Kinetic regimes in III-V nanowire growth

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Since the early days of III-V growth in MBE, the III/V ratio has been recognized as critical in controlling the detailed behavior. This is especially true for nanowire growth. The III/V ratio dramatically affects various aspects of the growth, including the size of the catalyst droplet. This in turn presumably affects the wire diameter and growth stability.

In growth of GaP nanowires, in-situ microscopy reveals surprising fluctuations in atomic-scale growth rates [1]. These fluctuations are correlated with the introduction of crystal defects. The fluctuations are dramatic for typical high V/III ratio, but can be suppressed by growing at low V/III ratio. This has important consequences for precise control of e.g. ultra-thin tunnel barriers.

The contrasting behavior at high vs low V/III ratio can be explained by a model that focuses on the very different transport mechanisms of the group V and group III species. Ga diffuses readily across the surface, while As or P evaporates before it can diffuse far. A simple model incorporating this picture reproduces key features of the behavior, including the variable sensitivity to crystal defects. The model also describes how the VLS growth morphology and growth rate depend on source-gas pressures, making predictions that are consistent with the available experimental information. Thus it provides a simple and useful perspective on the effects of V/III ratio in VLS growth.

[1] Y.-C. Chou, K. Hillerich, J. Tersoff, M. C. Reuter, K. A. Dick, F. M. Ross, unpublished.