Competition between electronic Kerr and free carrier effects in an ultimate fast switched semiconductor microcavity

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The emergence of photonic integrated circuits [1] promises a transition from conventional electronic switches to optical switches. Light serving them as the information carrier has to be manipulated on ultrafast timescales for retaining high data rates. Photonic crystals or microcavities are therefore key ingredients for the on-chip all optical data communication since they allow the capture and release of photons on demand [2].

We present here our results on ultrafast switching of a planar GaAs-AlAs microcavity by means of the electronic Kerr effect. Excitation of free carriers is avoided by choosing the sum of the pump and the probe photon energy to be well below the bandgap energy of GaAs ($E_{probe}+E_{pump}\leq E_{gap}$). Moreover, the energy of the pump photons is carefully chosen to be less than half of the bandgap of the GaAs ($E_{pump}\leq E_{gap}/2$) [3]. Using these conditions two-photon generation of free carriers is suppressed while working at a probe frequency of 7800 cm^{-1} (λ=1282 nm), which is in the original telecom wavelength range. We present here the results for the switching at different pump intensities. The ultrafast change of the resonance frequency depending on the pump intensity is shown in Figure 1 (a).

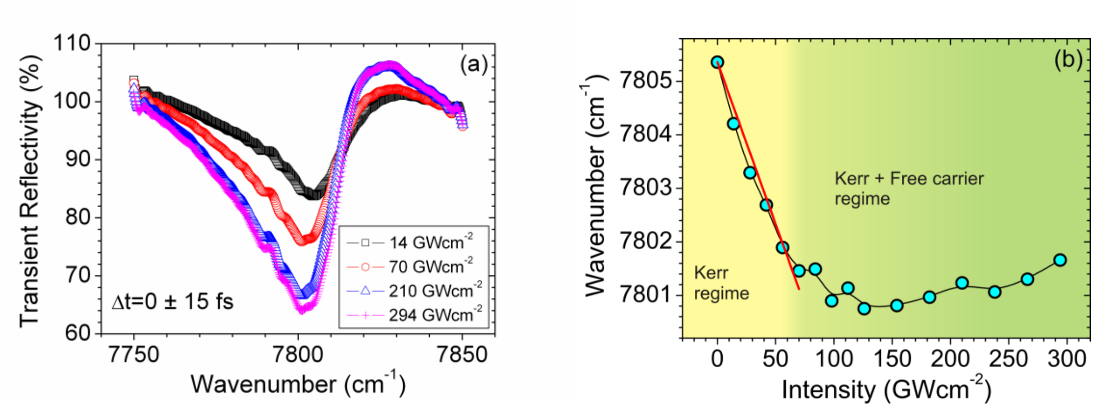

Fig. 1 (a) Reflectivity vs. frequency at different pump intensities. (b) Cavity resonance frequency vs. pump intensity at zero delay between pump and probe.

The intensity of the pump beam is scanned starting from 15 GWcm^{-2} up to 300 GWcm^{-2}. We observe first a linear red-shift of the cavity resonance for pump intensities up to 70 GWcm^{-2} as a result of the electronic Kerr effect shown in Figure 1(b). Increasing the intensity of the pump beam further results in an increase of three-photon generated free carriers. This results in a blue shift of the cavity resonance, which is evident for pump intensities exceeding 150 GWcm^{-2}. In the intermediate region we observe the competition between the electronic Kerr effect and the free carriers. Our results show that there is an optimum pump intensity for the switching of semiconductor microcavities via electronic Kerr effect.

References

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