simulated field for a sample implanted and annealed at 450 °C at a reverse bias of 1 V is shown in Fig. 9. High electric fields can be observed across the p-i junction, these fields reach peak values at the corners of the implanted regions. The peak electric field is ~150 kV/cm, which is well in excess of the value for the onset of tunneling currents and impact ionization in InAs [5] leading to a sudden and sharp increase in the current and potentially causing the failure of the device when stressed under this high current. These results indicate that for the development of planar InAs APDs either the implantation depth will have to be much deeper or inclusion of guard ring will be required to suppress edge breakdown.

In addition to the optical and electrical characterization we have attempted to assess the diode reliability by performing repetitive reverse IV measurements up to 1 V. We observed a random and sudden breakdown in some of these devices after repeated operation; this takes the form of an abrupt switch in the IV characteristics from diode like behavior to a short circuit. At present the operation lifetime before this breakdown occurs appears to be random. Currently we cannot ascertain the origin of this failure mode since this behavior has not been observed in the reference etched device nor has any change been observed in the resistivity of the implanted layers used for the TLM analysis.

4. Conclusions

This work has shown that it is possible to use He implantation with InAs to produce highly resistive areas and that when combined with post implantation annealing, a sufficiently high resistive region can be formed to allow the fabrication of a planar photodiode. Due to the implantation conditions used in this work an isolation depth of only around 2 µm has been achieved despite the total device thickness being 8 µm. As such this appears to have limited the upper voltage limit that the diodes can be operated to due to the onset of edge breakdown.

We have measured similar external quantum efficiencies for an implanted and subsequently annealed device as we would obtain for a reference etched device. These results also suggest that it may be possible to use implantation techniques to fabricate photodiodes in narrower bandgap materials such as InSb to allow the realization of long wavelength planar detectors.

In summary we have performed He ion implantation into InAs and performed post implant annealing. From TLM measurements we have shown that the sheet resistance of InAs can be dramatically increased. By also performing implantation on p-i-n structures we have shown that it is possible to produce planar photodiodes with comparable efficiencies to reference etched diodes.

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