Journal of ELECTRONIC MATERIALS, Vol. 42, No. 11, 2013
DOI: 10.1007/s11664-013-2712-y

Investigation of Radiation Collection by InSb Infrared Focal-Plane Arrays with Micro-optic Structures

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Three designs of micro-optic structures have been analyzed by two-dimensional simulation. Compared with traditional spherical microlenses, the micro-optic structures have the same ability to collect radiation and do not have the disadvantages of traditional microlenses. In our analysis the micro-optic structures are simple grooved notches above the space between two adjacent mesas. We also investigate the characteristics of InSb focal-plane arrays with both spherical microlenses and micro-optic structures under oblique incident radiation. Empirical formulas were derived to describe the response and crosstalk as a function of incident radiation angle. Our results show that the micro-optic structures can be effectively used in radiation collection for InSb infrared focal-plane arrays.

Key words: InSb infrared focal-plane arrays, microlens, micro-optic structure, response, crosstalk

INTRODUCTION

InSb, a narrow-band-gap semiconductor with cutoff wavelength of 5.5 μm at 77 K, has been widely used for thermal imaging in numerous military and civil fields because of its excellent absorption ability in the spectral range of 3 μm to 5 μm, superior fundamental properties, and simple material growth.[1–8] For InSb infrared focal-plane arrays (FPAs), spherical refractive microlenses are usually used to concentrate incident light from the pixel area onto a much smaller active area to reduce crosstalk without sacrificing response.[9] However, the geometric parameters, i.e., aperture side length, sag height, and focal length,[10] of a spherical microlens array have a significant effect on device performance. Additionally, the small size of the microlenses not only limits their focusing ability but also increases the difficulty of the manufacturing process.[11] In this work, three designs of micro-optic structures have been investigated. Compared with microlenses, the micro-optic structure, consisting of a simple grooved notch above the space between two adjacent mesas, has the same ability to collect radiation. Additionally, the characteristics of FPAs with both spherical microlenses and micro-optic structures have been analyzed under oblique incident radiation. Empirical formulas obtained describe the response and crosstalk as a function of incident radiation angle. The results show that the micro-optic structures can be effectively used in radiation collection for InSb infrared FPAs.

(Received December 13, 2012; accepted July 24, 2013; published online August 21, 2013)

METHODS

The spectral response and crosstalk of InSb FPAs were studied by using two-dimensional (2D) numerical simulations. The model used in this paper is based on the drift–diffusion method, where the well-known Poisson's equation

$$\nabla^2\psi = -\frac{q}{\varepsilon_s}(p - n + \Gamma) \quad (1)$$