Plasmonic vanadium dioxide microbolometers with wavelength and polarization sensitivity

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100-word abstract

Improved accessibility to high performance infrared technology is a necessity in fields as diverse as firefighting and spectroscopy; in many cases the cost to benefit ratio is too high. The current low-cost infrared detector market is dominated by vanadium dioxide microbolometers which suffer from lower performance than photodetectors and display poor spectral selectivity. Incorporating plasmonic nanostructures into vanadium dioxide based thermally-engineered arrays can enable high performance multispectral and polarisation sensitive detection without the need for filters and cooling. A variety of designs including plasmon-enhanced bolometers and multilayer suspended membranes are presented.

250-word summary

Uncooled infrared microbolometers are significantly cheaper than cooled sensors but concurrently sacrifice performance. Outperforming existing microbolometer platforms will benefit fields such as the emergency services (e.g. fire, search and rescue) and healthcare (e.g. pharmaceuticals, thermography). Vanadium dioxide (VO_2) currently leads the market in low cost infrared technology, largely by virtue of its near-to-room temperature dielectric-metal phase transition and strong absorption in the infrared regime. Plasmonic nanostructures in VO_2 have recently been demonstrated to produce alterations in optoelectronic properties via localized surface plasmon resonance.

Nanostructured VO_2 metamaterials presented in this work achieve optoelectronic properties optimised for specific infrared applications by tailoring their geometric parameters. Plasmonic resonance within these metamaterials is characterised by peak optical absorption in the far field, concentration of electromagnetic ‘hotspots’ in the near field and highly inhomogeneous heat generation and distribution at the nanoscale. Plasmonic heating is shown to reduce the surface resistivity and effective phase transition temperature of VO_2. Plasmonic nanostructures also feature wavelength and polarisation selectivity, thus enabling spectral and polarisation specific response. This selectivity is achieved without filters, reducing cooling requirements and consequently lowering costs.

The combination of the technologically matured VO_2 platform, novel plasmonic nanostructures, and the capability to combine multiple pixels into a multispectral sensing array, would have a significant impact on infrared sensing and imaging.