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Impact of the atomic-step finishing by CMP on the wettability of SiC substrates

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Epitaxial growth is an essential step in the fabrication of micro/nanoelectronic devices. In integrated circuits fabrication, the development and miniaturization of Si-based electronic devices owe very much to the ease of cutting and atomic finishing conditioning of Si wafers for subsequent processing. In contrast, the physical characteristics and therefore surface morphology of SiC crystal is a serious drawback of SiC electronics as its finish is typically poor in planarization with presence of scratches, voids, etc. The intrinsic difficulties in SiC wafer slicing and cutting affect the homogeneity and orientation of terraces, even when atomic step can be been obtained by a certain chemical mechanical polishing (CMP) processing [1].

Our CMP SiC substrates show atomic step terraces of remarkable uniformity and free of scratches and contamination (Fig. 1, left). Studied CMP-processed surfaces consist in 6H-SiC on-axis cut and 3.5º off-axis cut, both Si and C face can be polished. Contact angle measurements indicate a tendency towards hydrophilicity, as well as dependence on strictly surface chemistry as seen for the different polarities, i.e. C face versus Si face. This behavior can be seen as a macroscopic indicator of a good polish finish (atomic step) achieved by the use of our CMP process. Reproducibility (reliability of CMP) is also confirmed.

Systematic contact angle characterization has been performed on CMP and mechanical polishing (MP) SiC as preparations prior to further processing. In particular, the relative change of contact angle has been monitored respect to: 1) standardized SiC cleaning (acetone+HF etching+IPA+N_2 blow); 2) wetting (IPA+N_2 blow); 3) aging. CMP SiC (Fig.1, center and right) has lower contact angles as compared to MP SiC (data not shown), as expected from a finer surface finishing. The results for various chemical treatments can be summarized as follows. Contact angles as a function polarity are smaller for Si as compared to C face, for both on-axis cut and 3.5º off-axis cut. The effect of standard cleaning is a significant decrease of contact angles immediately after the chemical treatment. The effect is more pronounced on the Si face and quantitatively larger as compared to simple wetting. Within one day, contact angles tend to recover their original reference values (aging). CMP-4H-SiC shows similar behaviors (data not shown).

These characteristics are mainly attributed to the natural oxidation and contamination of the surface. A higher sensitivity of the Si face can be an indication of a higher tendency to oxidation; which may have some direct impact in terms of fabrication of metal contacts for SiC electronic devices. Last but not least, the relative change on the contact angles under the same chemical treatment on MP SiC samples is smaller or negligible, which corroborates the readiness of atomic step CMP. Quantitative determination of surface properties of CMP conditioned SiC surfaces, such as surface free energy as a fingerprint of intermolecular interactions on the processed SiC surface, are among the properties that can be determined. The impact of conditioning is correlated and applied to, respectively, subsequent processing, 1) epitaxial graphene deposition on SiC [1] and 2) SiC electronic device fabrication

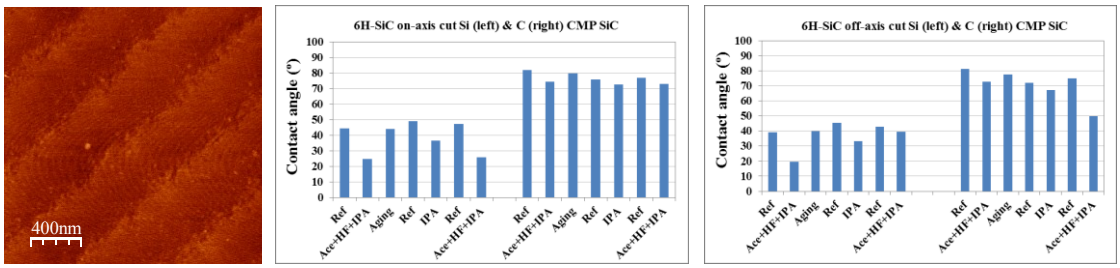

Figure 1. (Left) AFM image of CMP-6H-SiC, C face, on axis cut sample. Summary of the variation of contact angles as a function of chemical treatment, for 6H-SiC on (center) and off (right) axis cut samples, for both Si and C polarities.

[1] Formation of graphene onto atomically flat 6H-SiC, G. Rius *et al*. Materials Science Forum (2014).