Differential membrane-based nanocalorimeter: fabrication and characterization

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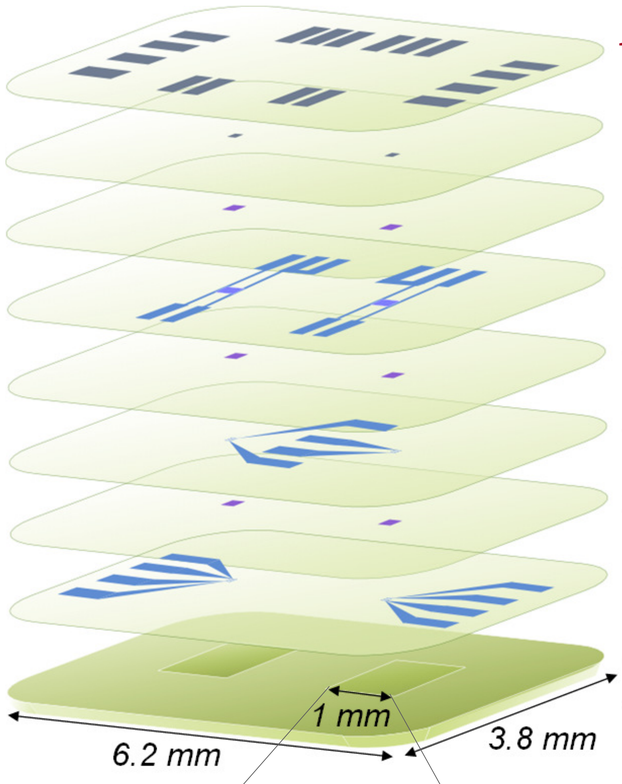
Layout



10. Al bonding pads, 70 nm

9. Al thermalization layer, 70 nm

8. AlO_x insulation layer, 90 nm

5-6-7. Ti leads, Au leads, GeAu sensors

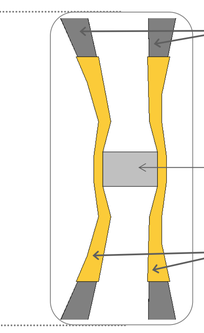
4. AlO_x insulation layer, 170 nm

3. Ti offset heaters

2. AlO_x insulation layers, 110 nm

1. Ti AC heaters

0. Si frame with pre-etched dual Si_3N_4 membranes, 150 nm

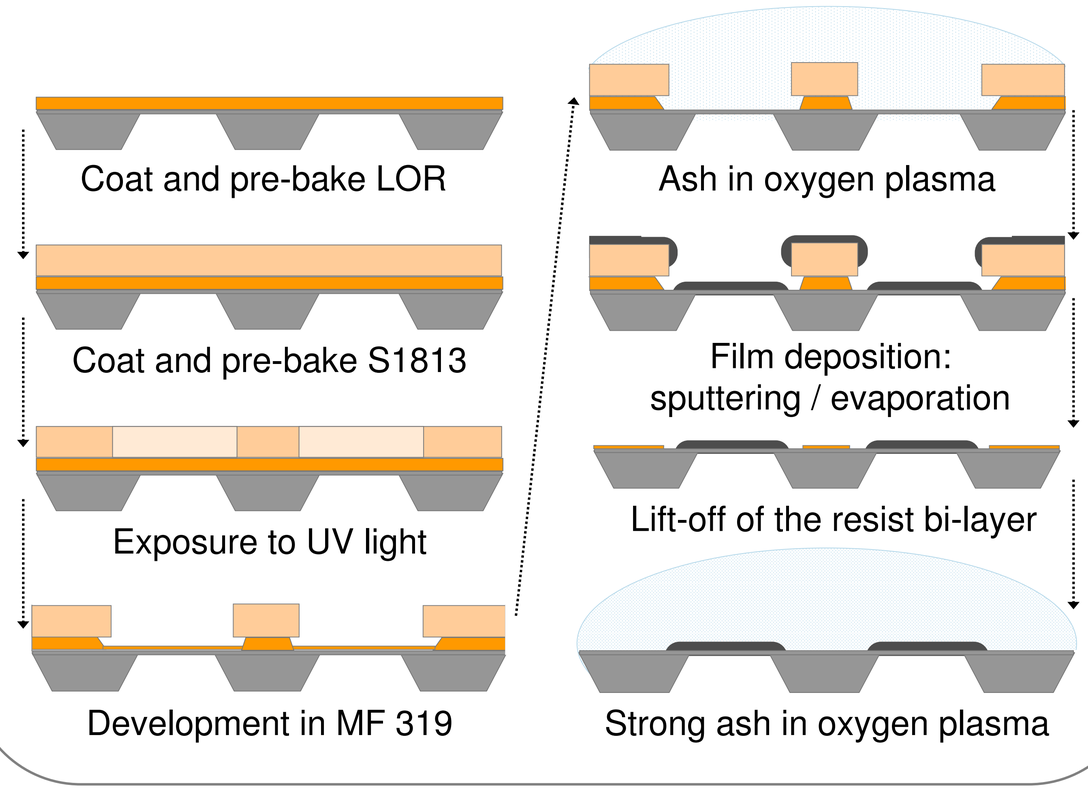


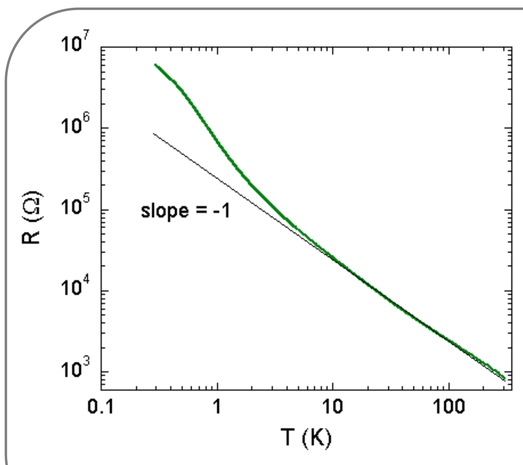
5. Ti external leads: 45 nm

7. GeAu sensor: 100 nm

6. Au internal leads: 100 nm

Fabrication of each layer

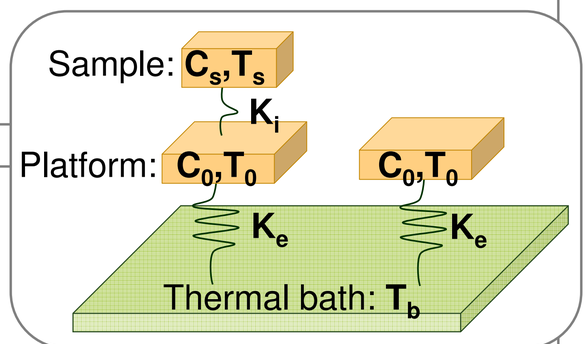




*R vs T plot thanks to Susanna Latos.

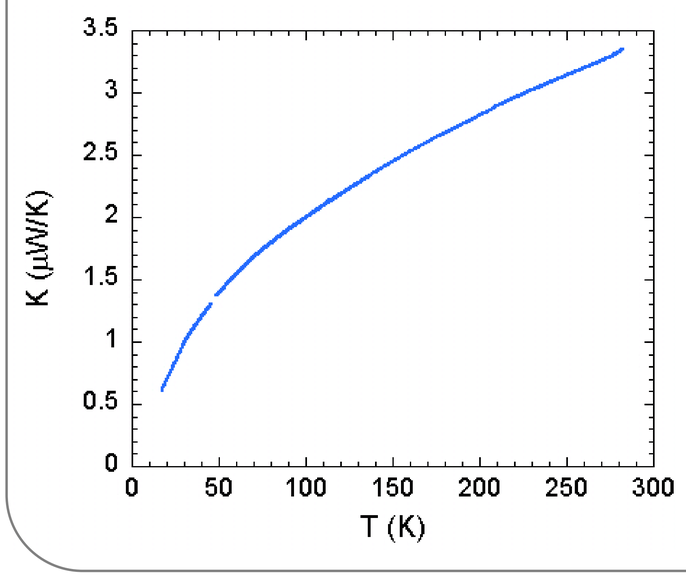
7. GeAu sensors

- Sputtering target, Au concentration: 17%
- Annealing 190 °C for 1 hour on hot-plate
- Measurement of T_{off} included:
  - T_b not needed
  - possible high current: resolution

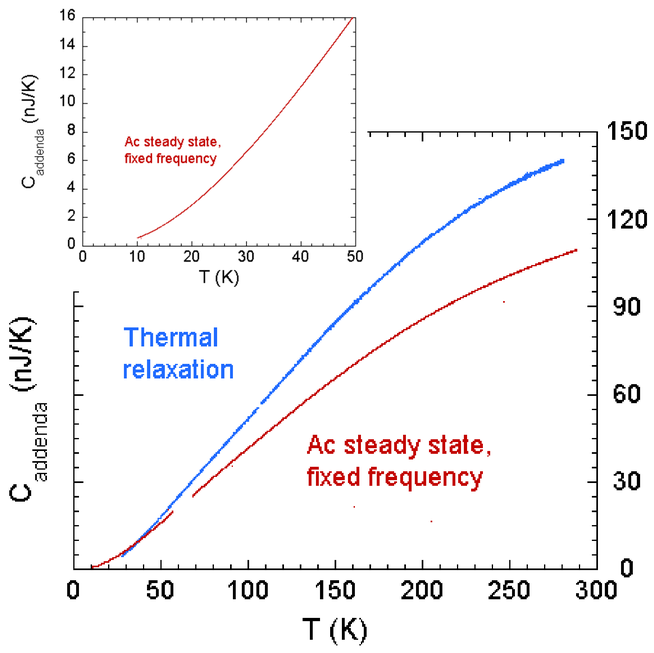


Characteristics

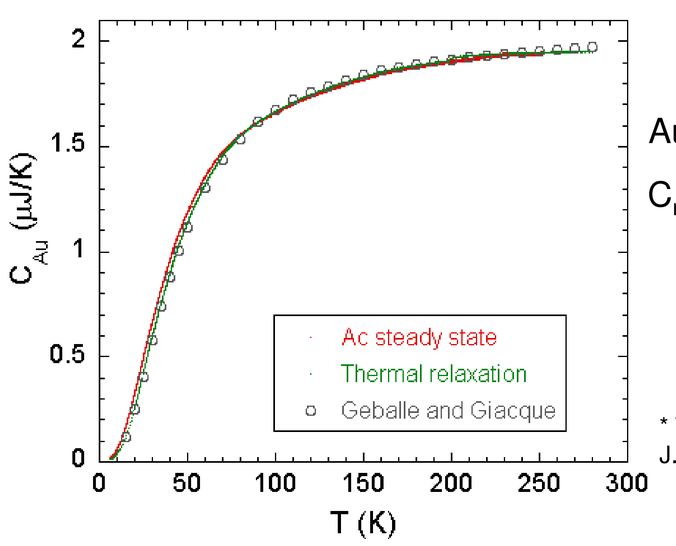
Thermal conductance K_e



Platform heat capacity C_0



Au heat capacity C_S



Au grain: m = 12.7μg

C_{nom} (300K) = 1.65 μJ/K

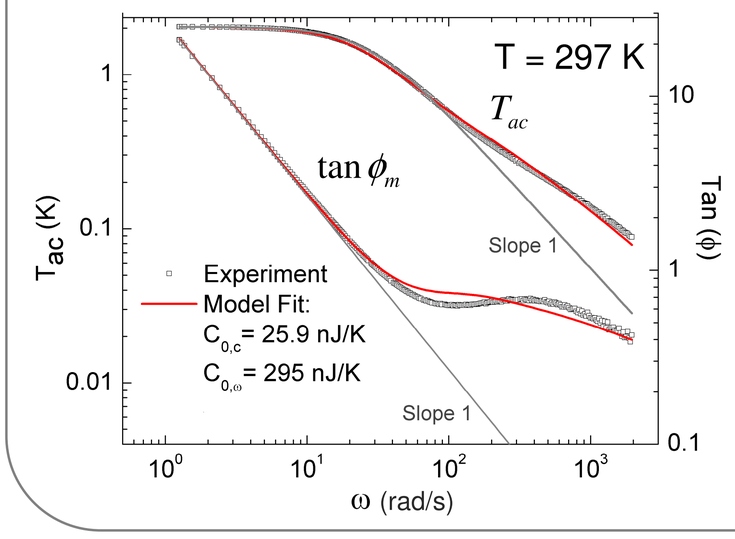
* T.H. Geballe and W.F. Giacque, J. Am. Chem. Soc., 74 (1952) 2368

AC method: frequency dependence and sample thermal link

$$T_{ac} = \frac{P_0}{\sqrt{K_e^2 + (\omega C_0)^2}}, \quad \tan\phi_m = \frac{K_e}{\omega C_0}$$

$$K_e(\omega) = K_\omega \cdot h(\omega)$$

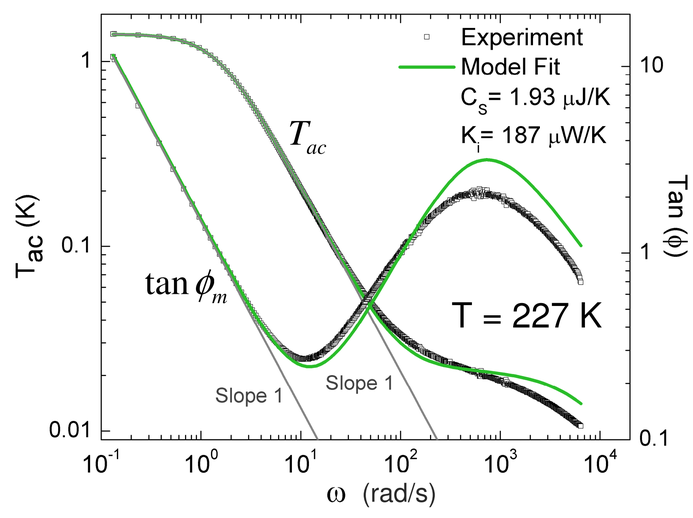
$$C_0(\omega) = C_{0,c} + C_{0,\omega} \cdot l(\omega)$$



Using the fitting parameters for ω = 58 rad/s:

$$C_0 = (25.9 + 295 \cdot l(58))\frac{nJ}{K} = 110\ \frac{nJ}{K}$$

$$T_{ac} = \frac{P_0}{\sqrt{K_e^2 + (\omega \bar{C})^2}}, \quad \tan\phi_m = \frac{K_e + K_i \cdot f}{\sqrt{(\omega \bar{C})^2 + K_e^2 - (K_e + K_i \cdot f)^2}}$$



$$\bar{C}^2 = C_0^2 \cdot f + \left(C^2 + C_S^2 \frac{2K_e}{K_i}\right) \cdot g$$

$$C = C_0 + C_S$$

$$\begin{cases} g(\omega) = \dfrac{1}{1 + (\omega\tau_i)^2} \\ f(\omega) = \dfrac{(\omega\tau_i)^2}{1 + (\omega\tau_i)^2} \end{cases}$$

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