The analysis of Fig. 7 leads to the following results. The ± 3% thickness variation leads to a less than ± 5% change of the PBG, in agreement with the threshold criterion given in [14] and discussed in the introduction, confirming that the PBG itself is robust with respect to fabrication tolerances. The distance of the BSW state from the upper band edge frequency is larger for the optimized design (41 ± 2)% with respect to the original design (31 ± 2)%. As a result of the larger energy spacing the optimized BSW sensor is more robust with respect to thickness and band edge variations.

Conclusions

BSW based surface wave sensors can lead to improved performance when comparing with the SPR counterparts [24, 32]. But the fabrication requires one to prepare dielectric stacks with many parameters exhibiting tolerances. The effect of such tolerances has been analyzed experimentally. Numerical simulations assuming independent thickness variations of all layers in the stack have been performed for comparison.

We found a good agreement between experimental and simulated distributions of BSW resonance angle, depth and width. The multilayer deposition with layers' thickness tolerance of ± 3% results in less than 0.3% relative error of the BSW resonance angle. This guarantees that the fabrication technology produces sensors that fit to the angular window of the optical reading system, even for small angular ranges.

The results show that optimization of the BSW sensor leads to a small improvement of the performance, in terms of LoD for example, if polychromatic illumination is used.

The results also show that monochromatic illumination enables one to achieve, for the present PhC design, the performance required for practical biosensing applications [35]. For the optimized sensors the limit of detection becomes $LoD_V = 1.3 \times 10^{-7}$ RIU ($LoD_S = 0.26$ pm) for an angular detection window of $A = 0.9$ deg. The limit of detection of not optimized sensors suffers of a large uncertainty (e.g., $(\sigma/\mu)_{LoDv} = 34\%$). Therefore, even if a given sensor operates in the correct angular window, it could show a LoD_V that is far from the design value. Layers thickness optimization will improve the LoD_V and significantly reduce its relative uncertainty (7%), too. This indicates that batches of optimized sensors show small performance variations and can be used safely in high throughput sensing applications.

A deeper analysis indicates that the improved robustness of the optimized PhC is to be attributed to BSW states lying deeper in the photonic band gap.

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