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Diamond 2D-photonic crystals for highly sensitive label-free biosensors

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In this work we demonstrate design and fabrication of 2D diamond photonic crystals (PhC) allowing record bio-sensing sensitivities higher than surface plasmon resonance (SPR) state of the art. Indeed recently, new bio-sensing techniques have been studied to get integrated label-free optical biosensors and more sensitive alternatives to the well-known SPR sensors. PhC based structures are promising candidates thanks to their remarkable optical properties and their slow optical modes showing an enhanced sensitivity to refractive index changes at the PhC surface. Among the dielectric materials available for PhC fabrication, diamond is recognized to be an outstanding material in terms of physical properties, bio-compatibility and surface functionalization offering the advantage of a water-based chemistry essential for bio-molecule grafting¹. Here, polycrystalline diamond is probed directly from the surface with angular reflectivity measurements.

In the case of angular interrogation of the PhC, a decrease of reflectivity is observed for a particular angle when a single wavelength light is coupled to a PhC mode. In this case, it can be shown that this angle value is all the more sensitive to a refractive index change at the PhC surface as the group velocity of the mode is low². A 2D PhC has been designed with such a property, i.e. with a mode frequency hardly varying with the interrogation angle (Fig. 1 a). The PhC has been fabricated of polycrystalline diamond grown by microwave plasma assisted chemical vapor deposition (MPCVD) on a 2-inch silicon wafer and subsequently smoothed by plasma etching and bonded on a silica on silicon wafer. The PhC, with a period of 384 nm and hole separation as small as 40 nm is patterned into the diamond with electronic lithography and O₂ plasma etching³ (Fig. 1 b).

Optical experiments were performed at different angles and wavelengths to validate the simulations of the band diagram. The measured reflectivity spectrum is in good agreement with the simulated one (Fig. 1 c). Using this structure, the sensitivity, deduced from numerical simulations, indicates values as high as 4871° per unit refractive index change, i.e. a value more than 10 times higher than the state of the art of SPR sensors opening the road of highly sensitive label-free biosensors taking advantage of diamond surface chemistry versatility.

References

1. S. Szunerits, R. Boukherroub. *J Solid State Electrochem*, **12** (2008), Pg 1205-1218.
2. Z. Yu, S. Fan. *Optical society of America*. **19**, No. **11** (2011), Pg 10029-10040.
3. C. Blin, et al. *Optics Letters*. **41** No. **18** (2016), Pg 4360-4363.

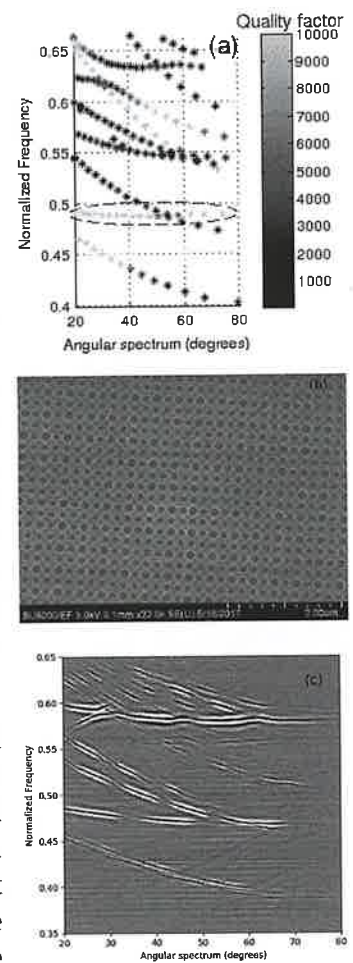


Fig 1 - Simulated band diagram (a). Fabricated diamond PhC (b). Measured band diagram (c)