Atomically precise control of heterointerfaces for high-performance SiGe-based heterodevices

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SiGe-based heterodevices have become increasingly attractive as a high-speed device for telecommunication. In order to increase the device performance, it will become indispensable to develop ultra-small pattern formation and self-aligned processes to minimize the device size, as well as atomically controlled growth to prepare atomically precise heterostructures.

Our final goal is to develop the atomic-order surface reaction processes and create new functional SiGe-based devices on the sub-0.1 μm length scale. We have already fabricated high-performance MOSFETs with the $Si_{0.5}Ge_{0.5}$ channel formed at 500 ^{o}C and also super-self-aligned shallow-junction electrode MOSFETs with a 0.1ì μm gate length by utilizing *in-situ* impurity doped selective $Si_{1-x}Ge_x$ epitaxy on the source/drain regions at 550 ^{o}C by CVD.

As a basis of process, we have formulated low-temperature epitaxial growth and doping characteristics of in-situ doped $Si_{1-x-y}Ge_{1-x}C_y$ films by a modified Langmuir-type rate equation. The next stop for creating a new group IV semiconductor is Si or Ge epitaxal growth over the material already-adsorbed on Si(100) or Ge(100). We have generalized Langmuir-type self-limiting formation of 1-3 monolayers in the thermal adsorption and reaction of hydride gases (SiH_4, GeH_4, CH_4, CH_3SiH_3 , PH_3 and NH_3) on Si(100) and Ge(100) taking into account hydrogen desorption from the surface as well nitridation by a nitrogen plasma.

We have achieved the heteroepitaxial growth of Si/N (quarter of a monolayer)/Si(100) at 385 ^{o}C using a flash-heating, and Si/P (half of a monolayer)/Si(100) at 450 ^{o}C.

These results pave the way to fabricating new group IV semiconductor heterointerfaces and elucidating their properties.