The basic mechanism of anisotropic graphene growth on 4H-SiC{1-10n} for large and uniform graphene wafer

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One of the important issues to realize graphene-based devices is the difficulty in fabricating a graphene wafer of large, uniform and high crystalline quality[1]. Thermal decomposition of SiC is a promising growth technique due to its simple process without transfer process onto semi-insulating substrates[2]. However, the graphene growth mechanism should be different depending on the choice of SiC planes by reflecting the manner of atomic rearrangement of SiC surfaces. Until now, four kinds of different SiC crystal planes have been reported as a template for graphene growth by thermal decomposition; Si-terminated face (Si-face), C-terminated face (C-face), A-plane and M-plane[3,4]. Among these planes, the Si-face is known as a special plane to make highly uniform graphene having the specific interface layer in the form of $6\sqrt{3}x6\sqrt{3}$ reconstruction. This layer contributes to the suppression of further SiC decomposition underneath, thus the graphene growth on the Si-face follows a step flow like growth mechanism. However, the existence of this layer degrades electric carrier mobility because of carrier scattering due to the carrier transport from SiC to graphene. Meanwhile, the other planes do not have any stable interface layers during the decomposition, where the growth of non-uniform graphene arises with high carrier transport properties. For the purpose of fabricating graphene with large, uniform and high carrier mobility, an intermediate characteristic between Si-face and other planes is needed. To meet this requirement, high index planes of 4H-SiC {1-10n} are promising, which are mixed planes consisting of each characteristic of Si-face and M-plane. Graphene growth on these planes has not been reported so far, thus the growth mechanism of graphene on these planes is worth investigating.

In this report, for studying the graphene growth mechanism on 4H-SiC {1-10n}, various kinds of mesa structures were fabricated first on 4H-SiC (000-1) substrate by laser digging followed by thermal etching process, and then the sidewall of the mesa structures was focused to observe the difference of the growth mechanism. We observed graphene growth on {1-10n} and {11-2n} for the comparison. Graphene were grown inside a TaC container in 6.67kPa of Ar environment, at 1600˚C for 15min. Samples were analyzed by atomic force microscopy (AFM), low-energy scanning electron microscopy (SEM) and Raman spectroscopy.

In figures, (a) shows a SEM image of mesa-structures on 4H-SiC(000-1), which has two anisotropic sidewalls consisted of {1-10n} and {11-2n}. Graphene were grown on these planes, on which graphene ribbon-shaped graphene islands and triangular-shaped graphene islands were formed respectively. In this research, we observed coalescence of ribbons without domain boundaries. This indicates there is connections between graphene and SiC like Si-face, in addition to this, the density of the connections are estimated half of that of Si-face. For these advantages, we propose the {1-10n} plane is suited for graphene growth as a template to make large, uniform and high mobility graphene wafers.

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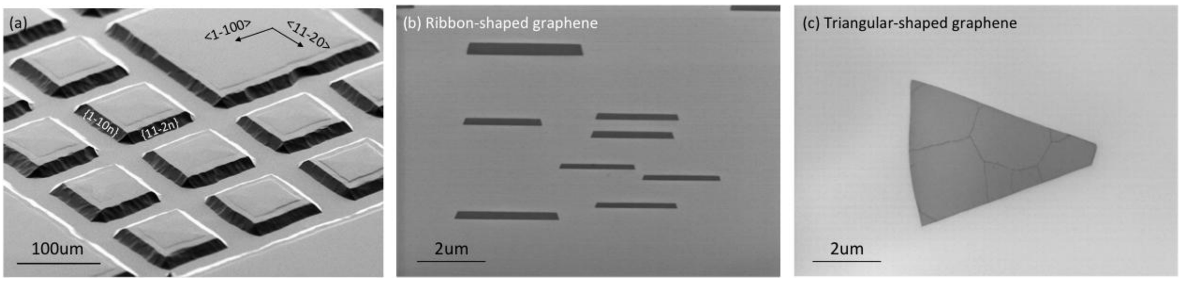

(a) mesa-structures on 4H-SiC(000-1), which sidewalls are {1-10n} and {11-2n}. (b) ribbon-shaped graphene islands formed on {1-10n} planes. (c) Triangular-shaped graphene islands formed on {11-2n} planes.