Electronic Supplementary Material (ESI) for Nanoscale.

Supporting Information

Epitaxial GaAs/AlGaAs core–multishell nanowires with enhanced photoluminescence lifetime

Chen Zhou,[a] Xu-Tao Zhang,[b,c] Kun Zheng,[d] Ping-Ping Chen,*[b,c] Syo Matsumura,[e] Wei Lu,[b,c] and Jin Zou*[a,f]

[a]Materials Engineering, [f]Centre for Microscopy and Microanalysis, The University of Queensland, Brisbane, Queensland 4072, Australia. *Email: j.zou@uq.edu.au

[b]State Key Laboratory for Infrared Physics, Shanghai Institute of Technical Physics, Chinese Academy of Sciences, 500 Yutian Road, Shanghai 200083, People's Republic of China. *Email: ppchen@mail.sitp.ac.cn

[c] University of Chinese Academy of Sciences, 19 Yuquan Road, Beijing 100049, People's Republic of China

[d]Institute of Microstructure and Properties of Advanced Materials, Beijing University of Technology, Beijing 100124, People's Republic of China

[e]Department of Applied Quantum Physics and Nuclear Engineering, Kyushu University, Motooka 744, Nishi-ku, Fukuoka 819-0395, Japan

From EDS measurements of the nanowire bottom region in two grown samples, the Al concentration is ~15 at.% in two samples, which is consistent with EDS measurements of corresponding cross-sections as shown in Fig. 2e and 3e. For sample A, Al concentration in the nanowire shell was measured as ~20 at.% and the core and shell diameter/thickness can be estimated as 20 and 30 nm, respectively. Therefore, the Al concentration per nanowire volume can be estimated as (60 × 20% + 20 nm × 0%)/80 nm = 15%. Similarly, for sample B, the core, inner-shell and outer-shell diameter/thickness can be estimated as 20, 2 and 28 nm, respectively, so that the Al concentration per nanowire volume is estimated as (56 nm × 20% + 4 nm × 38% + 20 nm × 0%)/80 nm ~15.9%.

The redshift of the main peaks in Fig. 4a can be calculated by 1240/828 - 1240/831 ~ 5.4 meV

From **Table S1 and S2**, the time-resolved PL GaAs spectra in Fig. 4b both show Mono exponential decay, in which the carrier lifetime was determined as ~4.75 ns in sample A and ~6.37 ns in sample B.

Table S1 Mono-exponential decay fitting of time-resolved PL GaAs spectrum taken from sample A, as shown in Fig. 4b.

Model 1	$y = A_1 \times \exp(-{}^{x}/{t_1}) + y_0$	
Results	Value	Stand error
y_0	0.03634	6.9431E-4
A_1	0.96881	0.00119
c	4.75363	0.0144

Table S2 Mono-exponential decay fitting of time-resolved PL GaAs spectrum taken from sample B, as shown in Fig. 4b.

Model 1	$y = A_1 \times \exp(-{}^{x}/{t_1}) + y_0$	
Results	Value	Stand error
y_0	0.012	0.012
A_1	0.859	0.00243
t_1	6.370	0.05547

Fig. S1 shows time-resolved PL GaAs spectra taken from two grown samples by using an increased power density of 2.58 μJ/cm^2/pulse. By fitting the decay with a monoexponential curve, the carrier lifetime was estimated ~2.37 ns in sample A and ~3.22 ns in sample B, in which sample B has a ~36% longer carrier lifetime than sample A. These results were consistent with PL lifetime measurements with a low power density, and confirmed the advantages of our unique core-multishell nanostructures that may be used for high-efficiency optoelectronic applications. The relative low carrier lifetime measured under the high power density can be possibly due to the increased carrier density so that excited carriers have an increased chance to recombine.[1]

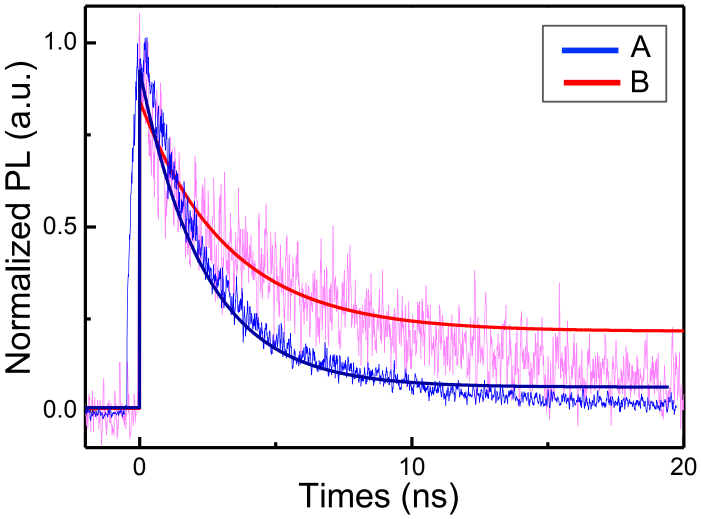

Fig. S1 Time-resolved PL GaAs spectra taken from the GaAs/AlGaAs core–shell nanowire in sample A and core–multishell nanowire in sample B. The laser power density of 2.58 μJ/cm^2/pulse was used.

Reference

1. L. Ya. Karachinsky, S. Pellegrini, G. S. Buller, A. S. Shkolnik, N. Yu. Gordeev, V. P. Evtikhiev, and V. B. Novikov, *Appl. Phys. Lett.*, 2004, **84**, 7.