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Development of highly doped passivation in the GaInP/GaAs double heterostructure for use in laser cooling

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Current refrigeration technology for cooling space-based IR focal plane arrays and sensors uses mechanical cryocoolers reaching temperatures down to approximately 75-120K. Such systems contain moving parts, which in time can wear out and contain refrigerants which can leak. These properties limit reliability and operational lifetime. Mechanical coolers produce vibrations which can lead to blurring during image acquisition. A balanced assembly minimizes vibrations, but does so at the expense of increased payload mass. A solid state optical cryocooler is an attractive alternative. Cryogenic temperatures have been achieved with rare-earth doped crystals but a direct band-gap semiconductor offers the advantages of direct integration with on-board sensors and opto-electronics as well as the possibility of lower overall temperatures. Cooling of a bulk semiconductor has not yet been realized. It has recently been theorized that high levels of n-doping in candidate semiconductor double heterostructures can reduce the minority carrier density at the GaInP/GaAs interface and increase nonradiative lifetime (G. Rupper, JAP, 2010). We will report on attempts to fabricate the GaInP/GaAs heterostructures with high ($\approx 10^{19}$ cm^{-3}) doping density in the GaInP passivation layer grown by MOCVD. Further, we will report on the impact to nonradiative lifetime. Comparisons will be made to the nonradiative lifetime obtained with more modest levels of doping density ($\approx 10^{17}$ cm^{-3}).

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