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WC/p-diamond interface reaction at 600 K for stable diodes

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Introduction Diamond-based Schottky-barrier diodes (SBD) are promising to handle high voltages (>10 kV) at high temperatures (>500 K). If studies on high blocking voltages were intensive, then at the opposite, studies on high temperature stability were limited. In particular, post-annealing treatments ensuring stable SBD operations at T > 600 K have been reported in the literature. However, interfacial reactions giving better SBD electrical properties were not explained. In this study, we will examine the high temperature interfacial reaction mechanism between diamond and Schottky metal.

Experiment Our strategy was to use a high temperature oxidation resistant metal as Schottky contact, insensitive to the diamond termination. We selected tungsten carbide (WC) for such resistance and its strong adhesion on diamond. The SBD structure employed was a vertical configuration (Fig. 1) [1]. The diamond substrate was heavily boron-doped ($p^+ > 10^{20}$ cm^{-3}) and capped with a undoped layer ($p^- \sim 10^{15}$ cm^{-3}). WC was deposited by sputtering. The evolution of the Schottky interface has been followed by mean of the intrinsic Schottky barrier height (ϕ_B). The intrinsic ϕ_B was obtained from the extrapolated value of the linear $\phi_B(n)$ when the diode ideality factor (n) was unity [2].

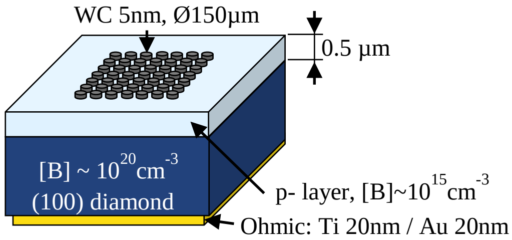

FIG. 1. Schematic of the WC/p-diamond SBD structure with a vertical configuration.

Results & discussion The plot of n vs. ϕ_B (Fig. 2a) displays the progressive evolution of SBD electrical properties through the vacuum annealing at 600 K. We observed a reduction of ϕ_B and n consecutively to the annealing duration. After each annealing, we denoted a linear $\phi_B(n)$ feature which provided an accurate intrinsic ϕ_B value. As shown on Fig. 2b, the evolution of the intrinsic ϕ_B through the post-annealing at 600 K revealed an exponential decay, whose time constant was 9 minutes. Hence, a vacuum post-annealing at 600 K during 90 minutes was sufficient to obtain stable SBDs electrical properties. Afterward, the linear $\phi_B(n)$ feature was well-preserved at 400, 500, and 600 K. It indicated not further changes at the Schottky interface.

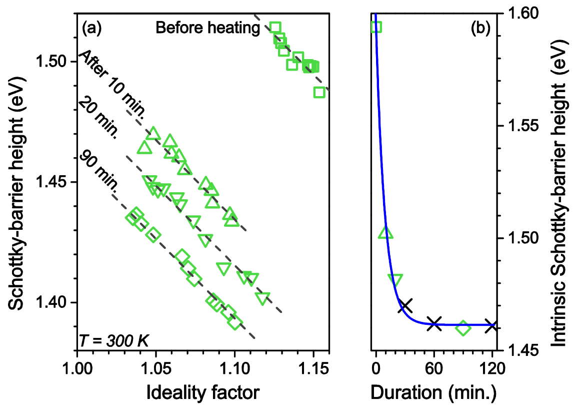

FIG. 2. Progressive evolution during post-annealing at 600 K of (a) ϕ_B versus n, and (b) intrinsic ϕ_B of lateral WC/diamond-based SBDs structure. The dashed lines are linear least-squares fits to the experimental data. The solid blue line represents the exponential fit.

[1] A. Fiori *et al.*, Phys. Stat. Solidi A, DOI :10.1002/pssa.201431216, (2014).
[2] R. T. Tung, Mater. Sci. Eng. R **35**, 1 (2001).