Experimental investigation on modified Preston model by utilizing stop polishing method

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Demands for the digital twin technology are increasing to precisely control the Material removal rate (MRR) and its distribution within a wafer in the next-generation Chemical Mechanical Polishing (CMP) process. Preston's law, i.e., $MRR = k_p pv$, is a useful model for the digital twin. Estimation techniques for polishing pressure p and relative velocity v are almost established, meanwhile, the polishing efficiency k_p is not well modeled. This is due to the nature of the complexity in the process itself and the difficulty in direct measurement of k_p distribution. On the other hand, the stop polishing method proposed by the authors can attain the direct measurement of the MRR distribution within the wafer surface, and hence can be used to visualize the k_p distribution. By utilizing the stop polishing method, Preston's law for oxide CMP is modified and the model parameters are identified in the present study. In addition, k_p distribution is modeled considering the slurry supply position.

The modified Preston's law represented by $MRR = k_p p^{\alpha} v^{\beta}$ was modeled as a power function of relative velocity and polishing pressure. From the error norm map calculated by solving $\|\boldsymbol{MRR} - k_p \boldsymbol{p}^{\alpha} \boldsymbol{v}^{\beta}\|$, optimal set of parameters $(\alpha, \beta) = (0.92, 0.52)$ is identified (see Fig.1). Fig. 2 compares the estimated MRRs assuming even k_p and p within the wafer with the measured ones in the stop polishing experiments. The measured results are distributed on the identified curves.

Assuming the modified Preston model, the k_p distribution is calculated as shown in Fig.3. The experimental results indicated larger k_p at the pad rotation radius of greater than the slurry supply radius. This fact indicates the importance of slurry supply conditions. Considering the slurry positions dependency, a novel k_p distribution function is modeled in the present study. The estimated result agreed well to the experimental one, see Fig. 3.

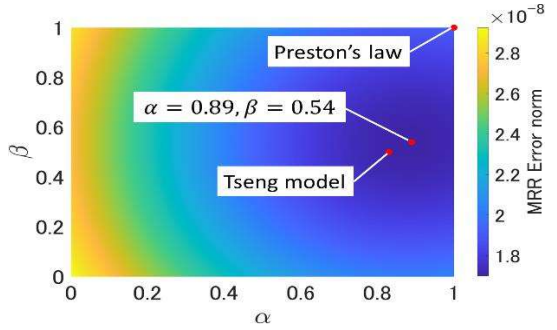

Fig.1 MRR error norm v.s. α and β

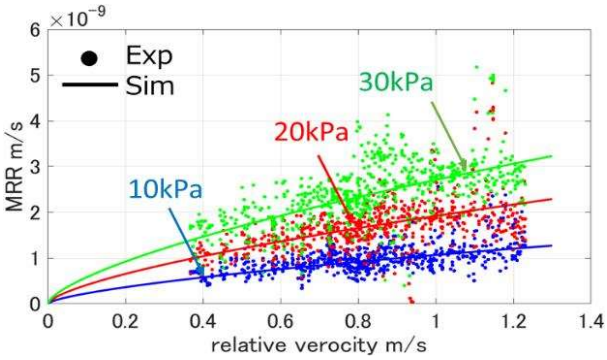

Fig.2 Comparison of measured and estimated MMR

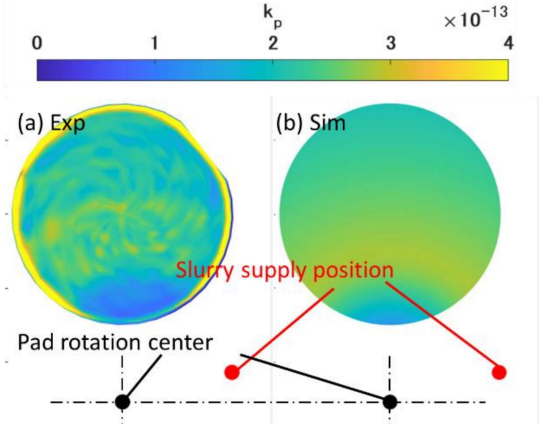

Fig.3 Material removal efficiency distribution

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