Group IV terminations of (100) and (111) diamond surfaces

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Surface properties of diamond, such as the surface electric dipole, electron affinity, conductivity, topography and chemical reactivity may be significantly altered by changing the atomic layer which terminates the crystal.

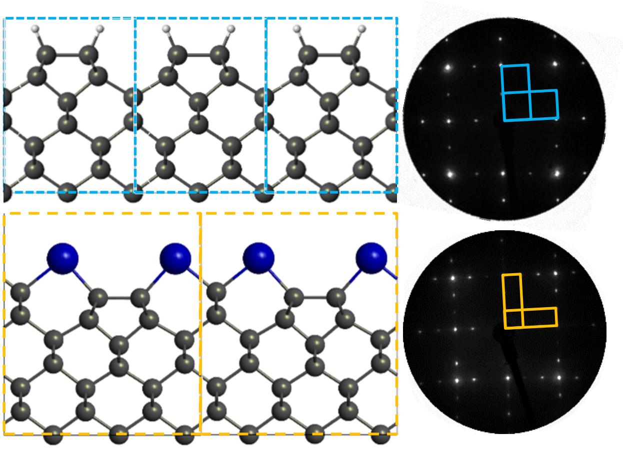

Figure 1 - Top: the C(100)-(2×1):H surface, and bottom: the C(100)-(3×1):0.667Ge surface which we have developed, with their corresponding LEED patterns

The hydrogen-terminated surface of diamond, for example, is well known for its negative electron affinity, which gives rise to a low ionization potential. As a result, when functionalized with hydrogen and exposed to moist air or to strongly electron accepting molecules such as $C_{60}F_{48}$ and MoO_3, diamond exhibits a subsurface hole accumulation induced by surface transfer doping[1]. This layer occurs within a highly asymmetric quantum well which supports a two-dimensional hole band possessing a strong and tunable spin-orbit interaction, illustrating the potential for application of surface conducting diamond for spintronics[2]. As diamond possesses a range of properties desirable for next-generation electronics, expanding the range of achievable surface functionalities increases the potential for novel devices.

Our recent work has explored the termination of diamond surfaces with silicon and germanium, which causes a striking change in the surface reconstruction as shown in Figure 1, and the creation of derivatives from those terminations. Our method is believed to generate topologically flat, chemically homogenous surfaces, which allow further functionalization and access to chemistries not previously accessible on diamond. Following our previous work[3] which has shown the susceptibility of the oxidized silicon-terminated surface to p-type transfer doping, we have investigated other ways in which the silicon-terminated diamond surface may be modified and expanded our process to silicon termination of the (111) diamond surface.

High-resolution core-level photoemission and low energy electron diffraction, performed at the Australian Synchrotron, were used to examine the chemical and physical structure of the germanium-oxide-, silicon-oxide-, and silicon-fluoride-terminated (100) diamond surface, as well as measurements of the hydrogen-terminated and silicon-terminated (111) surface. We hope that the generation of new surface functionalities will open potential new avenues for progress in biosensing, high power electronics, and nitrogen vacancy centre research.

References

1. P. Strobel, *et al. Nature* **430** (2004), 439.
2. G. Akhgar, *et al. Nano Lett.* **16** (2016), 3768.
3. M. Sear, *et al. Applied Physics Letters* **110** 1 (2017), 011605.