Modeling of In-plane Expansion and Buckling of SiGe Islands on BPSG

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There has been increasing interest in compliant substrates for integration of heterogeneous epitaxial materials. In this talk, borophosphorosilicate glass (BPSG) on silicon is used as a compliant substrate to allow the relaxation of strained SiGe layers [1]. The talk will focus on the dynamics of the relaxation process.

The SiGe layers are first grown in a strained state on a (100) silicon wafer by CVD, and then bonded to the BPSG wafer. After the silicon substrate under the SiGe is removed by the Smart-Cut process and selective etch, the SiGe is patterned into islands. The samples are then annealed at 800 °C to allow the SiGe to relax. The progress of the relaxation is followed by X-ray diffraction from the (400) peak of the SiGe layers.

The relaxation takes place by two competing mechanisms: in-plane expansion and out-plane bending (namely, buckling). The in-plane expansion of the SiGe islands is observed by X-ray diffraction from its (400) peak, while the buckling is measured by AFM.

The characteristic time of in-plane expansion is linearly proportional to the island area. And the buckling rate is independent of the island size. Islands will buckle if the in-plane expansion alone is not fast enough to relax the strain. We studied the buckling dependence of the island size and it clearly shows islands smaller than 40um have negligible buckling.

We modeled the 2-D in-plane expansion. It is in reasonable agreement with our experimental data of small islands, but it underestimates the relaxation speed for bigger islands. We predict that the underestimation stems from the fact that in the 2-D model we ignore the relaxation contribution of the buckling. The viscosity of BPSG at 800°C extracted from the 2-D model based on the experimental data is about $9x10^{10}$ poise.

Surface roughness of the center of the 200um SiGe islands is measured as a function of anneal time at 800°C to study the buckling rate. In-plane expansion in this case can be neglected because the center of big islands relaxes solely by buckling. N. Sridhar, *et. al.* [2], have recently developed theory for buckling of SiGe islands on BPSG. It is shown that the buckling amplitude grows exponentially over time. Our data agrees well with their theoretic prediction. If the fastest growing mode in the buckling is assumed to dominate, based on the buckling rate we then can extract the viscosity of BPSG at 800°C, which is almost the same as the one given above. This is an sound evidence that the models for 2-D in-plane expansion and buckling are valid in our case.

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Reference:

1. K. Hobart, *et. al. Journal of Electronic Materials,* 29, 897 (2000).
2. N. Sridhar, *et. al.* to be published