Vacuum Technology Empowering Semiconductor Manufacturing:

Structural Design and Functional Coating Applications

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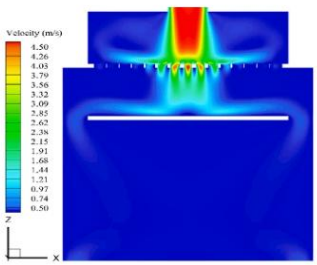
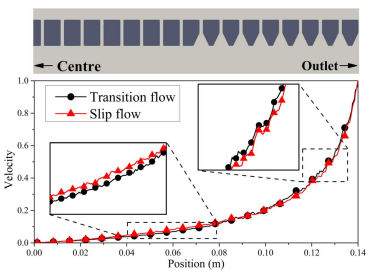
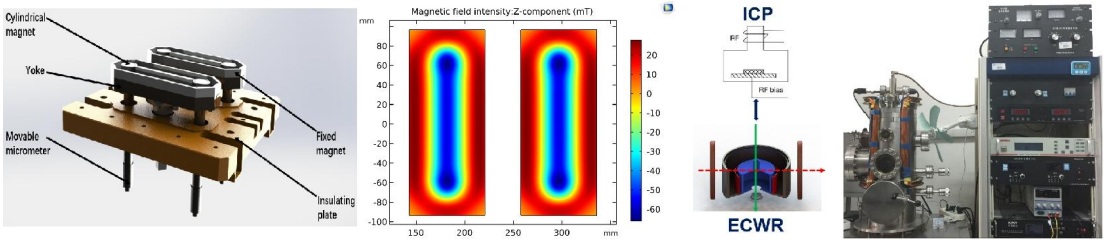
Abstract: Semiconductor manufacturing technology is the cornerstone of the information age, and vacuum technology, as one of its core supporting technologies, plays a crucial role in improving chip performance, reliability and yield. This report will focus on the structural design methods of semiconductor vacuum equipment and key components (showerhead, sputtering cathodes, ion sources, particle purging devices), and explore the application of customized vacuum coating to improve the performance of core semiconductor components (spindles, screw pump rotors, etc.). The report will cover the following contents: (1) Structural design of semiconductor vacuum equipment and key components: The working principle, performance requirements and challenges of key components such as showerhead, sputtering cathodes, ion sources and particle purging devices are introduced. The innovative structural design method based on the basic science of fluid mechanics, electromagnetic field and plasma physics is described to achieve high efficiency, uniform and stable process performance. (2) The application of customized vacuum coating in semiconductor core parts: Analyze the failure mechanism of semiconductor core parts (spindle, screw pump rotor, etc.) under extreme conditions such as high temperature, high pressure, strong corrosion. This paper introduces customized vacuum coating schemes designed for different failure mechanisms, including wear resistant coating, corrosion resistant coating, insulation coating, etc. Demonstrate the remarkable effect of customized vacuum coating in improving component service life, reliability and yield. (3) Future outlook: Explore the development trends and challenges of vacuum technology and functional coatings in next generation semiconductor manufacturing. Look forward to the development opportunities and prospects of China in the field of semiconductor vacuum equipment and key components. This report will combine theoretical analysis, experimental data and practical cases to comprehensively demonstrate the key role of vacuum technology in semiconductor manufacturing, and provide new ideas for promoting the integration of basic scientific research and industrial application.

Key words： Semiconductor Manufacturing, vacuum technology, structural design, functional coating, showerhead, sputtering cathode, ion source, particle purge device, spindle, screw pump rotor







References：

[1] Wansuo LIU, Xiangji YUE, Zeng LIN*. Study on characteristics of microchannel jet for showerhead in different fluid regimes based on hybrid NS-DSMC methodology[J]. Microfluidics and Nanofluidics, 2024, 28(3): 12.

[2] Yun-peng He, Shi-bo Bi, Ji-ping Yin, Shao-bo Lv, Rui-sheng Wang, Zeng Lin*. Prediction of midfrequency sputtering cathode erosion position with vertical magnetic field[J].Surface Engineering, 2021,37(3):381-389.

Individual resume：

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