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Thermal stabilization of ultraprecision turning machines

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Abstract

For the production of optics with form errors below 100 nm, single point diamond turning machines require extremely stable temperatures within their key components. These key components include all parts that are relevant for positioning of the tool or the workpiece, namely the machine bed, the linear axes, and the main spindle. The design goal of the Innolite IL300 turning machine is to achieve a temperature stability of under ±0.1°C in all key parts. Reasonable operating conditions, which take into account a warm-up process and preconditioning of the outside temperatures (room, cooling water) to ±1°C, are presupposed. The envisaged ten-fold thermal stabilization requires a dedicated system which protects the temperature sensitive machine parts by providing continuous flows of temperature-controlled air, oil and water. For this purpose, the IL300 follows a thermally robust mechanical design. The granite machine bed, the hydrostatic linear axes, and the aerostatic main spindle are all protected by at least one cover structure from environmental changes. The two-level cascade temperature control system also focuses on robustness. First of all, external circuits with low precision mixing valves reduce the temperature variation of externally provided cooling water down to ±0.1°C. Internal circuits then use this pre-conditioned water to continuously provide air, water and oil flows with a much higher precision of ±0.01°C. This paper describes the general design as well as a detailed performance analysis of all subsystems

Accuracy, Machine, Temperature

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1. Main section heading Bold, space 12pt bef., 3pt aft., 1.5 line

Insert your introduction here. The introduction begins broadly and funnels down to the transition to the rest of the paper. It begins by identifying an important problem in society. Next it frames the question analysed in the paper. Next it summarizes previous work and describes why this research is different from previous work; this is a brief literature review. Finally, it summarizes exactly what will follow in the paper; generally using one sentence to summarize each of the sections that follow. First line by 0.25cm

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Do not forget to include your methodology. It is exceedingly important that all readers clearly understand your methodology. The methodology section frequently contains a series of numbered equations containing variables. Define all variables. Do not use numeric values, numeric examples or include results in this section. Do not repeat equations; refer to equations by equation number. List all assumptions. Identify the limitations of the methodology. Use as many sections and subsections as needed to organize the methodology.

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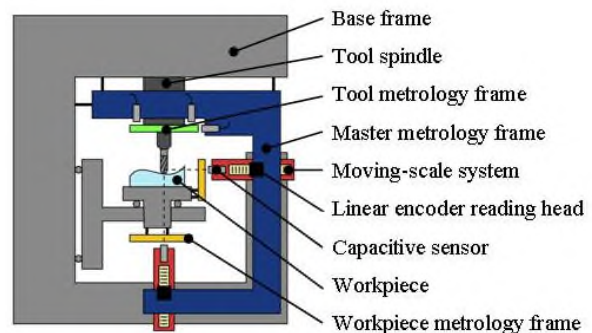High-res images should be kept within column/page margins

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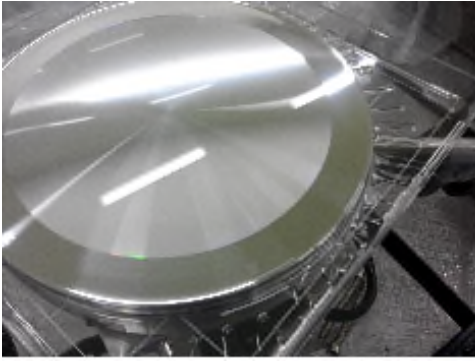High-res mages should be kept within column/page margins

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Table 1 (note: larger tables can be set over 2 text columns) calibri 8

Component		Uk = 2/nm
Affecting reproducibility	Thermal erorrs for ΔT = 0.5 °C	37
	Dynamic errors and sensor noise	9
	Non-repeatable geometric errors	5

4. Main section heading

Remember to include results. Apply the methodology to generate numeric results. If measured data are available, compare the numeric results to measured results. Comment on agreement between theoretical and measured results.

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[1] Strite S and Morkoc H 1992 *J. Vac. Sci. Technol*. B **10** 1237-39
[2] Jain S C, Willander M, Narayan J and van Overstraeten R 2000 *J. Appl. Phys*. **87** 965
[3] Kendall M A F and Quinlan N J 2004 Intradermal ballistic delivery of micro-particles into excised human skin for drug and vaccine applications *J. Biomech.* **37** 1733-41
[4] Nakamura S, Senoh M, Nagahama S, Iwase N, Yamada T, Matsushita T, Kiyoku H and Sugimoto Y 1996 *Japan. J. Appl. Phys.* **35** L7