World Academy of Science, Engineering and Technology
International Journal of Physical and Mathematical Sciences
Vol:13, No:03, 2019

Laser-Dicing Modeling: Implementation of a High Accuracy Tool for Laser-Grooving and Cutting Application

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Abstract : The highly complex technology requirements of today's integrated circuits (ICs), lead to the increased use of several materials types such as metal structures, brittle and porous low-k materials which are used in both front end of line (FEOL) and back end of line (BEOL) process for wafer manufacturing. In order to singulate chip from wafer, a critical laser-grooving process, prior to blade dicing, is used to remove these layers of materials out of the dicing street. The combination of laser-grooving and blade dicing allows to reduce the potential risk of induced mechanical defects such micro-cracks, chipping, on the wafer top surface where circuitry is located. It seems, therefore, essential to have a fundamental understanding of the physics involving laser-dicing in order to maximize control of these critical process and reduce their undesirable effects on process efficiency, quality, and reliability. In this paper, the study was based on the convergence of two approaches, numerical and experimental studies which allowed us to investigate the interaction of a nanosecond pulsed laser and BEOL wafer materials. To evaluate this interaction, several laser grooved samples were compared with finite element modeling, in which three different aspects; phase change, thermo-mechanical and optic sensitive parameters were considered. The mathematical model makes it possible to highlight a groove profile (depth, width, etc.) of a single pulse or multi-pulses on BEOL wafer material. Moreover, the heat affected zone, and thermo-mechanical stress can be also predicted as a function of laser operating parameters (power, frequency, spot size, defocus, speed, etc.). After modeling validation and calibration, a satisfying correlation between experiment and modeling, results have been observed in terms of groove depth, width and heat affected zone. The study proposed in this work is a first step toward implementing a quick assessment tool for design and debug of multiple laser grooving conditions with limited experiments on hardware in industrial application. More correlations and validation tests are in progress and will be included in the full paper.

Keywords : laser-dicing, nano-second pulsed laser, wafer multi-stack, multiphysics modeling
Conference Title : ICOLS 2019 : International Conference on Optics, Lasers and Spectroscopy
Conference Location : London, United Kingdom
Conference Dates : March 14-15, 2019