Evolution of Mechanically Formed Bow Due to Surface Waviness and Residual Stress Difference on Sapphire (0001) Substrate

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Single crystalline sapphire is one of the most widely used wafers for modern high-technology electronic and optical devices owing to the well-established mass production, own physical properties with high thermal, mechanical, and chemical stability, and lattice constants suitable for growth of highly crystalline films. When single crystalline wafers are used as substrates, the curvature of the wafer surface usually called bow is inevitable. Since bow can degrade the quality of deposited film by defects generation or undesirable strain at the interface, to reduce the bow and surface roughness, procedures such as lapping, annealing, and polishing are followed after wafer slicing. Although single crystalline sapphire has sufficiently high hardness for the device applications, surface waviness after abrasion and residual stress within wafer can induce bow. In this study, we revealed the mechanism of bow evolution using high-resolution X-ray diffraction and Raman spectroscopy following each wafering steps. We found that bow in single crystalline sapphire wafer is mainly determined by the irregularly abraded surface after wafer slicing at earlier wafering process. This kind of bow is significantly reduced after lapping and annealing procedure. However, additional surface polishing can inflict stress on the surface and increase bow due to residual stress difference between the polishing surface and the opposite surface. While bow can be effectively reduced by further polishing on the opposite surface, the surface lattice remains still strained.