SCALABLE TOP-DOWN FABRICATION OF (IN,GA)N NANOWIRES FROM EPITAXIAL LAYERS

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(In,Ga)N nanowires offer properties that make them attractive as semiconductor electrodes for solar water splitting and CO2 reduction. However, achieving good control over their morphology, composition, and doping level is challenging in bottom-up growth. Here, we present the fabrication of such nanowires by combining the epitaxy of (In,Ga)N layers with subsequent top-down structuring.

500-nm-thick (In,Ga)N layers with In contents up to 16% are grown by plasma-assisted molecular beam epitaxy on GaN(0001) templates. X-ray diffractometry, secondary ion mass spectrometry, and cathodoluminescence as well as photoluminescence spectroscopy reveal a low strain relaxation degree (≈10% for 12% In), narrow x-ray profiles, low threading dislocation density (≈109 cm-2), uniform composition, and narrow emission band. This high degree of structural perfection ensures an excellent basis for top-down nanowire fabrication.

Nanoislands resulting from the dewetting of a Pt film during annealing are used as a mask for a sequence of etching steps. This process is suitable for the synthesis of large-scale nanowire ensembles. By adjustment of the processing conditions, we can tailor the nanowire dimensions. X-ray reciprocal space maps indicate the efficient elastic relaxation of the epitaxial strain by the nanowire morphology (see figure). This effect also explains the red shift observed by cathodoluminescence spectroscopy between the nanowires and the underlying layer. Furthermore, the nanowire ensemble exhibits a substantially higher photoluminescence intensity than the layer, which is partially caused by the annealing during dewetting. In conclusion, we demonstrate a scalable procedure for the fabrication of (In,Ga)N nanowire ensembles with high level of control over their properties.