A novel deep-UV polymer for integrated photonics: waveguides structures towards cascade of multiple micro-resonators

Nolwenn Huby, Rigoberto Castro-Beltran, David Pluchon, Daphné Duval, Marion Specht, Hervé Lhermite, Bruno Bêche

A novel deep-UV polymer for integrated photonics: waveguides structures towards cascade of multiple micro-resonators

N. Huby[1], R. Castro-Beltran[1], D. Pluchon[1], D. Duval[1], M. Specht[1], H. Lhermite[2], B. Bêche[1,3]

[1]Université de Rennes 1, IPR CNRS 6251, Rennes, 35042, France
[2]Université de Rennes 1, IETR CNRS 6164, Rennes, 35042, France
[3]Institut Universitaire de France, IUF-Paris, 75000, France

email: bruno.beche@univ-rennes1.fr ; http://blogperso.univ-rennes1.fr/bruno.beche/

Summary

An overview of targeted current research on integrated photonics based on the new deep-UV210 organic material is given. We report on the interest in this new material and properties coupled to deep-ultraviolet (DUV) lithography processes towards the realization and optical characterization of sundry photonics structures. Such structures include sub-wavelength waveguides, pedestal and tapers waveguides until serial of optical micro-resonators (MRs) shaped as disk, ring, stadium and racetrack.

Introduction

Integrated optics is increasingly used in sensors and telecommunication applications. Moreover, the ability to develop new photonic devices through simple, low cost and mass production fabrication steps based on new organic materials allowing the sub-wavelength resolution is substantial. The idea is to decrease the resolution limits on the patterning techniques to the submicrometer scale. In order to fabricate various photonic devices such as sub-wavelength waveguides and serial families of micro-resonators (MRs), we have developed deep ultraviolet (DUV) lithography processes using the chemically amplified UV210 photoresist |1] as polymer and a modified lithography system which allow a reduction in the optical lithographic wavelength from 365 nm to 248 nm. The overall optical characterization and responses such as evolution of the UV210 optical index function on the irradiation dose, propagation losses measurements, optical resonances of the MRs-devices, quality factors and strong extinction rate on the resonance of family filters will be presented during the talk.

Discussion

Handling all the adequate technological steps, involving DUV lithography processes and control of the index value of the polymer by irradiation, we demonstrate that such

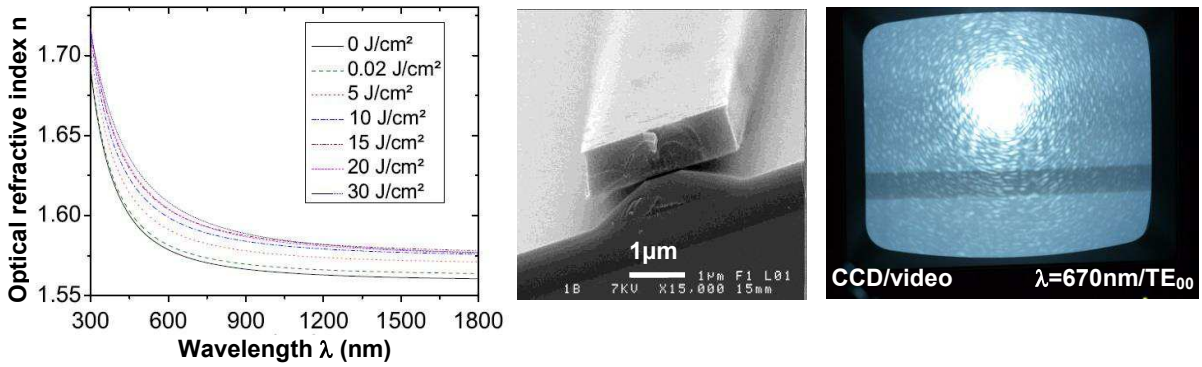

Fig. 1. Ellipsometric dispersion curves ascribed to the optical refractive index values of UV210 thin films with different deep-UV irradiation doses; scanning electron microscopy (SEM) image of a UV210 pedestal rib-waveguide; propagation and cross-sectional detection of a TE_{00}-single mode into a UV210 rib-waveguide.

a polymer, allowing 300nm-well-defined patterns, is totally appropriate for the realization of sundry photonics structures: sub-wavelength waveguides [2], tapers and pedestal ribs, gap and cascade of multiple optical micro-resonators shaped as disk, ring, stadium and racetrack [3,4]. As an example, the optical losses for the TE_{00} and TM_{00} single-mode propagation regime have been measured and estimated to be a few dB/cm for both polarizations in serial kind of waveguides [2]. Furthermore, the ability to develop various families of resonant integrated structures called MRs on UV210 with a few 100nm-gap-scale was also obtained. Optical spectral analysis and FFT-treatments demonstrate the presence of optical resonances with high extinction

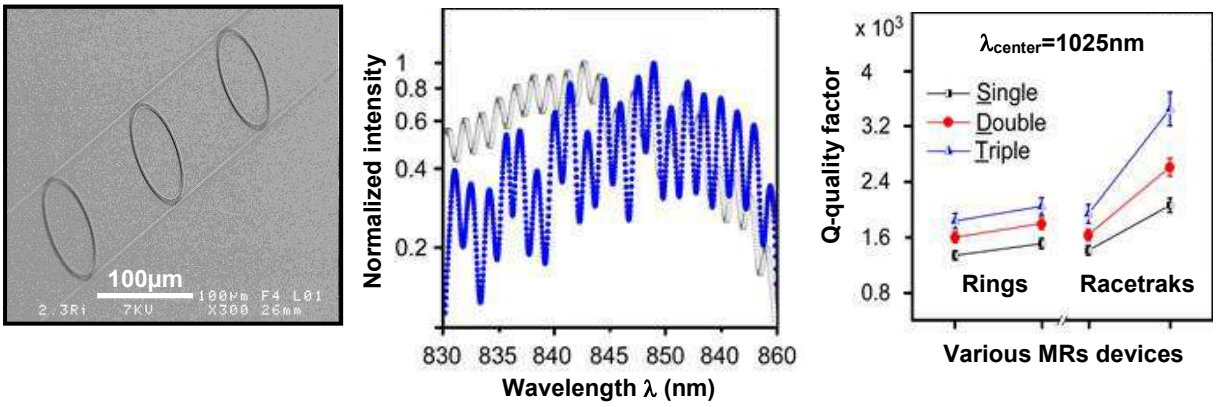

Fig. 2. SEM image of a cascade made of three ring micro-resonators (triple-cascade-MRs); resonances transmissions spectra at λ_{center}=845nm corresponding to a single-ring-MR and a cascade of triple-ring-MRs; evolution of the quality Q-factor values at λ_{center}=1025nm as a function of various family-MRs and configurations (single, double and triple MRs with ring and racetrack shapes with sundry geometrical dimensions).

rate and the improvement of the quality factor by cascades of devices [3,4]. All the measurements are totally in agreement with the theoretical behavior (analytical and numerical methods) |5].

Conclusion

The high capacity of the chemically amplified UV210 polymer to develop various families of integrated components such as sub-wavelength optical elements and waveguides, cascades of MRs with different geometries and dimensions is highlighted in this work. The high quality and reproducible of the fabrication process by DUV lithography has been validated by Nomarsky microscopy, SEM images and totally confirmed by microbeam profiles. According to these evidences and complete optical characterization, all these designs and devices are markedly suitable for telecommunication and metrology applications.

References

[1] http://hone.mech.columbia.edu/wiki/lib/exe/fetch.php?media=wiki:uv210.pdf
[2] D. Duval, H. Lhermite, C. Godet, N. Huby, B. Bêche, *Institute of Physics Publishing - J. Opt. A: Pure Appl.,* **12**, pp. 055501-055507, 2010
[3] D. Pluchon, N. Huby, H. Lhermite, D. Duval, B. Bêche, *Institute of Physics Publishing I - J. Micromech. Microeng.,* **22**, pp. 085016-085024, 2012
[4] R. Castro Beltran, N. Huby, G. Loas, H. Lhermite, D. Pluchon, B. Bêche, *Institute of Physics Publishing - J. Micromech. Microeng.,* submitted, 2014
[5] T. Begou, B. Bêche, N. Grossard, A. Goullet, J. Zyss, G. Jézéquel, E. Gaviot, *Institute of Physics Publishing - J. Opt. A: Pure Appl.,* **10**, pp. 055310.1-055310.9, 2008