PhD Project	Under the Skin of Ultra-Precision Manufacturing	
Short title	UnderSkin	
Supervisory Team	Main Supervisor	Prof David Walker
	Co-Supervisor	Prof Rakesh Mishra
Research Centre		Laboratory for Ultra-precision Surfaces, Daresbury site Part of the Huddersfield Centre for Precision Technologies
Eligibility		Students who are eligible for UK home tuition fees, and with a relevant first or upper-second class degree.
Funding available		Tuition fee waiver, bursary of £15,609
Deadline for applications		2nd July 2021 for an October 2021 start date
For application process see link **Informal applications to**		https://courses.hud.ac.uk/2021-22/full-time/postgraduate/engineering-phd/#topic:00006190_2591 d.d.walker@hud.ac.uk

Project Summary

This studentship concerns research in advanced robotic manufacture of ultra-precision surfaces in glassy materials, required for numerous applications in science, medicine and industry. Fine surface processing involves “rubbing” rather than cutting, is of limited predictability, and still poorly understood. The studentship is associated with a major new EPSRC-funded project to deepen that understanding, by exploring challenging multi-physics, multi-scale science at the interface between computational fluid dynamics and molecular dynamics. This will be informed by controlled experiments with extensive process-monitoring, with modelling reinforced by machine-learning. The end-game is to use real-time process-monitoring to keep processes ‘on track’, reducing manufacturing cost, time and defect-rate.

Background to the research area

The manufacturing context is precise optics such as lenses and mirrors that underpin a huge range of applications, including remote-sensing from space, astronomy, photolithography of semiconductor chips, laser-physics, medical diagnostics, security & defense. In the future, energy from laser-fusion may require huge numbers of optics, with repeated refurbishment due to laser damage. A topical application for mass-produced optics is autonomous electric vehicles, requiring cameras, sensors and advanced lighting.

Today, corrective ultra-precise finishing of most pre-ground glass and similar materials relies on abrasive-slurry processes, due to sheer practicality and versatility. Given the underlying complexities, results are imperfectly predictable (even on CNC machines or robots), requiring repeated and costly iterations of polish⇔metrology. Sometimes, the surface quality regresses for no obvious reason, and unexpected artefacts are common. In attempting to resolve this, there is one key factor over which we have neither knowledge nor control:- the micro and macroscopic details of how abrasive slurry traverses the work-piece/tool interface, particularly for complex surfaces. Flow can be laminar or turbulent, slurry-starvation can occur, and at the other extreme, aqua-planing. These all affect speeds/trajectories of the individual slurry particles carried by the liquid medium through the interface with the part, and so the chemical/mechanical interactions with the glass. These in turn drive the instantaneous material removal rates and their inherent variability.

Context for the student research – the new EPSRC-funded project

EPSRC has awarded a major research grant to a Consortium led by Huddersfield's Laboratory for Ultra Precision Surfaces at Daresbury, in collaboration with the Computational Fluid Dynamics (CFD) group on-campus led by Prof Mishra, the Molecular Dynamics (MD) group at Sheffield Hallam University and the Hartree Supercomputer Centre at Daresbury. The objective is to create the world's first multi-scale model of ultra-precision abrasive processes, demonstrating predictive capabilities that promise to be the key to improve process-convergence. The broad scope of the project involves:-

i) Mechanistic understanding of the physical-chemical contributions to glass polishing
ii) CFD modelling to predict **micro**scopic slurry-particle velocities and trajectories, as input to:
iii) MD modelling, to predict removal-rates at **nano-**scales
iv) Combined in development of a **macro**scopic model to predict removal in real-time
v) Accommodating real-life processing-geometries (flat – to – complex surfaces)
vi) Supported by gathering extensive real-time (DC-300Hz) process-data (forces, torques, acoustics, abrasive-slurry conditions) and post-process data (surface-metrology) on a range of sample parts processed under different conditions.
vii) With machine learning algorithms applied to the accumulated data-base to complement and reinforce modelling

Opportunities for the student's research contribution

We are now seeking a student to work within the multi-institute project team, and contribute to *a* selected aspect of Huddersfield's part of the overall project outlined above.

The preferred – but not the only acceptable – area of work would focus on the exciting opportunity presented by the *interface* between hands-on experimental work, data capture & interpretation, and helping to develop and verify the predictive macroscopic model.

Qualifications and background

We are considering candidates for a funded PhD Studentship, which is open to individuals meeting academic requirements who are eligible for UK home tuition fees. There is considerable flexibility in the specific area(s) in which the successful candidate will contribute to the EPSRC project described above, which in turn will influence the appropriate qualifications and experience. Overall, the project would suit a Mechanical Engineering or Physics graduate with computational, modelling or experimental skills. Degree course-content in Materials Science would be advantageous.

The project will include a significant element of adventure, and the successful candidate will be prepared to tackle unexpected problems, be inventive and willing to stretch beyond past fields of experience. Good written and verbal communication skills in English are essential. Computer literacy is a requirement, alongside a willingness to learn specific modelling codes depending on the detailed project. For the preferred area of work (as above) general competence in experimental technique is required, and training will be provided for safe and effective use of CNC and robot polishing platforms, supporting software and metrology instrumentation.

The studentship will be physically located at the National SciTech Daresbury Science and Innovation Campus (near Warrington), where the Huddersfield Laboratory for Ultra Precision Surfaces is based in a new building, close to the Hartree Supercomputer Centre.