

## Damage reduction in phosphorus-ion implanted (001) diamond by plasma annealing

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Phosphorus doping of (001) diamond has been done by ion implantation with various ion energies and fluences under the conditions without amorphization in diamond. SIMS measurements show that the doping concentration can reach about  $5 \times 10^{19} \text{ cm}^{-3}$  at 100 nm depth, whereas the vacancy concentration is below  $2 \times 10^{22} \text{ cm}^{-3}$  as shown by SRIM simulations. Post-implantation annealing at a temperature  $< 1200 \text{ }^\circ\text{C}$  by plasma heating may partially recover the damaged diamond lattice as characterized with scanning transmission electron microscopy (Fig. 1) and nano-beam diffraction.

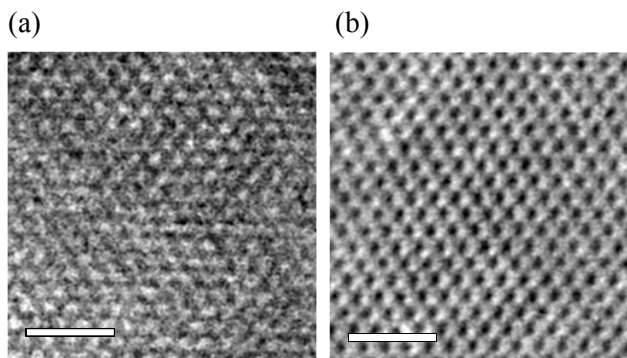


Fig. 1. High-angle dark field STEM images in zone axis  $\parallel [110]$  acquired from the region near the depth of 100 nm. (a) As-implanted diamond showing no dumbbell lattice, and (b)  $1200^\circ\text{C}$  annealed one exhibiting the dumbbell structure.