Electronic Supplementary Material (ESI) for Nanoscale Advances.

Supporting Information

Spectrally selective microbolometer based on planar subwavelength thin films

Qianqian Xu[1,2], Ziji Zhou[1,2], Chong Tan[1,2], Xiaohang Pan[1], Zhengji Wen[1], Jinguo Zhang[1, 3], Dongjie Zhou[1,2], Yan Sun[1], Xin Chen[1], Lei Zhou[4], Ning Dai[1,5], Junhao Chu[1,3] and Jiaming Hao[1,3*]

[1] State Key Laboratory of Infrared Physics, Shanghai Institute of Technical Physics, Chinese Academy of Sciences, Shanghai 200083, China

[2] University of Chinese Academy of Sciences, Beijing 100049, China

[3] Shanghai Frontiers Science Research Base of Intelligent Optoelectronics and Perception, Institute of Optoelectronics, Fudan University, Shanghai 200433, China

[4] State Key Laboratory of Surface Physics and Key Laboratory of Micro and Nano Photonic Structures (Ministry of Education), and Physics Department, Fudan University, Shanghai 200433, China

[5] Hangzhou Institute for Advanced Study, University of Chinese Academy of Sciences, Hangzhou 310024, China

*E-mail: jmhao@fudan.edu.cn

Supporting Information

Table S1: Calculated and measured resistance of the fabricated microbolometers.

Bolometers	ρ_{Au} $(\Omega \cdot cm)$[1]	Cal. Resistance (Ω)	Exp. Resistance (Ω)
bare Au-200	3×10^{-6}	115	115
bare Au-500		110	120
bare Au-800		135	146
MIM-200	top: 8×10^{-6} bottom:3×10^{-6} (Parallel Connection)	102	104
MIM-500		98	104
MIM-800		120	134

The calculated resistance (R) is obtained by using $R = \rho \cdot l/s$, where ρ, l, s are the electrical resistivity, length, and cross-sectional area of the resistor, respectively.

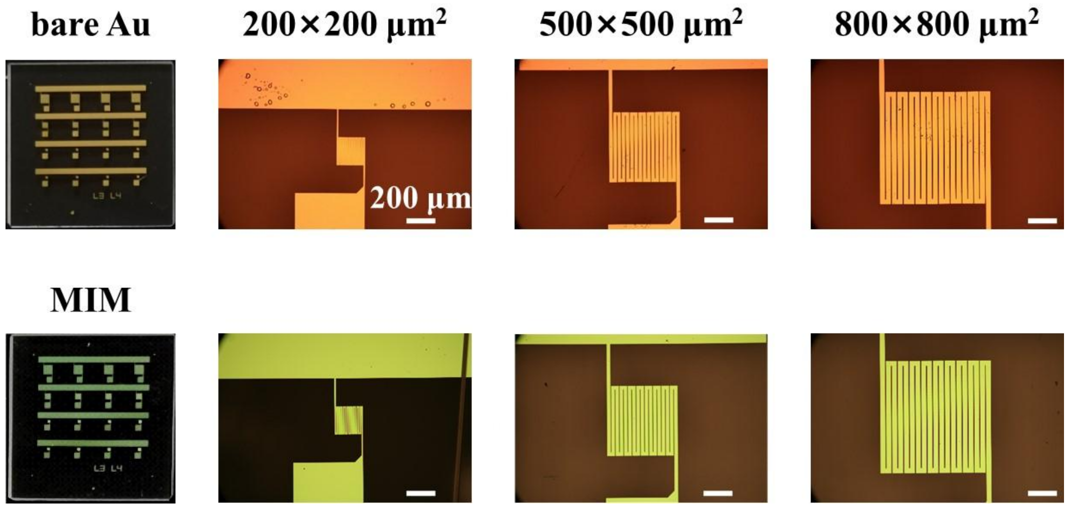

Figure S1: Photographs and microscope images of the fabricated two types microbolometers with various efficient areas, scale bars are 200μm.

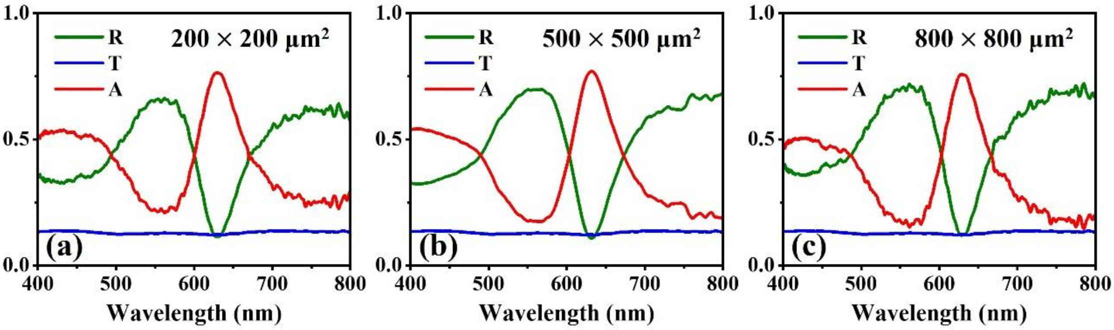

Figure S2: Experimental measured absorption spectra of the MIM microbolometers with three area size.

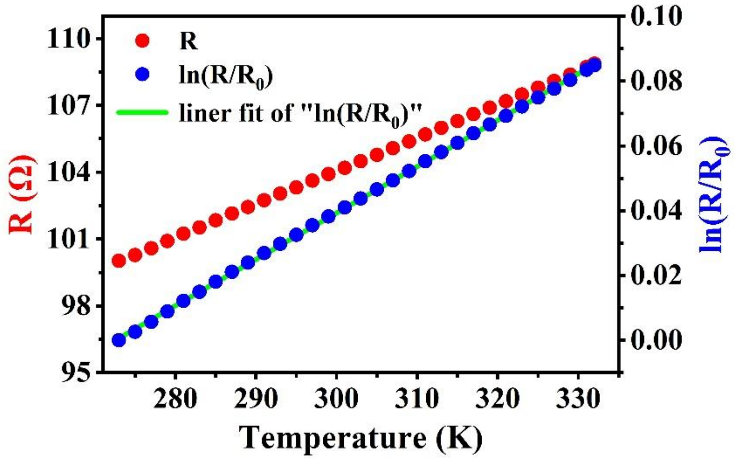

Figure S3: The experimentally measured the resistance change of the fabricated microbolometer (magenta dotted line) under 0.2 mA and corresponding calculated $\ln(R/R_0)$ (blue dotted line). R_0 is the resistance of the device at temperature of 273 K, and the fitted TCR is 0.0014 K^{-1}.

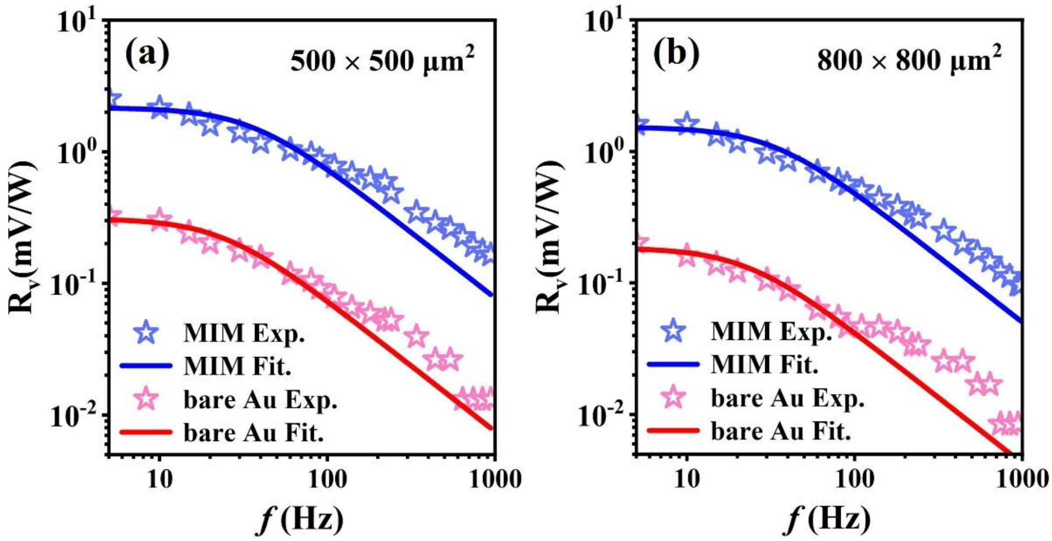

Figure S4: The experimentally measured responsivities of microbolometers with efficient area size of 500×500 μm^2, and 800×800 μm^2, as a function of modulation frequency.

Note 1：Calculation of the thermal conductance

The thermal conductance G can be theoretically calculated by[2]

$$G = k \cdot S/h \tag{S1}$$

Where k, S and h are the thermal conductivity of material, the contact area, and the heat transfer distance, respectively.

Firstly, 2D heat distributions were calculated based finite element methods. In the simulations, we replace the winding structure as planar thin films for both MIM and bare Au devices to simplify the calculation, the sizes and thicknesses for each film are as the real devices. The planar thin film structures serve as the heat source on a quartz substrate. The heat conductivities of gold, alumina, and quartz were taken from literature[2]. The thermal power density of the heat source of MIM structures is set one order of magnitude larger than that of the bare Au control samples. After getting heat distribution of each device at the response time, we then utilize the lateral heat transfer distance d and vertical heat transfer distance t obtained from the simulated results to calculate the contact area ($S=d^2$) and distance ($h=t$). Finally, the effective thermal conductance G, and the ratio of the absorption coefficient at 638 nm to the effective thermal conductance (η/G) for each microbolometer can be calculated using Eq. (S1). The calculated results are listed in Table S2.

Table S2: Calculated G and η/G of the fabricated microbolometers.

Bolometers	τ *(ms)*	*S (m²)*	*h (m)*	*G(W/K)*	η/G
bare Au-200	4.29	2.03×10^{-7}	1.50×10^{-4}	1.86×10^{-3}	47.28
bare Au-500	6.60	5.63×10^{-7}	1.50×10^{-4}	5.18×10^{-3}	17.02
bare Au-800	6.90	1.21×10^{-6}	2.00×10^{-4}	8.35×10^{-3}	10.55
MIM-200	2.14	1.60×10^{-7}	1.20×10^{-4}	1.84×10^{-3}	413.19
MIM-500	4.50	5.93×10^{-7}	1.50×10^{-4}	5.45×10^{-3}	139.38
MIM-800	4.85	1.44×10^{-6}	1.50×10^{-4}	1.32×10^{-2}	57.39

SI references:

1 G. Kästle, H. G. Boyen, A. Schröder, A. Plettl and P. Ziemann, *Phys. Rev. B*, 2004, **70**, 165414.

2 F. P. Incropera, D. P. DeWitt, T. L. Bergman and A. S. Lavine, *Fundamentals of Heat and Mass Transfer*, New York: Wiley, 1996.