ABSTACT

High-Q Micro-resonators for Trapping and Detecting a Single Atom on a Chip

Michael Rosenblit[1], Yonathan Japha[1], Peter Horak[2], and Ron Folman[1]

[1]Department of Physics and Ilse Katz Center for Meso- and Nanoscale Science and Technology, Ben-Gurion University of the Negev, Beer-Sheva, Israel
[2]Optoelectronics Research Centre, University of Southampton, Southampton, UK

Recent progress in the manufacturing of high Q dielectric microresonant structures enables their use as photonic devices that can manipulate and/or detect single atoms on a nanometer scale. Of specific interest is the wafer-based manufacturing of resonators where a good control of the physical characteristics can be achieved during fabrication and during operation, while at the same time allowing integration with other functions on the chip.

We investigate the possibility of simultaneously trapping and detecting single atoms near the surface of a substrate using the external fields of optical whispering gallery modes (WGMs) supported by a toroidal microcavity and we compare their trapping and detection efficiencies with those of a mode of a very small Fabry-Perot resonator. Both resonators have the advantage of a small electromagnetic mode volume and a high achievable Q value [1, 2].

We have calculated the evanescent fields of some optical WGMs and found that for efficient atom-mode coupling the atom should be placed within 80 – 180 nm from the disk. Such close proximity should be feasible by balancing the attractive van-der-Waals/Casimir forces with repelling blue detuned resonator light which is also used for atom detection. Additionally, red detuned light is used to create a trap. We show that the latter "all-optical" trapping should be possible and stable [2].

We discuss atom detection efficiencies in such systems depending on key parameters such as atom distance from the surface, intensity of red- and blue-detuned laser fields, and disk size, and compare these with the corresponding results for the Fabry-Perot configuration.

We also discuss experimental feasibility and compare with first experiments in the field [3,4].

References

1. M. Rosenblit, P. Horak, S. Helsby, R. Folman, Phys. Rev. A, 70, 053808 (2004)
2. M. Rosenblit, Y. Japha, P. Horak, R. Folman, Phys. Rev. A, 73, 063805 (2006)
3. P. E. Barclay, K. Srinivasan, O. Painter, B. Lev and H. Mabuchi, Appl. Phys. Lett., 89, 131108 (2006)
4. T. Aoki, B. Dayan, E. Wilcut, W. P. Bowen, A. S. Parkins, T. J. Kippenberg, K. J. Vahala and H. J. Kimble, Nature, 443, 671 (2006).