# PV Manufacturing Initiative

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**Abstract**

The Manufacturing Research Center at Georgia Tech is addressing the handling, transport and inspection of thin polycrystalline silicon sheet. Polariscopy is being used as a prototypical inspection station around which the handling and transport of wafers will be done. In addition, the research program also includes the development of software tools for the exchange of information between the manufacturing steps.

## 1 Introduction

The Manufacturing Research Center (MARC) at Georgia Tech is currently addressing photovoltaics manufacturing as a part of an NREL grant. Part of the Initiative deals with the creation of a laboratory that will address the handling and transport of thin wafers, residual stress inspection and the development of software tools for the exchange of information. The purpose of the lab will be to research and develop new manufacturing techniques in order to both improve the quality and yield, and lower the cost of photovoltaic devices. A focal point of the laboratory will be an industrial scale manufacturing pilot line which will be used to investigate the handling and fracture of thin polycrystalline silicon wafers such as those produced by RWE Schott Solar, BP Solar, and Evergreen Solar. This work was initiated in May 2005 and this paper describes the layout of the laboratory and the software and instrumentation design.

## 2 Pilot Line Description

The pilot line will contain several manufacturing cells that are connected by conveyors or other material transfer mechanisms, as shown in Figure 1, “Laboratory Equipment Layout and Process Flow”. The first cell will be used to study forces exerted by pick-and-place grippers on thin silicon wafers and their resulting deformation, and residual stresses present in wafers. A 4-axis SCARA robot equipped with either Bernoulli, vacuum or mechanical grippers will pick up wafers using precisely-controlled grip forces and position them in a near-Infrared Polariscope (a stress measuring system based on near Infrared Photoelasticity technique) so that residual stresses can be measured. After a wafer has been inspected, it will then be moved to a conveyor by the robot and transferred to the back metallization station.

Upon arriving at the back metallization station, a material handling mechanism will place the wafer on a platform, and a stencil will be placed on top of the wafer. Solder paste will be applied to the wafer through the stencil either by using a squeegee or a sponge. Upon completion of the printing process, the stencil will be removed and the wafer will be moved to a second conveyor for transfer to the third station. This cell will be used to study the printing process and recommend material handling improvements.

Monitoring and control of the pilot line cells will be accomplished though a CAM XML-based (CAMX) factory information system. CAMX makes use of a virtual message broker which exchanges XML messages amongst assets in an enterprise across the internet. An application

server will be used to collect, store, and present manufacturing data through a web interface such as stress histories, wafer yield, work-in-process, and sensor output. Figure 2, "Software and Instrumentation Design", provides an overview of the proposed instrumentation design for the first manufacturing cell.

# 3 Conclusions

This research program addresses the handling, transport and inspection of polycrystalline silicon wafers used in PV manufacturing. The program also addresses the development of software tools for exchange of information between the various hardware tools and the manufacturing line manager. Ultimately, the program aims to improve the yield of thin wafers. The research results will be made available to the PV manufacturers.

# 4 Acknowledgements

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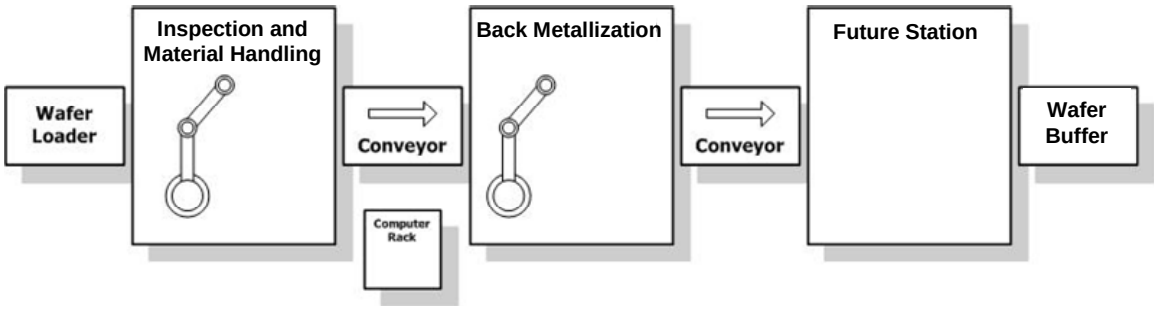


Figure 1. Laboratory Equipment Layout and Process Flow

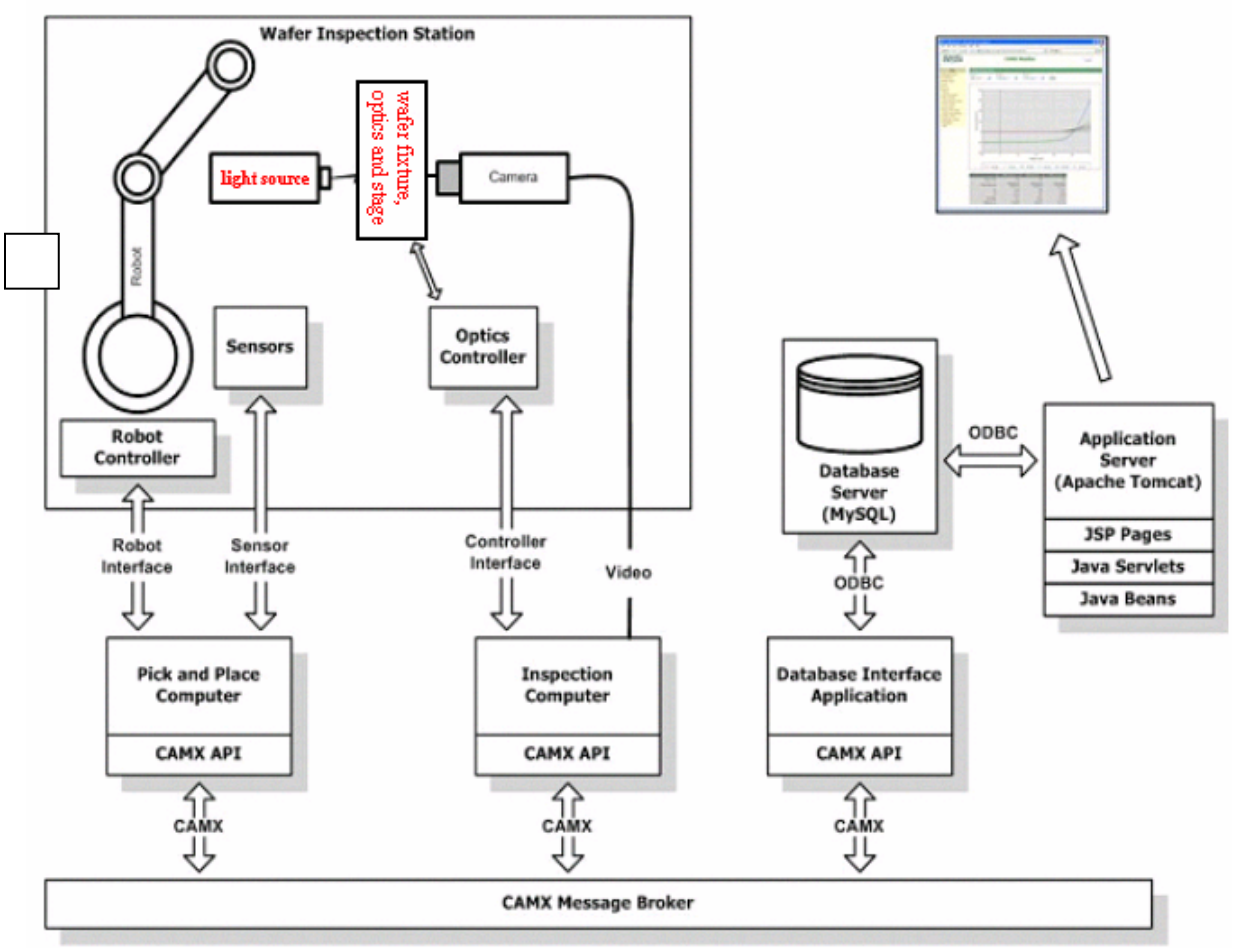


Figure 2. Software and Instrumentation Design