SAWtrain Research Highlight 10:
"Sidewall quantum wires on GaAs(001) substrates"

Planar quantum wires are important components for on-chip information exchange processes. In this publication, we study acoustic transport of charge carriers in sidewall quantum wires. The quantum wires (QWR) are fabricated by epitaxial overgrowth of a 10-nm quantum well (QW) on pre-patterned GaAs(001) substrates, as schematically shown in **Error! Reference source not found.**a. Here, the blue arrows depict the diffusion of adatoms from mesa top and bottom towards the sidewalls during overgrowth, which leads to the QWR formation. The ridge patterns are fabricated by photolithography and wet chemical etching. Scanning electron microscopy images depict fluctuations of the ridge sidewall shape, commonly known as line-edge-roughness, which originates in the photolithography process. However, the average fluctuations of approx. 10 nm are much smaller than the QWR width of approx. 200 nm. Therefore, we expect that these fluctuations will play only a minor role during acoustic charge transport.

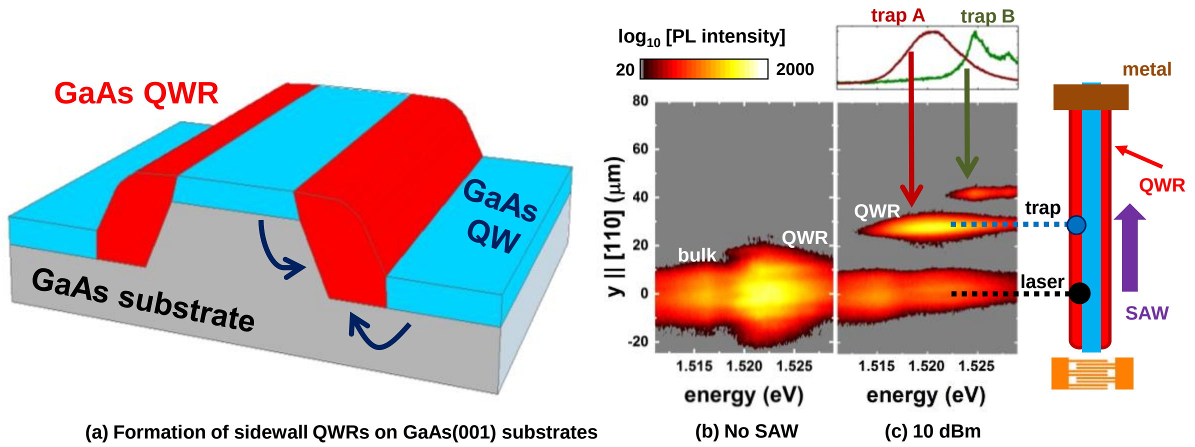

Figure 1: Formation of sidewall QWRs on GaAs(001) substrates (a). PL map of the sidewall without (b) and with SAW (c).

Concluding from a spatial photoluminescence (PL) map, the QWRs form along the [110] direction. The QWR resonance is red-shifted from the QW by 27 meV, which protects the QWR carriers during acoustic transport from escaping to the QW. **Error! Reference source not found.**b shows a map of the photoluminescence while exciting the ridge sidewall using a Ti:Sapphire laser with a wavelength of 809 nm. The low-energy resonance observed at 1.516 eV is attributed to substrate emission. The QWR resonance is clearly observed at 1.521 eV. The piezoelectric potential of a SAW captures and stores electrons and holes in its maximum and minimum respectively, transporting them along the QWR over tens of micrometers (Figure 1c). At certain locations, a recombination center preferentially traps one type of carriers. We observe PL with the arrival of the opposite polarity carriers, half a SAW period later. The majority of the traps show emission properties very similar to the emission of the QWR at the excitation spot, as is shown in the upper panel by the red curve. The green curve shows the spectrum of a different trap with different emission properties. Time-resolved measurements of the PL at the trapping location A show oscillations of the PL with the SAW frequency, proving that this kind of trap has a preference for one polarity.

In conclusion, we observe the formation of quantum wires on sidewalls of ridges aligned along the [110] crystal direction on GaAs(001) substrates. This type of QWRs are a promising candidate for information exchange processes between on-chip locations.

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