Technological University Dublin
ARROW@TU Dublin

Conference Papers

School of Manufacturing and Design Engineering

2015

Whispering Gallery Modes in a Ferronematic-Infiltrated Fibre Micro-Resonator for Magnetic Field Sensing

Vishnnu Kavungal
Technological University Dublin, vishnu.kavungal@tudublin.ie

Yuliya Semenova
Technological University Dublin, yuliya.semenova@tudublin.ie

Aseel Mahmood
Ministry of Science and Technology, Iraq

See next page for additional authors

Follow this and additional works at: https://arrow.tudublin.ie/engschmanconn

 Part of the Engineering Commons

Recommended Citation

Mahmood, A., Kavungal, V. & Ahmed, S. (2015). Whispering gallery modes in a ferronematic-infiltrated fibre micro-resonator for magnetic field sensing. *13th European Conference on Liquid Crystals*, September 2015. doi:10.21427/fcq9-aw70

This Conference Paper is brought to you for free and open access by the School of Manufacturing and Design Engineering at ARROW@TU Dublin. It has been accepted for inclusion in Conference Papers by an authorized administrator of ARROW@TU Dublin. For more information, please contact arrow.admin@tudublin.ie, aisling.coyne@tudublin.ie.

This work is licensed under a Creative Commons Attribution-Noncommercial-Share Alike 4.0 License

Authors
Vishnnu Kavungal, Yuliya Semenova, Aseel Mahmood, and Sudad S. Ahmed

This conference paper is available at ARROW@TU Dublin: https://arrow.tudublin.ie/engschmanconn/45

Whispering gallery modes in a ferronematic-infiltrated fibre micro-resonator for magnetic field sensing

Aseel Mahmood[1,2], Vishnu Kavungal[1], Sudad S. Ahmed[2], Peter Kopcansky[3], Vlasta Zavisova[3], Gerald Farrell[1], Yuliya Semenova[1]

[1]Photonics Research Centre, Dublin Institute of Technology, Kevin St., Dublin 8, Ireland;
[2]Department of Physics, College of Science, Baghdad University, Iraq;
[3]Institute of Experimental Physics SAS, Watsonova 47, 040 01 Košice, Slovak Republic
Corresponding author e-mail: aseel.mahmood@mydit.ie

1. Introduction

Whispering gallery mode (WGM) micro-resonators are remarkable optical devices whose small mode volumes and high Q-factors make them attractive for a wide range of applications such as filters, lasers, modulators and sensors [1]. WGMs can be excited in dielectric structures with circular symmetry, such as microspheres, micro-disks, and optical fibres, and can be imagined as closed-trajectory rays confined within the cavity by almost total reflections from the curved surface of the resonator. Spectral positions of the WGM resonances are highly sensitive to the geometrical dimensions of the resonator and refractive indices of both the resonator itself and its surrounding medium. Any refractive index perturbation of the inter-related media or a change in diameter results in variations of the WGM spectrum, offering the possibility to design various optical devices [2, 3].

Photonic crystal fibres (PCF) containing micron-sized air holes can be used as cylindrical WGM resonators whose refractive index can be altered by infiltrating them with various materials. In this work we propose a novel magnetic field sensors based on a PCF resonator infiltrated with a ferronematic liquid crystal. Effective refractive index of such a WGM resonator varies in the presence of magnetic field, and thus the value of the field can be related to the spectral shift of the WGMs.

Key words: whispering gallery mode, ferronematic liquid, photonic crystal fiber sensor

2. Experiment

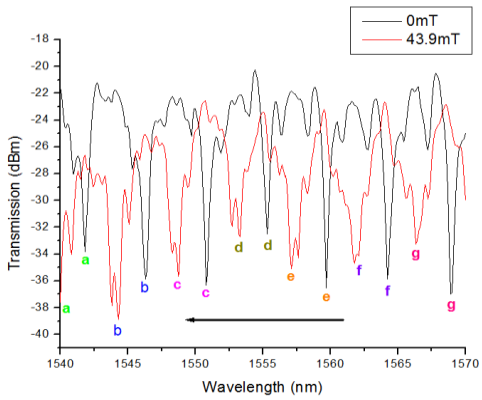

Fig.1: WGM spectra in the absence of magnetic field (black) and in the presence of magnetic field of 43.9 mT (red).

We studied WGMs in a cylindrical micro-resonator based on a 1.5 cm-long section of LMA-10 fibre infiltrated with a ferronematic liquid crystal mixture based on 6CHBT doped with magnetic (rod-like) nanoparticles (with an average diameter of 80 nm, mean length of 1200 nm and 2×10^{-4} volume concentration). WGMs were excited by evanescent coupling of a guided mode of a ~1 µm fiber taper placed perpendicularly and in direct contact with the resonator. Excitation of WGMs causes a series of dips in the transmission spectrum of the fiber taper. Fig. 1 illustrates the WGM spectra without magnetic field and in the presence of magnetic field of 43.9 mT. As can be seen from the figure, application of magnetic field results in a blue shift of the WGM spectrum with estimated sensitivity of ~0.0498 nm/mT.

3. Conclusion

In this work we experimentally demonstrate a novel magnetic field sensor based on a ferronematic-infiltrated WGM fibre resonator. The proposed sensor offers advantages of good sensitivity, small size and ease of fabrication.

References

[1] V. Zamora, A. Díez, M. Andrés and B. Gimeno: "Refractometric sensor based on whispering gallery modes of thin capillaries", *Opt. Express* 12011, **15**(19) (2007).

[2] V. Zamora, A. Díez, M. Andrés and B. Gimeno: "Cylindrical optical microcavities: Basic properties and sensor applications", *Photonics and Nanostructures – Fundamentals and Applications* **9**, 149–158, (2011).

[3] R. Yang, A. Yun, Y. Zhang, and X. Pu: “Quantum theory of whispering gallery modes in a cylindrical optical microcavity”, *Optik* **122**, 900–909 (2011).

View publication stats