Quantum Dot Detectors for Mid Infrared Sensing: Bias Controlled Spectral Tuning and Matched Filtering

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Quantum-dot infrared photodetectors (QDIPs), based on intersubband transitions in nanoscale self-assembled dots, are perceived as a promising technology for mid-infrared-regime sensing since they are based on a mature GaAs technology, are sensitive to normal incidence radiation, exhibit large quantum confined stark effect that can be exploited for hyperspectral imaging, and have lower dark currents than their quantum-well counterparts. High detectivity ($D^* = 10^{11}$ cmHz$^{1/2}$/Watt at 9 μm) QDIPs have been recently shown to exhibit broad spectral responses (~2 μm FWHM) with a bias-dependent shift in their peak wavelengths. This controllable, bias-dependent spectral diversity, in conjunction with signal-processing techniques, allows us to extend the operation of the QDIP sensors to a new modality that enables us to achieve: (1) spectral tunability (single- or multi-color) in the range 2-12 μm; and (2) multispectral matched filtering in the same range. The spectral tuning is achieved by forming an optimal weighted sum of multiple photocurrent measurements, taken of the object to be probed, one for each bias in a set of prescribed operational biases. For each desired spectral response, the number and values of the prescribed biases and their associated weights are tailored so that the superposition response is as close as possible to the response of a sensor that had been optically tuned to generate the desired response. The spectral matching is achieved similarly but with a different criterion for selecting the weights and biases. They are selected, in conjunction with orthogonal-subspace-projection principles in hyperspectral classification, to nullify the interfering spectral signatures and maximize the signal-to-noise ratio of the output. This, in turn, optimizes the classification of the objects according to their spectral signatures. Experimental results will be presented to demonstrate the QDIP sensor's capabilities in these new modalities.

Key Words: Quantum dot, self assembled, infrared detectors, spectral tuning, matched filtering