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RP-CVD GROWN Ge ISLANDS FOR 1.3-1.6 µm PHOTODETECTION

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To face the future bottlenecks of metallic interconnects in integrated circuits, optical interconnections would be of great interest but require that near-infrared optical components, i.e. light sources, modulators and photodetectors, can be manufactured using a technology compatible with the silicon industry. This study focuses on the elaboration of {Ge islands/Si spacer} stacks for optoelectronic devices in the 1.3-1.6 micrometer range. Ge is an attractive material due to its band gap which is lower than silicon. Ge/Si layers were deposited in a 200 mm industrial cluster tool equipped with reduced pressure chemical vapor deposition chambers. We, first of all, report on the influence of the main deposition process parameters on single Ge islands layers morphology (islands size, shape and surface density). At 650 and 700°C, a Stranski-Krastanov growth occurs (i.e. 2D growth followed by 3D growth): pyramids are first nucleated then evolve into domes which further plastically relax to form big multifaceted domes. Photoluminescence analyses have been correlated with layers morphology (dependence of photoluminescence spectra on islands size and surface density). Optical properties of layers deposited at 650°C are better than the ones of layers grown at 700°C (fig 1). The low energy emission line is, indeed, centered at 1.58 micrometer for such layers. Consequently, further developments have been conducted at 650°C. Gas-phase parameters (germane partial pressure and total pressure) act in a big way on the surface density and domes size : domes surface densities up to 1.8×10^{10} per square centimeter were obtained, with mean diameter and height of 70 and 10 nm respectively (fig 2). We have, then, investigated the growth of {Ge islands/Si spacer} stacks. Vertical ordering of islands in successive layers has been analyzed, mainly as a function of the silicon spacer thickness and island size. Islands growth on buried island layers has been precisely studied, in order to optimize the amount of Germanium and hence the islands density for each layer. Islands growth is modified either by strain field induced by buried islands and by the silicon layer surface morphology. Different regimes of vertical and in-plane self-organization of islands are evidenced as a function of the silicon spacer thickness (Fig 3 and 4). Photoluminescence analyses of islands stacks have been used to point out the best deposition conditions and layers sizes for optical applications. We have, indeed, analyzed the optical properties of miscellaneous vertical and lateral islands correlations schemes. Finally, we will present results on basic optoelectronic devices (sources, modulators, photodectors) showing that Ge islands-based structures are good candidates for optical interconnections. The ability of industrial deposition systems to grow such structures is also evidenced.

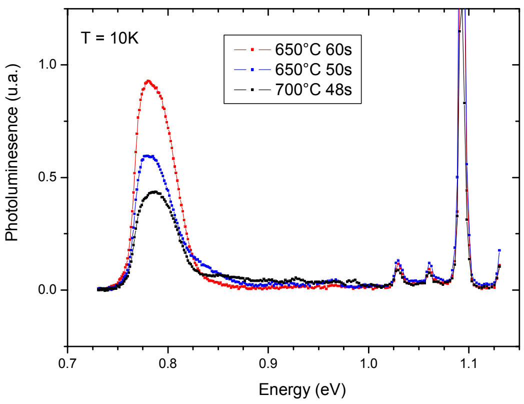

Fig 1 : Photoluminescence spectrum of single Ge QDs layers deposited by RP-CVD at 650°C and 700°C

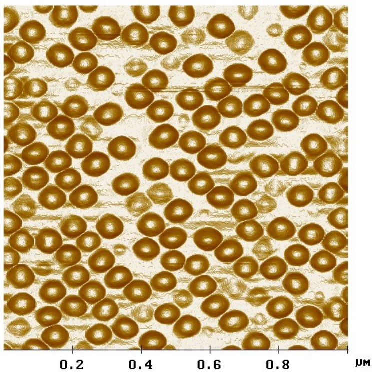

Fig 2 : Surface morphology of a single plane of Ge islands on Si(001) (AFM).

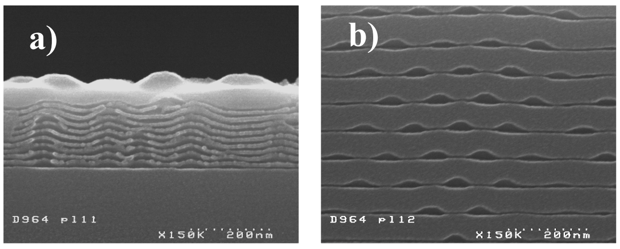

Fig 3 : SEM pictures of {Ge islands/Si spacer} stacks with 17 nm (a) and 75 nm (b) thick Si spacer.

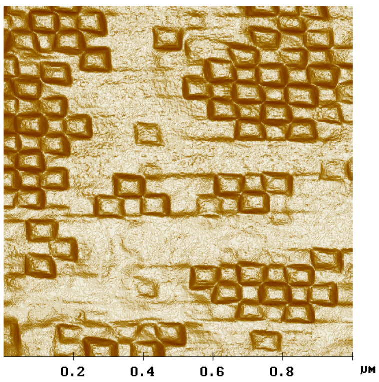

Fig 4 : Surface morphology of a {Ge islands/Si spacer} stack with 75 nm thick Si spacers (AFM).