TAILORING SINGLE-DOMAIN Si(100) SUBSTRATES FOR GaP GROWTH BY Ga-DRIVEN TRANSFORMATIONS OF SURFACE STEPS AND TERRACES

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For GaP-on-Si(100) heteroepitaxy, currently considered as a model system for monolithic integration of III-V semiconductors on Si(100), the surface steps of Si(100) have a major impact on the quality of the GaP film. Monoatomic steps cause antiphase domains in GaP with detrimental electrical properties. A viable route is to grow the III-V epilayer on single-domain Si(100) with biatomic steps, but preferably not at the expense of reduced terrace widths introduced by miscut substrates.

We have performed in situ investigations of the influence of Ga deposition on the surface terrace kinetics of Si(100) at elevated substrate temperatures by low-energy electron microscopy (LEEM). Starting from nearly equally distributed T_A- and T_B-terraces of a two-domain Si(100) surface, submonolayer deposition of Ga resulted in a transformation into a surface with prevailing T_A-terraces (Figure 1). By increasing deposition rate or decreasing temperature, we induced restructuring of Si(100) into a surface dominated by T_B-terraces as previously reported by Hara et al. [1]. The occurrence and mutual transformations of surface structures with different terrace and step structures in a narrow range of temperatures and Ga deposition rates are discussed (Figure 2).

The evolution of these surface structure transformations proceeds via three stages: (i) fluctuations of vicinal monoatomic steps, (ii) local merging of adjacent fluctuating steps and formation of a local biatomic step acting as nuclei for (iii) biatomic step growth along the direction of the steps (Figure 3).

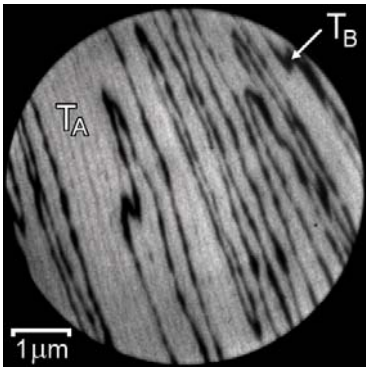

Figure 1. Dark-field LEEM image of a 90:10 distribution of T_A and T_B terraces on well-oriented Si(100) after 40 minutes of Ga exposure at 660 °C.

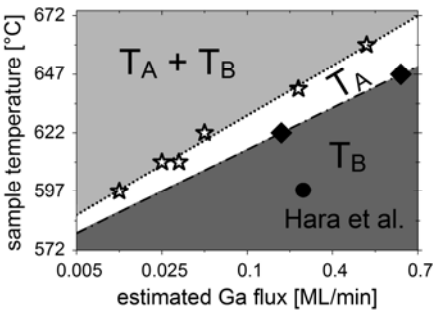

Figure 2. Existence regions for domain structures of Si(100) as a function of temperature and Ga flux. Stars and diamonds denote parameters for transformations into T_A- and T_B-dominance, respectively.

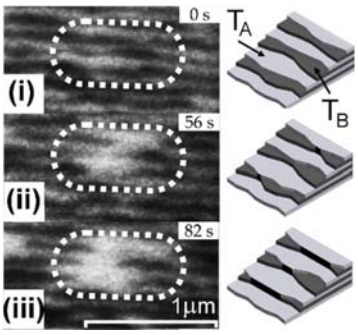

Figure 3. Ga-driven formation of biatomic steps and a local T_A domain.

References

[1] S. Hara et al., J. Appl. Phys. 98, 083513 (2005)