Thermo-plasmonics on vanadium oxide and silicon-based infrared sensor platforms

Xu Fang

[1]School of Electronics and Computer Science, University of Southampton, UK
E-mail: x.fang@soton.ac.uk

We present recent experimental and numerically simulated results in integrating plasmonic nanostructures with vanadium oxide and silicon thin films for developing infrared sensors with various functionalities. We also present a theoretical model, the modified Maxwell Garnett model, for interpreting hysteresis in vanadium dioxide.

A microbolometer is a type of photodetector that utilises the dependence of material resistivity on temperature in the light detection. Its unique properties such as extremely broadband response and room-temperature operation have led to its widespread use in various application. Its relatively simple sensor structure, at the same time, provides an ideal platform for nanoengineering.

We demonstrate both numerically and experimentally that plasmonic nanostructures fabricated on top of thin films of vanadium oxide and silicon, the two most commonly used sensing materials in microbolometers, regulate the distribution of light and heat at the nanoscale. This phenomenon is used to develop functionalities such as wavelength and polarisation sensitivity in the photodetection [1]. This result may be used to improve the performances of a variety of vision systems in the infrared.

We further present a theoretical model for interpreting optical hysteresis, where the optical properties of a material depends on not only the current temperature but also those in the history [2]. Hysteresis is a phenomenon that crucially affects the performances of vanadium oxide-based infrared sensors. The standard Maxwell Garnett model, a theoretical model widely used in effective medium analysis, is modified here to allow it to be used in hysteresis analysis. The model requires very few input parameters, providing a phenomenological approach to describing electromagnetic hysteresis in not only vanadium dioxide but also may other phase change materials.

[1] H. Takeya, J. Frame, T. Tanaka, Y. Urade, X. Fang & W. Kubo. Bolometric photodetection using plasmon-assisted resistivity change in vanadium dioxide. *Scientific Reports* 8, 12764 (2018).

[2] J. Frame, N. Green & X. Fang. Modified Maxwell Garnett model for hysteresis in phase change materials. *Optical Materials Express* 8, 1988 (2018).