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ELECTRICAL PROPERTIES OF ELEVATED TEMPERATURE IMPLANTATION OF SWIFT HEAVY ION IN GaAs.

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ABSTRACT

The Effect of substrate temperature on electrical characteristics of n+ type GaAs implantated with ^{197}Au is reported. Single crystal n+ GaAs of <100> orientation have been implanted with 100 MeV ^{197}Au to the dose of 1e14 ions/cm^2 at room temperature and at 100^{o}C. Implanted samples were annealed at different temperatures from 100^{o}C to 350^{o}C. Room temperature current – voltage characteristics of as implanted and annealed samples were recorded. The characteristics were compared with similar characteristics of samples implanted at room temperature. We conclude that defects are sensitive to the substrate temperature during implantation. Current – voltage characteristics shows that the defects are more stable for high temperature implantation compared to room temperature implantation.

KEYWORD: Ion implantation, electrical characterization, annealing

INTRODUTION:

Ion implantation in semiconductors in the MeV range has diverse applications and also diverse areas of studied. The initial technological driving force was to form deep conducting layers in silicon and this application stimulated keen interest in specifically studying damage production by MeV ions and its removal by thermal annealing [1,2]. Technologically MeV ion beams are now used for isolating III-V devices [3]. In case of GaAs, the electrical characteristics shows complex behavior with annealing treatment when it is implanted in the MeV range [4,5].

In this work we attempt to understand the effect of substrate temperature on electrical characteristics of 100 MeV ^{197}Au implanted n$^+$ type GaAs substrates.

EXPERIMENTAL DETAILS:

The samples used in this experiment were one side mirror polished n$^+$ type GaAs substrates having an area of 7 mm x 7 mm and thickness of 400 µm. All the samples were carefully cleaned in organic solvents. Implantations were carried out on polished side at room temperature and at 100^{o}C with 100 MeV ^{197}Au ions to a dose of 1e14 ions/cm^2 using the NEC 16 MV pelletron acclerator [6]. During the implantation the beam current was held at 6-12 pnA and the Au beam was scanned to bombard the full sample surface. The annealing of samples is done isochronally for 10 minits up to 450^{o}C in high purity nitrogen ambient in a rapid thermal annealing (RTA) system.

The electrical measurements have been done between a small area of contact dot on the front surface (implanted side) and a large area contact on the back surface of the sample. The ohmic contacts were fabricated by vacuum deposition of uniform coating of Au-Ge-Ni alloy on the back and dots of area 0.0045 cm^2 through a metal mask on the top surface of each sample. For the samples, which are to be annealed below 400^{0}C, the ohmic contacts were made before the implantation.

In this work electrical measurements have been carried out using Keithley Electrometer 2400 before and after annealing the samples over a range of temperature from 100^{0}C to 450^{0}C.

The current-voltage (I-V) measurements between the top and the back contact were carried out at room temperature. I-V measurements were made on two to three dots on each sample and found to be repeatable. Although I-V measurements have been done on one selected dot on each sample after annealing treatment, in some cases they have been checked on more than one dot and found to be representative of the result reported here.

RESULT AND DISCUSSION

I-V characteristics have been measured for as-implanted samples and samples annealed up to 450^0 C.

We observe Figure 1 and figure 2 that I-V curves are weakly non-linear. We have estimated effective resistance in the linear portion of the curve where the series resistance is dominant.

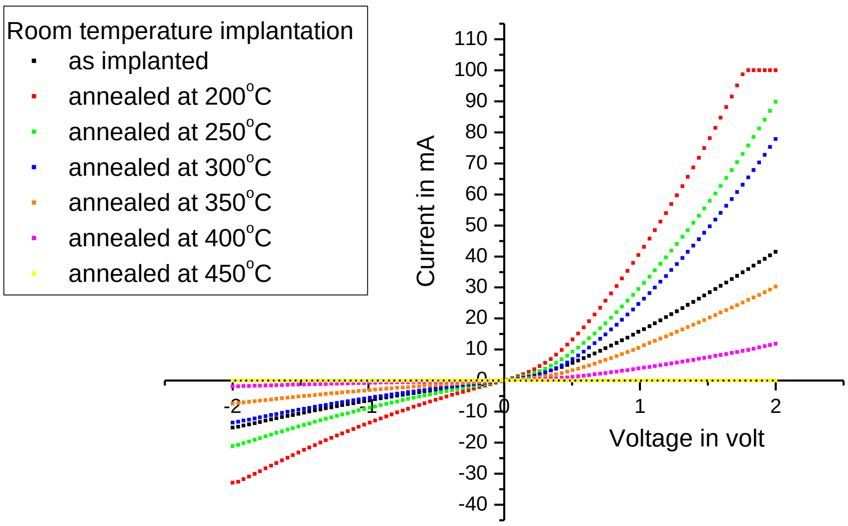

Fig (1): I-V characteristics of as-implanted and annealed samples for dose 1e14 ions/cm^2 implanted at room temperature.

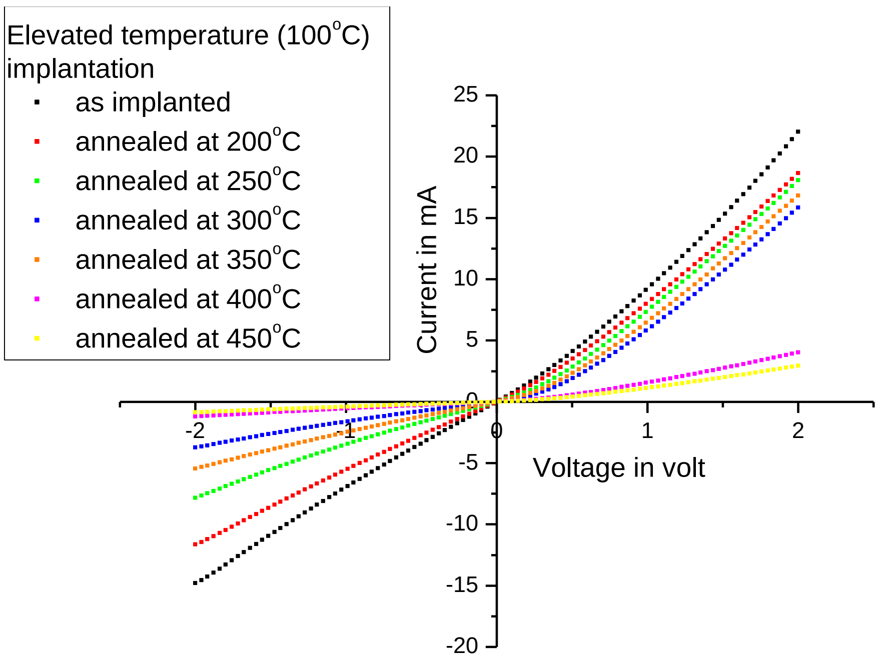

Fig (2): I-V characteristics of as-implanted and annealed samples for dose 1e14 ions/cm^2 implanted at elevated temperature of 100^{o}C.

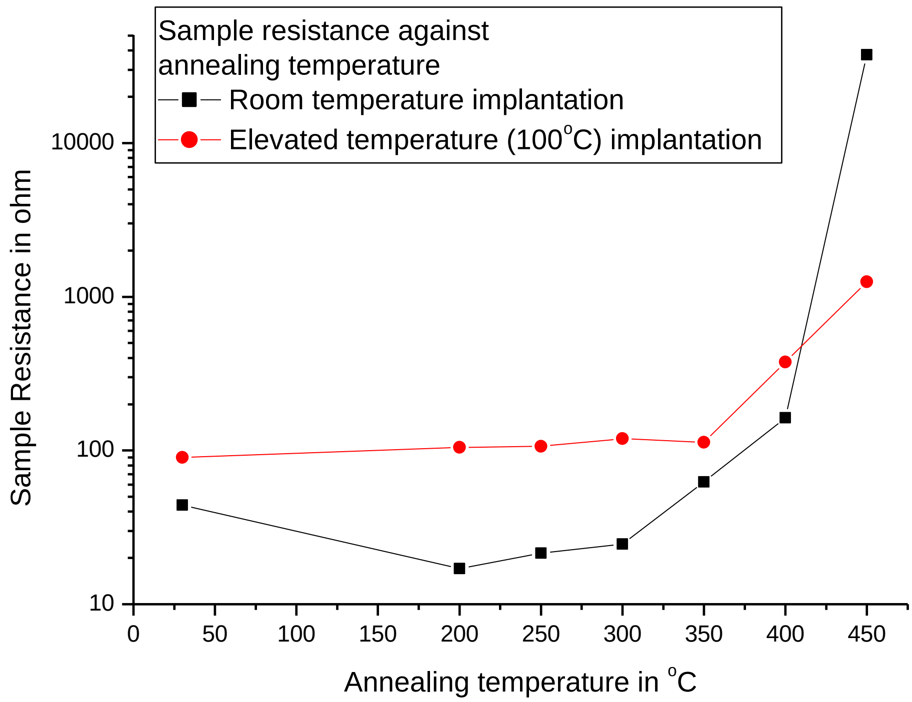

Fig (3): Room temperature values of effective resistance measured as above for different annealing temperatures for sample implanted at room temperature and at 100°C.

We observe that resistance of a samples for dose 1e14 ions/cm^2 implanted at room temperature and implanted at elevated temperature 100°C are 44Ω ohm and 90 ohm respectively. The higher as-implanted resistance for elevated temperature implanted substrate indicated lower defect density.

We observe from Figure 3 that there is no appreciable change in the substrate resistance for annealing up to 300^0 C for both samples as compared annealing above 300°C. The conduction mechanism for the samples annealed up to temperature 300°C may be hopping between defect states.

After annealing to 450^{0}C resistivity of the sample increases suddenly and its resistance become 162 Ω and 376 Ω respectively. Annealing to higher temperature leads to the reduction in the defect density inside the substrate. Higher value of resistance indicates that the carriers are trapped by the defect states existing in the band gap. The extent of trapping is observed relatively greater for samples implanted at elevated temperature of 100°C. This indicates that the defects are more stable for elevated temperature implantation as annealing up to 450^{0}C.

CONCLUSION

We have implanted ^{197} Au in a single crystal n+ GaAs substrates at an energy of 100 MeV to the dose of 1e^{14} ion/cm^2 at room temperature and at 100°C. Current Voltage I-V curves measured over annealing temperatures from 100^{0}C to 450^{0}C shows weak nonlinearity. The substrate implanted at 100°C shows comparatively higher as-implanted resistance and also higher resistance with annealing temperatures. The defects are more stable for high temperature implantation compared to room temperature implantation. The higher resistivity of the implanted and annealed substrates after 350^{0}C annealing may be due to reduction in defect density and trapping of charge carriers by the defect states existing in the band gap.

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