A GEOMETRICALLY DEFINED ALL-DIAMOND PAD CONDITIONER

Joakim Andersson  
Tribomaterials Group at the Ångström Laboratory  
Uppsala University, Sweden

Markus Forsberg  
Solid State Electronics at the Ångström Laboratory  
Uppsala University, Sweden

Patrik Hollman  
Nova Diamant  
Uppsala, Sweden

Staffan Jacobson  
Tribomaterials Group at the Ångström Laboratory  
Uppsala University, Sweden

ABSTRACT

This work presents a geometrically defined pad conditioner fabricated by anisotropic etching of silicon to produce a well-defined mold and subsequently CVD diamond layer is deposited on this mold. Finally, the silicon wafer is etched away, exhibiting the all-diamond tool surface.

The new type of pad conditioner offers very sharp pyramidal tips, all equal in size. The excellent sharpness leads to high roughening capability while keeping the pad removal low. The precise tip position and height results in a unique uniformity of scratches produced, hence offering a new level of process control.

INTRODUCTION

The importance of controlled and stable chemical-mechanical polishing (CMP) processes increases as the number of metal layers increases and the feature sizes decrease. The polishing pad needs to be conditioned to avoid so called pad glazing. Glazing results in a decreased removal rate from the wafer due to a reduced effective pressure. The roughing produced by the pad conditioning should restore this removal rate. Further, the removal from the pad itself should be kept as low as possible since each pad exchange and subsequent re-qualification reduces the uptime of the CMP-system.

The pad conditioning tool has the form of a metal disk or ring equipped with diamond particles. The tool is rotating and swept over the rotating pad. The precision of the pad conditioner surface is limited by the variation in diamond particle size, shape, orientation and distribution.
The new type of pad conditioner offers several appealing features. The pyramidal very sharp tips are all equal in size and their surface roughness, positioning, shape and sizes are all extremely precise, as determined by the high-precision characteristics of anisotropic silicon etching. The excellent sharpness leads to high roughening capability while keeping the pad removal low. The precise tip position and height results in a unique uniformity of scratches produced, see Fig. 1. Almost ideally sharp tips of identical height results in scratch depths being proportional to the applied load. This offers a new level of process control. Each conditioner tool is virtually identical, which offers a stable conditioning process. The surface is all-diamond, facilitating in-situ pad conditioning during metal CMP. A laboratory test was performed to determine the capacity of the new pad conditioner. Very limited damage to the tips was detected. Glazed and conditioned pads were investigated in the SEM. The scratch depth to load relation was investigated both theoretically and experimentally. The positive effect of a narrow tip height distribution was demonstrated by scratching planar plastic surfaces, and comparing with conventional tools, see Fig. 2. FEM analysis was performed to estimate the stresses in the diamond film for different diamond thicknesses and backing materials. A prototype was also tested in an industrial CMP-system.

Figure 2. Comparisons between appearances of conventional and geometrically defined conditioning tools and their ability to create controlled, evenly sized and densely distributed scratches on a flat plastic surface. 
Top row: conventional commercial conditioner and resulting scratches in a flat plastic surface. 
Bottom row: the geometrically defined all-diamond conditioner and resulting scratches.