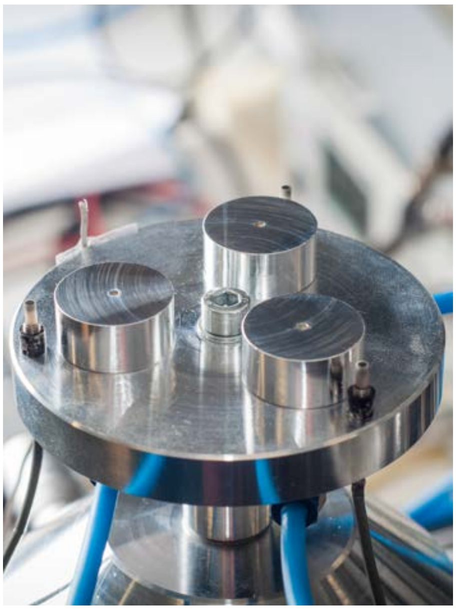
Tribotronics: Design of ‘frequency tuned' air bearings

Challenge: Study the dynamic properties of orifice-restricted air bearings and design an actively controlled air bearing support for a long stroke, high speed, and linear stage.



Background: Air bearings provide an industry standard, trusted support type for linear and planar stages. These bearings are traditionally designed to have a high normal stiffness. In a recent MSc-project an initial investigation into the dynamic properties of orifice-restricted air bearings was performed, resulting in a better understanding of said properties. Using this it is possible to design actively controlled air bearings with a specific combination of load carrying capacity and frequency dependent stiffness and damping. It is time to use this understanding in the improved design of an aerostatic support of a long stroke, high speed, and linear stage.

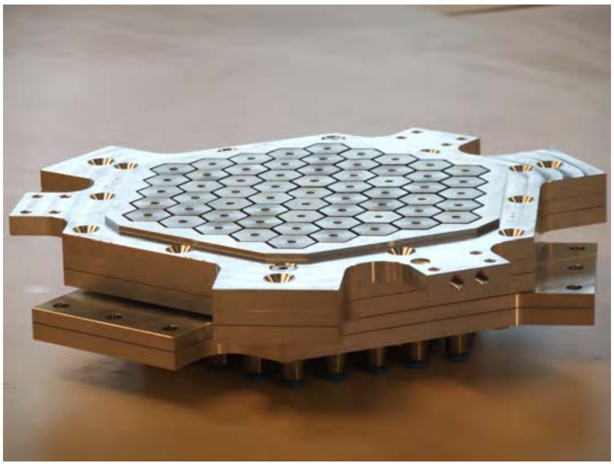
Opportunities: Research development, mathematical model development (COMSOL, Matlab, SimMechanics), experimental verification, and publishing papers.

Please contact for more details:
Ron van Ostayen (R.A.J.vanOstayen@tudelft.nl)
Mechatronics System Design and Tribology (PME)

Tribotronics: Design of a deformable surface contactless handler: Mechanical design

Challenge: Study the properties of the TU Delft contactless handling concept and current implementation in the 'Flower-Bed' and develop the next step in its mechanical design

Background: The innovative contactless handling concept developed in our group provides a method to handle and transport (very) thin products such as Si-wafers, solar cells and foil without any mechanical contact with very high accuracy and speed. In this it is unique in the world!



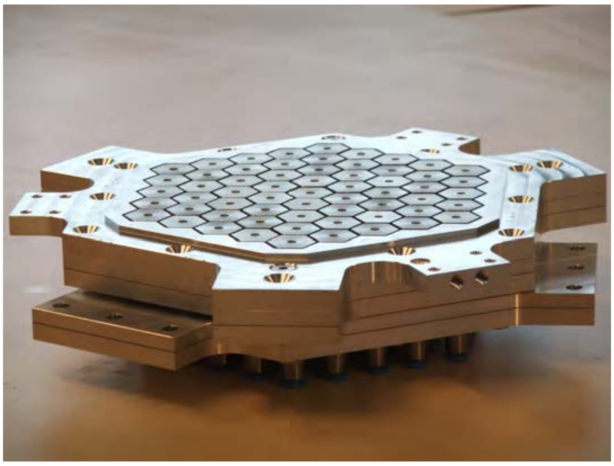
The current status is demonstrated in the Flower-Bed developed in a recent PhD-project and related MSc-projects. The Flower-Bed has a control bandwidth of close to 80Hz, which is ok, but needs to be higher in order to provide the required accuracy. A possible method for this improvement is the re-design of the mechanics of the deformable surface actuator, using static and dynamic balancing techniques and modal analysis.

Opportunities: Research development, mathematical model development (COMSOL, Matlab, SimMechanics), experimental verification, and publishing papers.

Please contact for more details:
Ron van Ostayen (R.A.J.vanOstayen@tudelft.nl)
Mechatronics System Design and Tribology (PME)

Tribotronics: Design of a deformable surface contactless handler: Integrated actuator design

Challenge: Study the properties of the TU Delft contactless handling concept and current implementation in the 'Flower-Bed' and develop the next step in its actuator design



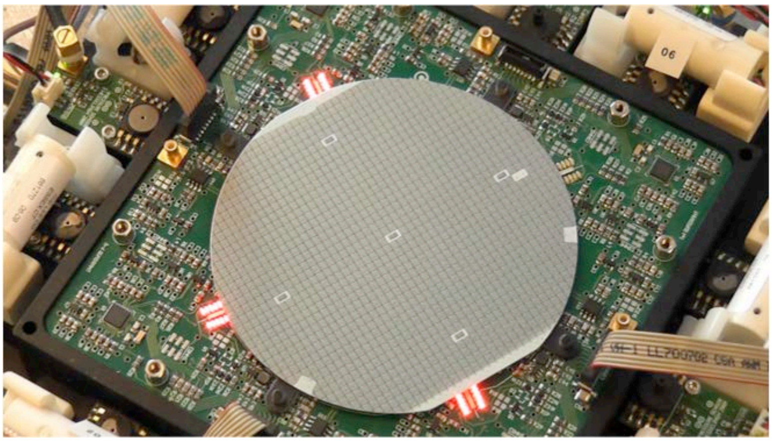
Background: The innovative contactless handling concept developed in our group provides a method to handle and transport (very) thin products such as Si-wafers, solar cells and foil without any mechanical contact with very high accuracy and speed. In this it is unique in the world!
The current status is demonstrated in the Flower-Bed (Figure) developed in a recent PhD-project and related MSc-projects. The Flower-Bed has a control bandwidth of close to 80Hz, which is ok, but needs to be higher in order to provide the accuracy required in future applications. Reluctance actuators are powerful, and low-cost, however with a strong non-linear negative stiffness. A possible compensation for this non-linearity could be a non-linear mechanical spring, incorporated in the design of the deformable surface actuator.

Opportunities: Research development, mathematical model development (COMSOL, Matlab, SimMechanics), experimental verification, and publishing papers.

Please contact for more details:
Ron van Ostayen (R.A.J.vanOstayen@tudelft.nl)
Mechatronics System Design and Tribology (PME)

Tribotronics: Design of a fixed geometry contactless handler: micro-pneumatics

Challenge: Study the properties of the TU Delft contactless handling concept and current implementation in the 'Wafer-Stage' and develop the next step in its pneumatic component design



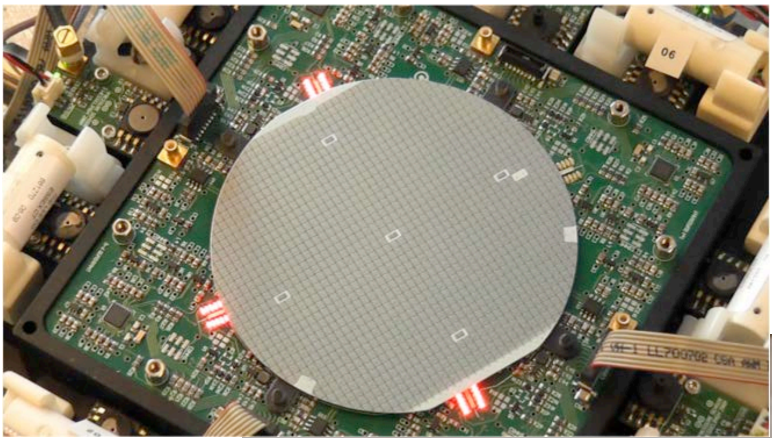
Background: The innovative contactless handling concept developed in our group provides a method to handle and transport (very) thin products such as Si-wafers, solar cells and foil without any mechanical contact with very high accuracy and speed. In this it is unique in the world!
The current status is demonstrated in the 'Wafer-Stage' developed in a recent PhD-project and related MSc-projects. After some iterations the 'Wafer-Stage' has a control bandwidth of close to 80Hz. A possible improvement in both the performance and the manufacturability of the fixed-geometry contactless handler is the further development and integrated design of the pneumatic components (controllable valves and switches), with the purpose of miniaturization and integration of these components in the design of the contactless handler.

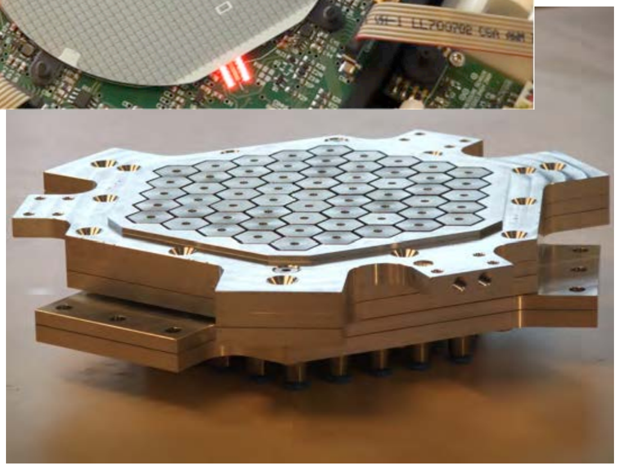
Opportunities: Research development, mathematical model development (COMSOL, Matlab, SimMechanics), experimental verification, and publishing papers.

Please contact for more details:
Ron van Ostayen (R.A.J.vanOstayen@tudelft.nl)
Mechatronics System Design and Tribology (PME)

Tribotronics: Contactless handling of bowed and warped substrates

Challenge: Study the properties of the TU Delft contactless handling concept and current implementation in the 'Wafer-Stage' and 'Flowerbed' and model, check and improve the ability to carry bowed and warped substrates





Background: The innovative contactless handling concept developed in our group provides a method to handle and transport (very) thin products such as Si-wafers, solar cells and foil without any mechanical contact with very high accuracy and speed. In this it is unique in the world!
The contactless handling concept has a high out-of-plane stiffness and is therefore capable to flatten substrates if necessary. However, this capability only kicks in when the substrate is close enough to the system. But how to modify the system so it will successfully pick up strongly bowed and warped substrates? This is an open question that is both challenging and essential in order to bring this concept on to the market.

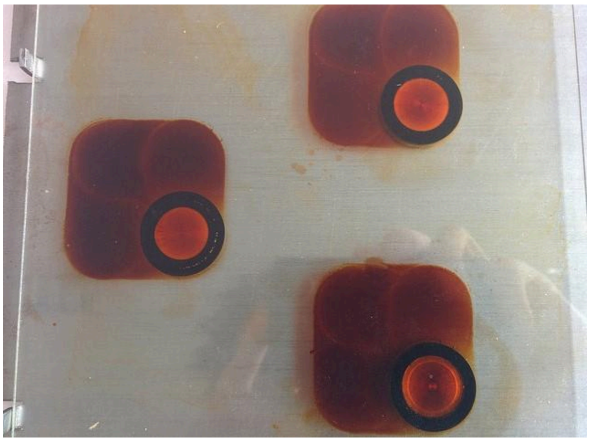
Opportunities: Research development, mathematical model development (COMSOL, Matlab, SimMechanics), experimental verification, and publishing papers.

Please contact for more details:
Ron van Ostayen (R.A.J.vanOstayen@tudelft.nl)
Mechatronics System Design and Tribology (PME)

Development and optimization of Ferro-fluid bearings: Computational modelling

Challenge: Study the current TU Delft ferrofluid bearing modeling and design methods and develop the next step in this computational modeling topic

Background: In the presence of a magnetic field a ferrofluid will exhibit a change in viscosity and show an internal pressure increase. Both effects can be used to design ferrofluid based hydrodynamic or hydrostatic bearings. Ferrofluid hydrostatic bearings seem deceptively simple. Easily constructed and tested, yet very challenging to understand indeed.
The current mathematical models are sufficient for a first understanding of these bearings, however more detailed modeling is required to better understand and qualitatively predict the performance of these bearings.



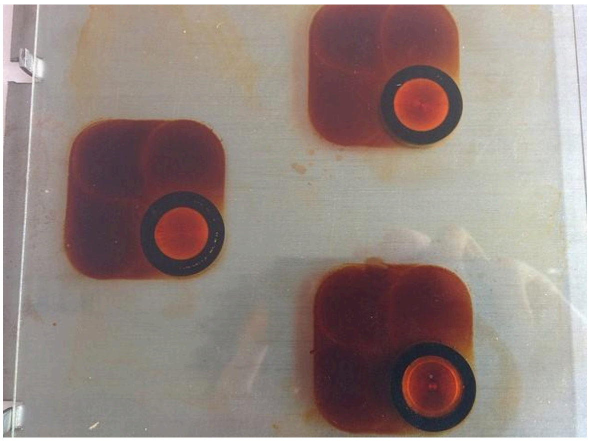
Opportunities: Research development, mathematical model development (COMSOL, Matlab, SimMechanics), experimental verification, and publishing papers.

Please contact for more details:
Ron van Ostayen (R.A.J.vanOstayen@tudelft.nl)
Stefan Lampaert (S.G.E.Lampaert@tudelft.nl)
Mechatronics System Design and Tribology (PME)

Development and optimization of Ferro-fluid bearings: Improving the sealing characteristics

Challenge: Study the current TU Delft ferrofluid bearing modeling and design methods and develop the next step in particular with respect to the sealing characteristics

Background: In the presence of a magnetic field a ferrofluid will exhibit a change in viscosity and show an internal pressure increase. Both effects can be used to design ferrofluid based hydrodynamic or hydrostatic bearings. Ferrofluid hydrostatic bearings seem deceptively simple. Easily constructed and tested, yet very challenging to understand indeed.
Another function of ferrofluids is to seal two compartments relative to each other. The challenge is here to develop methods to increase the sealing performance (maximum pressure difference) of these ferrofluid seals.



Opportunities: Research development, mathematical model development (COMSOL, Matlab, SimMechanics), experimental verification, and publishing papers.

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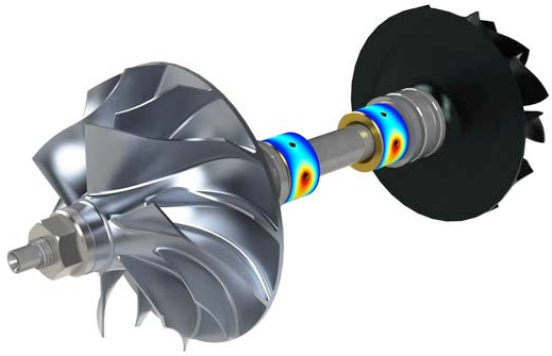
Ron van Ostayen (R.A.J.vanOstayen@tudelft.nl)
Stefan Lampaert (S.G.E.Lampaert@tudelft.nl)
Mechatronics System Design and Tribology (PME)

Design and validation of x-high speed aerodynamic / aerostatic bearings

Challenge: Study the current TU Delft rotor bearing modeling and design methods and develop the theory and design methods for extremely high-speed aerodynamic and/or aerostatic bearings for gas turbine and turbocharger applications

Background: Automotive turbochargers run typically at extremely high rotating speeds, and are usually supported on hydrodynamic floating ring bearings (FRBs). These FRBs are a low cost and high performing solution to a challenging design problem. The main disadvantage of FRBs is however the substantial friction loss at high speeds. Air bearings could do better in this respect?



Opportunities: Research development, mathematical model development (COMSOL, Matlab, SimMechanics), experimental verification, and publishing papers.

Please contact for more details:
Ron van Ostayen (R.A.J.vanOstayen@tudelft.nl)
Rob Eling (R.P.T.Eling@tudelft.nl)
Mechatronics System Design and Tribology (PME)

Tribology and Optimization

Challenge: The combination of tribology and structural and topological optimization is a challenging one. Most of the mathematical models used in full film tribology are (very) expensive, in particular in the study of the dynamical behavior of rotor-bearing systems.

Optimization of systems described using these very expensive models can be reduced in cost by using multiple models, ranging from low-cost / lower quality to high-cost / maximum quality.
This approach is sometimes called LoFi / HiFi modeling and is one of the possible methods to find a robust optimal design for these very complex systems.

Develop and test this method for the optimization of a high-speed rotor-bearing system (turbocharger).

Opportunities: Research development, mathematical model development (COMSOL, Matlab, SimMechanics), and publishing papers.

Please contact for more details:
Ron van Ostayen (R.A.J.vanOstayen@tudelft.nl)
Matthijs Langelaar (M.Langelaar@tudelft.nl)

Tribotronics

Challenge: The combination of mechatronics and tribology is challenging one. Two disciplines that traditionally are not that related are now very much interacting in high precision systems and elsewhere. The development of the understanding, mathematical modeling and experimental validation of this new discipline is one of the focus areas in our group.

Air bearing technology, ferrofluid technology and other advanced bearing solutions are of interest in this research.
Thorough understanding using mathematical modeling using advanced modeling software (e.g. COMSOL, Matlab, SimMechanics) is essential here.

Any topic that (somewhat) matches this description may be studied in our group, and any student is free to suggest these topics.
We might also find a nice topic after exploring your interests and our needs during a meeting.
So let us know if you have a topic or set of interests that might fit!

Opportunities: Research development, mathematical model development (COMSOL, Matlab, SimMechanics), experimental verification, and publishing papers.

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Ron van Ostayen (R.A.J.vanOstayen@tudelft.nl)
Mechatronics System Design and Tribology (PME)