Deposition of Ohmic Contacts on NanoLEDs Devices By Surface Cleaning

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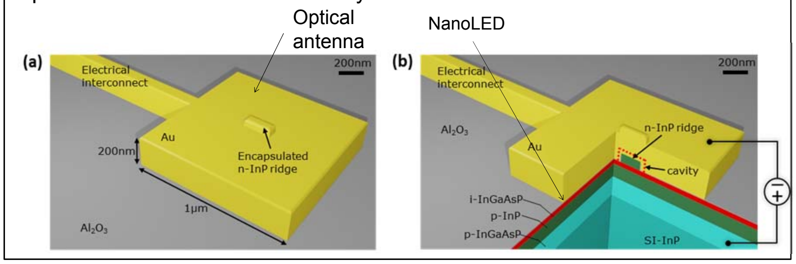
Abstract.- **NanoLEDs are seen as a possible light source components of optical interconnects in the replacement of electrical interconnects. However, many problems have to be solved for this to become a reality. NanoLEDs suffer from a high contact resistance (~10^{-4} ohm-cm^2). This is detrimental to the device performance and reliability because of the excess heat generated from the large voltage drop due to the series resistance. Native oxide on InP surface is considered to be one of the factors that contribute to the high contact resistance since it works as an insulator, which makes it really hard for the device to conduct current. In this experiment, Transfer Length Method (TLM) test structures were fabricated. The native oxide on some of the structures was removed by the application of different compositions of HCL and H_2SO_4 while other structures were left untreated with the purpose of comparison of final results. Contact resistivity, P_c, was extracted from the samples afterwards. The results are analyzed, and the optimum cleaning method is discussed.**

1. Motivation

In modern integrated circuits, about 50% to 80% of the power is lost through the copper interconnects that electrically connect transistors. For this reason, there is a strong push to replace copper interconnects by optical interconnects because they are faster and more efficient.



2. Objectives

- Remove native oxide from InP surface by wet etch processes.
- Chemicals' etching rate must not degrade the device to any extent.
- Reduce contact resistivity, P_c, by depositing ohmic contacts.

4. Results

Treatment	Contact Resistivity, P_c	Workability
2 M H_2SO_4 for 5 min	Shottky Diode behavior/ R_t couldn't be obtained.	✖
2 M HCL for 5 min	2.0×10^{-5} Ω-cm^2	
HCL + $(NH_4)_2S$	1.43×10^{-5} Ω-cm^2	
No Treatment	Shottky Diode behavior/ R_t couldn't be obtained.	✖
Al_3O_2 layer + HCL	2.30×10^{-5} Ω-cm^2	
Al_3O_2 layer + No Treatment	1.45×10^{-5} Ω-cm^2	

5. Conclusion and Future Work

- HCL contains higher solubility rates of the oxides compared to H_2SO_4
- HCL etched about 1 nm of the InP Surface. Not too bad for a strong chemical.
- A higher concentration of H_2SO_4 was likely needed to observe better results.
- A better contact surface was achieved.
- Since P_c for "HCL" and "Al_3O_2 + no treatment" resulted in the same order of magnitude, which is about 10^{-5} Ω-cm^2, it can be concluded that native oxide isn't that factor contributing to high contact resistance. Contaminants formed during the process of fabrication, such as the application of O_2 plasma etch back process might be oxidizing the device, or other contaminants were formed on the surface after the treatment.
- As future work, wet etch processes will be applied to actual nanoLEDs devices for the removal of surfaces contaminates. Process of fabrication will be studied as well.

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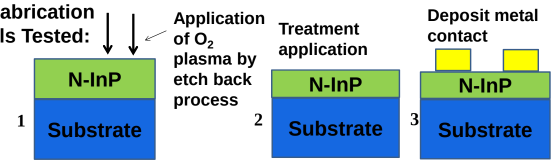
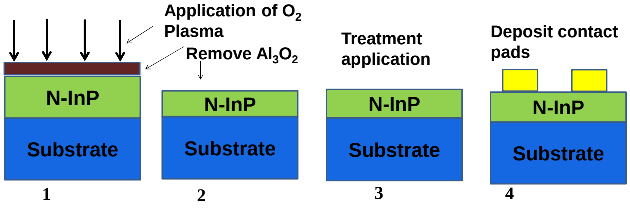
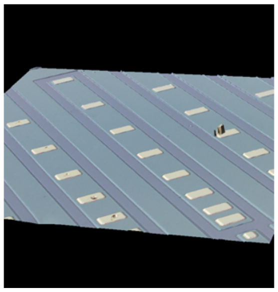
3. Methods

- **Two Processes of fabrication**
- **Process 1, Chemicals Tested:**
  - 2 M HCL for 5 min
  - HCL + $(NH_4)_2S$
  - No treatment
  - 2 H_2SO_4 for 5 min

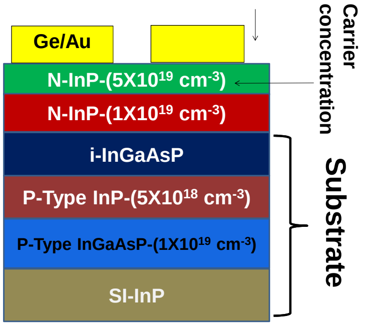


- **Process 2, Chemicals Tested:**
  - 2 M HCL for 5 min
  - No treatment





Final structure with TLM structures in it.

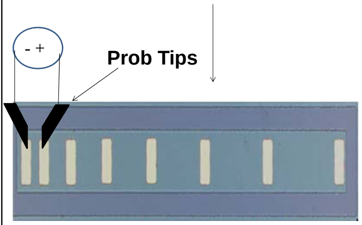


Six structures were fabricated. One for every treatment.

Once the structures are fabricated measure contact resistivity, P_c.

Procedure to extrant P_c.
Apply a voltage between contact pads in a row, by using a semiconductor parameter analyzer and a probe station. Measure current.

- **Probe Station**
- **Semiconductor Parameter Analyzer HP 4145b**



- Obtain an IV curve for every space in a row.
- Obtain total resistance, R_t for every IV curve. Graph R_t Vs. distance.
- Obtain R_t when D = 0.
- Obtain P_c from:

$$R_t = 2\left(\frac{\sqrt{R_{sh}\rho_c}}{W_{pad}} \coth \frac{L_{pad}}{\sqrt{\frac{\rho_c}{R_{sh}}}} \right).$$