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Characterization of Single Barrier Microrefrigerators at Cryogenic Temperatures

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Abstract

Experimental characterization of single barrier heterostructure thermionic cooling devices at cryogenic temperatures is reported. The device studied is a cylindrical shaped InGaAs microrefrigerator, in which the active layer is a 1 micron thick $Al_{0.218}$ In $_{0.527}$ $Ga_{0.255}$ As heterostructure barrier with n-type doping concentration of 6.68×10^{16} cm^{-3} and $In_{0.53}Ga_{0.47}As$ emitter/collector of $5x10^{18}$ cm^{-3} n-doping. Device diameter ranges from 50-100 microns. Full field thermoreflectance imaging technique has been utilized to measure the distribution of temperature change on the device top surface when different current excitation values were applied. By reversing the current direction, device behavior in both cooling and heating regimes was studied. Using a sinusoidal excitation, the contributions of Peltier cooling/heating and Joule heating in the device were separated. At an ambient temperature of 100K, a maximum cooling of 0.5K was measured. This value is about 1/3 compared to the measured maximum cooling value at room temperature (1.3K). The paper will describe the device structure and the first reported thermal imaging at cryogenic temperatures using thermoreflectance technique.