# State estimation of CMP process using model-based simulation


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This paper presents a model-based Chemical Mechanical Polishing (CMP) simulation towards the future digital twin technology. It is known that the CMP performance is roughly estimated by “Preston's law”, i.e., material removal rate (MRR) is proportional to the material removal efficiency, the polishing pressure, and the relative velocity. The techniques for estimating the polishing pressure and relative velocity are almost established [1], whereas modeling of the material removal efficiency has not been fully investigated.

In this study, we assume that the polishing efficiency is unevenly distributed within the wafer surface and varies dynamically due to various reasons. The spatial and dynamic variation in the material removal efficiency is modeled mathematically. In addition, it is known that the rotational torque of the platen depends on the MRR [2]. Considering this MRR/torque dependency, we developed an inverse analysis technique to identify the model parameters representing the process model.

To analyze the spatial distribution of MRR on a wafer, stop-polishing test was conducted, where the wafer carrier rotation was stopped. The state parameters were identified from the in-process data of the CMP machine. Fig.2 demonstrates that the estimated polishing resistance and MRR distributions agree with the experimental results. This fact indicates that CMP process is accurately estimated by the proposed method. The proposed method is available to estimate state quantities that are difficult to measure directly, such as the friction coefficient distribution and its time-varying profile on the wafer, see Fig.3.

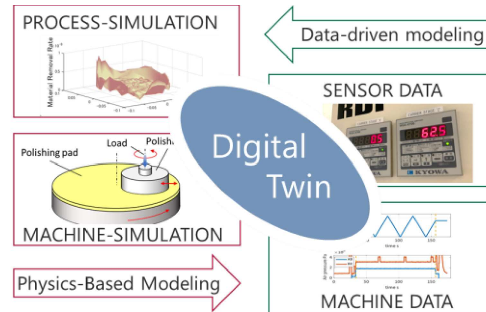


Fig.1 Schematic image of a digital twin for CMP process simulation

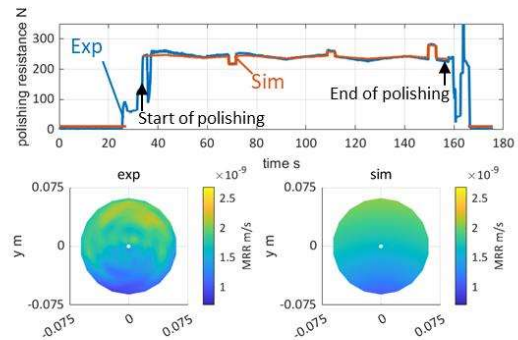


Fig.2 Comparison of measured and estimated polishing resistances and MRRs

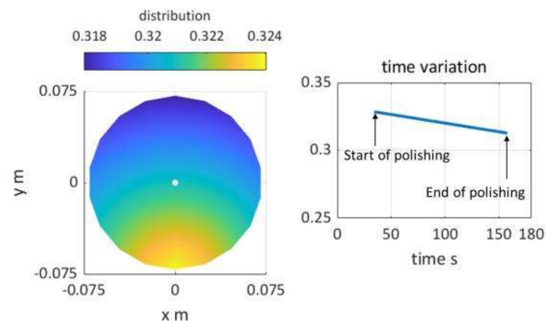


Fig.3 Estimated results: (left) distribution of time-averaged friction coefficients (right) time variation of spatial-averaged friction coefficients


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## References


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