Mechanism of step unbunching phenomenon on 4° off-axis 4H-SiC (0001) surface

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In the graphene growth process by thermal decomposition of SiC, step bunching of the SiC surface occurs. The higher step height, the greater the electrical resistance of the graphene covering the step[1]. Therefore, it is necessary to maintain a flat surface with low steps. Recently, a stap unbunching phenomenon was discovered on on-axis 4H-SiC (0001) surfaces, in which steps that had once become high due to step bunching separated into lower steps by the subsequent heating at the lower temperature[2]. On the other hand, weather or not the step unbunching phenomenon occurs on 4° off-axis substrates, which have much high step density, and its mechanism remains unclear. Thus, in this study we aimed to elucidate the mechanism of step unbunching on 4° off-axis 4H-SiC (0001) substrates.

First, the 4° off-axis 4H-SiC (0001) substrates were heated at 1650°C under atmospheric pressure of Ar/H_2 (vol.%) in order to obtain high steps. Then, the sample temperature was directly lowered to 1400°C, and kept at this temperature for 4~20 minutes. The surface morphology of the samples was observed by an atomic force microscope (AFM).

Figure 1 shows the AFM topographic images and the corresponding height profiles of the samples heated (a) at 1650°C for 10 minutes, and (b) at 1650°C for 10 minutes followed by holding at 1400°C for 20 minutes. In (a), steps with a height of approximately 20-50 nm were observed. In (b), the number of high steps decreased and broad facets of approximately 2 μm were formed, which suggest step unbunching, as indicated by red arrows in the figure. In addition, surface irregularities as shown by blue arrows, which were not b=observed on on-axis substrates, were found on some facets. These results suggest that the step ubunching on 4° off-axis substrates proceeds via a different mechanism form on-axis substrates.

References:

[1] H. Watanabe and T. Hosoi, Intech 9 (2012) 235-150.

[2] R. Sakakibara, J. Bao, K. Yuhara, K. Matsuda, T. Terasawa, M. Kusunoki and W. Norimatsu, Appl. Phys. Lett. 123 (2023) 031603.

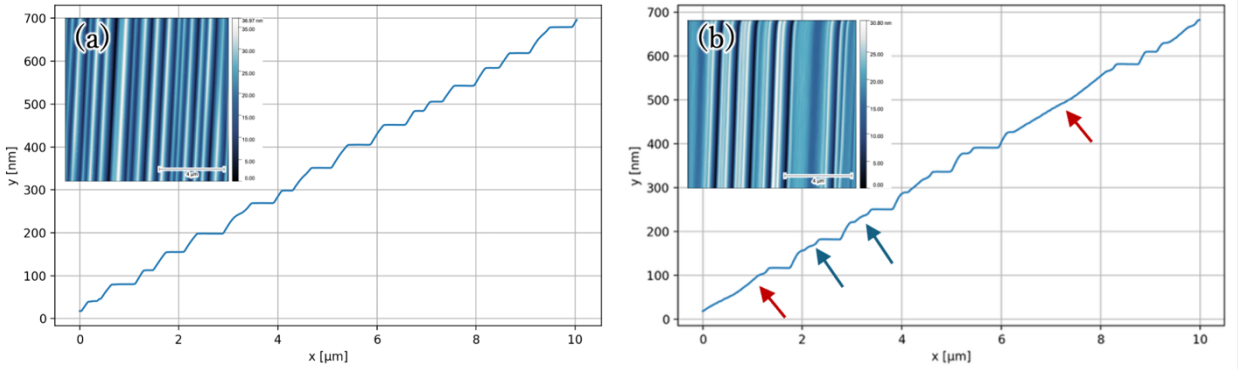

Fig: AFM topographic images and corresponding height profiles of samples (a) held at 1650°C for 10 minutes and (b) subsequently held at 1400°C for 20 minutes.