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kSA ACE deposition rate determination for Al, Ga, and In

In order to determine the minimum detectable growth rate of Al, Ga, and In, the kSA ACE tool was mounted to an MBE deposition chamber (Veeco GEN III) that was also fitted with a kSA 400 RHEED system and Staib RHEED gun. The absorption *A* of the source material flux was monitored using the ACE system at various process conditions, while the kSA 400 monitored the RHEED oscillations to determine a growth rate *G* on a stationary witness sample. These measurements were plotted as *A* vs. *G*, and the curves were fitted to a modified Beer's Law equation to determine a fitting coefficient *α* that indicates the sensitivity.

$$A = 1 - Be^{-\alpha G}$$

Figure 1. The kSA ACE tool consists of light source and detector assemblies to measure optical absorption of atomic flux within a growth chamber by mounting directly to or near optical viewports. Here, the kSA ACE optics heads are seen on a production MBE chamber. In this setup, the optics heads are mounted to independent floor stands to decouple from the reactor.

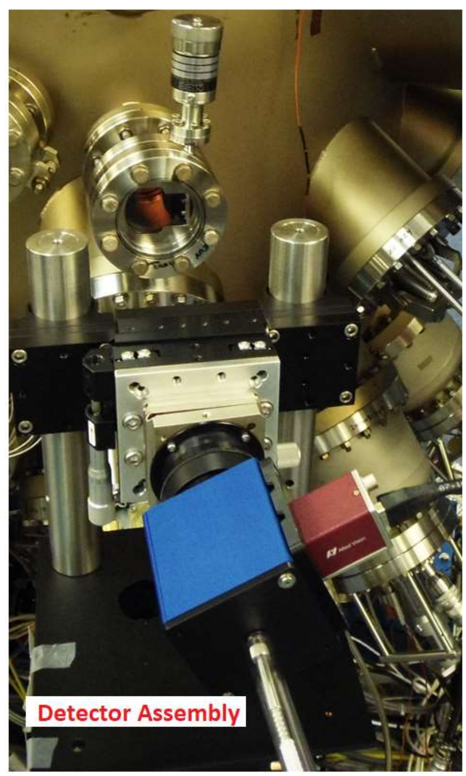
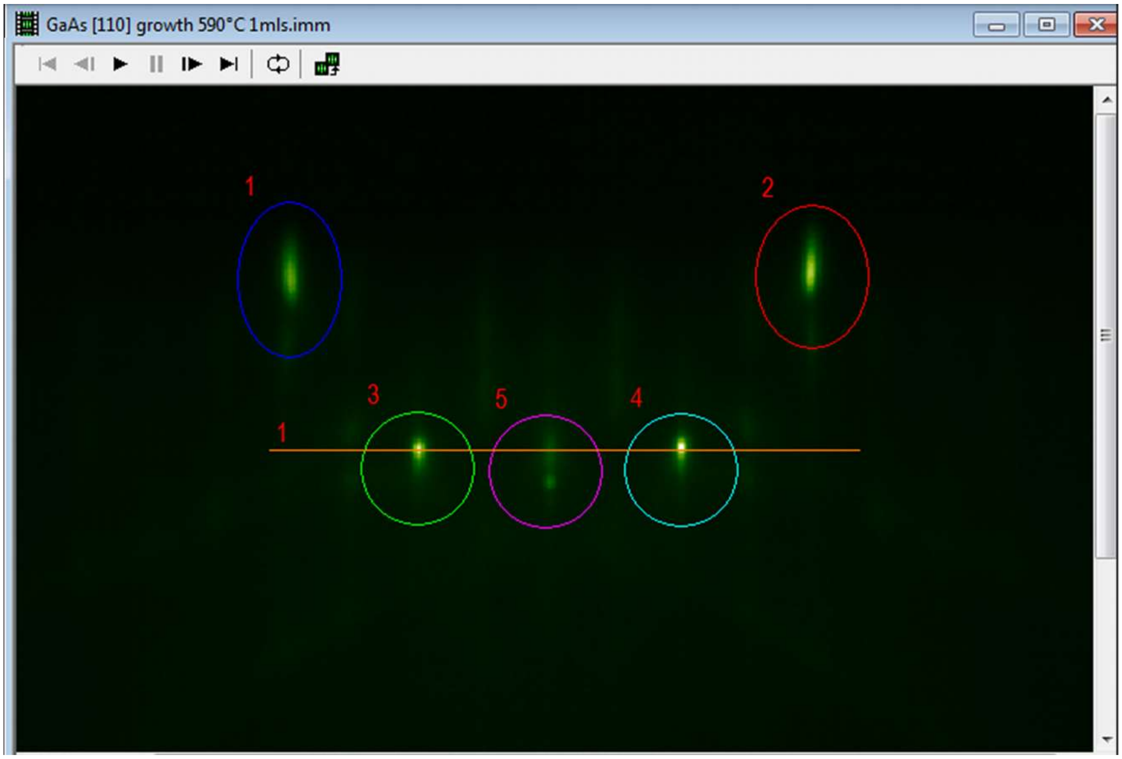


Figure 2. RHEED patterns were monitored during growth using a kSA 400 to establish *G*. This example shows RHEED patterns for GaAs [110] growth at 590 °C and the accompanying temporal oscillations that are analyzed within the kSA 400 software.



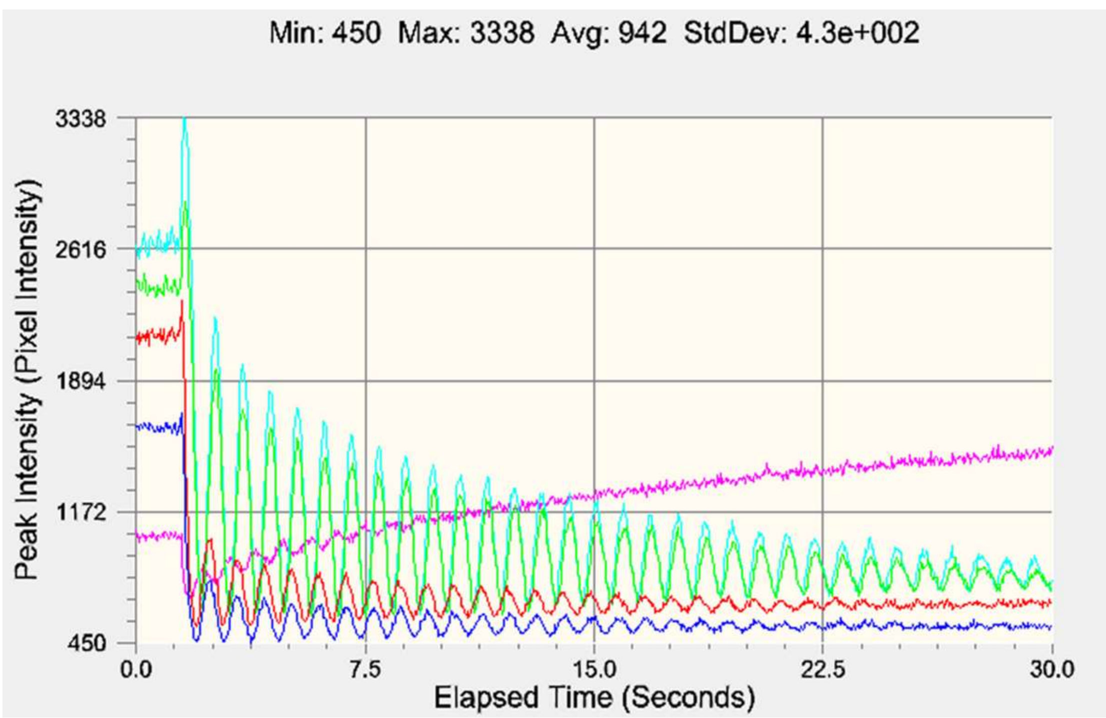
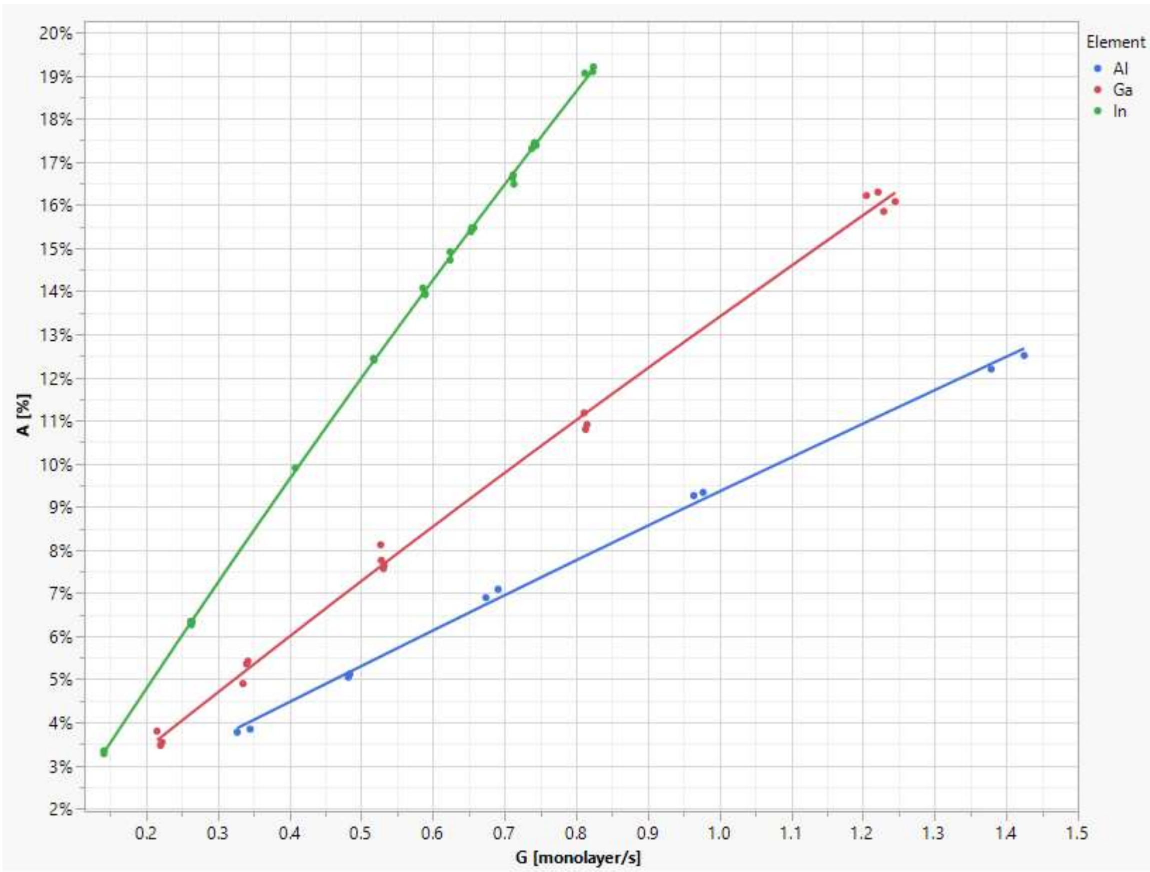


Figure 3. Atomic flux absorption for Al, Ga, and In was monitored – concurrently with *G* from the RHEED system – during growth in As-rich conditions. For these elements, *A*(*G*) is fitted to Beer's Law and *α* was determined to be 0.262, 0.137, and 0.0878 s/monolayer, respectively. Note that while the lowest growth rates tested for all 3 elements resulted in ~ 3-4% absorption, the kSA ACE tool can typically resolve absorption down to ~ 0.3%.



In Beer's law fit: $A = 1 - 1.00337e^{-0.26200 \cdot G}$

Ga Beer's law fit: $A = 1 - 0.99304e^{-0.13716 \cdot G}$

Al Beer's law fit: $A = 1 - 0.98925e^{-0.08750 \cdot G}$