Design, Fabrication, and Characterization of a CMOS-Compatible Plasmonic Photodetector

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Abstract

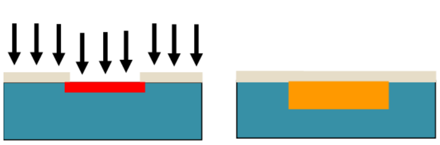
- The primary goal of this project is to design and manufacture a novel detector array and readout circuit (ROIC) that incorporates plasmonic technology to create the sensor needed for Smart Lighting applications.
- The proposed integrated device has potential applications for
  - Smart-lighting systems such as in visible light communication,
  - Light's spectral calibration
  - Energy harvesting photovoltaic systems used for self-powered sensors.
- The first prototype of detector array has been fabricated and tested
- A preliminary electrical characterization of the shallow junction photodetector without plasmonic structure has been performed

Technical Approach

- A detailed study of PN junction detector is preformed for optimized sensitivity and performance
- The process of CMOS-compatible plasmonic photo-detector starts with fabrication of the shallow junction photo-detector arrays.
- The fabrication is performed at the Manufacturing Technology Training Center (MTTC) at the University of New Mexico (UNM).
- The shallow junction detector is used in order to obtain the most benefit of resonance surface plasmon enhancements.
- This effort consists of two distinct plasmonic structures:
  1. nanoparticle plasmonic structures made by Prof. Hatice Altug (Boston University)
  2. plasmonic nanostructure made by Prof. Steve Brueck (University of New Mexico). The devices are currently in the fabrication process at MTTC facility at UNM.
- A thorough device characterization will be undertaken as soon as the fabrication processes for the plasmonic structures are complete.

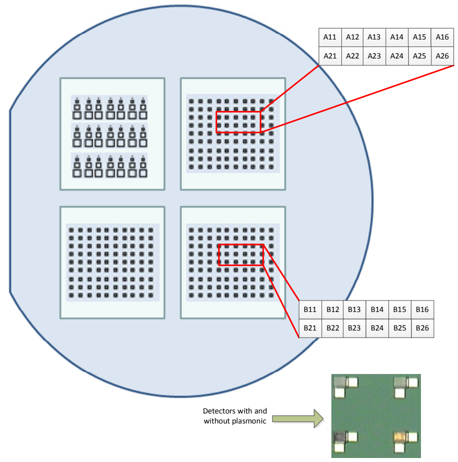
Structure of planar PN Detector

(a) Pre-dep (b) Drive in

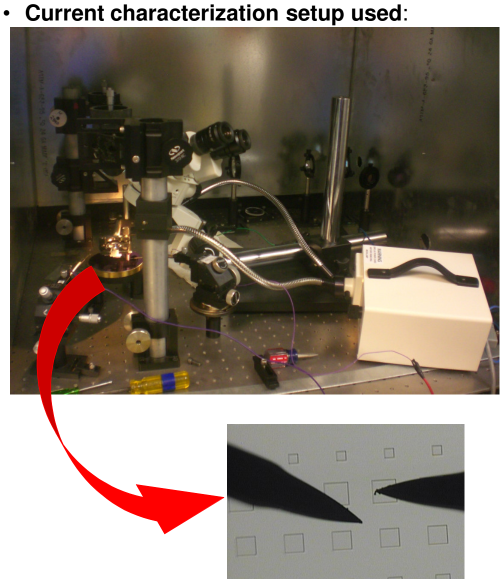


Characterization

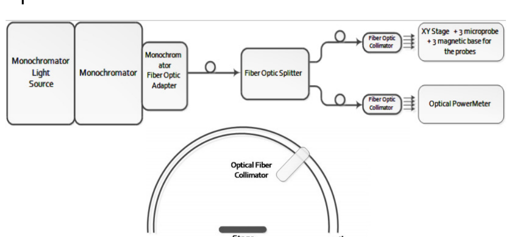
- A wafer with shallow Junction photodetectors were fabricated at MTTC at UNM.
- Nanoparticle plasmonic structures were fabricated at Prof. Altug's lab at Boston University on the photodetectors in regions marked as A and B.



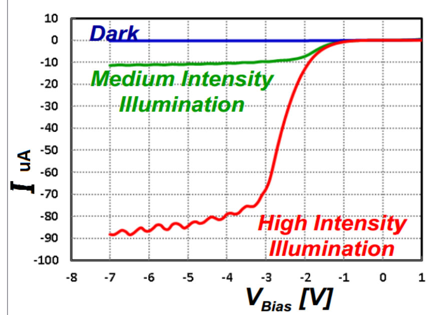
- **Current characterization setup used**:



- We are in the process of making a specific setup that can scan the whole visible regime using a monochromator and apply different wavelengths to the detector in different angle of incident.
- For every wavelength, the system records the photo-current and makes IV curve for the device.



Initial Results Before Plasmonic



Conclusions

- An array of photodetectors with shallow junction were fabricated at MTTC (UNM)
- The junction is shallow to have better compatibility with plasmonic structure on the top
- Initial measurements confirms the functionality of the shallow photodetector
- Two different plasmonic structures are designed at UNM and BU
- The UNM structure is under fabrication and the BU fabrication is complete and is now under characterization

Societal Benefits

Health, Safety, and Well-being

Through frequent monitoring of the spectrum of light in the workplace or home, the information will be fed into a computer for analysis based on approved health guidelines for lighting. The results will be used to control the spectrum of light so as it is most healthy to the persons in the room for the conditions (e.g., time of day). The device being developed here serves as a monitor and relay agent of spectral information of light.

Increased Productivity

Healthy lighting, both in terms of spectrum and intensity, can increase individuals' productivity. Through the technology developed here, outdoor lighting conditions can be mimicked in the office regardless of weather condition (rain or shine).

Acknowledgements

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