InGaAs/GaAs 量子ドットナノワイヤにおける プラズモニックレーザ発振

Plasmonic lasing from GaAs nanowires containing InGaAs Quantum Dots

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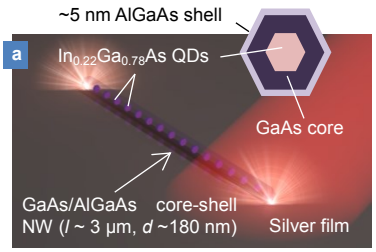
Nanolasers are crucial components for the on-chip integration of nanophotonics and electronics with low power consumption. The miniaturization of lasers to scales comparable to that of electrical components is an area of active research, and plasmonic nanowire (NW) lasers are a promising candidate to achieve this goal. Having demonstrated a plasmonic NW laser based on bulk GaAs dispersed on an ordered silver thin film [1], we now incorporate multi-stacked InGaAs/GaAs quantum dots (QDs) into the NWs as a gain medium. Better temperature stability can be expected with QDs as the gain medium due to carrier confinement effects. In this presentation, we report the first observation of plasmonic lasing using semiconductor QDs as the gain medium.

The NWs used in this study are similar to those reported in ref. 2, comprising of $In_{0.22}Ga_{0.78}As$/GaAs QD (diameter ~ 40 nm, height ~ 2 nm) stacks in GaAs NWs with average length and diameter of 3 μm and 180 nm, respectively. The diameter of the NWs are below the diffraction limit and no photonic modes can be supported. The NWs are dispersed on a silver film as shown in Fig. 1a to enable plasmonic modes, and low temperature (7 K) micro-photoluminescence experiments were performed with a pulsed semiconductor laser (λ = 785nm) as an excitation source. The power dependent spectra of a lasing sample shown in Fig. 1b, showing a broad Gaussian emission at low pump powers. Beyond the threshold of ~40 μW, a sharp peak emerges at ~845 nm originating from the QD emission. The integrated output power from the lasing peak exhibits an S-shaped power dependence as shown in Fig. 1c. The concurrent linewidth narrowing behavior is an indication of lasing behavior. Furthermore, gain clamping is observed when lasing is achieved.



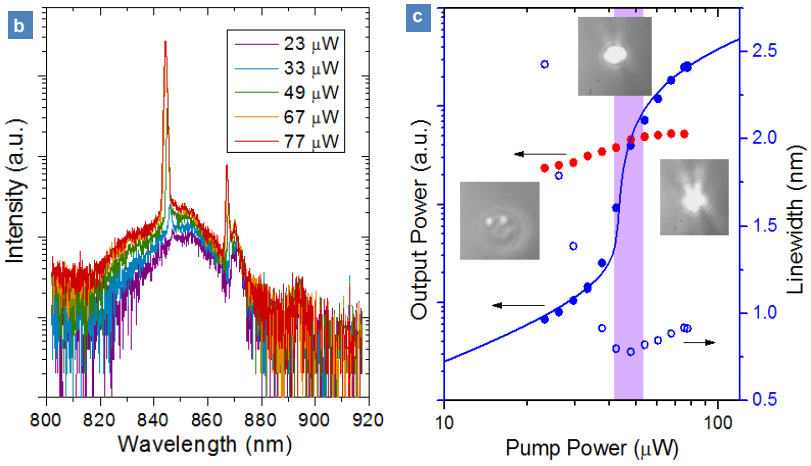


Figure 1. (a) Schematic of multi-stacked InGaAs/GaAs QD in nanowire, placed on a silver film. Inset shows the cross-section of the NW at the location of a QD. (b) Power dependent spectra of plasmonic nanowire showing transition from spontaneous emission (23 μW) to stimulated emission (49 μW) to lasing (77μW). (c) Output power and rate equation fitting for lasing peak (blue curves), and output power for background spontaneous emission (red dots) showing gain clamping when lasing is achieved. The stimulated emission regime is highlighted in purple. Insets show microscope image of nanowire emission for each regime.

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References [1] J. Ho *et al.*, *ACS Photonics* 2, 165 (2015). [2] J. Tatebayashi *et al.*, *75th JSAP Autumn Meeting* 18a-A6-4 (2014).