A transparent, thermally tunable microwave absorber based on patterned vanadium dioxide film

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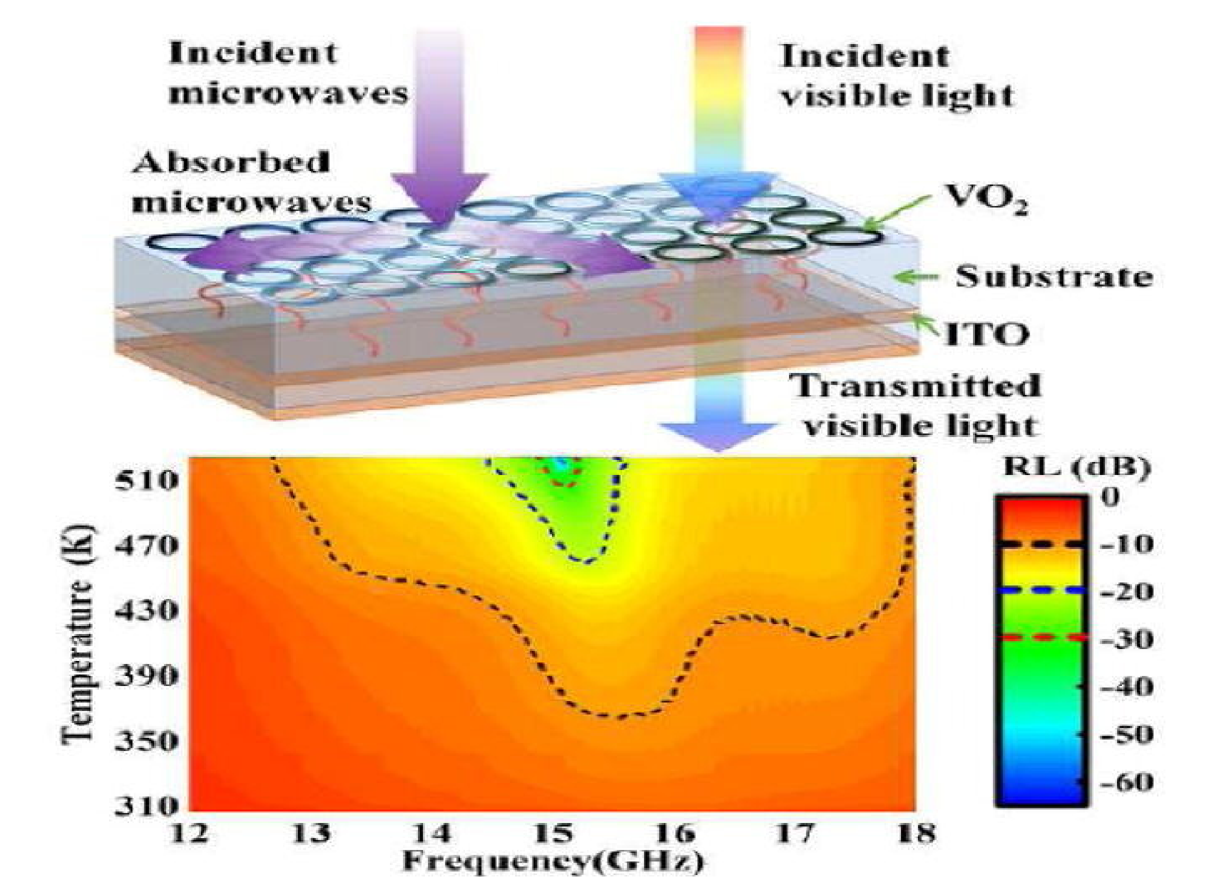

Graphical abstract. Credit: *Engineering* (2022). DOI: 10.1016/j.eng.2022.10.005

Recently, the rapid development of optoelectronic devices has made human life more convenient. However, these devices emit large amounts of electromagnetic radiation, which not only endanger human health, but also cause unacceptable malfunctions in electronic systems. Therefore, electromagnetic shielding technology that eliminates the adverse electromagnetic waves is of vital importance to protect sensitive circuits from interference and preserve a healthy living environment.

The absorption-based electromagnetic shielding technology is the most ideal method of electromagnetic shielding at present because electromagnetic waves cannot return to space and are completely eliminated. In particular, optical transparent and tunable microwave absorption technology, which can be tuned in real time and applied in visual observations, has attracted great attention for its scientific and application values.

Vanadium dioxide is a promising candidate material for tunable absorbers due to its drastic insulator-to-metal phase transition (the change of sheet resistance is five orders of magnitude in theory) near room temperature and various transition-triggering mechanisms (such as thermal heating, optical excitation, and bias voltage). However, most studies on vanadium dioxide tunable absorbers focus on the terahertz and infrared bands, and the optical transmittance of vanadium dioxide film is almost zero in the visible band, which limits its application in the optical field.

In a recently published paper in *Engineering*, a research team from Harbin Institute of Technology demonstrated a transparent thermally tunable microwave absorber based on a patterned vanadium dioxide film that has a simple structure composed of top-patterned vanadium dioxide film, transparent substrate (quartz glass), and bottom transparent reflective layer (double-layer indium tin oxide).

Taking advantage of the thermally tunable sheet resistance of vanadium dioxide film, the researchers realized a reflection loss amplitude tuning from -4.257 to -60.179 dB. Meanwhile, the optical transmittance of this absorber can exceed 84.9% at 620 nm, which is the first time vanadium dioxide film has been applied in a visible transparent microwave absorption field, and it is also the first time a modulation depth of more than 50 dB has been achieved in the case of high visible transparency. In addition, the absorber in this paper can achieve near-unity absorption (99.993%) at 15.060 GHz at 523.75 K.

In the published paper, the researchers developed a transmission line model based on the equivalent circuit method to mechanistically analyze the electromagnetic transmission characteristics of the vanadium dioxide absorber.

The tunable absorption of the absorber is mainly due to the temperature-depended sheet resistance of vanadium dioxide film, which allows the absorber to provide a different impedance matching degree to the free space. This work also experimentally measured absorption performance of the vanadium dioxide absorbers with different duty cycles and demonstrated that the temperature of near-unity absorption and the temperature tuning range can be adjusted by varying the duty cycle of the patterned vanadium dioxide film.

This innovation proposes a transparent, thermally tunable vanadium dioxide absorber with simple composition, high optical transmittance, thermally tunable microwave absorption performance, large modulation depth, and an adjustable temperature tuning range. The absorber could be applied to tunable sensors, thermal emitters, modulators, thermal imaging, bolometers, and photovoltaic devices. It can pave the way for developing vanadium dioxide film in the field of optical transparency and the realization of high transparency and large modulation depth in the field of transparent tunable absorption.

More information: Zhengang Lu et al, Transparent Thermally Tunable Microwave Absorber Prototype Based on Patterned VO2 Film, *Engineering* (2022). DOI: 10.1016/j.eng.2022.10.005

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