MEASURING THE ALIGNMENT ACCURACY OF SURFACE MOUNT ASSEMBLY CIRCUIT BOARD MASKS

D. Gauthier, M.D. Levine, A.S. Malowany †
and N. Bégnoche, G. Lefebvre ‡

† McGill Research Center for Intelligent Machines
3480 University Street, Montréal, Québec, Canada, H3A 2A7

‡ IBM Canada Lteé
23 Boulevard De L'Aéroport, Bromont, Québec, Canada, J0E 1L0

Abstract

An automated system for measuring the alignment accuracy of an exposed photosensitive film resist circuit pattern on a metalized ceramic substrate is described. The system is robust and capable of handling low contrast images with high noise levels and varying degrees of degradation of the circuit pattern. The technique that we will present involves estimating, with the aid of a calibrated vision system, the actual coordinates of two predefined salient features of the circuit pattern, component pads, and calculating the horizontal, vertical, and rotational deviation of the expose mask. The vision algorithm that was implemented will be detailed and its development as an optimization problem, to satisfy the speed, accuracy, and hardware constraints of the system will be discussed. Measurements are accurate to the nearest 2.5 microns and the processing time of each ceramic substrate is not more than sixty seconds using an IBM AT microcomputer.

KEYWORDS – Alignment, registration, template matching, machine vision.

1. Introduction

In recent years, automated electronic assembly technology has been utilizing miniaturized surface mountable integrated circuit packages to produce assemblies that are more densely populated, reliable, and cost effective than traditional through-the-hole circuit board assemblies. The production of high quality assemblies is dependent upon the accuracy with which their basic elements: a substrate, conductive circuit patterns and electronic components, can be registered or aligned with one another. In part, the required accuracy is attained by adhering to rigorous quality control standards at each stage of the manufacturing process. The exacting tolerances imposed by these standards necessitates the implementation of sophisticated automated measurement and inspection procedures, for which image processing systems are fast becoming an invaluable and integral tool. We describe an approach for measuring the alignment accuracy of surface mount assembly circuit board masks.

The production of a surface mount assembly board's circuit pattern involves several stages. Layers of metal are sputtered onto the surface of the substrate and then coated with a film of photosensitive resist. Exposure is achieved by projecting a circuit mask onto the photosensitive film with ultra violet light. The film is developed, leaving a visible image of the circuit pattern on the metalized substrate. The registration of the circuit pattern is then measured. If it is not within specifications, adjustments are made to the position of the expose mask, the resist is removed, and the process is repeated. Otherwise, the substrate is etched, producing the conductive circuit pattern onto which the electronic components will be soldered.

An automated computer vision based measurement system provides a reliable and efficient means of examining the registration of circuit masks. Several advantages over performing the task manually includes increased throughput due to high speed location of pre-programmed inspection positions, improved location accuracy, more consistent measurements, and the possibility of implementing more diverse testing. These factors enable an automated system to yield a final product which can conform to more rigid specifications. In addition, statistical analyses of the data, which can be easily integrated into an automated system, can aid in process control by identifying trends and allowing problems to be diffused before they become serious.

This paper describes an automated system, that was developed as part of a feasibility study for IBM Canada Ltd., for measuring the alignment accuracy of an exposed photosensitive film resist circuit pattern on a metalized ceramic substrate of a surface mount assembly module. The design constraints of the automated system were as follows. Cost effective hardware had to be employed with the heart of the system being an IBM AT microcomputer. The system had to be robust, capable of handling low contrast images with high noise levels and varying degrees of degradation of the circuit pattern. Measurements had to be accurate to the nearest 2.5 microns. Deviations of the circuit pattern from its nominal position of up to $\pm$ 51 microns had to be measured. Finally, the total processing time could not exceed sixty seconds per part.

The technique that we will present involves estimating the actual coordinates of two predefined salient features of the circuit pattern, component pads, and calculating the horizontal, vertical, and rotational deviation of the expose mask. The vision algorithm that was implemented will be detailed and its development as an optimization problem, to satisfy