The morphological effect of top-hat beam shape on laser drilling of micron-scale high aspect ratio holes in silicon nitride

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The manufacturing trend toward product miniaturisation and the incorporation of micro functional features in products requires new tools, methods and also to take into account new considerations regarding material behaviour at micro and sub-micron scales. High aspect ratio (depth to diameter ratio) micro holes are critical features in many high value components, in particular for electronic industry, e.g. interconnecting vias of printed circuit boards and guiding blocks of interface probe cards for 3D wafer bumps. Controlling the morphology and quality of the holes is an important factor in such applications and the use of ultra-short lasers as a flexible non-contact tool are critical for achieving the necessary geometrical and dimensional accuracy. In this research based on the refracted beam shaping theory, an appropriate beam delivery system has been designed for drilling micro holes with a top-hat beam shape. The morphology of the high aspect ratio holes in terms of cylindricity and side walls' tapering together with their effects on penetration depth are analysed employing a high resolution X ray Computed Tomography (XCT). The capabilities of such beam shaping solutions and also their limitations in terms of sensitivity to defocusing and HAZ are investigated and compared with the results achievable with Gaussian beams.