MANUFACTURING TRIBOLOGY IN THE NANO-MANUFACTURING ERA

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ABSTRACT
In 1966 a report published by UK Department of Education and Science introduced the concept of tribology, which was defined as the science of interacting surfaces in relative motion. Tribology in practice studies friction, wear and lubrication. These processes affect each other with interacting causes and effects: one aspect of tribology is the study of their interactions.

One of the fields in which these interactions play a large effect is manufacturing in general and manufacturing processes in particular. From macro manufacturing processes (milling, turning, drilling, boring, etc) to micro (grinding, superfinishing) and nano manufacturing processes (polishing, lapping, CMP) friction, wear and lubrication are the main phenomena governing these processes.

This paper will focus on micro and nano abrasive processes and emphasize the application of tribological knowledge on the outcomes of these processes. A study case regarding nano polishing of AlTiC magnetic head will be described together with a special tribo-technology, which will allow the generation of surfaces with Ry of 0.2 nanometers. Also molecular dynamics (MD) simulations of nanoindentation, nanoscratching and friction coefficient at the nano level will be presented.

INTRODUCTION
The abrasive processes are well known as finishing processes. In most of them the removal of material is at micro and nano levels. To study these processes using traditional analytic or FE methods is not always convenient or successful. This is true for new processes which combine mechanical processes with electrical processes. One such process is ELID grinding/lapping, a process which is about 10-15 years old.

Another process is as old as thousands of years, but the level of application is related to new products and new technology. Super-polishing of magnetic heads for the semiconductor industry is one of the main technologies used to obtain Hard Drives for our PCs. The accuracy of these components is now at the sub nanometer level and requires deep knowledge of tribology to solve and to optimize the process.

KEYWORDS
Wear, Abrasive Processes, Molecular Dynamics (MD)

ELID TECHNOLOGY: TRIBOLOGICAL ASPECTS
The ELID (electrolytic in process dressing) grinding was introduced ten years ago in Japan by a group of researchers from RIKEN [3]. The new method is expected to contribute greatly to precision grinding, particularly in the field of mirror surface finishing of hard and brittle materials. The Pin on Disk under ELID dressing conditions is the main study of this project, using a high speed video camera.

Fig. 1 ELID TECHNOLOGY PRINCIPLE
NANO POLISHING OF AlTiC MAGNETIC HEADS

Nano polishing of AlTiC ceramics is a very important process in the storage media industry. This processing results in a very flat surface with small surface roughness, allowing a very small gap between the head and the storage media (hard disk, floppy disk, etc.). The process can be optimized by taking the right decision in terms of polishing slurry selection (type, amount), plate material, time and pressure on the parts. Experimental data for AlTiC removal rate and surface finish will be presented together with the experimental set-up and AFM measurements of the topography of the surface.

MOLECULAR DYNAMICS (MD) SIMULATION

In order to be able to simulate the indentation and the scratch at the nano level as well as the determination of the friction coefficient at the same level, molecular dynamic modeling was used. The aim of this simulation was:

− to establish through a combination of both experimental and theoretical atomistic studies the dependence of the critical depth of cut for plastic deformation on the applied load, on the characteristics of the tool, on the relative orientation of the tool and the work piece, and on the presence of surface defects, subsurface voids and grain boundaries in the work piece.

− to characterize the condition of stability of the tool against wear

− to obtain a fundamental understanding of micro/nanoscale factors (including friction coefficient) that control fractures and brittle to ductile transition.

The simulation of a diamond indenter on a silicon carbide crystal will be presented together with a set of experiments which will validate the simulation. The friction coefficient will be determined for different cases.

CONCLUSIONS

Tribology has a deep impact on most of the manufacturing processes and particularly on the micro/nano abrasive processes. The continuous study of these processes aided by tribology will improve the quality of the product and will improve the economic factors of the fabrication.

REFERENCES