

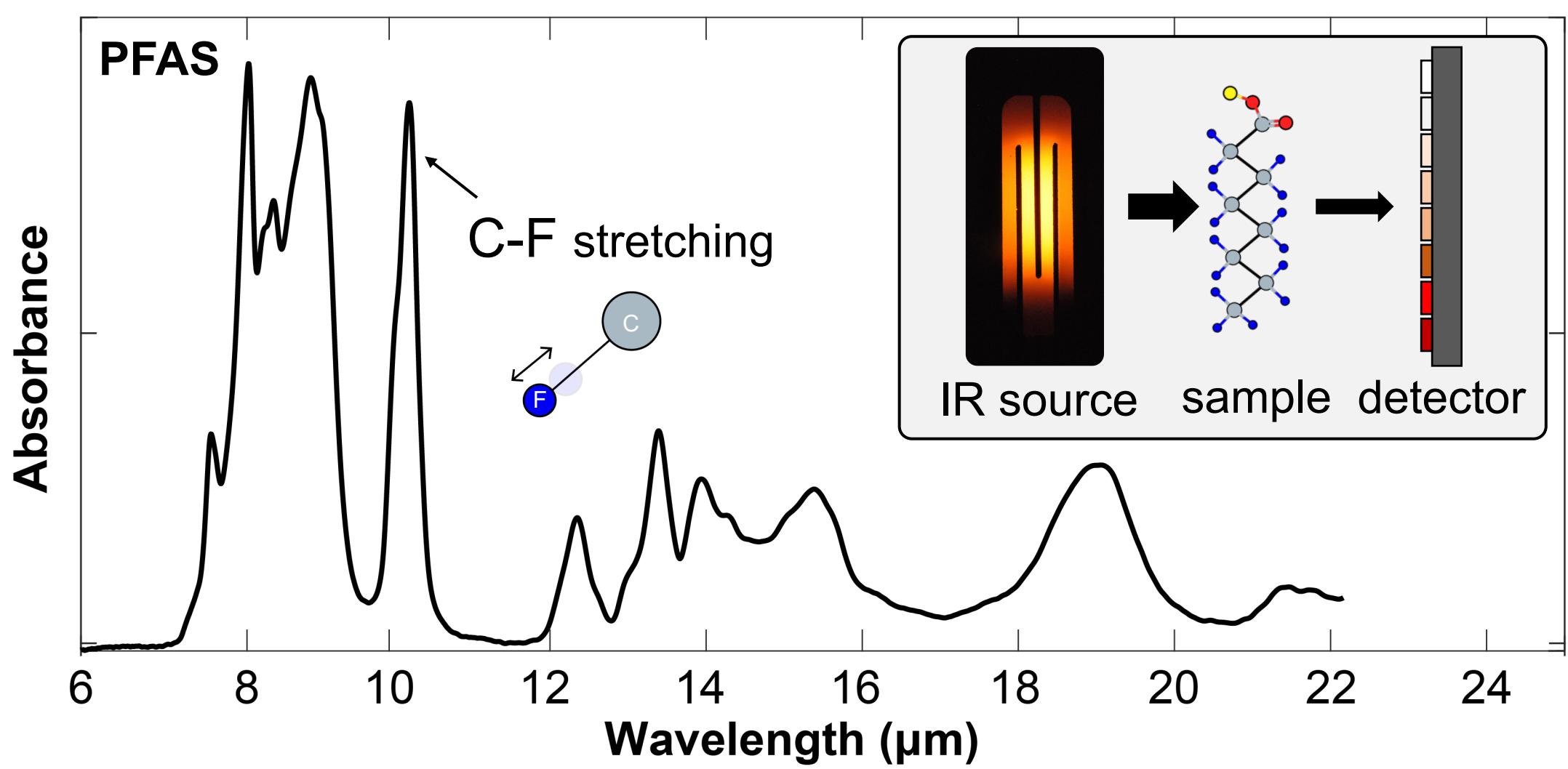
On-chip infrared spectroscopy with near-field detection

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1. Motivation

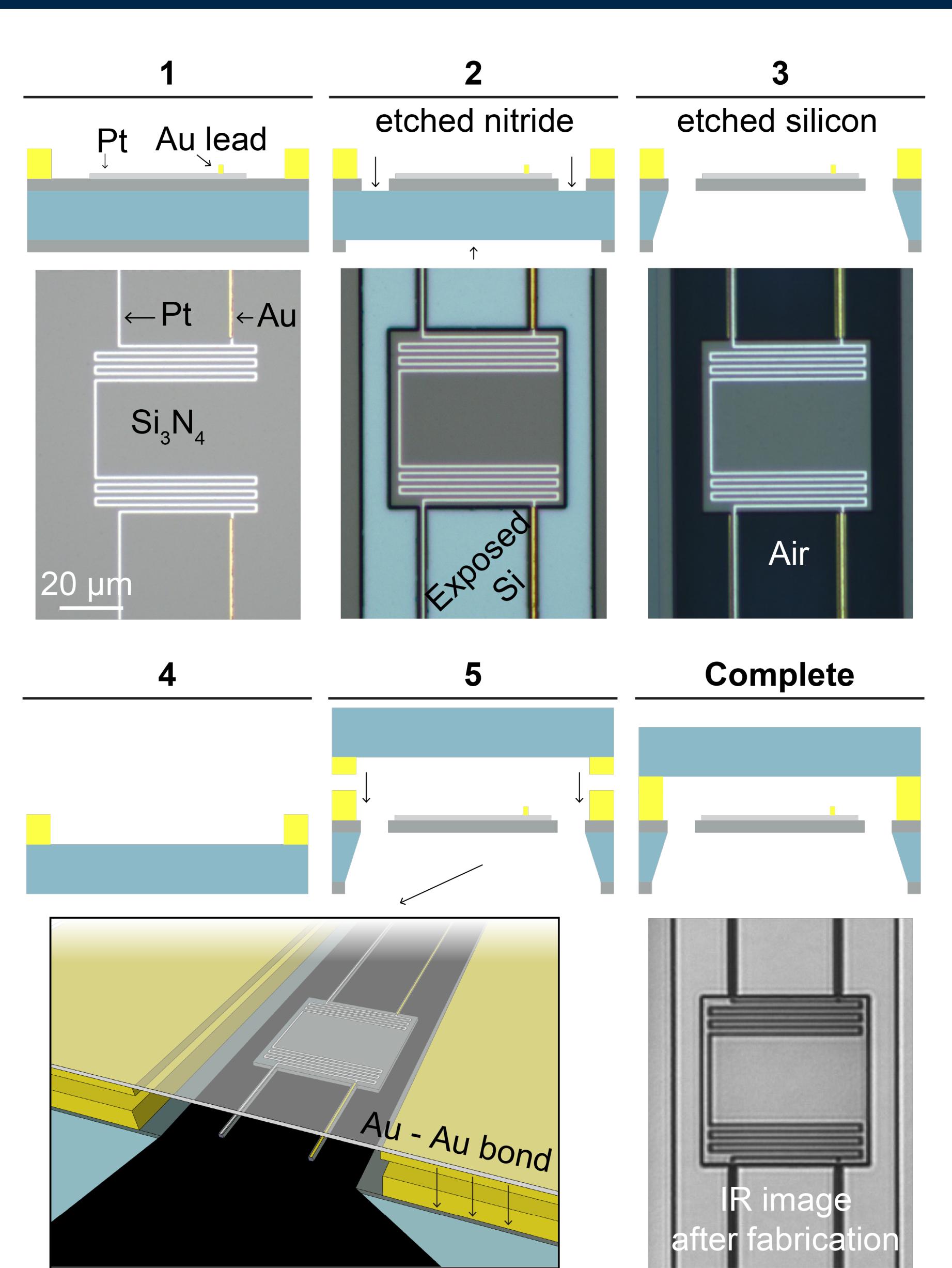
IR spectroscopy captures a vibrational fingerprint



Miniature IR spectrometers can provide cheap and portable analyte detection

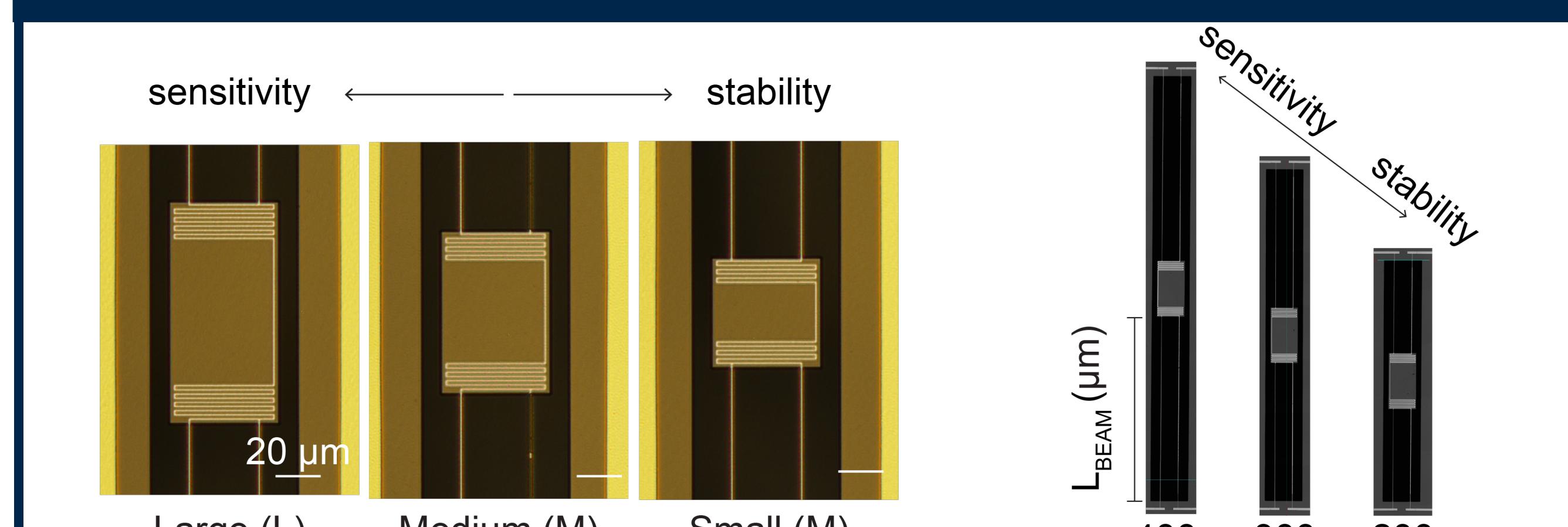


4. Fabrication



Fabrication steps: 1. Pt/Au lead, 2. etched nitride, 3. etched silicon, 4. Si₃N₄ layer, 5. Complete structure with Au-Au bond.

5. Sensitivity vs Stability



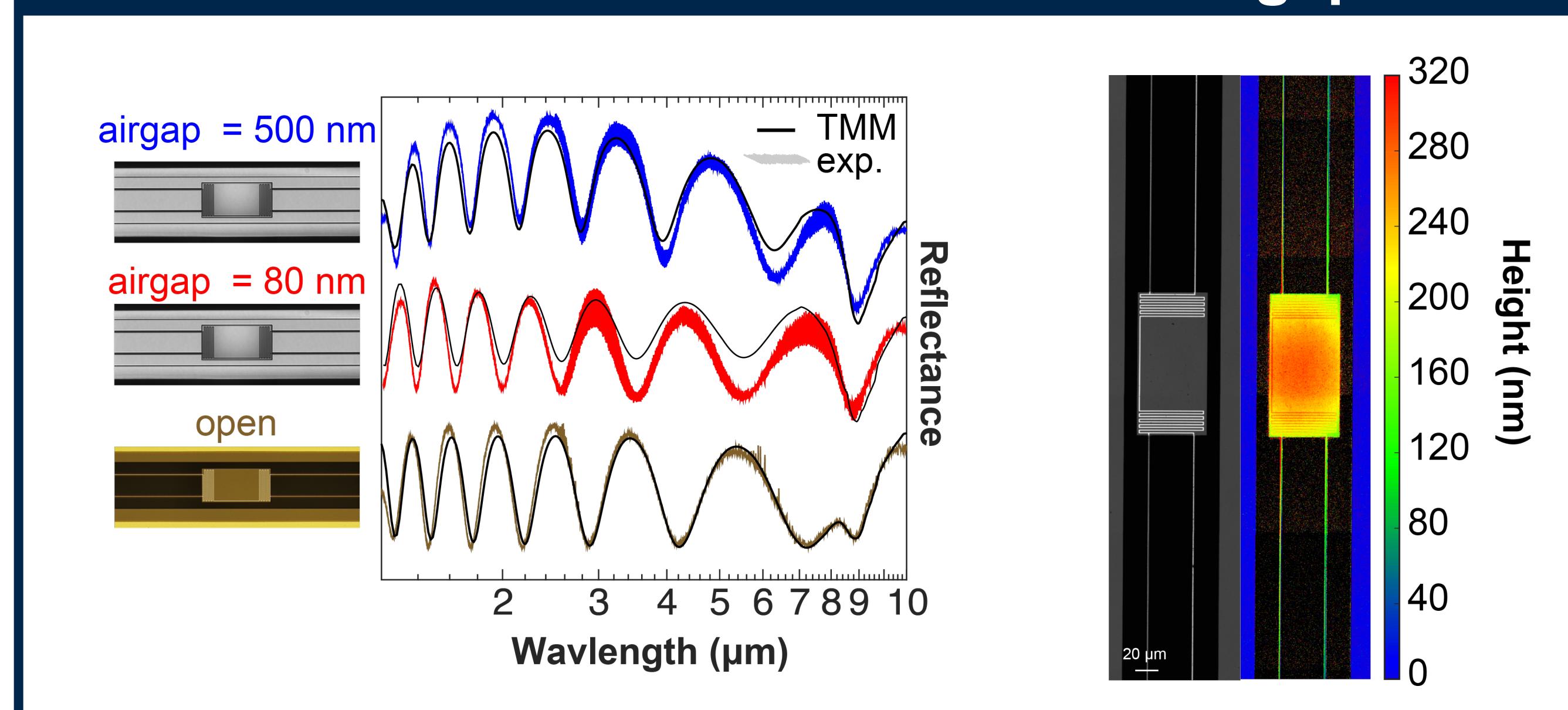
sensitivity ← → stability

Area and beam length dictate sensitivity and stability

Large (L) Medium (M) Small (M)

L_{BEAM} (μm): 400, 300, 200

6. Airgap Thickness (d_{gap})

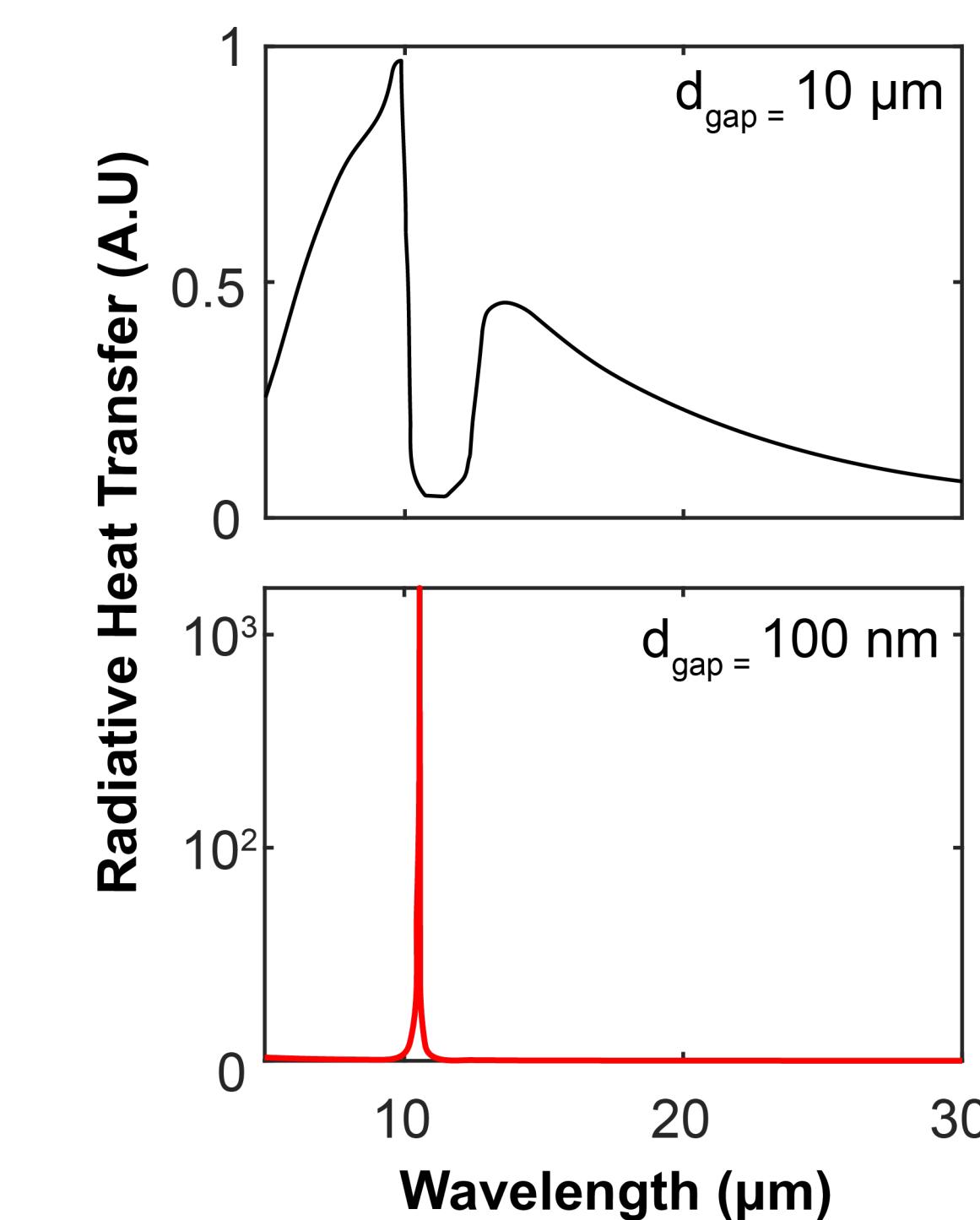


airgap = 500 nm
airgap = 80 nm
open

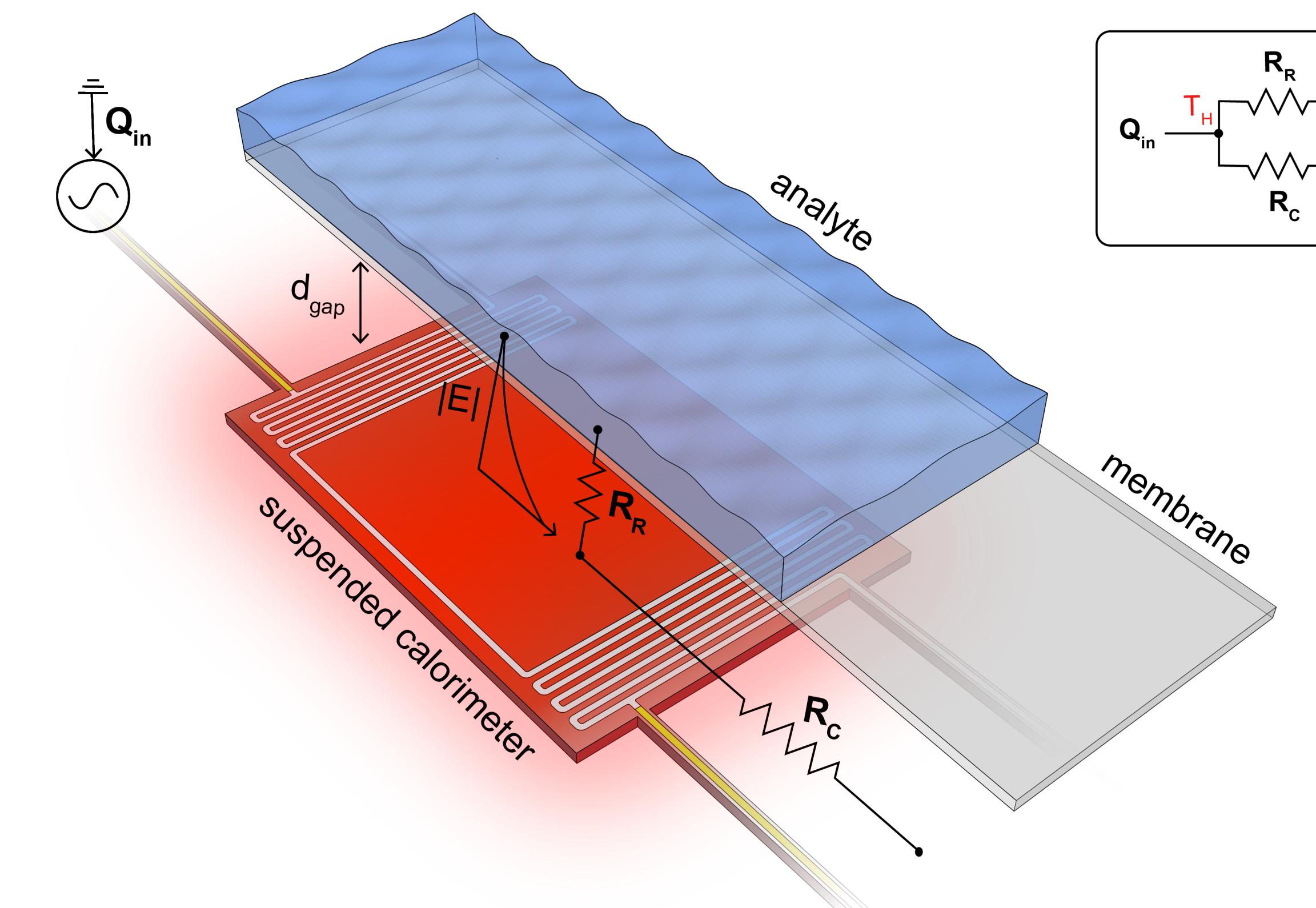
Reflectance vs Wavelength (μm) plot. TMM exp. is shown as a blue line, and experimental data are shown as red and blue curves. A color scale indicates height (nm) from 0 to 320 nm.

Airgap imprecision is due to calorimeter deflection

3. Our Solution – Replace traditional IR sources and photodetectors with "all-in-one" near-field calorimeters



Radiative Heat Transfer (A.U.) vs Wavelength (μm). Top plot: $d_{\text{gap}} = 10 \mu\text{m}$, bottom plot: $d_{\text{gap}} = 100 \text{ nm}$.

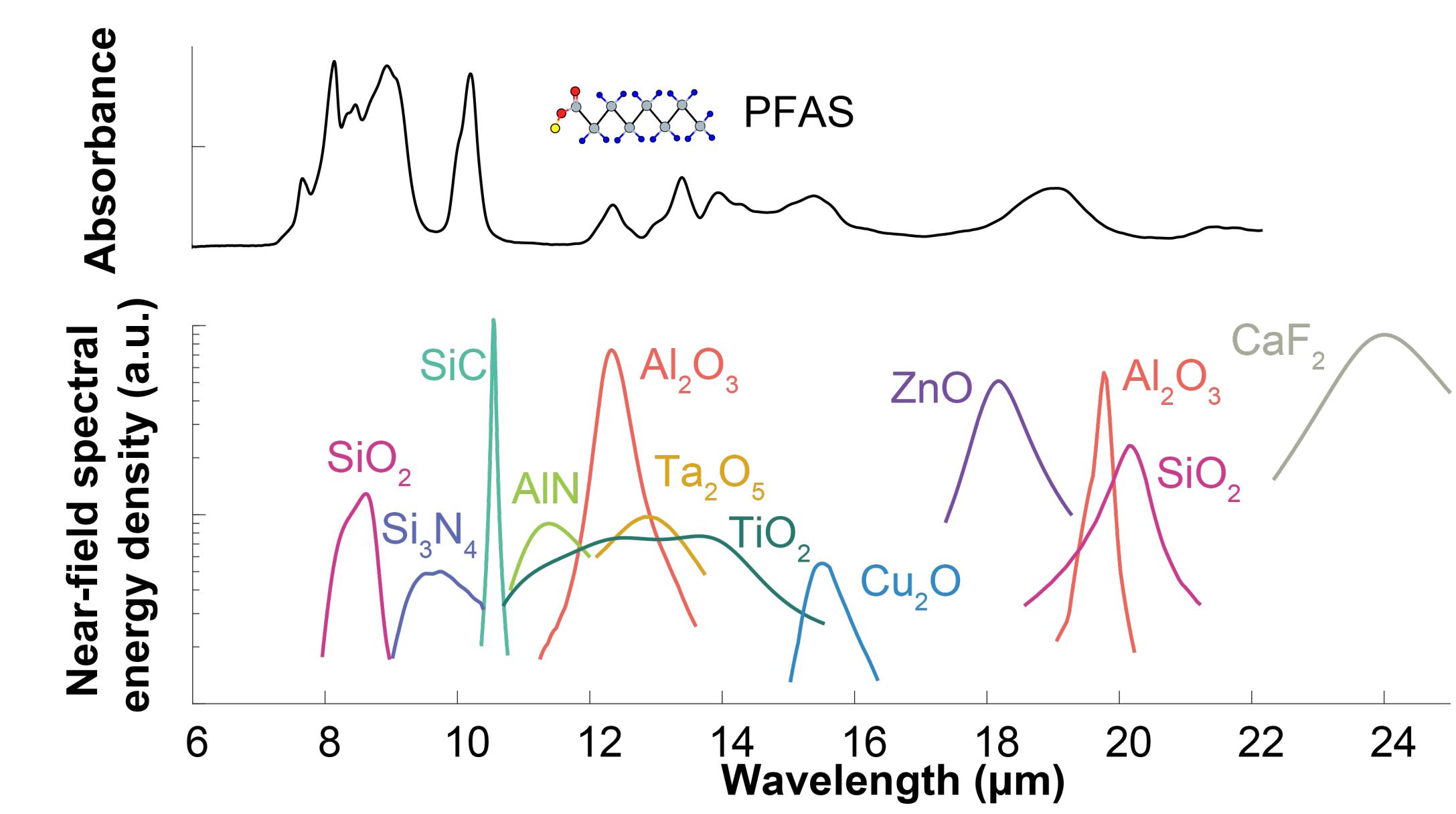


3D schematic of the suspended calorimeter structure. It consists of a membrane with a suspended calorimeter (containing resistors R_R and R_c) and an analyte layer. An inset shows the electrical circuit: Q_{in} is connected to the calorimeter through resistor R_R , and the output is measured across resistor R_c at temperature T_c . The background temperature is T_{∞} .

Near-field radiative transport offers high power densities and wavelength selectivity

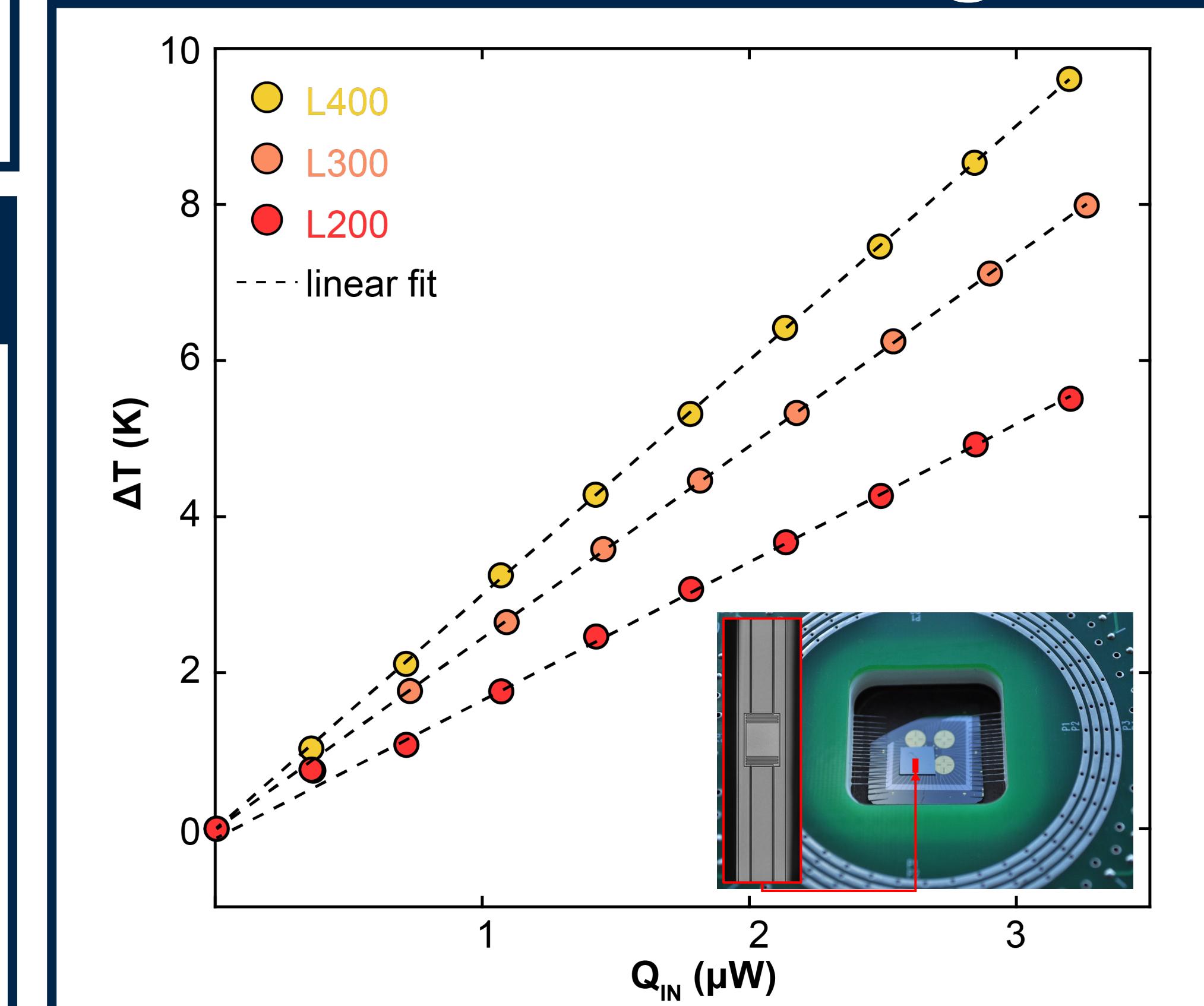
A new paradigm in IR spectroscopy

An array of calorimeters made from polar dielectrics and plasmonic materials can be utilized to provide a broad IR spectral range, substantially increasing the spectral range of current on-chip spectrometers



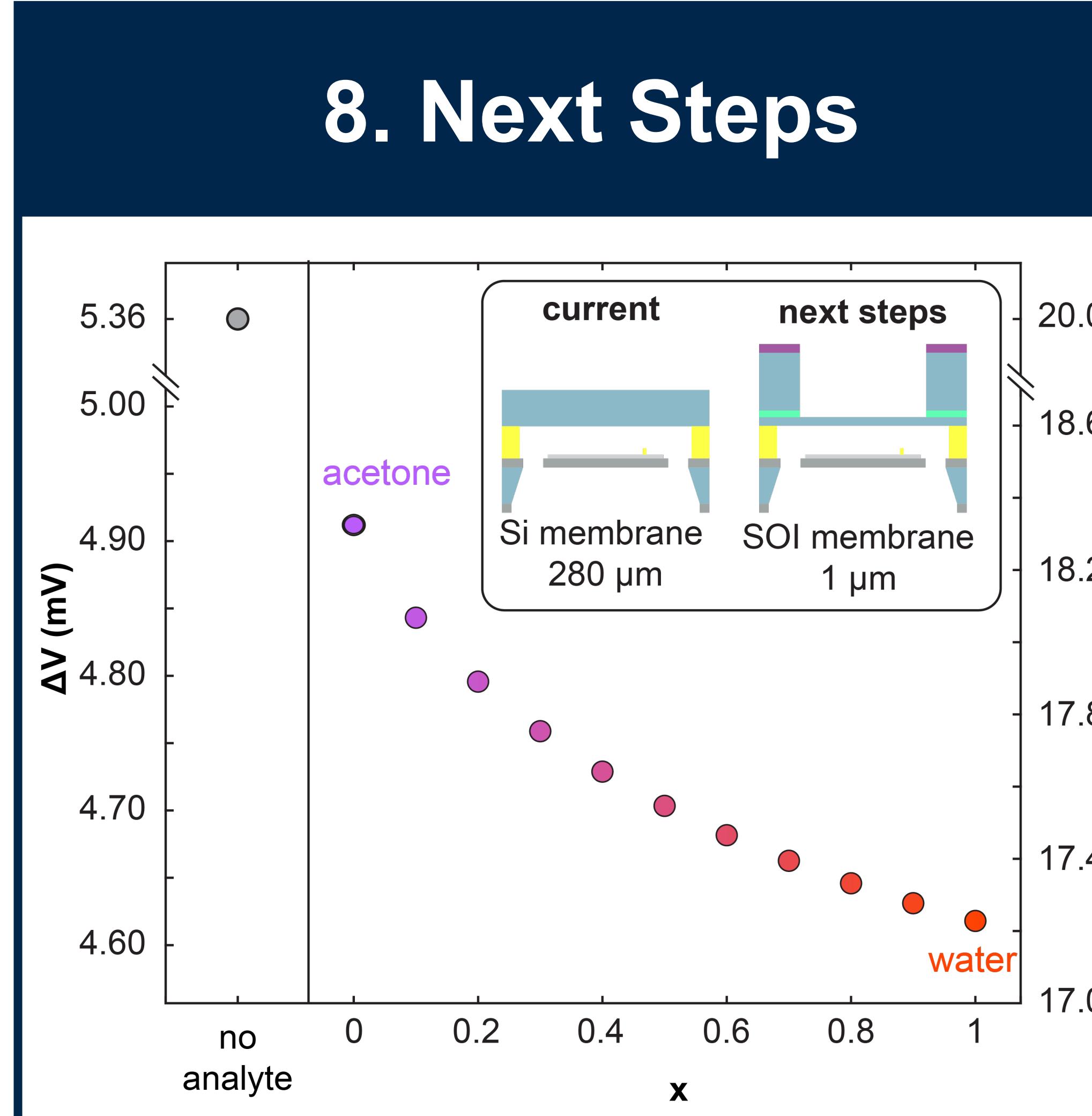
Absorbance vs Wavelength (μm) plot for PFAS. Below it, a plot shows Near-field spectral energy density (a.u.) vs Wavelength (μm) for various materials: SiC, Al₂O₃, ZnO, CaF₂, SiO₂, Si₃N₄, AlN, Ta₂O₅, TiO₂, Cu₂O.

7. Preliminary Thermal Testing



ΔT (K) vs Q_{in} (μW). Data points for L400 (yellow), L300 (orange), and L200 (red) beams are plotted with a linear fit. Inset shows an SEM image of the beam structure.

Thermal conductance of the beams (without analyte) meets expectations



ΔT (K) vs x (no analyte, acetone, water). The plot shows ΔT decreasing as x increases. Inset shows a schematic of the membrane stack: Si membrane (280 μm) and SOI membrane (1 μm).

To distinguish between different analytes, a thinner membrane must be implemented

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