

## Relationship between structural changes, hydrogen content and annealing in stacks of ultrathin Si/Ge amorphous layers

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**Resume :** Amorphous Si, Ge and SiGe alloys are often doped with H in order to passivate the dangling bonds.

However, H is not stable against light soaking and heat treatments yielding degradation of the electrical-optical properties. We present results on the structural instability, as a function of annealing, caused by H in multilayers (MLs) of alternating 3 nm thick a-Si and a-Ge layers deposited by sputtering. H was added at flow rates of 0.4, 0.8, 1.5, 3 and 6 ml/min. By ERDA it was seen that for flow rates

$\geq 1.5$  ml/min the effective H content incorporated in the samples saturates at  $\sim 16$  at. %. IR optical absorbance shows that mostly Si and Ge monohydrides form. Annealing was done at 673 K for times of 1 to 10 h. The evolution of the properties of the MLs as a function of annealing and H content was followed by IR optical absorbance, TEM, AFM, ERDA. With increasing annealing time/temperature and H content the surface morphology degrades with formation of bubbles and craters whose size and density increase up to 9  $\mu\text{m}$  and  $6.7 \times 10^5 \text{ cm}^{-2}$  for a H flow rate of 6 ml/min. The signal of Ge-H and Si-H complexes almost completely vanish in the IR absorbance spectra upon annealing indicating that H is released to the lattice. This supports the conclusion that it is the released H that produces the bubbles and the craters when the H bubbles blow up because of a too high internal pressure. ERDA experiments performed on single layers of a-Si and a-Ge, showing a faster H released from a-Si than from a-Ge, and energy filtered TEM (EFTEM) maps, showing larger broadening of the a-Si layers in the ML structure, suggest that upon annealing H is first released from a-Si layers. This is in agreement with published data reporting on the lower binding energy of Si-H with respect to Ge-H in amorphous materials.