BAPVC Annual Project Report

Project Title: Laser Wafering
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Summary:

The focus of this work is the design and understanding of a novel semiconductor wafering technique that utilizes the nonlinear absorption properties of band-gapped materials to achieve bulk (subsurface) morphological changes in matter using highly focused laser light. A method and tool was designed and developed to form controlled damage regions in the bulk of a crystalline sapphire wafer leaving the surfaces unaltered. The controllability of the subsurface damage geometry was investigated, and the effect of numerical aperture of the focusing optic, energy per pulse, wavelength, and number of pulses was characterized for a nanosecond variable wavelength laser.

Key Accomplishments:

The researchers developed a model to for the subsurface laser ablation in sapphire as shown in Figure 1. The combination of a ray-optics and electron plasma accurately predicted the shape, size, and location of permanently modified material in the bulk of sapphire for multiple focusing optics, laser wavelengths, number of pulses, and a wide range of beam power.

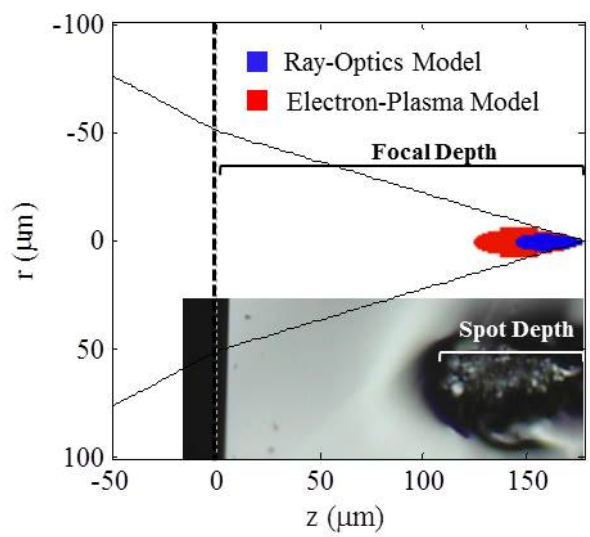

Figure 1: Ray-optics and electron-plasma bulk laser damage models compared to optical microscope image of bulk damage region. Damage spot formed from a single laser pulse at 315 μJ energy per pulse, 667 μm wavelength, focused 100μm beneath the surface with NA=0.50 reflective objective.

Lastly, having characterized the parameters controlling subsurface damage spot formation, arrays of damage were formed in the bulk of a crystalline sapphire wafers to attempt layer liftoff. Multiple samples of varying spot size, depth, spacing, and array area were prepared as well as some additional laser machining processes like outline surface ablation and corner drilling to allow preferential etch penetration. A plane of subsurface damage was

demonstrated. However, complete layer liftoff was not achieved to date. In order to fully define a laser wafering process, other methods of damage layer preparation and/or material liftoff should be attempted.

Future Work:

Other techniques for mechanically assisted layer liftoff after subsurface laser damage plane formation will be attempted. A layer of subsurface damage was demonstrated but the liftoff has not yet been achieved. Etches for the layer of damage are being investigated to further weaken the damage plane so that subsequent thermal or mechanical stress can achieve the final goal of lift off.