

**MS16.02.02 NEW DATA ON DEFECT ASSISTED GROWTH MECHANISMS.** Nai-Ben Ming, National Laboratory of Solid State Microstructures, Nanjing University, Nanjing 210093, P. R. CHINA

The 2D heterogeneous nucleation assisted by the defects and the successive stages of layer-by-layer growth of a fcc(111) surface on which emerged the outcrops of a dipole of screw dislocation, a piece of stacking fault [1], an A-Type twin lamella (re-entrant corner growth)[2,3], and a B-type twin lamella (rough stripe growth) [4,5] have been studied in a unified manner [6]. The influences of supersaturation, bond energy, growth temperature and characteristic parameters of the defects upon the growth kinetics and surface morphology for different defect mechanisms have been compared [7].

Reference:

- [1] Nai-Ben Ming, K.Tsukamoto, I. Sunagawa, and A. A. Chernov, *J. Crystal Growth* 91 (1988)11-19
- [2] Hua Li, Xing-Dong Peng and Nai-Ben Ming, *J. Crystal Growth* 139 (1994)129-133
- [3] Hua Li and Nai-Ben Ming, *J. Crystal Growth*, 152 (1995)228-234
- [4] Nai-Ben Ming and I. Sunagawa, *J. Crystal Growth*, 87 (1988)13-17
- [5] Nai-Ben Ming and Hau Li, *J. Crystal Growth*, 115 (1991)199-202
- [6] Nai-Ben Ming, *J. Crystal Growth*, 128 (1993)104-112
- [7] Hua Li, Xing-Dong Peng and Nai-Ben Ming, *J. Crystal Growth*, 149 (1995)241-245

**MS16.02.03 FAST GROWTH FROM SOLUTIONS: MECHANISMS AND DEFECTS.** L.N.Rashkovich\*\*\*, I.V. Alexeev\*, J. De Yoreo\*\*, \*Institute of Crystallography, Russian Acad. Sci.; \*\*Lawrence Livermore National Laboratory; \*\*\*Physics Department, Moscow State University.

Considerable increase in the rate of crystal growth from solution without reduction in crystal quality is possible using high levels of supersaturation,  $s$ . Growth of KDP and ADP crystal faces at supersaturations of up to 17% was investigated. Dislocation hillocks remain on the faces even at the maximum  $s$ , but at  $s > 8-10\%$ , 2-dimensional nuclei are generated on the terraces between steps. Their generation is followed by a reduction in hillock slope. The shape of hillocks on the prism and bipyramid faces has been described. Use of atomic force microscopy made it possible to image hollow channels surrounding dislocation sources with Burgher's vectors larger than one unit step. Because the dislocation spiral has to by-pass these channels, their presence lowers the activity of sources at high  $s$ . The shape of a polygonal spiral was computed taking into account the by-passing of the channel and the tensions in the dislocation core. The effect of impurities on the shape of elementary steps, generation of macrosteps and the relation of these factors to the quality of crystals has been researched theoretically and experimentally. Applying in situ Michelson interferometry, the effect of Fe, Cr, and Al-ions and organic impurities on the dependence of the effective tangential step speed,  $v$  on  $s$  has been investigated. The results show that it is possible to increase the normal growth rate of prismatic faces at constant  $s$  by reducing the content of these impurities or decreasing the pH. The positive effect of crystallization growth temperature on the stability of highly supersaturated solutions and reduction of impurity adsorption has been demonstrated.

**MS16.02.04 SURFACE DIFFUSION AND INCORPORATION OF GROUP III ATOMS DURING III - V MBE.** Tatau Nishinaga, Department of Electronic Engineering, The Graduate School of Engineering, The University of Tokyo, 7-3-1 Hongo, Bunkyo, Tokyo 113, Japan

In MBE of III - V compounds, the group III atoms first arrive on the surface and migrate to the step where they are incorporated if the group V atoms come and fix them. If there is no group V atoms come, the group III atoms can easily detach and migrate to the next step. Hence, the diffusion length for incorporation of group III atoms depends strongly on the group V pressure. This has been clearly observed where inter-surface diffusion takes place. For instance, in MBE of GaAs, Ga diffuses from (111)A to (001) and the growth rate decreases on (001) surface exponentially as a function of the position from the corner where two faces meet. The diffusion length of incorporation takes the value of around 1 micron meter[1]. This means the group III atoms pass over many steps and the steps do not act as 100 percent sink. If all the group III atoms cannot enter the step, the rest should wait and this means the concentration increases resulting in the increase of the supersaturation at the step edge. When this happens on the vicinal surface, the critical temperature of mode transition between 2D nucleation and step flow should increase.

Basing on this model, the mode transition temperature was measured by changing group V to III flux ratio. It was found that the transition temperature decreases as the group V flux is increased[2]. This is explained in terms of the change of supersaturation at the step edge.

- [1] S. Q. Shen, D.Kishimoto and T.Nishinaga : *Jpn. J. Appl. Phys.*, 33(1994)L11.
- [2] K. Miwa and T. Nishinaga : The 1st Topical Meeting on Structural Dynamics of Epitaxy and Quantum Mechanical Approach, Jan. 1996, Tokyo, p.p.25-30.

**MS16.02.05 REAL-TIME MONITORING OF CHEMICAL VAPOR DEPOSITION PROCESSES: EFFECTS OF PRESSURE AND FLOW.** Klaus J. Bachmann, Nikolaus Dietz, Amy Miller, Christian Höpfner, Departments of Chemical Engineering<sup>(a)</sup>, Materials Science and Engineering<sup>(b)</sup> and Physics<sup>(c)</sup>, Jeffrey S. Scroggs, Hien T. Tran, Grace Kepler, Kazufumi Ito, H. Thomas Banks, Center For Research in Scientific Computation, North Carolina State University, Raleigh, NC 27695-7919

Real-time non-intrusive optical monitoring of the reproducibility of initial surface conditioning and the kinetics of nucleation and growth in chemical vapor deposition (CVD) processes, is important for both the development of closed-loop feedback control and progress in the fundamental understanding of CVD. Recently we have shown that the combination of p-polarized reflectance (PR), laser light scattering (LLS) and reflectance difference spectroscopy (RDS) is ideally suited for this task under low pressure conditions, where the ambient is represented by a dielectric constant close to one. The accommodation of these techniques to elevated pressure/high flow CVD, which is desirable in the context of controlling point defect chemistry related optical and electrical properties of compound heterostructures presents a challenge because temporal and spatial variations in the dielectric function of the ambient phase degrades their accuracy. In this paper we briefly review the methods of optical monitoring of CVD processes that have been applied thus far in conventional regimes of pressure and flow and assess their potential under conditions of high pressure growth. This includes a critical evaluation of design criteria for the implementation of optical process monitoring under the conditions of high pressure vapor transport (HPVT) and of migration enhanced CVD processes at elevated pressure. Also, we compare optical real-time process monitoring to complementary methods, such as, mass spectrometric sampling. The results of finite difference computations for specific designs of HPVT and CVD reactors are presented and related to the monitoring and control of the growth kinetics. The paper concludes with an outlook at applications of real-time optical process monitoring in condensed phases.