Planar GaInSb CCDs

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In recent years there has been a major effort in developing CCD imagers in narrow-bandgap semiconductors. The purpose is to develop high performance, self-multiplexed area imagers in the IR which are the analog of Si CCD imagers in the visible region. CCD operations have been reported in many non-silicon materials, including Ge, InSb, GaAs, and HgCdTe. In this paper we report for the first time the successful fabrication and testing of CCDs in a III-V ternary epitaxial layer, GaInSb. The cut-off wavelength of GaInSb layers can be compositionally tuned from 1.7μm at 77K. The development of CCDs on alloy semiconductor epitaxial layers offers the potential of more versatile device structures to tailor to different application requirements. For example, the GaInSb/GaSb CCD imager can be operated in the backside-illuminated mode without thinning the GaSb substrate. This is because the energy bandgap of the GaSb substrate is greater than that of the GaInSb epitaxial layer. The backside-illuminated feature is essential for high density, high resolution, mechanically rigid IR area imagers.

The CCDs were fabricated using a planar technology on single crystal, n-type GaInSb layers which were grown by liquid phase epitaxy (LPE) technique on GaSb substrates. The carrier concentration in the layer was typically $\sim 10^{14} cm^{-3}$, sometimes as low as $\sim 5 \times 10^{13} cm^{-3}$. The CCD test structure is a four-phase, overlapping-gate, surface channel, 4-bit (19 transfer gates) shift register. The input/output diffusion were formed by Be ion-implantation. The gate insulator is formed by low temperature ($\sim$ 200°C) chemical vapor deposition of SiO_2 doped with NH_3. The electrodes were formed by thermal evaporation of Al. The CCD was tested under low background at 195K. Initial results show that the charge transfer efficiency of 0.97 has been obtained.

In this paper we also report the results of MISFETs fabricated on the GaInSb epitaxial layers. The MISFETs are essential for incorporating on-chip signal processing functions. It has been measured that the GaInSb MISFET characteristics follow the ideal square law relation of FETs over the temperature range of 20-300K. The hole mobility in the inversion layer was $180 cm^2/v\text{-}sec$ at 195K. The threshold voltage was found to vary inversely as the operating temperature. Detailed discussions on these results will be presented.

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