Integrated visible light detector

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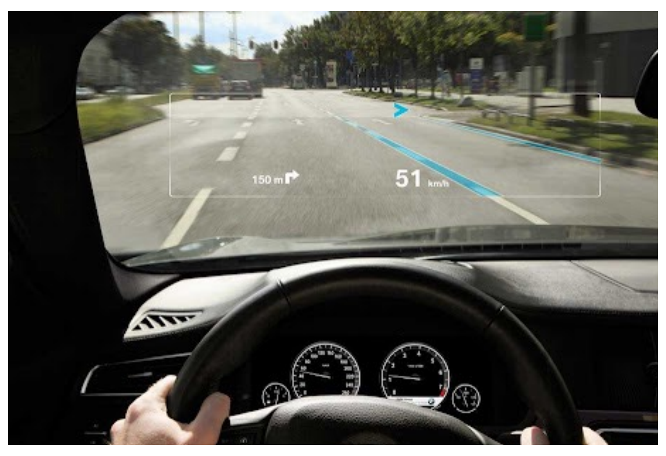
In this work, we report on the fabrication and testing of a novel integrated detector for visible wavelength range that is based on the well-known photoconductive properties of amorphous Silicon (a-Si). The device is realized on top of Si_3N_4 core waveguides by etching a sub - millimetric trench in the cladding and depositing the a-Si inside of it, with a specific pattern for interaction reduction. A responsivity of 10 mA/W and a sensitivity of -45 dBm have been demonstrated.

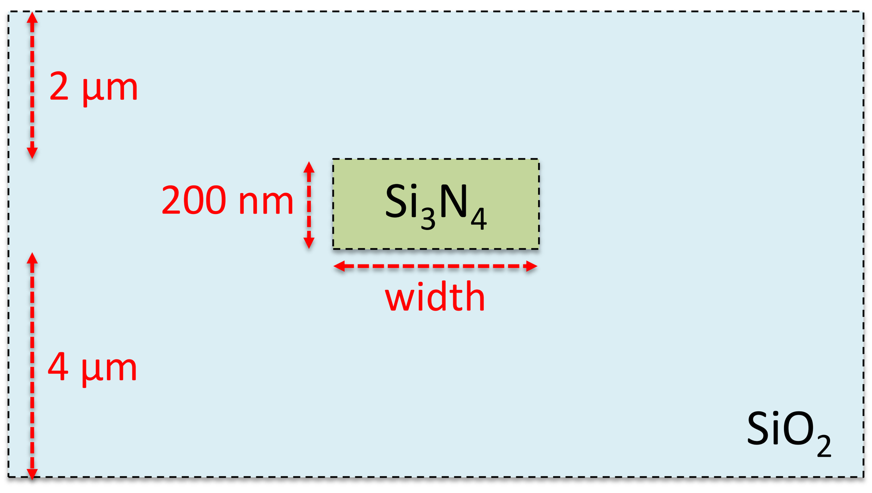
The visible wavelength range

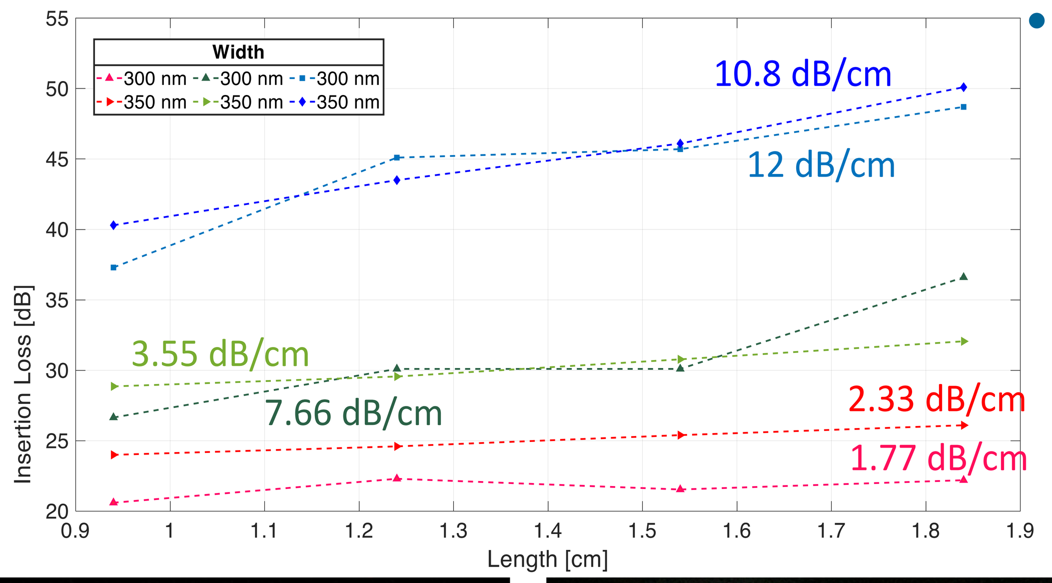
- Integration of various photonic components on a single chip, including light sources and detectors, is a critical route toward the realization of dense photonic integrated circuits (PICs). These are of interest not only for traditional applications in data and telecommunications but also for applications in imaging, metrology, biosensing, nanomedicine, and quantum optics which typically require operation in the visible wavelength range.
- Many companies and university are now working in this wavelength range, with a particular focus on the 630, 520 and 450 nm wavelengths (RGB): University of Fukui (JP)[1] presented a device measuring 8×4×3 mm able to project a 1280 × 720 colour video. In this context, an integrated visible detector will help reducing dimension and costs.



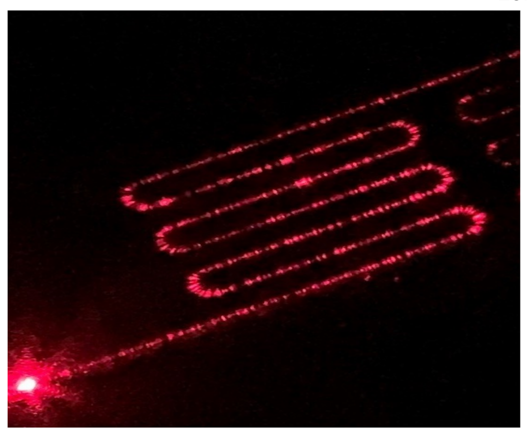
Visible platform

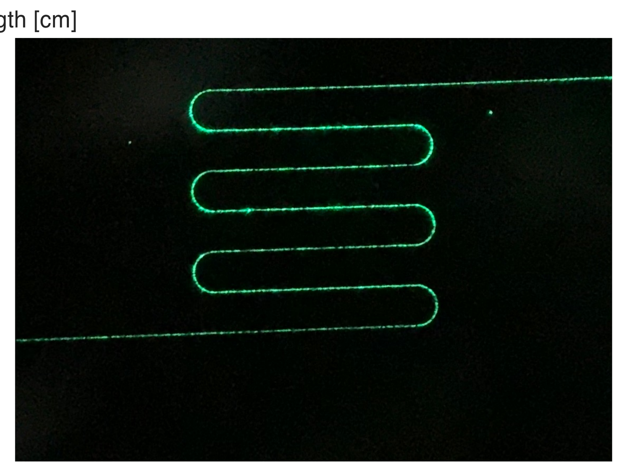
- A Si_3N_4 core waveguides is building block we designed and tested for our integrated photonic circuits, consisting in a 200 nm thick Si_3N_4 film completely etched till the Bottom Oxide layer and cladded by 2 µm of SiO_2.

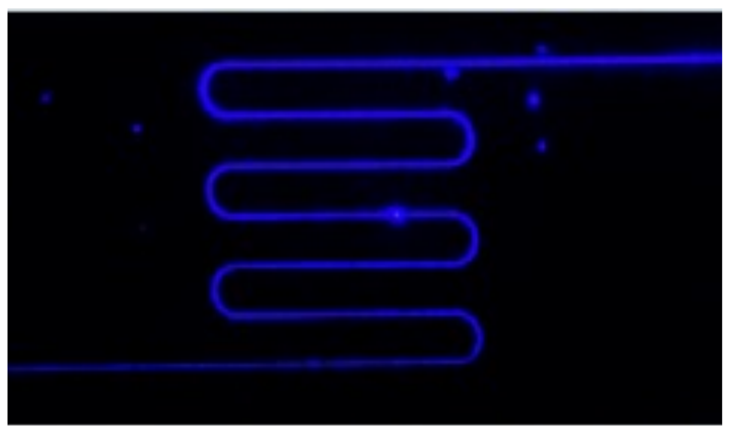




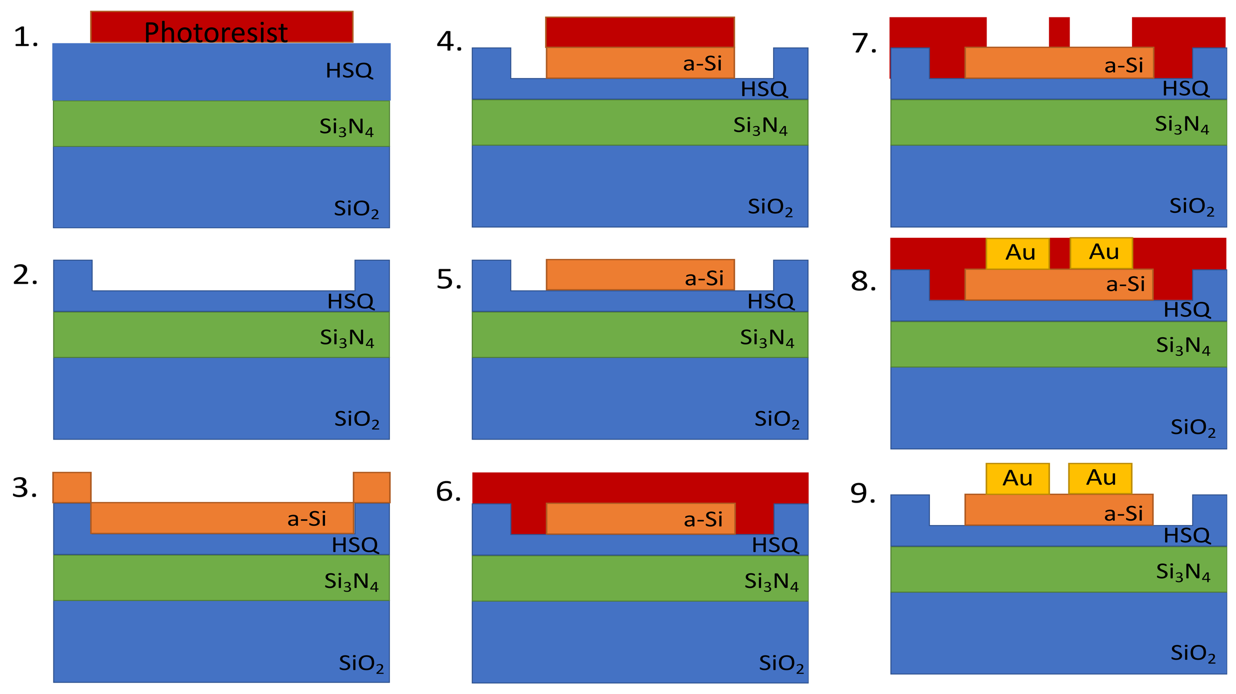
- The fabricated spirals presented a progation loss that is comparable with the state of the art[2]: 1.77 dB/cm for 660 nm, 3.55 dB/cm for 520 nm and 10 dB/cm for blue







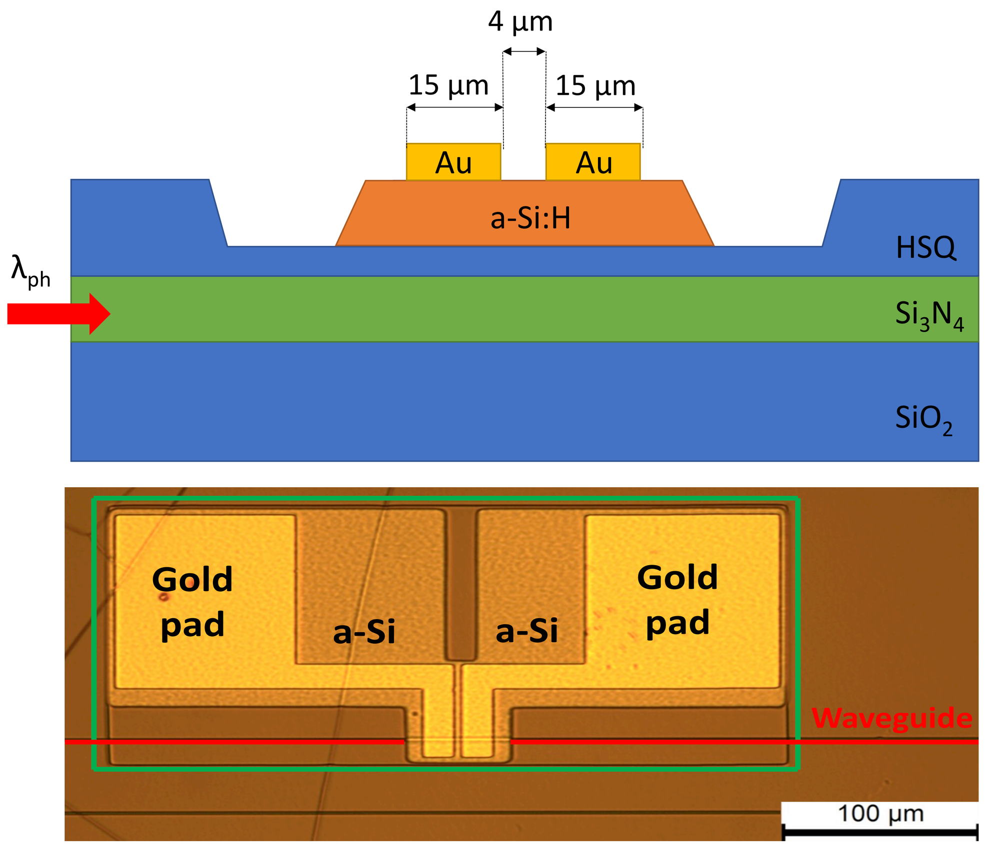
Fabrication process flow

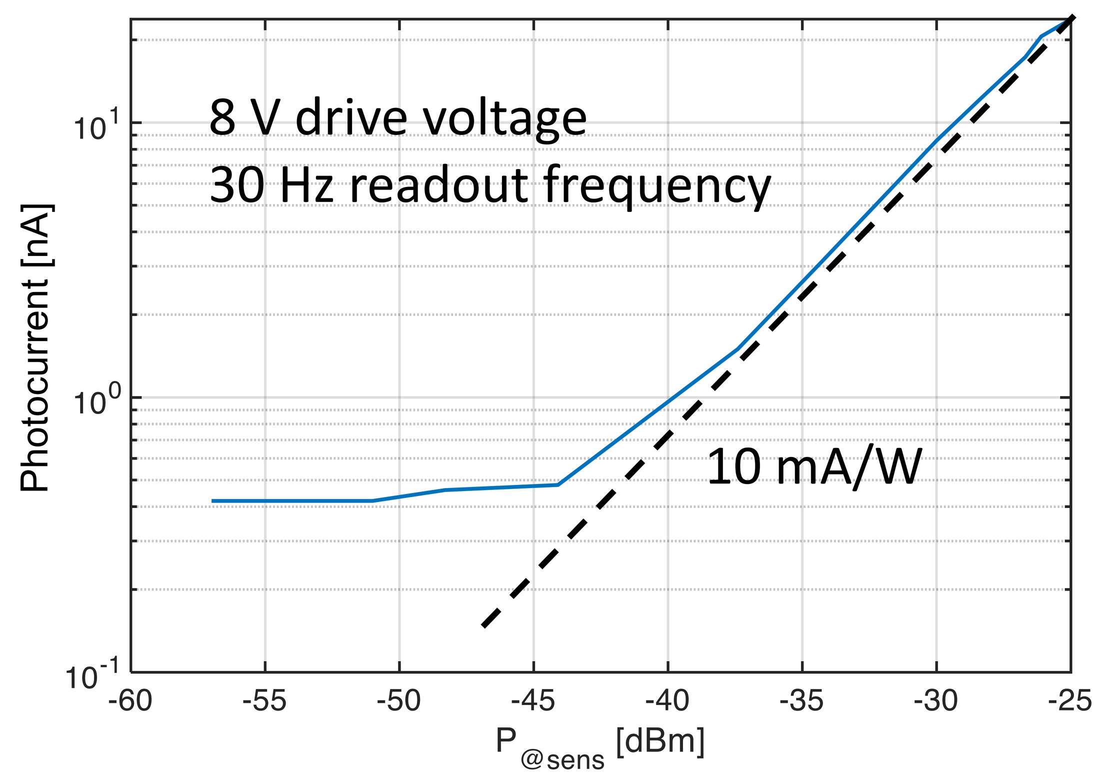


- Cladding thinning by Direct writing lithography and reactive ion etching (1,2)
- Amorphous Silicon (a-Si) deposition by plasma enhanced chemical vapor deposition (3)
- Patterning of a-Si through direct writing lithography and reactive ion etching. This will define the interaction area between the light and the a-Si (4,5).
- The electrical contacts are then made by a final lithography, the deposition of the pads through thermal evaporation and the successive lift-off step (6,7,8).
- **The detector is 34 µm long, making it very compact and suitable for any photonic integrated circuit** (9).

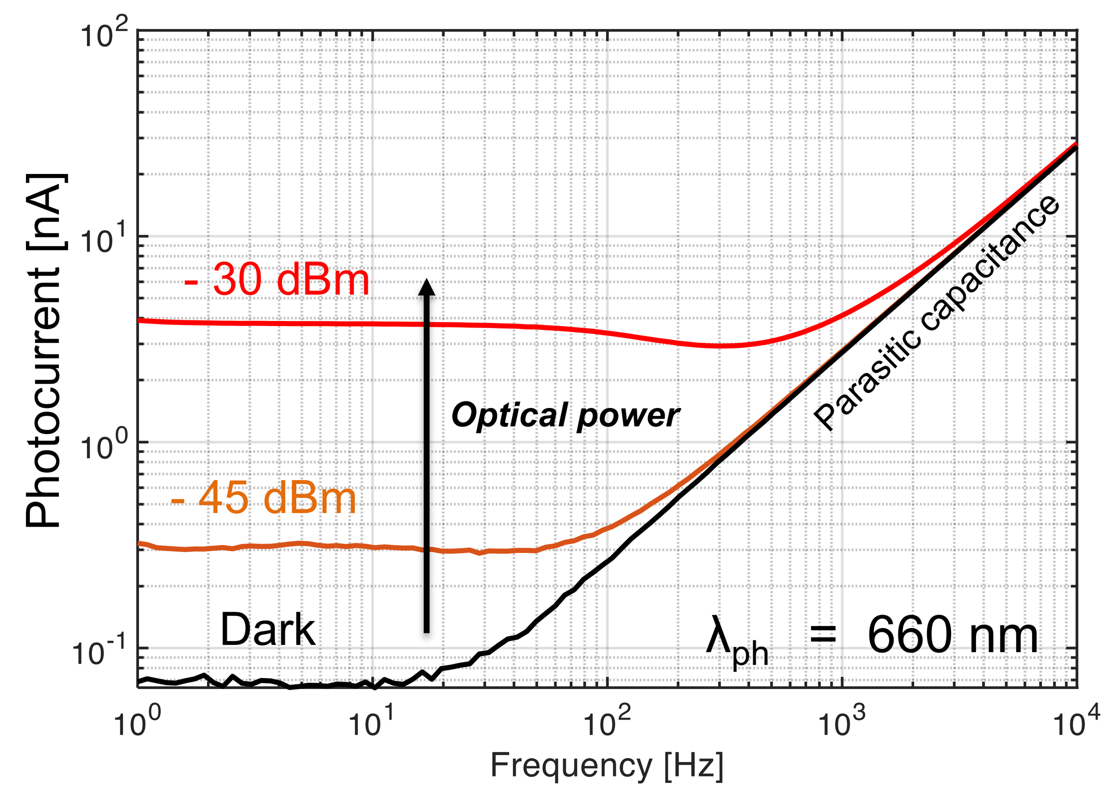
Detector characterization

- The chip is bonded to a PCB, reducing the parasitic capacitance that limits the bandwidth of the detector. A laser diode at $\lambda = 660$ nm, is edge coupled to the the Si_3N_4 core waveguide on chip while the responsivity of the detector is estimated by impedentiometric measurement.





- Photocurrent of ~4 nA @ –30 dBm
- Sensitivity -45 dBm @30Hz
- Bandwidth 1 kHz at -30 dBm
- Dark current 65 pA (@ 8 V)
- Responsivity 10 mA/W
- Length 34 µm



References

[1] A. Nakao, S. Yamada, T. Katsuyama, O. Kawasaki, K. Iwabata, K. Horii, and A. Himeno, "Compact Full-color Laser Beam Scanning Image Projector Based on a Waveguide-type RGB Combiner", Proceedings of the International Display Workshops, p. 649, Dec. 2020.

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