# In-depth Analyses of P-type Silicon Solar Cells by Laser-Induced Breakdown Spectroscopy (LIBS)

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## Introduction

Following the rapid development in the field of renewableenergy, the photovoltaic industry is rushing to meet the growing demand and is investing in processes, materials and research to achieve the necessary scale to reduce the cost of electricity produced by photovoltaic panels. Polycrystalline silicon photovoltaic cells are the most popular and economical cells in the market due to their cost-effective manufacturing methods and cheap substrates, with factories incorporating production quality control systems to continuously optimize the manufacturing process to maintain their efficiency and performance[1]. In this context, we have analyzed polycrystalline silicon solar cells by LIBS laser induced breakdown spectroscopy to characterize the nature and determine the content of impurities present in these cells[2].

## Experimental

A Q-switched Nd-YAG laser source (Quantel YG 980) operating at its fundamental wavelength (1064 nm) with apulse width of 7 ns is used in the ablation process with 20 mJ of laser energy focused onto the sample surfaces in air. The plasma emission light recorded by Echelle spectrometer (Aryelle 200, LTB Lasertechnik Berlin) coupled with a gated intensified charge coupled detector ICCD (iStar, Andor). Data acquisition and analysis were performed using Sophi software (LTB).

## Results and Discussion

Using the NIST database, the position of the lines allows us to identify the elements present in the solar cell; we will first look for the most intense lines of all the elements present in the periodic table. After an analysis of the spectrum emitted from 200 to 790 nm (fig. 1) and hundreds of lines identified, we found eight elements: silicon, silver, aluminum, calcium, sodium, carbon, magnesium and potassium. Most of the emission lines lie in the UV region and the visible region. The temperature of the plasma is deduced from these Boltzmann plots and the condition of the ETL (local thermodynamic equilibrium) is verified bythe McWhirter criterion. The impurities found in metallurgical silicon come mainly from raw materials processing during wafers fabrication.



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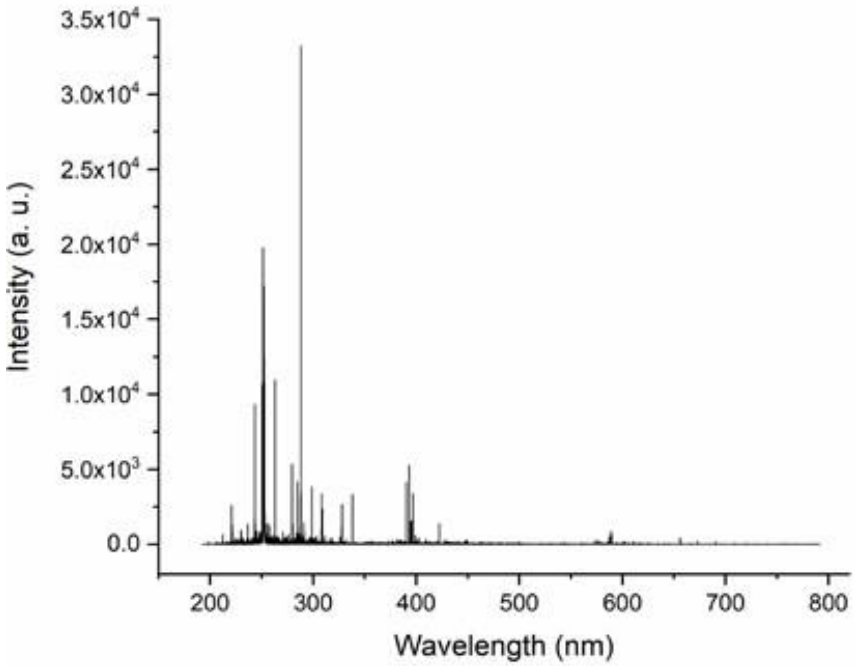


**Fig.1:** Solar cell emission spectrum recorded during LIBSanalysis.

By applying the CF-LIBS approach, the mass fractions of the elements detected in the solar cell were measured witha CF-IRSAC correction of the self-absorbed lines. In-depth profiling is investigated to follow in depth the concentration of elements detected in the solar cell.

## Conclusion

A spectroscopic study was made to analyze the photovoltaic cells based on polysilicon. The goal was to investigate the distribution of elements detected in the sample. Eight elements were detected in this analysis, which are: Silicon, Silver, Aluminum, Calcium, Magnesium, Sodium, Potassium and Hydrogen. The depth profiling allowed us to follow the distribution of theelements detected in the volume of the solar cell.

## References

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