Abstract

This Thesis is concerned with the design, layout, and testing of avalanche photodiodes (APDs). APDs are a type of photodetector and, thus, convert light signals into electrical signals (current or voltage). APDs can be fabricated using silicon (Si). In this Thesis, however, three integrated circuit (IC) chips containing various silicon-germanium (SiGe) APDs with different sizes, structures, and geometries were designed, laid out, and fabricated using the Austria microsystems (AMS) 0.35μm SiGe BiCMOS (S35) process. This was done in order to compare SiGe APDs to Si only APDs and investigate the hypothesis that SiGe APDs are capable of detecting longer wavelengths than Si only APDs. This is due to the smaller band gap energy associated with SiGe compared to that of Si.

The different SiGe APDs were tested and found to, indeed, have the capability of detecting slightly longer wavelengths than Si APDs. A 5μm x 5μm SiGe APD and 24μm x 24μm SiGe APD were found to have a spectral peak at 500nm and a cutoff wavelength (λc) of 1180nm compared to 480nm and 1100nm, respectively, for a 10μm x 10μm Si APD. The 24μm x 24μm SiGe APD was also found to have a responsivity of 0.34 A/W at 500nm and quantum efficiency (QE) of 85% at 450nm.

APDs differ from traditional photodiodes in that they possess an internal avalanche gain and, thus, produce a larger electrical signal than a traditional photodiode for the same amount of incident light. All photodiodes produce an undesired electrical signal, called dark current, even in a dark state with no light signal incident on the photodiode. Therefore, the gain and dark current associated with each of the fabricated APDs was also measured in order to determine the characteristics of the different SiGe APD variants. The 5μm x 5μm and 24μm x 24μm SiGe APDs have a zero bias (0V) dark current of 3pA and 5pA, respectively, compared to 3pA for the
10μm x 10μm Si APD. The 5μm x 5μm and 24μm x 24μm SiGe APDs and the 10μm x 10μm Si APD also have gains of 88,000 (98dB), 1390 (63dB), and 1000 (60dB), respectively.