

# Design of an Aerostatic Journal Bearing for Dicing Applications

By enabling stable, frictionless spindles, aerostatic bearings empower mechanical dicing to remain the backbone of next-gen electronics—combining cost efficiency with the precision needed for ever-smaller, denser PCBs and wafers.

Fabrizio Pauri<sup>1</sup>, Luigi Lentini<sup>2\*</sup>, Riccardo Ravaglione<sup>2</sup>,

<sup>1</sup>Carbomech S.r.l., Burolo (TO), Italy.

<sup>2</sup>DIMEAS, Politecnico di Torino, Italy.

[\\*correspondence E-mail:luigi.lentini@polito.it](mailto:luigi.lentini@polito.it) )

## Introduction and Goals

Aerostatic bearings are essential in high-precision systems, as their frictionless operation ensures repeatability and accuracy, long lifetime, and maintenance-free use [1, 2]. They play a crucial role in micromachining and advanced manufacturing, where dimensional precision and flawless surface quality are critical. One of the most relevant application is mechanical dicing, where high-speed electro-spindles have to cut ever-smaller wafers and high-density PCBs while minimizing vibration,

runout, and contamination. Although laser dicing can achieve high precision, the mechanical approach remains the dominant industrial choice due to its superior balance of cost, scalability, and process reliability. This work addresses the design of an aerostatic journal bearing for an electro-spindle operating from 20 to 100 krpm, aiming at sub-micrometric runout ( $<0.1 \mu\text{m}$ ), low vibration amplitude, and adequate radial stiffness. The study focuses on comparing bushing discharge configurations.

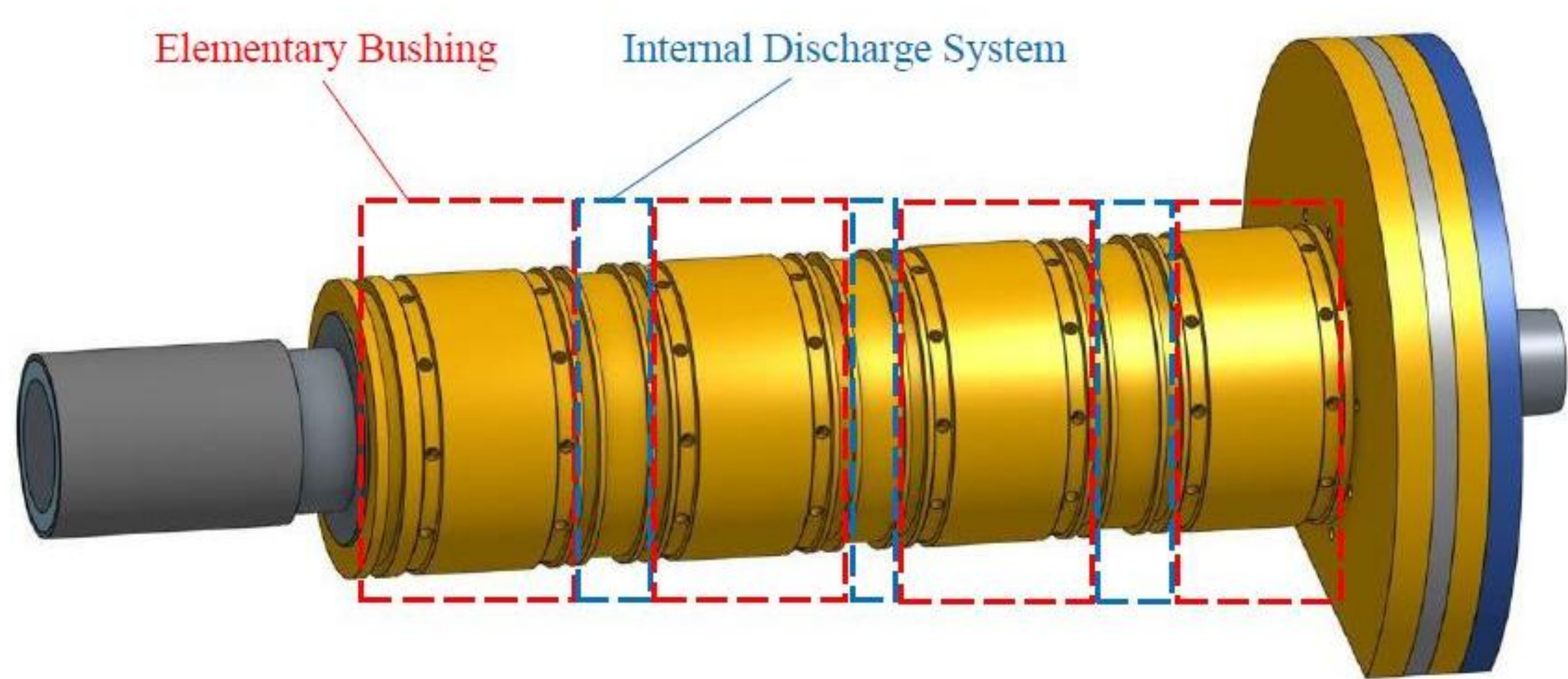


Figure 1. electro-spindle supported by aerostatic bearings for mechanical dicing operations .

## Methodology

Figure 1 shows the 3D view of the radial aerostatic bearing. As can be seen, it is designed as a series of four “elementary bushings” that are separated by internal discharging ports. This preliminary investigation aims at comparing different discharge configurations of the bushing. The implemented numerical models simulate the performance of the bushing:

- with internal discharging slots
- with internal discharging holes
- without internal discharging ports

## Results

Figure 2 compares the static results obtained in the cases (a), (b) and (c), presented in the previous section. Results were obtained in the presence of a radial clearance  $c = 15 \mu\text{m}$  and a supply pressure of 0.7 absolute MPa. The solution which employs internal discharging slots, i.e., four independent “elementary bushings, makes it possible to obtain the highest load capacity and stiffness (about 60 and 80  $\text{N}/\mu\text{m}$  at 0 and 100 krpm). Conversely, the solution without internal discharging ports provides the lowest air consumption (20 l/min), load capacity and stiffness. The solution with internal discharging holes represent a trade-off solution. Moreover, solution (b) tends to solution (a) increasing the rotational speed. Future work will focus on the research of an optimal geometry for case (b) and it will analyse the dynamic behaviour of the considered discharging systems.

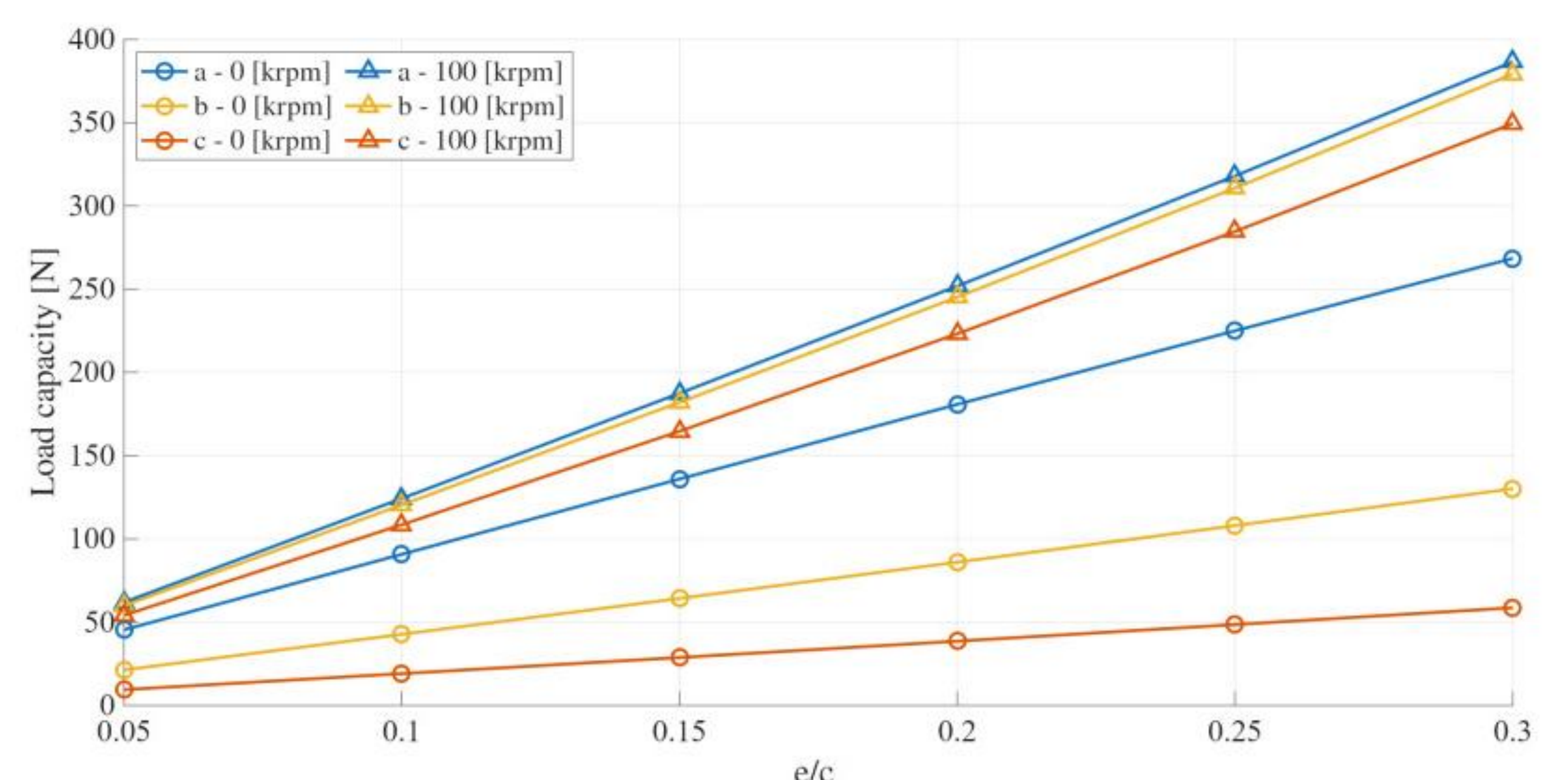


Figure 2. Comparison among the load capacity of the bushing in the presence of different discharge systems.

## REFERENCES

- [1] Al-Bender, F. (2021). *Air bearings: theory, design and applications*. John Wiley & Sons.
- [2] Wardle, F. (2015). *Ultra-precision bearings*. Elsevier.



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