# Design Of An Aerostatic Journal Bearing For Dicing Applications

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## Abstract

Aerostatic bearings are widely employed in high-precision systems, particularly in micromachining applications. Their contactless operation eliminates mechanical friction, enabling highly accurate and repeatable motion. This makes them especially valuable in metrology and advanced manufacturing, where precision and surface quality are critical. The absence of wear, combined with long operational life and maintenance-free operation, further enhances their suitability for such demanding environments.

One notable application is mechanical dicing, where high-speed precision spindles are used to cut semiconductor wafers and other delicate materials with minimal vibration and runout. In this context, gas bearings are preferred over conventional ball bearings due to their superior rotational accuracy, low thermal generation, and absence of particle contamination—factors that are essential for achieving narrow kerfs and preventing damage to sensitive substrates. Their ability to maintain consistent performance over time without lubrication also reduces downtime and enhances the reliability of dicing equipment in industrial settings.

This work focuses on the design of an aerostatic journal bearing for an electrospindle intended for mechanical dicing. The primary objectives are to achieve sub-micrometric runout (below 0.1 μm), low vibration amplitude, and adequate radial stiffness—ensuring high machining accuracy and extended spindle life across a speed range of 20 to 60 krpm, without compromising system stability.

The design process begins with a static analysis, where a sensitivity study is conducted to determine a suitable initial geometry, including bearing length, diameter, and the number, size, and position of the supply holes. The selected parameters are optimized to maximize static stiffness while maintaining reasonable load capacity and air consumption. A subsequent dynamic analysis refines the design parameters by ensuring sufficient damping, allowing the bearing to suppress vibrations effectively during operation. The final stage involves a stability analysis of the spindle system.

Future work will focus on extending the model to include thermal and structural deformation effects, thereby improving the predictive capability and robustness of the design.

## Figures used in the abstract

**Figure 1** : Aerostatic journal bearing used in dicing processes.