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Growth of a submonolayer quantum dot infrared photodetector in the presence of a c(4x4) surface reconstruction

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Generally, InAs quantum dots are fabricated on GaAs substrates using the Stranski-Krastanov (SK) growth mode, which consists in depositing a thin and strained InAs layer that partially relaxes to form small InAs islands that confine the carriers along the three directions of space, behaving as quantum dots (QDs). Since such nanostructures use to have a low areal density (1-5·10^{10} cm^{-2}) and their size can only be modified in a very limited range, an alternative method to grow QDs with a higher density is to use the submonolayer growth technique. Submonolayer quantum dots (SML-QDs) can be obtained by depositing a fraction of a monolayer of InAs material (30-50%) on GaAs in order to nucleate a high density (up to 1·10^{12} cm^{-2}) of small two-dimensional (2D) islands, and then covering it by a few monolayers of GaAs material. This cycle can be repeated as many times as necessary and, under the right growth conditions, the small 2D InAs islands of the next layers will pile up (due to the strain field) and will form QDs having the desired height. In this way, it is possible to grow nanostructures with a higher density and better size uniformity, that should be able to improve the performance of devices like lasers, infrared photodetectors and solar cells. A fundamental condition to grow SML-QDs is the nucleation of small 2D InAs islands that should persist as they are covered by the following layers. According to the STM studies of Krzyzewski *et al.*[1], the growth should occur in As rich conditions and with a (2x4) surface reconstruction to have a successfull piling up of these small 2D InAs islands. However, since InAs must be grown around 500 ^{o}C, which normally yields a c(4x4) surface reconstruction, the growth conditions that are needed to maintain a (2x4) surface reconstruction require an extremely low As flux. This is difficult to reach and means that the other fluxes of material also need to be very low, leading to very long growth times. In order to circumvent these drawbacks, we decided to grow a SML-QDIP in usual growth conditions to check its performance. Such a device showed a high detectivity at normal incidence, confirming that the SML-QDs were successfully formed and were optically active.

[1] T. J. Krzyzewski, P. B. Joyce, G. R. Bell and T. S. Jones, Surf. Sci. **517**, 8-16 (2002).