Comment on “Low-temperature homoepitaxial growth on high-miscut Si(111) mediated by thin overlayers of Pb” [Appl. Phys. Lett. 75, 2954 (1999)]

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COMMENTS

Comment on "Low-temperature homoepitaxial growth on high-miscut Si(111) mediated by thin overlayers of Pb" [Appl. Phys. Lett. 75, 2954 (1999)]

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Wei and Su recently published a letter in this journal on low-temperature homoepitaxial growth of silicon mediated by thin overlayers of Pb.[1] A significant portion of the experimental work reported in their letter was performed in our laboratory (depositions, Rutherford backscattering analysis, and electron microscopy). Those experiments were poorly controlled and produced major inconsistencies that made the work unfit for publication. A subsequent, more systematic, investigation revealed the origin of these inconsistencies and established the precise conditions for high-quality growth. Our report on the latter work appeared in this journal several months prior to submission of Ref. 1.[2] The purpose of this comment is to correct the factual errors reported in Ref. 1.

Foremost among these is the claim that high-quality Si films can be grown on vicinal Si(111) for Pb coverages of 0.8–1.0 ML ($1\ \mathrm{ML}=7.83\times10^{14}\ \mathrm{atoms\ cm}^{-2}$) by first depositing the Pb overlayer and subsequently growing the Si film without continuously supplying the sample surface with additional Pb. As reported in Ref. 2, the growth of arbitrarily thick, high-quality Si films requires a Pb coverage of 1.0 ± 0.1 ML which cannot be achieved under the conditions outlined in Ref. 1 because Pb desorbs from the surface of the growing film. We have observed evaporation of Pb from vicinal surfaces including those from the same substrate material used by Wei while working in our laboratory. To maintain a constant Pb coverage at substrate temperatures of 280 °C or higher, one must deposit Pb during the growth of the Si film. For example, at 295 °C a Pb flux of 0.12 ML min^{-1} is needed to maintain a Pb coverage of 1.0 ML on the sample surface.[2] The Pb coverages reported in Ref. 1 were measured at the end of the deposition of Si. By wrongly assuming that the final Pb coverages they measured represent the actual coverages during growth, Wei and Su have overlooked the effect of Pb desorption on their results.

The misinterpretation of ion channeling spectra in Ref. 1 undermines the authors' claim that high-quality films can be grown with submonolayer coverages of Pb at the surface. It is stated in Ref. 1 that ion channeling measurements made on a film grown with a Pb coverage of 0.12 ML, shown in Fig. 1(a) of Ref. 1, give a minimum yield of 62.5%. However, examination of the ion channeling spectra shows that the 50-nm-thick film grown with 0.12 ML Pb is nearly indistinguishable from the film grown without Pb. The film grown without Pb, if thick enough, would have had a minimum yield of 100%, as does the thicker film shown in Fig. 1(c) of Ref. 1. The reported minimum yield is deceptively low because the film is too thin to be reliably measured by ion channeling in the backscattering geometry given the energy resolution of the particle detector used in the study (FWHM≈20 keV). Other ion channeling spectra in Ref. 1 have been misinterpreted in a similar manner. We have analyzed the data from the work performed at Harvard University that is reported in Fig. 3 of Ref. 1. We find that most samples used to show that high-quality growth is possible with a Pb coverage less than 0.9 ML are thinner than 30 nm. These films are too thin for the adequate determination of minimum yield from the measured spectra. Thus, there is no clear evidence that high-quality films can be grown with a 0.8 ML Pb overlayer as asserted in Ref. 1.

Small quantities of trapped Pb—approximately 0.01 ML—in films described in Ref. 2 allowed the unambiguous identification of the substrate–film interface in transmission electron micrographs of our samples. Proper determination of the position of the substrate–film interface is very important in understanding the effect of Pb on Si homoepitaxial growth. The lack of a marker of the interface in the electron micrographs presented in Figs. 2(b) and 2(c) of Ref. 1 undermines the reliable use of these sample images for the explanation of the growth process including the authors' claim that high-quality growth can proceed for a limited thickness with insufficient Pb.

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[1] L.-C. Wei and C.-s. Su, Appl. Phys. Lett. **75**, 2954 (1999).

[2] P. G. Evans, O. D. Dubon, J. F. Chervinsky, F. Spaepen, and J. A. Golovchenko, Appl. Phys. Lett. **73**, 3120 (1998).

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