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Improvement in Electrical Properties of Laser Annealed Ion Implanted GaAs

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The overall aim of this work is to study whether we can produce high conductivity ohmic contacts for GaAs devices. Work we have published[1] only partially fulfils this aim, and this paper discusses our recent progress towards achieving our aim. Previously, we showed that samples implanted at room temperature with doses of 1.10^{15} to 5.10^{15} ions/cm^2 of Te, Se, Sn and Ge could produce electron concentrations in excess of 1.10^{19} cm^{-3} when annealed with a single 15 ns pulse from a Q-switched ruby laser of energy density 1-1·5 J/cm^2 [1]. However, the electron mobility was, on average, about one third of the value expected for GaAs with that electron concentration. With the aim of increasing both the percentage electrical activity and the mobility, we have carried out thermal anneals at temperatures up to 900°C both before and after irradiation with a laser. For example, a number of samples which had been implanted with 1.10^{15} cm^{-2} of 300 KeV Se ions were thermally annealed at temperatures from 400 up to 900°C using Si_3N_4 coatings for temperatures above 600°C. After removal of the Si_3N_4 and laser annealing at an energy density of 0·5 J/cm^2, all samples had an electrical activity of 20% and mobilities of 500 to 600 cm^2/v.s. A sample which was subsequently annealed at 700°C for 15 min had only 2% activity and a mobility of about 850 cm^2/v.s. with the possible implication that precipitation occurs under these annealing conditions.

The variation of electrical activity with Si_3N_4 deposition temperature was also studied using samples implanted with a dose of 5.10^{15} cm^{-2} of 100 KeV Se ions. After irradiation with an energy density of 1·3 J/cm^2, the electrical activity increased from 7% to 15% as the deposition temperature was raised from 600°C to 900°C. The mobilities were similar with values of about 4-500 cm^2/v.s. Several other coated samples implanted with 10^{15} cm^{-2} of 100 KeV Se or Te ions were irradiated with 1·3 J/cm^2 prior to a thermal anneal at 900°C for 30 s. In these cases, the electrical activities were 10 to 15% and the mobilities 1200 to 1800 cm^2/v.s. Hence, a thermal anneal after laser irradiation would seem to increase the mobility without significantly affecting the electrical activity.

We have also found that the percentage electrical activity for laser annealed samples increased with increasing implant energy. Thus for a dose of 10^{15} Se^{+}/cm^{2} irradiated with 0·5 J/cm^{2}, the electrical activity of non-coated samples increased from about 15% to 31% as the ion energy increased from 100 to 400 KeV.

Summarising, detailed electrical measurements, including depth profiles, on samples of semi-insulating GaAs implanted with various donor ions will be presented in this paper. The effects of varying ion energy and dose, thermal annealing temperature either before or after laser irradiation and laser energy density will be discussed.

[1] B.J. Sealy, M.H. Badawi, S.S. Kular and K.G. Stephens, Boston Conference, November 1978.