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Editorial

Special issue on ‘‘microscopy of semiconductor growth processes’’

The insatiable desire to create novel structures for device applications frequently probes our knowledge of semiconductor growth processes very deeply. How can we precisely control interface structure and composition at the atomic level? Will a strained semiconductor layer relax or not? Is it possible to utilize growth instabilities and alloy decomposition to self-assemble regularly spaced nanostructures of uniform size? This special issue describes some of the key and unique contributions microscopy has made in the quest to answer such questions.

It has been said that if a picture is worth a thousand words, then a movie is worth a thousand images. Dramatic movies of semiconductor growth processes can now be obtained during ultrahigh vacuum (UHV) vapor deposition inside carefully modified microscopes. Such techniques include Low Energy Electron Microscopy (Blakely and Umbach, Phaneuf, et al.), UHV Transmission Electron Microscopy (Ross et al.), and Molecular Beam Scanning Tunneling Microscopy (STM) (Voigtländer). As shown in this issue, following events in real time allows observations of critical transitions and events which would be impossible to capture by the post mortem examination of many samples.

Many key issues in the growth of semiconductor materials concern the details of the surface during growth, and the integrity of buried interfaces after growth. The techniques of high resolution electron microscopy and transmission electron diffraction combined with direct methods as described by Grozea et al. offer great promise for understanding surface reconstructions and the role of adsorbates in the early stages of growth. Similarly, Yu discusses the technique of cross sectional STM, which is a new and important tool for exploring alloy layer and interface structure on the atomic scale. These methods will significantly compliment the arsenal of existing techniques to provide key structural and compositional information in the study of important growth issues.

Relaxation of strained epilayers by the introduction of misfit dislocations is a longstanding issue in the growth of semiconductor materials. A fresh perspective on this subject is provided by Goodhew and Giannakopoulos. Major challenges in this area include our inability to observe the operation of dislocation sources and multiplication mechanisms. The application of real time microscopy of these issues under carefully controlled growth conditions is a tantalizing prospect for the future.

The development of exciting microscopic techniques as described in this issue is being paralleled by spectacular advances in the theoretical modeling of semiconductor growth processes. Atomistic techniques, such as ab initio methods can be used to understand the structure and electronic properties of the surface reconstructions, steps, interfaces and defects investigated by microscopy. On larger length scales, theories of material transport can be applied to understand the dynamics of surface evolution such as the ripening of strained islands. Undoubtedly, state of the art microscopy and the latest theoretical methods will be increasingly combined to provide a new level of insight into fundamental growth processes. This is truly an exciting time for semiconductor growth physics.

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