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Evolution dynamics of Ge nanostructures on Si surfaces

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The real time evolution dynamics of nanoscale Ge islands on both Si (001) and (113) surfaces is explored using ultra-violet photoelectron emission microscopy (UV-PEEM). The islands were prepared by in situ Ge deposition of ~ 10 ML with a growth rate of 0.1 - 0.6 ML/min at temperatures of 450 - 550°C followed by annealing at temperatures up to 700°C. The shape and size of the evolving islands was observed by in situ, real time PEEM. For Ge deposition of ~ 3 ML, we observed island formation on both surfaces indicating the transition from strained layer to island growth. On Si (001) circular islands formed and grew larger without new island nucleation during further deposition. Annealing at higher temperature led to an increase in the average size of the islands and a decrease in the island density, indicating Ostwald ripening through diffusion of Ge on the surface. In contrast, on Si (113) we observed the formation of elongated island structures oriented along the [33-2] direction, which showed further growth in length during continuous deposition. However, annealing at a higher temperature led to the transition of the elongated islands into shorter islands with an indented shape. AFM measurements showed that the islands grown on Si (001) were dome shaped structures while the islands on Si (113) were flat tops of (113)-orientation with multiple side facets. The shape evolution of the islands is discussed in terms of strain relaxation and kinetic effects.