CONDITION MONITORING OF MICRO-DRILLING PROCESSES ON GLASS BY USING MACHINE VISION

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ABSTRACT
Optical and medical devices require micro-drilling of holes on glass. Brittle fracture occurs during the drilling. Cone and radial cracks are generated due to impact load and walking when a drill hit a glass to make a hole. To produce good holes without cracks and fracture, a condition monitoring of glass drilling processes is required. In this paper, to develop a cost-effective direct monitoring system in micro-drilling processes on glass, a machine vision unit with the edge detection and 3D measurement functions is studied. It consists of a CCD camera with a zoom lens attached to the precision servo stage and a novel illumination unit. Performance of the developed machine vision system is verified in micro-drilling processes on glass using diamond and carbide drills.

KEYWORDS
Brittle fracture, Crack, Condition monitoring, Glass drilling, Micro-drilling, Machine Vision

INTRODUCTION
Today, glass is widely used in various types of industries, such as semiconductors, optical components, flat panel displays, micro biochips, etc. The industries seek machining methods to fabricate smaller and smaller products, and therefore micro-hole drilling technology is required. As glass is manufactured isotropically, it is difficult to obtain precision micro-holes through machining processes. Some methods have introduced for micro-hole making. As EDM (Electric Discharge Machining) and laser machining have severe thermal damage and poor hole quality, micro-drilling through machining is preferred in the industries [1].

In a micro-hole drilling process on glass, blades of a micro-drill inflict impact loads on the glass. As the brittle material receive impact load, brittle fracture may occur as radial and/or conic cracks [2,3]. In order to find good drilling conditions and make good quality holes on glass parts, a direct type of condition monitoring system is required [4-6]. As general methods for measuring the hole quality in micro-drilling processes, SEMs (Scanning Electron Microscope) [7,8], Confocal microscopes [8], and laser-based sensing units have been used. However, they are very sensitive, expensive and difficult to be implemented in the working environments. Consequently, development of a cost-effective and rugged direct monitoring system is necessary.

In this paper, a precision 3D machine vision measurement system is proposed to measure hole quality and inspect drill wear in micro-drilling of glass material. Positional errors of fine holes, shape of cracks, and quality of hole surfaces are influenced by drilling conditions. In order to find good machining conditions, in which cracks do not occur and a clean machining surface is kept, qualities of fine holes and surfaces under different machining conditions should be constantly monitored. A machine vision system equipped with a zoom lens, a CCD camera and a novel illumination unit is developed. Using the edge detection method [9], hole quality, cracks due to brittle fracture, and drill wear are precisely quantized.

EXPERIMENTAL SET-UP
In the micro-drilling process, the machine accuracy affects the preciseness of micro holes. Therefore, a high-speed spindle with tight accuracy is required to increase the hole quality.