超高速波長変換素子に向けた InAs 量子ドットを有する GaAs/AlAs 多層膜三結合共振器

GaAs/AlAs triple-coupled cavity with InAs quantum dots for ultrafast wavelength conversion devices

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A GaAs/AlAs triple-coupled multilayer cavity structure has been proposed for novel ultrafast wavelength conversion devices[1]. Three cavity modes with the optical frequencies ω_1, ω_2, ω_3 are realized in the triple-coupled cavity structure that consists of three cavity layers with the same effective optical thickness. The frequency separation between two adjacent modes is identical, that is, ω_1-ω_2 = ω_2-ω_3. The Four-wave mixing (FWM) signal with $2\omega_2$-ω_1 should be efficiently generated in the triple-coupled cavity because the frequency is coincident with another mode frequency, ω_3. A significant improvement in the wavelength conversion is expected by introducing good nonlinear materials such as InAs quantum dot (QDs) in the cavity. Recently, we have investigated the FWM in GaAs/AlAs triple-coupled cavity with 3.4 ML InAs QDs[2], which were embedded in the strain-relaxed $In_{0.35}Ga_{0.65}As$ layer to extend the resonance wavelength over 1.5 μm. The degenerate FWM signals in the incident pulse spectrum covering the two cavity-mode wavelength have been clearly observed. However, the wavelength-converted signals were unclear.

In this study, we grew the GaAs/AlAs triple-coupled multilayer cavity structure with InAs QDs, which were embedded in GaAs cavity without strain-relaxed layer and has no absorption at 1.5 μm. The structure were shown in Fig. 1. The substrate rotation was stopped twice during growth of topside cavity in order to obtain a thickness distribution. The frequency separations of the cavity modes depending on the cavity layer thickness were measured using reflection spectra as shown in Fig. 2. Three reflection dips were due to the cavity modes and equivalent frequency separation between two adjacent modes was obtained. The wavelength-converted FWM signals were clearly observed.

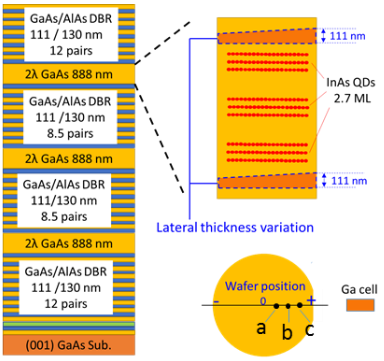

Fig.1. Sample structure

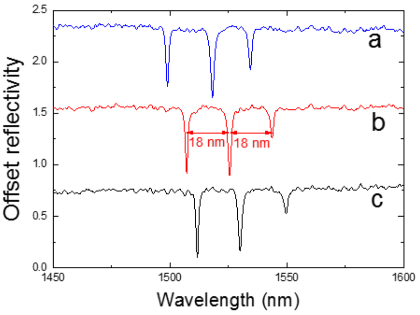

Fig.2. Measured reflection spectra

[1] T. Kitada et al., Appl. Phys. Lett. **103** (2013) 101109.
[2] M. Ogarane et al., Jpn. J. Appl. Phys. **54** (2015) 04DG05.