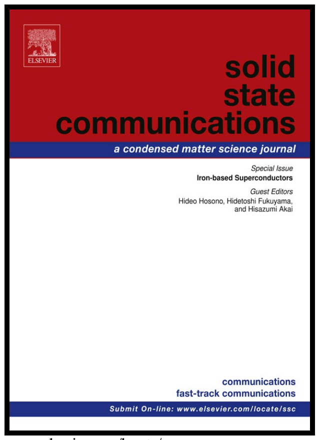
Author's Accepted Manuscript



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PII: S0038-1098(17)30105-9
DOI: http://dx.doi.org/10.1016/j.ssc.2017.04.006
Reference: SSC13170

To appear in: *Solid State Communications*

Received date: 12 January 2017
Revised date: 6 April 2017
Accepted date: 7 April 2017

Cite this article as: Tao Hu, Wei Xie, Lin Wu, Yafeng Wang, Long Zhang and Zhanghai Chen, Optimized polaritonic modes in Whispering Galler Microcavities, *Solid State Communications* http://dx.doi.org/10.1016/j.ssc.2017.04.006

Optimized polaritonic modes in Whispering Gallery Microcavities

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Abstract

We study both theoretically and experimentally the quality factor characteristic and the optimized polaritonic modes in a whispering gallery microcavity. The quality factors (Q-factors) of the resonant modes are determined by two main factors, i.e., the so called cavity loss and media loss. These two factors determine the final Q-factor and spontaneously lead to an optimized wavelength range for polariton modes. By using finite element analysis (FEA), we present the numerical simulation of resonant frequencies, field distributions and quality factors of the TE polarized whispering gallery modes (WGMs), which agree well with the experimental results. The control of optimized resonance in polaritonic system will be very useful for the development of semiconductor lasers with low threshold.

Keywords: whispering gallery modes, quality factor, finite element analysis, exciton polaritons

1. Introduction

Microcavities (MCs) with gain media have drawn much attention due to their significant applications in optoelectric devices, such as low threshold semiconductor lasers [1, 2, 3, 4], optical memories and photonic integrated circuit chips [5, 6]. To increase the emission flux and reduce the device's volume, an optimized way is to process the gain media directly to be a resonator (as seen in Fig. 1(b)). Recently, some works based on such type of MCs have been reported, e.g., GaN nanowire lasers [7, 8] and ZnO whispering gallery resonators [9, 10, 11, 12, 13]. These optically confined systems themselves are gain media and are ideal for the investigation and control of light-matter interaction, e.g. the strong coupling effect between the cavity field and excitonic states of gain materials [14, 15, 16, 17]. Moreover, such polaritonic systems are more advantageous for developing ultraviolet (UV) lasers because the reabsorption of gain emission during the MC path is no longer a part of energy consumption, comparing with the big challenge in traditional microcavity systems to reduce the MC's absorption loss in UV region.

The Q-factor is a key point to steer the optical properties in MC systems. For a traditional planar MC with embedded thin layers of gain media (as seen in Fig. 1(a)), light escapes at the boundary (cavity loss) and is absorbed by the media as well (media loss). If the media is very thin and the reflectivity of the reflectors in the MCs is not so high, the cavity loss is dominant. In this case, the Q-factor is mainly determined by the cavity mirrors. However, in structures shown in Fig. 1(b), gain media itself is the MC, light is confined due to the total internal reflection at the crystalline facets (if $n_{dielectric} \geq 1/sin60°$) and cavity loss can be very small while the optical length of WGMs is relatively longer, the media loss can be bigger than that in Fig. 1(a). Hence, the media loss is

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