Nanometers Wide Avalanche Regions for Single Photon Counting

Mid Term Review Meeting

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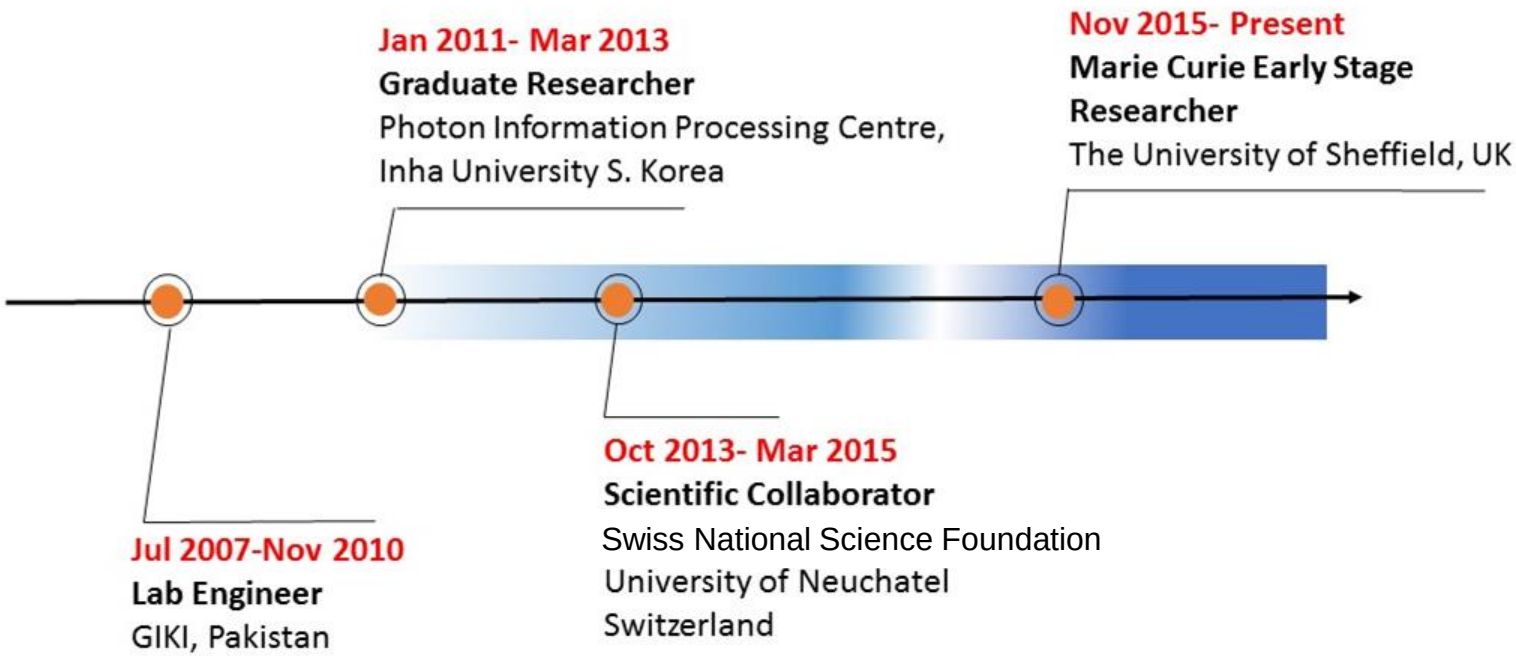
Dr. Jo Shien Ng

Introduction (Education and training background)

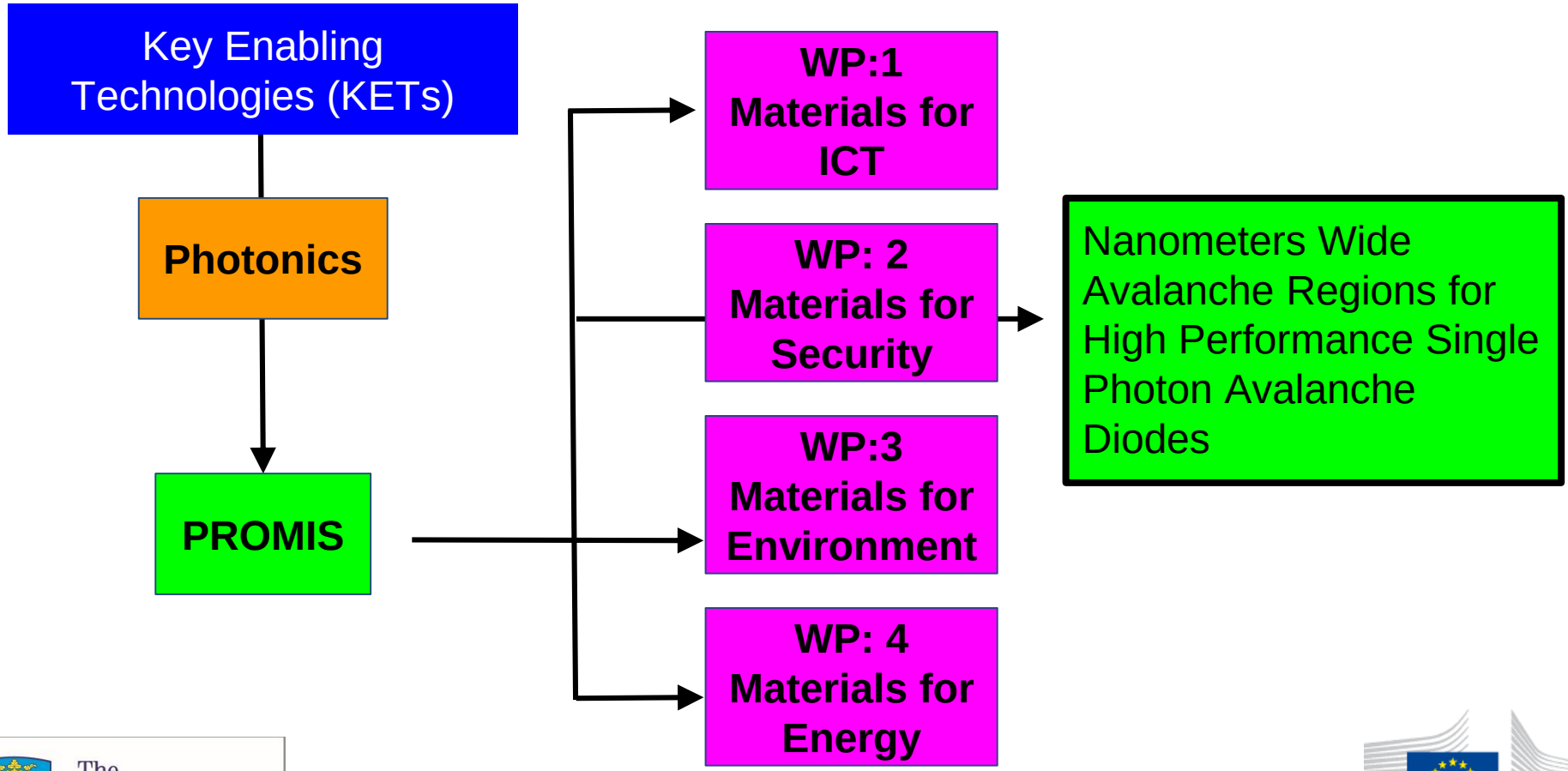
- B.Eng, Lasers and Optoelectronics (GIKI, Pakistan) 2007
- M.Eng, Electrical Engineering (Inha University, Incheon, Korea) 2013



Achievements

- Journal articles in Applied Physics Letters (1) and IOP Journal of Physics (1)
- 2nd best poster prize at PROMIS summer school, MBE conference, Montpellier, 2016
- Secured Jungseok Memorial Fellowship for graduate study at Inha University, S. Korea for two years (2011-2013)
- Secured 3rd position in Open House and Career Fair, GIKI, 2007

Introduction to the project



Background of the research project

Problem

- Avalanche gain is dependent on temperature
- Photon detection count of APDs is limited by high tunneling

Solution

- Use narrow avalanche layers to minimize temperature sensitivity
- Use wide bandgap to reduce tunneling

Objective of the project

Narrow avalanche layers will be used to reduce temperature sensitivity and increase tolerance to high tunneling current

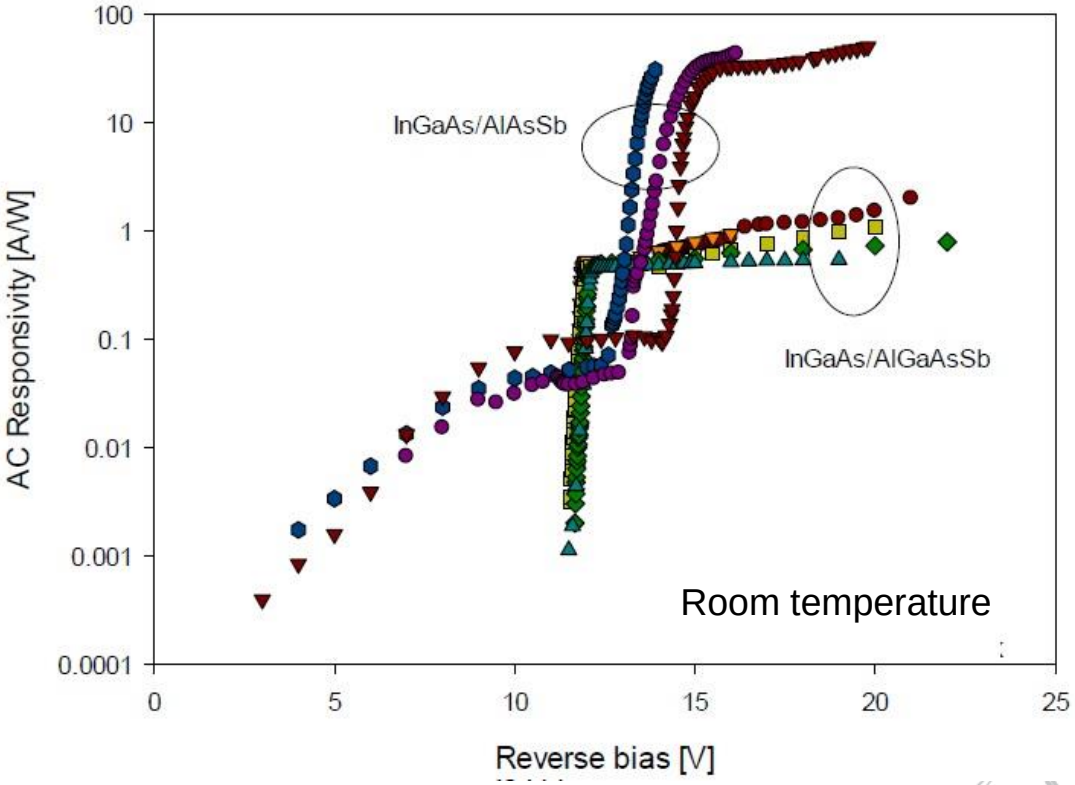
Experimental Techniques used

- **UV Photo-lithography and Wet Chemical Etching**
  - For device fabrication
- **Electrical Characterisation**
  - Current Voltage (I-V) measurement, Capacitance Voltage (C-V) measurement, Responsivity measurement
- **Sputtering and Thermal Evaporation**
  - Deposition of metal contacts and dielectric passivation

Results and Analysis

- Responsivity and gain measurement for AlAsSb and AlGaAsSb devices

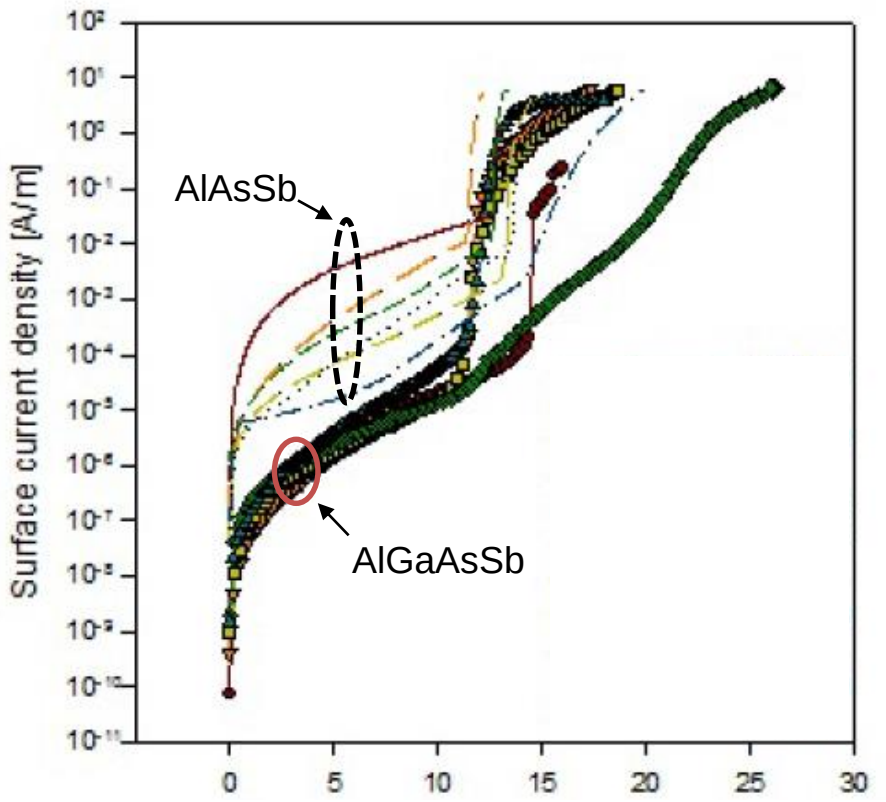
- AlAsSb devices show higher gain but lower responsivity
- AlGaAsSb devices show higher gain but lower responsivity
- Doping profile still needs optimisation



Results and Analysis

- Leakage current studies of AlGaAsSb

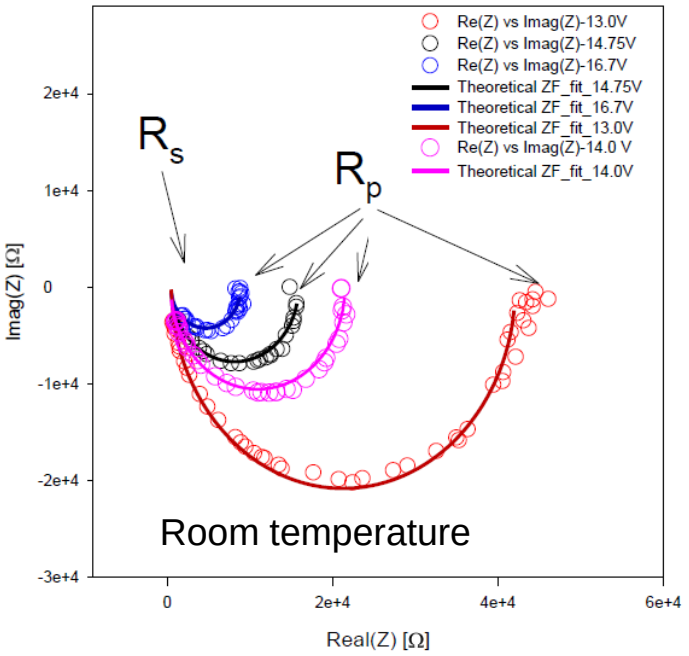
- AlGaAsSb shows reduced leakage current compared to AlAsSb
- Surface passivation investigated for AlGaAsSb
- AlN found to be stable passivation and did not degrade the surface leakage

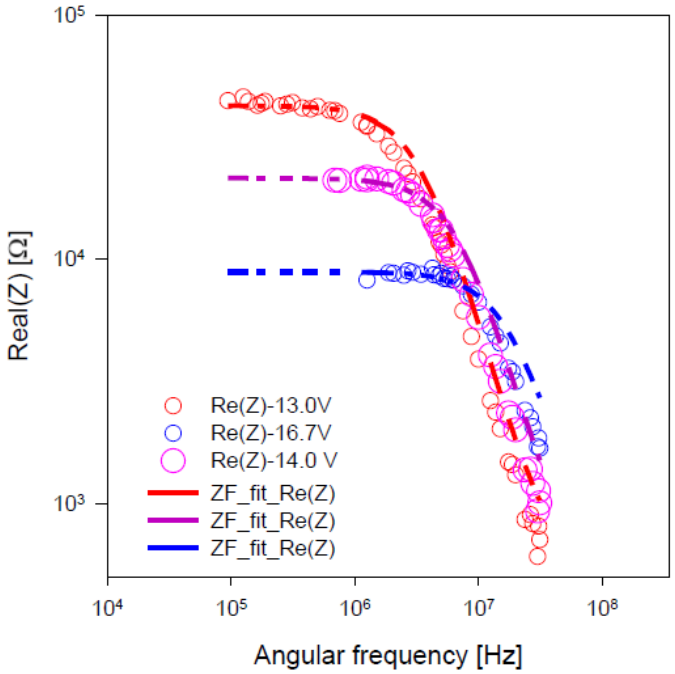


Results and Analysis

- Novel multiple frequency CV method for measuring capacitance for leaky devices

Capacitance measurements suggest an imperfect doping profile





Summary

- AlGaAsSb shows reduced surface leakage compared to AlAsSb
- AlN is a stable passivation for AlGaAsSb
- Doping profiles in device layers not optimised

Next step(s)

- Improved growth conditions of APD device layers
- Optimise the design of APD

Skills acquired

- Fabrication of APD devices
- Electrical characterisation of APD devices
- Modeling and simulation for device analysis
- Computational packages for data analysis

Outputs

- **Secondment for three weeks** at Universidad Autónoma de Madrid, 2016
- **Public talk** at Universidad Autónoma de Madrid, 2016
- **2 conference papers**, 19th International Conference on MBE, Montpellier, 2016
- **Student presentation** at PROMIS summer school (Cadiz University) and PROMIS workshop (University of Montpellier) 2016

Future Aspirations

Priorities for future (1: Highest priority, 2: Second highest…..)

After Ph.D

1. Develop photonic detectors technology as a postdoc
2. Work in industry developing sensing and detection technologies

Long term goal

Research and development in photonic sensing