Thinning of Sapphire Wafers by Magnetic Field-Assisted Finishing

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INTRODUCTION

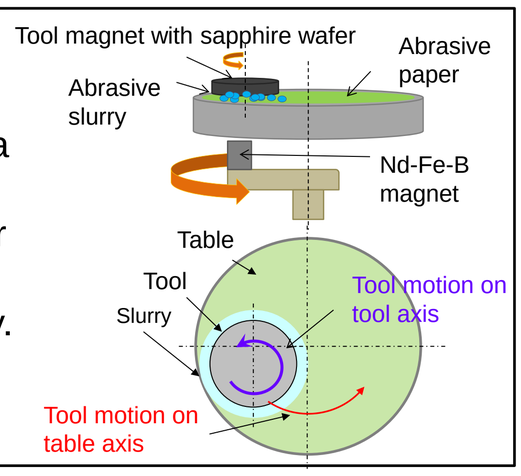
Sapphire possesses high strength, hardness, wear and abrasion resistance, chemical inertness, and a low coefficient of thermal expansion. These properties lead to its application in optical, biomedical, and mechanical components, but they also create machining difficulties. Current thinning techniques can only produce large batches of sapphire, which is not cost effective for applications requiring a small number of wafers. This project proposes the use of Magnetic Field-assisted Finishing (MAF) to thin sapphire wafers individually.

OBJECTIVES AND GOALS

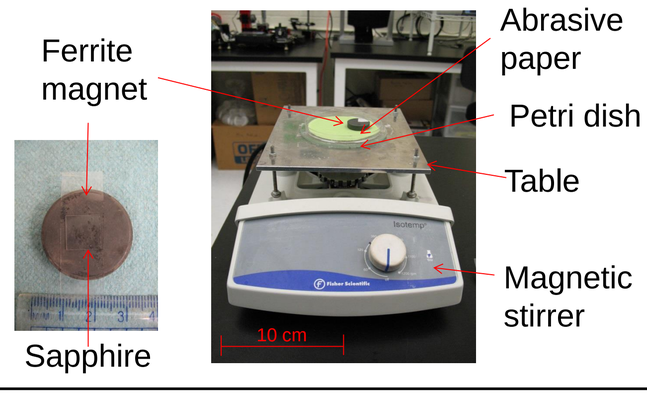
1. Refine MAF thinning techniques for individual sapphire wafers while improving surface roughness.
2. Characterize the magnet tool motion.
3. Clarify processing characteristics, especially the effects of abrasive grain size on the material removal rate and surface roughness.

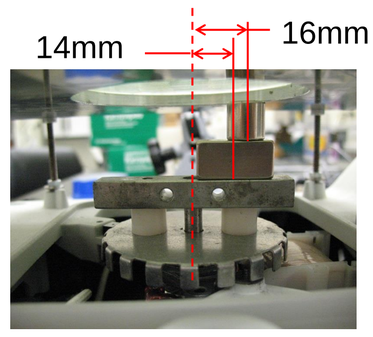
PROCESSING PRINCIPLES

- A magnetic stirrer is used to induce the planetary motion of a ferrite tool magnet, to which a sapphire wafer is attached, over an abrasive surface and an abrasive diamond particle slurry.
- Planetary motion generated by friction



EXPERIMENTAL SETUP



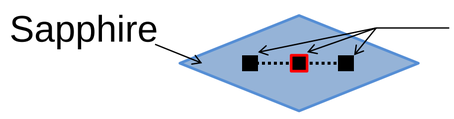


Nd-Fe-B magnet arrangement (below table)

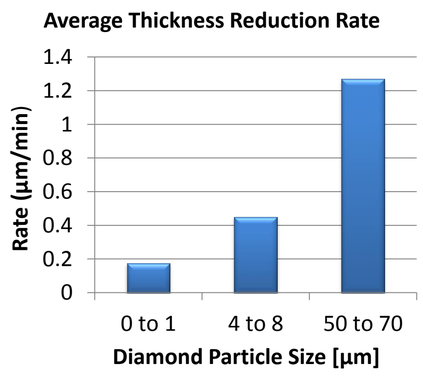
EXPERIMENTAL CONDITIONS

Abrasive Slurry	Oil based diamond particle slurry: 0-1 µm 4-8 µm 50-70 µm
Abrasive Surface	120 grit abrasive paper 3M Trizact abrasive paper 3M Trizact diamond tile
Magnet Revolution	300-350 rpm

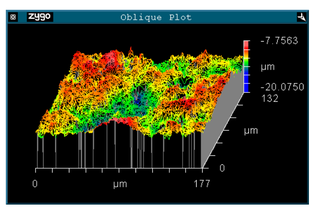
RESULTS – THICKNESS



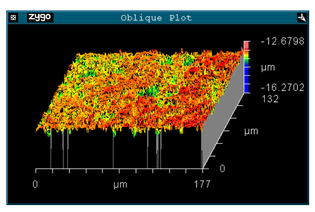
- Thickness averaged along diagonal (3 points) using a micrometer
- Roughness observed at center using a Zygo optical profilometer
- Maximum thickness reduction rate achieved with 50-70 µm particle size



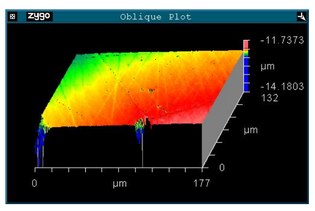
RESULTS – SURFACE ROUGHNESS



50-70 µm



4-8 µm



0-1 µm

- Surface roughness decreased with decreasing abrasive particle size

CONCLUSIONS

- It is possible to economically thin individual sapphire wafers using MAF processes.
- This method can effectively reduces thickness to about 250 µm.
  - Sapphire becomes too fragile

FUTURE PLANS

- Further research is devoted to reducing thickness below 250 µm and improving the surface smoothness using modified techniques and different abrasives.

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