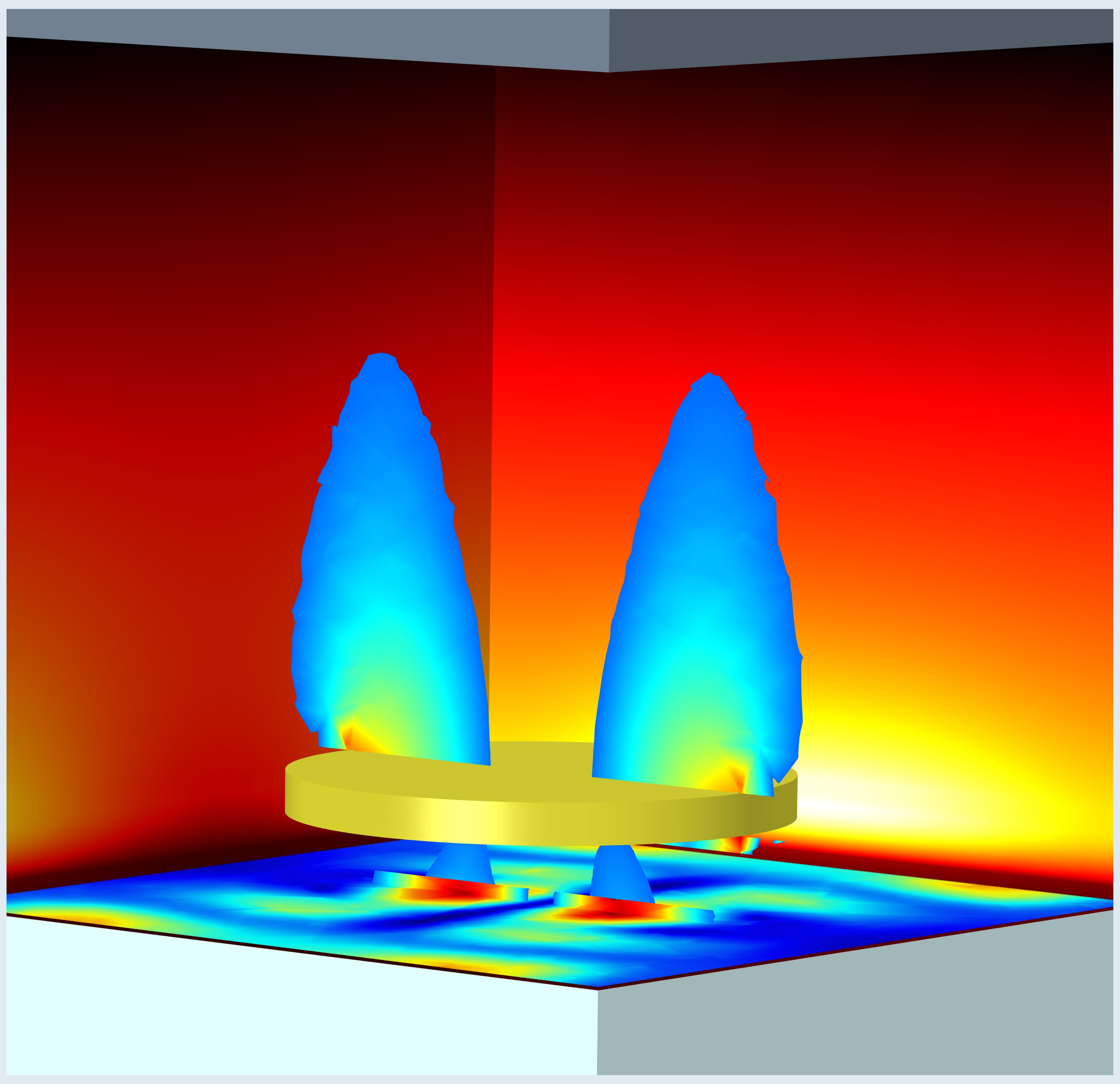

Meta Surface Design for Photo-Thermal Conversion Applied to IR-Sensing

Designing of perfect absorber in the IR range, using plasmon resonance in a MI-PCM-IM structure for photo-thermal conversion: towards integrated sensing device.

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Introduction & Goals:

The Internet of Things (IoT) is an emerging field with significant potential in industrial maintenance and assisting people with disabilities. As IoT relies on a vast network of sensors for optimal performance, the development of advanced sensor technologies is crucial. **Neuromorphic and spiking sensors** have emerged as promising solutions. Among the various technologies available, this work focuses on the use of phase change material (PCM) in combination with **vanadium dioxide (VO_2).** VO_2 undergoes a transition from an insulating to a metallic phase at around 70°C, a property that has been shown to enable spiking in temperature sensors (Ref. 1). This unique behavior makes VO_2 a compelling candidate as an active layer for **infrared (IR) sensing**. Instead of directly measuring heat, our approach involves detecting temperature changes induced by incident light through **photothermal conversion**. A metal-insulator-metal (MIM) structure is typically employed for such purposes (Ref. 2). In this study, we present simulations of a metamaterial perfect absorber designed for **photothermal conversion using a MI-PCM-IM** structure, highlighting its potential applications in sensing.

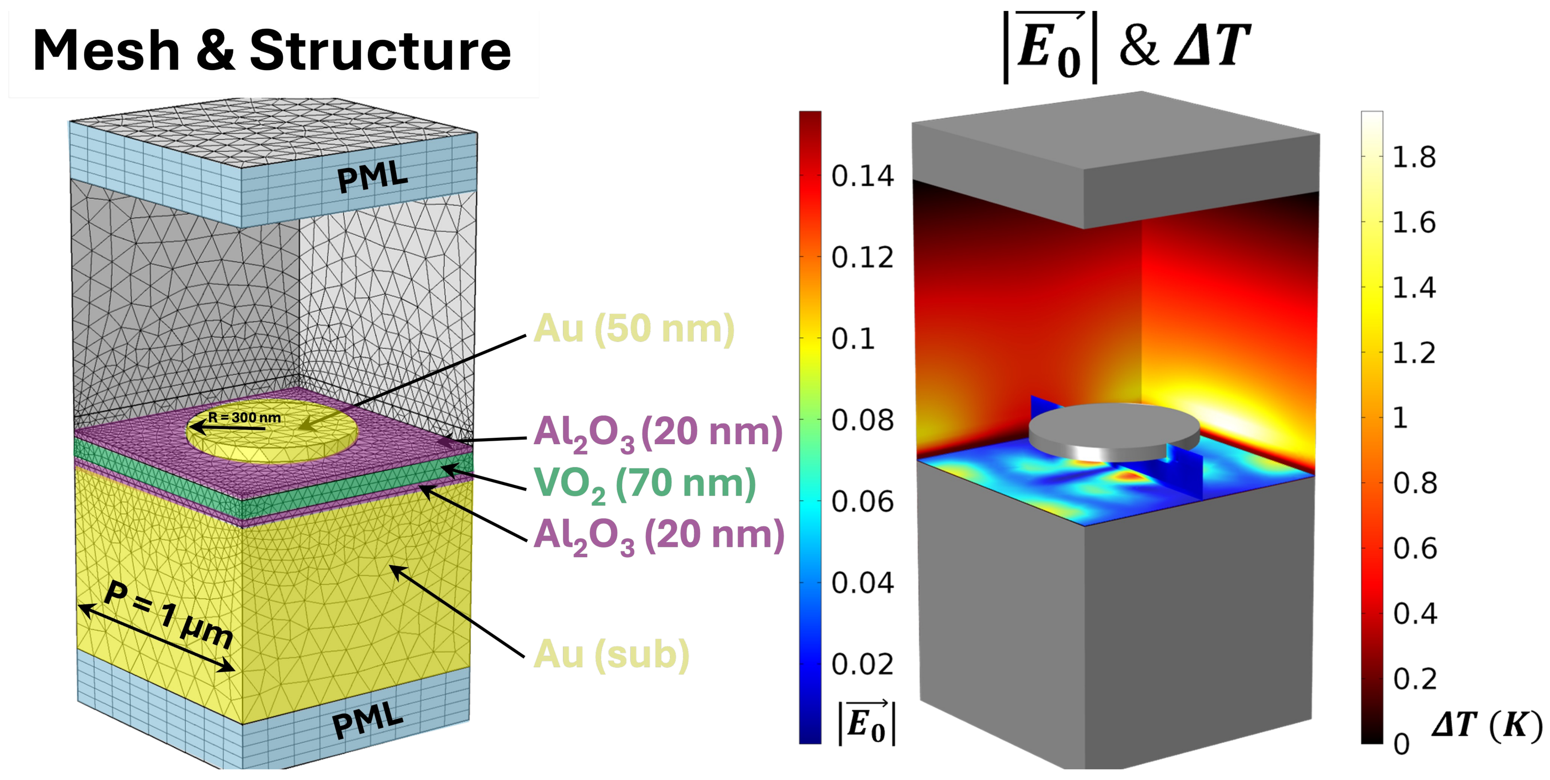

FIGURE 1. Left: The mesh and the structure used for the simulation. Right: The typical results with field enhancement and the temperature rise.

Methodology

The **electromagnetic wave module** is employed for the optical responses exhibited by the structure presented in Figure 1. **Perfectly matched layers** are positioned at the upper and lower extremities, while **periodic boundary conditions** are implemented on the parallel surfaces to simulate the nanoparticle network in an efficacious manner. The input is a plane wave with a polarization along the Y-axis and a power of P_{in}=10^5 W/m.

The simulation couples this with the **heat transfer in solids module** to generate heat sources based on the **optical power loss density**. By varying the input wavelength, power, and polarization, the behavior of the meta surface can be predicted. The optical response will be studied regarding the reflection/absorption coefficient and ΔT, which represents the average rise in temperature in the VO_2 layer (Figure 1).

Results

The behavior of the proposed structure was investigated by sweeping the input wavelength. The structure exhibits **near-perfect absorption (98%) at 1.47 µm**, accompanied by a secondary absorption peak (40%) at 3.2 µm. Each absorption peak is associated with a maximum in PT conversion (Figure 2.a).

Greater light absorption results in a more significant temperature increase, which is localized within the VO_2 nanoparticle. The maximum temperature is either directly beneath the nanoparticle or at its sides, depending on the specific plasmonic mode.

The evolution of the optical response has been studied in relation to the **period, the NP radius** and the metallic fraction of the VO_2 layer. For example, a **red shift** in the absorption peak has been observed **as the radius is increased** (Figure 2.b).

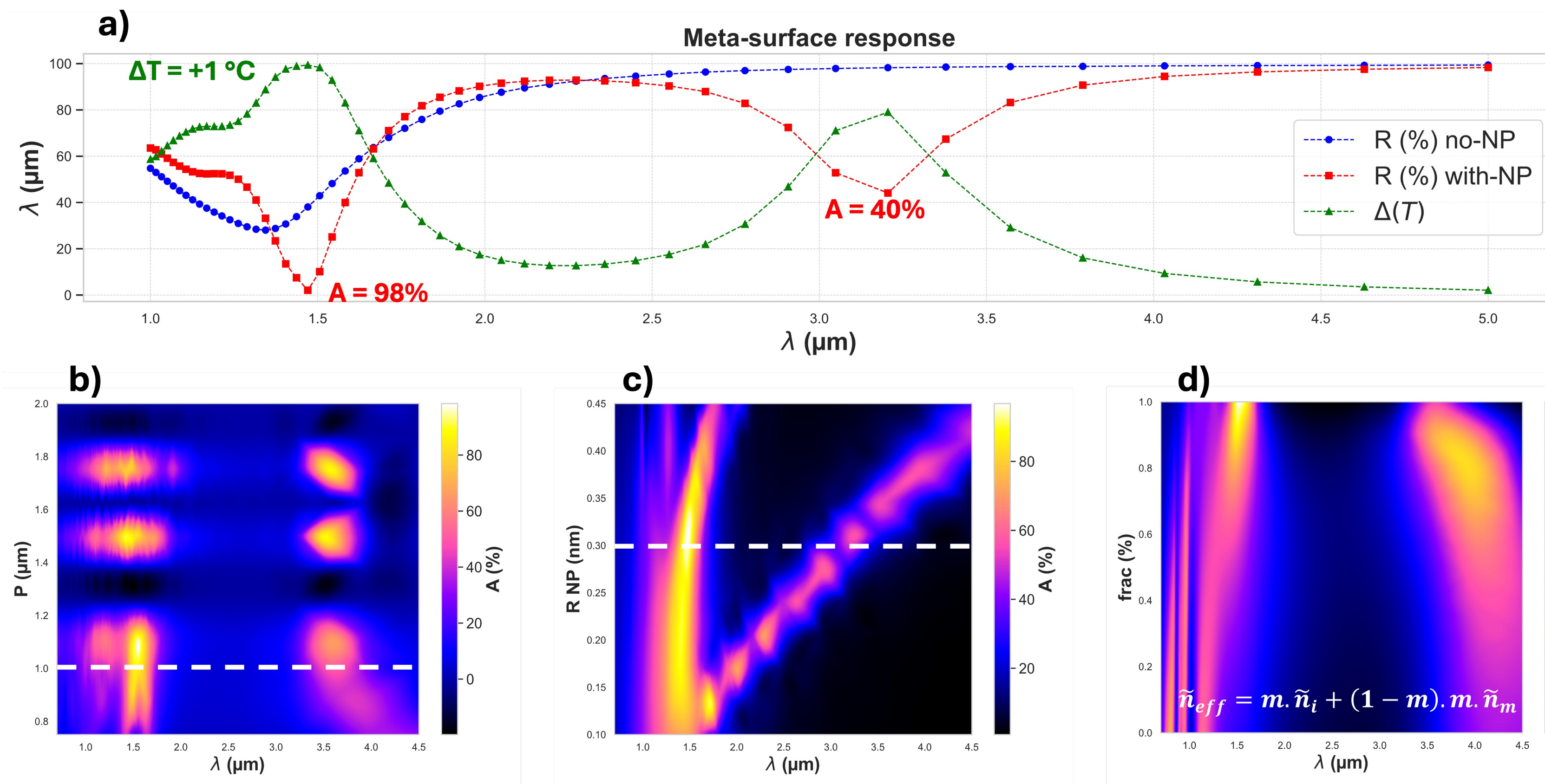

FIGURE 2. a) PT response of the meta-surface with and without the NP. Map of the meta-surface behavior with respect to b) period, c) NP radius, d) metallic fraction in the VO_2.

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