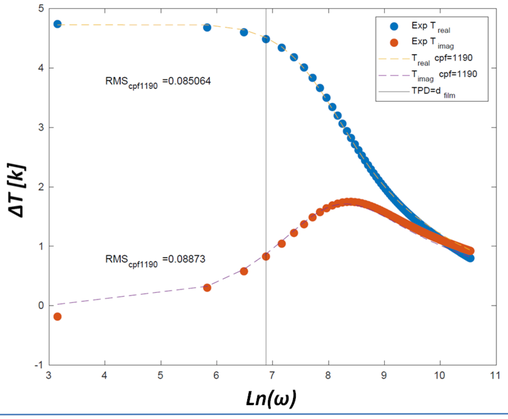
3ω heat transfer model fitting

From temperature response at various ω we infer k_{th} by fitting with thermal model. But…

- Tip and sample not at the same temperature (non ideal contact, water meniscus)
- Power input not equal to power entering the sample (radiation losses, parasitic heat paths)



Solution: increase thermal sensitivity and work under vacuum

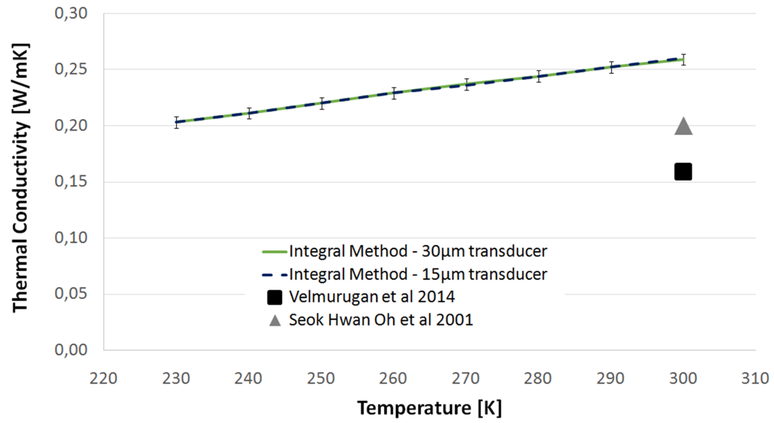


Model fitting is good both for real part and imaginary part of temperature oscillation. But…

- Specific heat value needed for fitting is lower than expected

3ω Results

V Velmurugan et al, *Int. J. ChemTech Res.*, 2014, 6(4), pp 2300-2305.
Seok Hwan Oh et al, *J. Micromech. Microeng.* 2001, 11, 221



Preliminary results with 3ω are incouraging

- Thermal conductivity is linearly decreasing with temperature although predicted value is higher than literature data at room temperature

Future steps

- Additional 3ω tests with different thermometers and different SU8 thickness
- SThM measurements on SU8 and comparison of results with 3ω data