Robotics Software
The GAGE Robot

We partnered with a NJ engineering firm to design a robot for one of the leading firms in the semi-conductor manufacturing industry. That company made high definition automated cameras which examined the crystalline structure of silicon wafers to detect imperfections in the manufacturing process. There were issues with the speed of the process in that the camera could do their work much faster than the wafers could be delivered to and received from the cameras. The task was complicated by very precise requirements on the way the wafers were presented to the cameras, and the fact that there were different size wafers used in the process to which the robot needed to be agnostic.

The robot was a polar robot with a Z axis, and two arms which shared another axis, slightly separated in the z-space. These arms extended and provided 'give and get' functionality, moving wafers from a cassette to a chuck which help the wafer while being processes, and back to the cassette. It is this simultaneous 'give and get' functionality which was the margin of efficiency in the process, and which lent the robot its name: the GAGE robot.

Because of the value of the wafers, the motion control of the robot must guard against machine failure. So there was vacuum control on the arms and on the chuck. The arms also contained sensors which were needed to precisely position the wafer on the chuck. Because the size of the wafer in each cassette was unknown, the first wafer was put on the chuck un-centered. Then arms 'pecked' four times around the circumference of the wafer, and chose the 'best fit' of three of the four pecks. (Wafers are flat on one side, so one of the pecks could have been made on the flat.) We ran a curvilinear least squares on the pecks, discarding the outlier, to determine the position of the wafer in x,y space, then algebraically computer its center. We repositioned the wafer so that its center and the chuck's center coincided to within .0003 inches. Then we used the sensors on the arms to circumscribe the circumference of the essential circle, and precisely located the flat. Then we needed to reposition the flat so that it was within .01 degree of arc oriented to specifications.

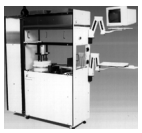
The camera would then examine the structure of the wafer, and signal the robot to remove it

and provide another. At the end of the cassette, the software would signal to the operator to remove the cassette of wafers, and load another.

Tests using the robot over tens of millions of cycles produced not a single malfunction, and resulted in a 27% improvement in throughput time.

HF Etcher

Another project we did was an HF Etcher machine. In the semiconductor industry, chips on wafers are coated with a waxy chemical to protect the wafer from acid. Then an engraving process is used to enable a sharp tool to remove that substance from the wafer, exposing only a limited portion of the surface. Then, the wafer is immersed into a bath of hydrofluoric acid. The acid will then etch the path for the circuits.



The difficulty with this process is that it is loaded with lots of toxic chemicals that need to be disposed of.

The HF Etcher produced an efficient and ecologically friendly way of processing without sacrificing speed.The processing area had cassettes of wafers to be processed, and a containment area into which wafers were loaded one by one to be processed. A robot controlled the movement of the product using vacuum processes on its arm. Manipulation of the robot and the vacuum, as well as other processes in the operation were controlled by a computer hidden in the lower panel.

Once the wafer was moved into the containment area, the lid was closed and sealed to prevent leakage of toxic material. In the containment area was a crucible into which a very small amount hydrofluoric acid was dropped and boiled. The gaseous HFl was then mixed with a gas to disperse it evenly throughout the containment environment.

After an appropriate period of time when the etching process was complete, additional gasses were added to the containment atmosphere to neutralize the chemical process, and neutralize the toxic effect of those elements. Then, the atmosphere was evacuated to the environment without hard, and the containment vessel was opened, allowing the wafer to be completed and another to be processed.

The chemicals and gas containers and regulators were located in the panel to the left of the processing area. All facets of the operation were controlled by our software: movement and control of the wafers, dispensing and boiling of the HFI, injection of the gasses, evacuation, and manipulation of the containment vessel.