Project Report

Automation of wafer handling

ELECTRONIC DESIGN LAB

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MOTIVATION

This Project is motivated by typical handling of wafers in Photovoltaic Industries. The processing of wafers to make solar cells is done in production line. The line consists of various processes and each process is done in its unit. The raw wafers are placed from stacks to cassettes for chemical cleaning which is done manually in most of the industries. The transfer of wafers from one unit to other is generally done manually. In between the processes, sometimes there is need to measure some parameters. To do so wafers are picked manually and placed on the measuring platform and then placed back in stacks. The segregation of wafers is also done manually. These all manual handling of wafers may lead to breakages. If most of the processes are made automated, then both human labour and breakages can be reduced. Though units with fully automated handling of wafers are available in market, but they have some disadvantages. Automation is coming integrated with the units. In order to automate processes, whole units have to be replaced, which is not feasible. The custom made robotic solutions are very expensive. These factors compel the manual handling of wafers in production.

This project aims to eliminate these problems of automation with a small, handy and cheap robotic arm which can be installed in the existing production lines.

INTRODUCTION

In this lab we are aiming to build a prototype of the machine which can be used to automate the wafer handling in labs and fabrication facilities.

The need for such kind of automated instruments is already mentioned in the motivation. The main purpose of this equipment is to pick and place the wafer from one location to other.

We aim to make a prototype of the pick and place type machine. This is the first stage of development. The other advancements which can be done to the same model include replacing sensor with the camera, which can segregate solar cells based on colour. It can be interfaced with the computer, so that a track of wafers can be kept after each processing step.

Currently the prototype developed will perform the following actions:

- Take input from the user of the source and destination
- Pick wafer from the source
- Find the most optimised movements which will lead to the fastest job
- Perform the motions
- Place the wafer at the destination
- This can be repeated as many times as the user enters
- The LCD gives the current operation of the machine as well as shows the input parameters
- The sensor will show alarm message if the wafer is found missing in the middle of operation.

Hardware Description

The prototype consists of the following parts:

- Head
- Arm
- Body

The head consists of a vacuum pump and sensor. It is used to hold the wafer through suction. This technique of suction is used so that no direct holding of wafers happens, which will guarantee the higher throughput in fabs. Another advantage is that no human intervention is needed, so the chance of contamination is reduced to a great extent.

The arm basically consists of two parts. The figure 1.1 shows the diagram of the whole machine in which are is the main part. The arm provides all degrees of freedom required to move the wafer in 3 dimensions. This consists of two parts. The first part is attached to the head while second part is attaches to the body.

The body is the base of the machine. It contains all the motors for controlling the movement, main circuit and keyboard-LCD interface for user end.

This picture gives an idea of how the machine (robotic arm) will look like. It will consist of the following parts:

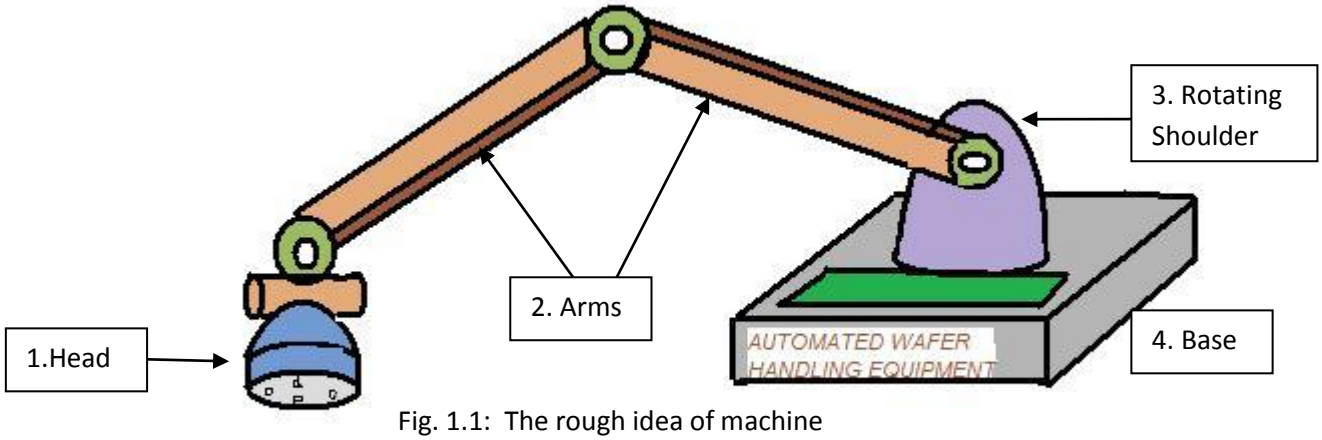

Fig. 1.1: The rough idea of machine

Detailed description of suction head

The vacuum pump of the head consists of the DC motor with a plastic fan. The suction of the fan is enough to hold silicon wafers. The motor and fan is enclosed in a cylindrical chamber. The outlet of the cylinder consists of the perforated fibre plate, which gives platform for holding the wafer.

The sensor is mounted on the inside of the fibre sheet. This consists of the IR led and photodiode. The working of sensor is simple. The IR LED sends beam of IR light onto the cylindrical outlet. If a wafer is present, it will reflect the light and the reverse biased photodiode will start conducting, thus we are able to detect the presence of wafer.

Description of the Arms:

The arms consist of the two metal rods, whose motion is controlled by the nylon strings. They provide the required degree of motion to the machine.

As shown in the figure, they consist of two parts and each part is separately controlled by the motors placed inside the body.

The length of arms decides the area accessible for the machine and the distance up to which the machine can pick and place wafers.

Description of the body:

The body consists of the motors, circuits and mechanical parts. It also contains the user interface, which is LCD and keyboard.

The motors control the arms by pulling the strings and the gravity does the reverse pulling. Using this method, we are avoiding the mechanical gears, which would have taken lot of space as well as make the machine bulky. The control using string (cable) is fairly accurate and using this we transferred all motion control to the body, making arms and head light weight.

The main circuit is described in the next section. The circuit takes input coordinates from the keyboard, and then calculated best possible movements and then give controlling signals to the motor driving circuit. With all the processes, the respective output is also shown on the LCD screen.

Working principle:

The machine is assumed to be in the origin of the coordinate system. The user enters the source and destination coordinates and hits enter. The machine calculates the best possible way to reach from source to destination. Then it goes to the source and picks up the wafer by sucking. It then manages its height and speed and goes to the destination. On reaching the destination, it again comes to normal height and place the wafer on the stack.

If in between the wafer drops, then it is displayed on the lcd. The LCD also shows the current status of the wafer i.e. if it is loaded or not. If loaded then it keeps on checking the status for dropping the wafer.

On reaching the destination, the head comes to the desired height and places the wafer by switching off the vacuum pump. After placing the wafer, it either comes back to the origin or repeat the process depending on the user input.

Software Part:

The program written on the microcontroller is the heart of the machine. This program checks for interrupts and give commands to all the motors. It also does the calculation of finding the best possible path from source to destination.

Circuit description:

The Circuit consists of the two parts. The first part is the main controller board and second is the motor controller circuit. The main controller gives the master commands to the second circuit.

The main board consists of the At-Mega 32 microcontroller along with LCD, Keyboard and Motor controller interface.

The motor controller circuit consists of the L293D buffer IC's which acts as current sources for the motors.

The motors consist of one stepper motor, which is used for rotation of the arm. There are two Dc motors for controlling arms. The first motor controls the first part of arm and the second motor controls the second part of the arm.