# Chapter 5 Conclusions and Future Works

## 5.1 Conclusions

In this thesis, a novel small pixel size infrared detector process is proposed and its related issues including p-n junction formation, mesa structure uniformity, surface passivation and electric characteristics are studied and described in chapter 2-4, respectively.

Beryllium ion implantation is used to form the p-n junction in this work to evaluate the feasibility and compatibility with the current device fabrication processes. A proposed simple test structure with mesa or planar diode configuration has been fabricated successfully. Based on the DC electrical measurement, the $R_0A$ of the smallest diode in our test structures with junction area as small as 20X20 um$^2$ is 7.6X10$^4$ Ω-cm$^2$.

By simulation, the performance of p-n diode with the similar device structure and processing can be evaluated and predicted. The experimental results indicated that the zero-bias resistance area product $R_0A$ of InSb p-n diode with junction dimension as small as 15um square can achieve 5X10$^4$Ω-cm$^2$. It should be noted that the detector pixel size with such dimension is very close to the optical diffraction limit in medium wavelength spectrum range.

In regarding to detector array uniformity issue, it has been shown that ideal (111) direction oriented InSb mesa structure for large format array application with much improved surface integrity can be realized using citric acid/hydrogen peroxide chemical system as opposed to the conventional lactic acid/nitric acid solution. Electrical characteristics including dark current and photo current are measured. Dark current distribution is measured and characterized. Highly uniform electrical distribution result confirms the consistence with the structure build with citric acid/hydrogen peroxide solution.

The ion implantation and planar technique will be integrated into InSb two-dimensional detector array process for high resolution and large format imaging applications ultimately. In this thesis, we have proposed a novel simple device structure and related processes, the electrical testing and analysis results illustrate that these developments are practicable. We have not integrated the smallest sensors with ROIC to verify this technique to practical imaging system due to the availability of small pixel size ROIC. However, we believe that the verification works to confirm the performance can be overcome in the near future by our team work.

## 5.2 Future Works

### 5.2.1 Verification

To implement the proposed structure and processes into the current technology requires ROIC have the same pixel size as the sensor devices to register and make electrical interconnection for the pixels in the sensor and ROIC respectively. Unfortunately, the cost to fabricate ROIC is very expensive. So, the practical approach is to layout the small pixel sensor chip with the proposed structure and reserve the spacing between the pixels with larger distance. This verification scheme may work with any currently available ROICs. The problem with this scheme may result from the electrical compatibility of the detector signal and specification of ROIC.

### 5.2.2 New materials and spectral ranges

In our work, we have constructed a simple and efficiency measurement and analysis platform for detector performance evaluation. This will be applicable to other new imaging sensor development programs based on new materials and different spectral ranges, such as the ultra violet (UV) image array, near infrared (NIR) detector array at 0.9 to 1.7 um, and long wavelength 8~12 um quantum-well infrared photodetectors (QWIP) or quantum-dot infrared photodetectors (QDIP) etc.