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To cite this version:
Audrey Valentin, Mary de Feudis, Ovidiu Brinza, André Tardieu, Riadh Issaoui, et al.. Characteristics of He ion implanted layers on single-crystal diamond. Surface and Bulk Defects in Diamond (SBDD) XXIII, Mar 2018, Hasselt, Belgium. hal-03578185

HAL Id: hal-03578185
https://cnrs.hal.science/hal-03578185
Submitted on 17 Feb 2022

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Characteristics of He ion implanted layers on single-crystal diamond

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Context:
- Heavy ion implantation used for contact fabrication [1]
- He ion implantation for N-V centers [2]

He ion implantation for the enhancement of ohmic contacts

1st result [3]: ohmic contact fabricated on He ion-implanted boron-doped samples
→ ohmicity improved
→ contact resistance decreased
→ ohmic contacts obtained even at a doping level of 2·1017 cm–3

Aim of the study: characteristics of He ion-implanted single-crystal diamond.

Ion implantation

Experimental: He ion implantation at various fluences (from 4·1017 to 5.5·1017 ions/cm²) with a home-made low-cost ion implanter.
One of the sample corners is marked during the implantation process.
Several annealing steps are performed after the implantation process.

Density profiling

Experimental: Surface profile measured by confocal microscopy (Keyence VK 9700)

- Before annealing, the effect on density is not observable
- After annealing, a step ~ 50 nm appears.
- After etching, a step ~ 60 nm is revealed.
→ The layer has the same density as graphite.

 Resistivity measurement

Experimental: 4-point probe resistivity measurement using a Keithley 4200 semiconductor characterization system.

Sheet resistance evaluation:
Classical formula $R = \frac{2\pi \ell}{T}$ where $F$ is calculated using the procedure detailed in [4] in our specific geometric case.

→ Before implantation, all the samples are insulating.
→ Before annealing: resistivity decreases with increasing ion fluence.
→ Annealing decrease the resistivity.
→ Long annealing (> 30 min) does not significantly affect the resistivity.
→ The final sheet resistance is close to the graphite sheet resistance.

Raman spectra

Experimental: Spectra acquired using a Horiba HR800 spectrometer @RT – 473 K.

→ Implantation induces the appearance of the G-band and the D-band: coexistence of disordered graphite and diamond.
→ Annealing shifts the G-band and D-band and decreases their width.
→ The G-band position shifts from 1555-1570 cm–1 (amorphous carbon) to 1585-1595 cm–1 (nanocrystalline graphite).

References