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Supplementary Materials for

A reflective millimeter-wave photonic limiter

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References

Other Supplementary Material for this manuscript includes the following:

Movies S1 and S2

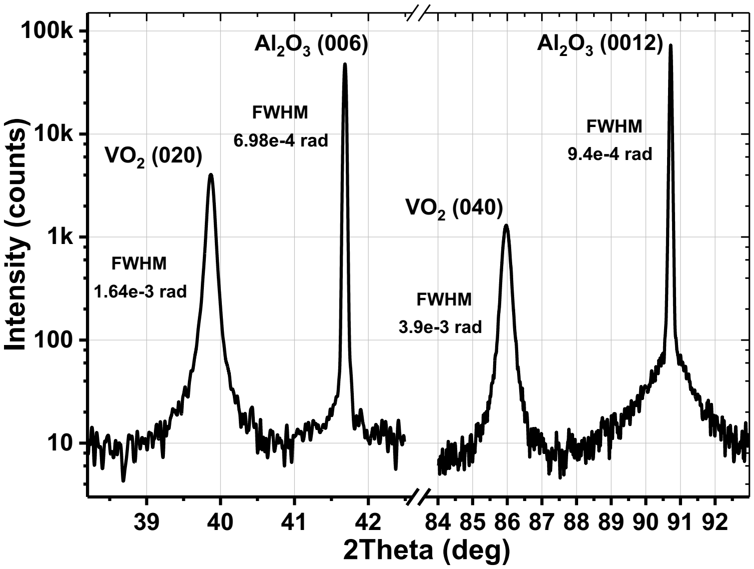

Fig. S1. X-ray diffractometry of the VO$_2$ film.

Room-temperature XRD plot of the ~150 nm thick VO$_2$ film deposited on sapphire substrate. The presence of highly oriented monoclinic VO$_2$ crystalline phase is indicated by the characteristic peaks (020) and (040) at 39.87° and 85.97°, respectively.

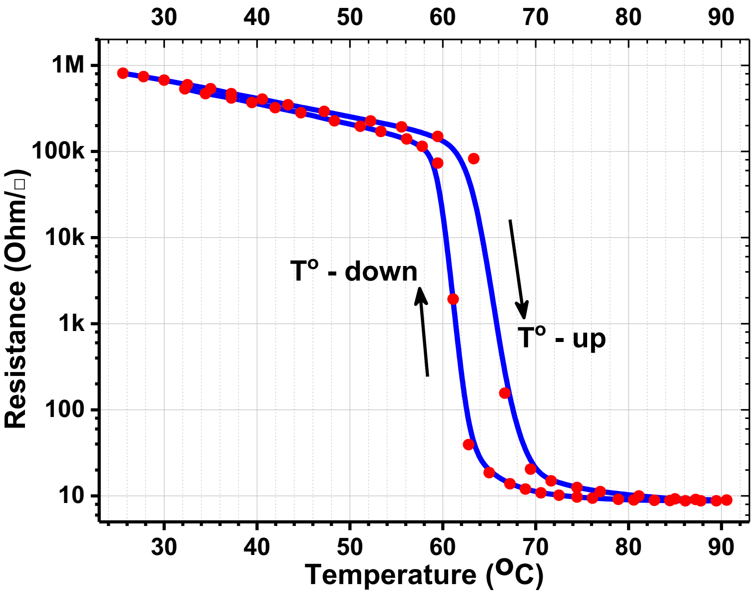

Fig. S2. Electrical properties of the VO_2 film.

Sheet resistance of the ~150 nm thick VO_2 film on sapphire substrate vs. temperature for the thermal cycle in a range from 20°C to 95°C. The abrupt change in the magnitude and hysteresis of the sheet resistance indicate the insulator-to-metal transition un the VO_2 film. The red dots are data points; the solid blue line is included for eye guidance.

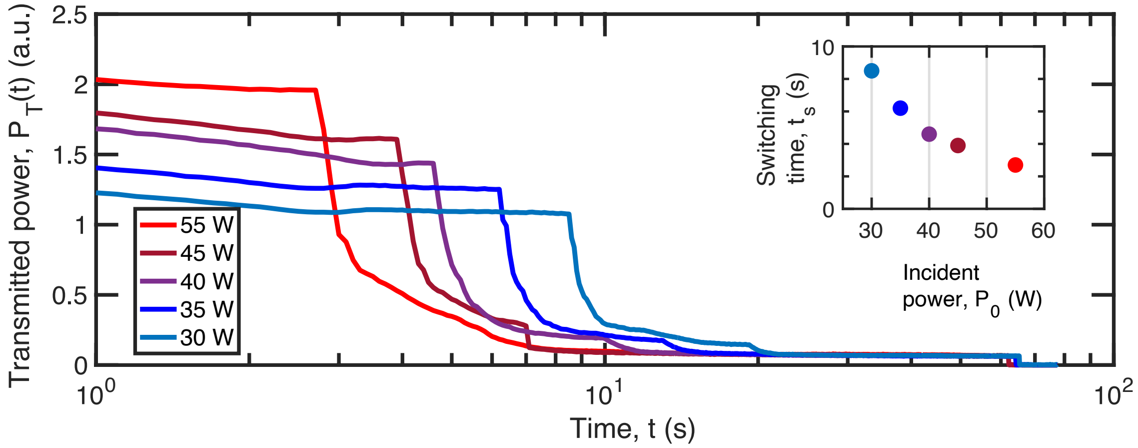

Fig. S3. High-power mm-wave measurements of the photonic limiter.

Time-varying transmitted power $P_T(t)$ of the photonic limiter (in arb. units) following excitation by a CW 95-GHz Gaussian beam of input powers $P_0 = 30, 35, 40, 45$, and 55 W, exiting the limiter via a 19-mm diameter metallic aperture. As compared to the measurements without the aperture in Fig. 4, the limiter has a sharper drop in transmitted power and a shorter switching time due to partial reflection from the aperture. Inset: switching time t_s, corresponding to the onset of the metallic phase in the VO_2 layer, versus the input power P_0.

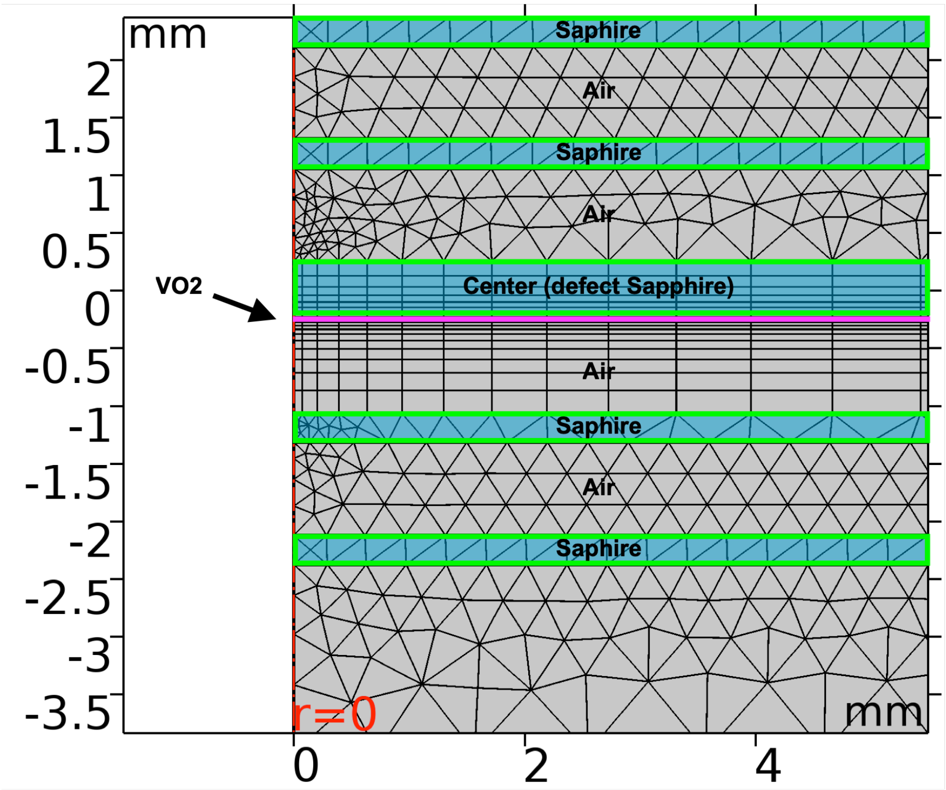

Fig. S4. COMSOL simulation mesh.

The varying mesh density used in the COMSOL simulations of the mm-wave limiter.

Material	Mass density, ρ ($\mathrm{kg/m^3}$)	Thermal conductivity, k (W/m·K)	Heat capacity, c (J/kg·K)
Sapphire	3980 [47]	20 [47]	756 [47]
Air, 1 atm, 298 K	1.184 [48]	0.026 [48]	1004 [48]
$\mathrm{VO_2}$	4031 [49]	6.5 [50]	656 [50]

Table S1. Material properties

Thermal and physical properties of the materials used in the heat transfer modeling of the mm-wave limiter.

Movie S1.

Heating of the VO_2 layer inside the photonic limiter following excitation by a CW 95-GHz Gaussian beam of input power $P_0 = 45$ W, captured with a FLIR infrared thermal camera. The metallic phase of the VO_2 layer manifests itself as the red spot in the center, where the beam intensity is maximum. At the end, when the input power is turned off, the VO_2 reverts from the metallic to the dielectric phase after a brief delay.

Movie S2.

COMSOL simulated propagation of a CW 95-GHz Gaussian beam of input power $P_0 = 554$ W through the multilayer of Fig. 1. The metallic phase of the VO2 layer, which occurs and blocks the beam in the center, is seen to grow in diameter with time following the excitation until reaching equilibrium.

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