(idw)
idw - Informationsdienst Wissenschaft
Nachrichten, Termine, Experten

Pressemitteilung

Universität des Saarlandes
Claudia Ehrlich

12.03.2025
http://idw-online.de/de/news848860
Forschungs- / Wissenstransfer, Forschungsergebnisse
Elektrotechnik, Energie, Maschinenbau, Werkstoffwissenschaften
überregional

Hannover Messe: Pumps and valves made from ultrathin elastomeric films are lightweight and energy efficient

Miniaturized pumps and valves that rely on the motion of dielectric elastomeric silicone films are being created in Saarland, Germany. Not only are these devices lightweight, compact and energy-efficient, but they also work without the need for compressed air, motors or lubricants. They are cleanroom-compatible and can be continuously controlled while operating. The research team led by Professors Stefan Seelecke and Paul Motzki from Saarland University will be exhibiting a prototype film-based vacuum pump at Hannover Messe from 31 March to 4 April. Their lightweight, low-energy technology is able to pull a vacuum down to 300 millibars of pressure (30% of standard atmospheric pressure).

Vacuum technology is ubiquitous, from the home vacuum sealers used to keep foods fresher for longer to the brake boosters used in cars. Vacuum systems are crucial in the medical field (surgical suction systems), in the pharmaceutical and biotech and foods sectors (freeze drying, distillation, etc.) and in industrial processing (robot grippers that sort products on conveyor belts). Creating a vacuum conventionally requires the use of a motor-driven vacuum pump. But in addition to consuming a lot of energy, these pumps are often bulky and noisy, and need to be serviced and lubricated, which is often difficult in cleanrooms or sterile environments.

The pumps and valves being developed by a research team led by Professors Stefan Seelecke and Paul Motzki at Saarland University and the Center for Mechatronics and Automation Technology (ZeMA) operate entirely without external motors – and consume little energy in the process. At the heart of these devices are thin silicone films that can be moved simply by applying a small electrical voltage. ‘Our technology is cost-effective to manufacture. And because the components are lightweight we save space and weight, meaning that the pumps and valves we’re developing are much more energy efficient than equivalent devices that use conventional technology. Compared with a commercially available pneumatic solenoid valve, i.e. one driven by an electromagnet, we can drive the same valve using 400 times less energy,’ explains Paul Motzki, Professor of Smart Material Systems for Innovative Production at Saarland University and Scientific Director/CEO at ZeMA gGmbH. And the Saarbrücken technology can be manufactured without needing expensive or hard-to-source materials like copper or rare earth elements. Another advantage is noise reduction, with film-based pumps significantly quieter than conventional compressor-driven pumps.

The silicone film itself has a thickness of only about one twentieth of a millimetre and the researchers are able to control the movements of these ultrathin films very precisely. This is because a highly flexible electrically conducting layer is printed onto each side of the film to create what is known as a dielectric elastomer. If the engineers apply a voltage to the elastomer film, the conducting layers attract each other, compressing the polymer and causing it to expand sideways, thus increasing its surface area. ‘We’re using these dielectric elastomers to develop novel drive systems that do not need to be equipped with additional sensors,’ explains Paul Motzki. By varying the applied electric field, the researchers can make the elastomeric film execute continuously variable flexing motions or make it oscillate or flex at some required frequency. Or they can hold the film in a specific fixed position without requiring the continuous supply of energy.

'These dielectric elastomer films are self-sensing and are able to act as their own position sensors,' says Motzki. A precise electrical capacitance value can be assigned to each deformation or change in position of the film. Even the slightest movement of the film results in a change in the capacitance. Using these capacitance values, the engineers are able to precisely quantify the spatial deformation of the film. By combining the capacitance data and AI-based machine learning, the team has developed a control unit that can predict and program motion sequences and thus precisely control how the elastomer film deforms. By incorporating these dielectric elastomer actuators into appropriately designed equipment, the research team are able to create motorless pumps that can pull a vacuum, valves that can deliver exact quantities of liquid, or components that can act as stepless switches.

The capacitance data also reveals if something is not functioning as it should, for example if the vacuum is too small, or if there is a foreign body blocking the valve or pump. These film-based pumps and valves are self-sensing, which means that they can perform their own condition monitoring and report back on where the problem lies. When problems arise with conventional pumps and valves in large-scale industrial plants, trouble-shooting is often considerably more complicated.

The Saarbrücken team are exhibiting at this years' Hannover Messe where they will be demonstrating the latest prototype of their film-based vacuum pump, which can create a vacuum of 300 millibar (about 30% of standard atmospheric pressure). 'Our technology is scalable. We can increase the pressure and volume flow by connecting our actuators and pump chambers either in parallel, in series or a combination of both,' says Professor Motzki. To help visitors to the trade fair visualize the underlying technology, the research team has built a demonstrator model, in which the dielectric elastomer film creates a vacuum inside a bell jar. As the pressure in the jar falls, the visitors can observe the balloon 'inflate' in size – an experimental demonstration that many may remember from their school physics class. As the air is sucked out from around the balloon, the air molecules in the balloon have more space in which to expand and the balloon grows in size – except that in this case it all happens without a loud compressor running in the background.

The Saarbrücken engineers can incorporate their pump and valve technology into a wide variety of equipment designs. The technology is robust and suitable for mass production and could be developed into marketable products within a few years. While at the Hannover Messe, the team will be looking for engage with interested commercial partners.

Hannover Messe, Saarland Innovation Stand, Hall 2, Stand B10

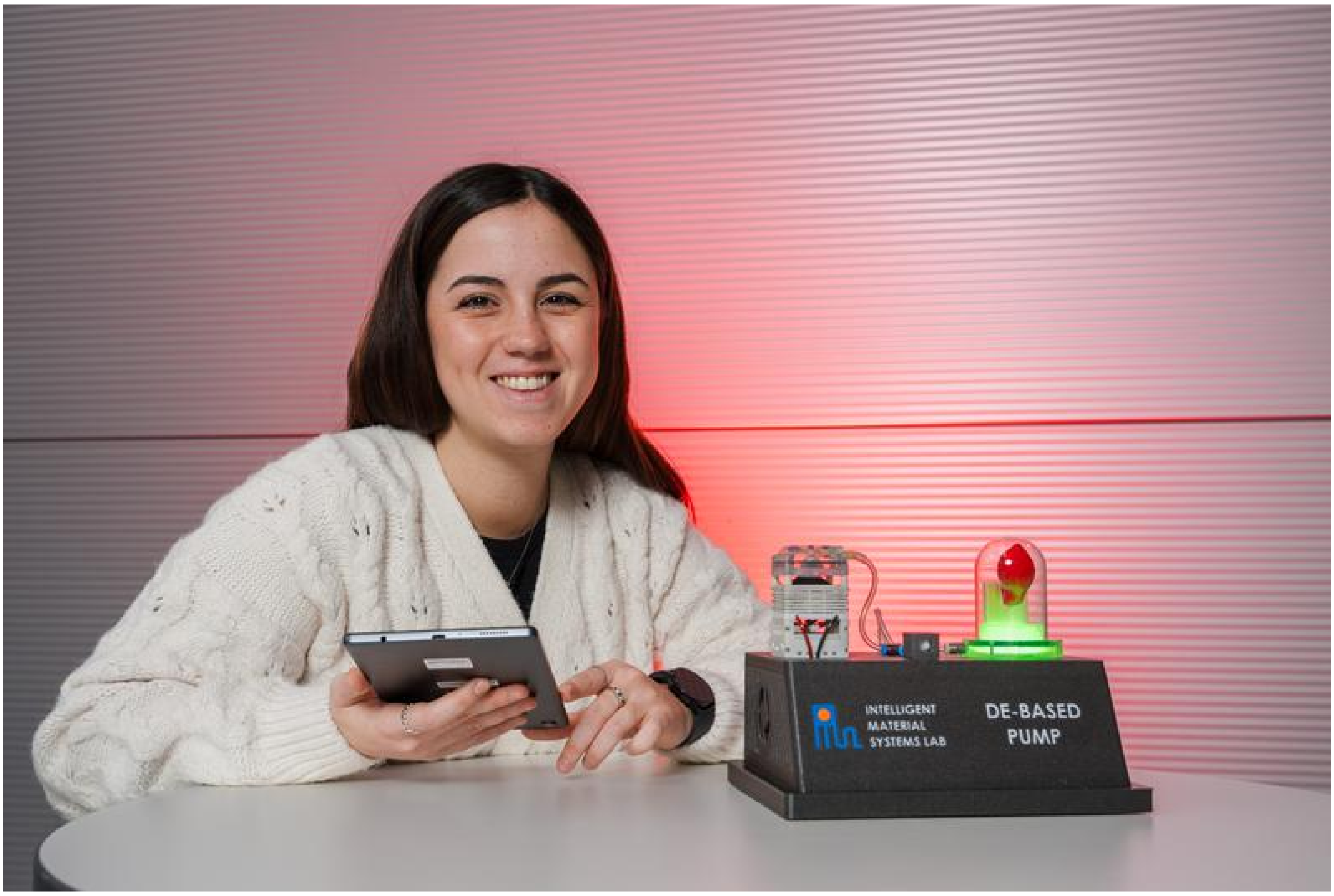
Background
The dielectric elastomer technology continues to be developed by graduate and PhD students conducting research under the supervision of Professors Seelecke and Motzki. The results have been published as papers in a variety of scientific journals. The research work has also received support from numerous sources. Funding from the EU was provided through a Marie Curie research fellowship. The Saarland state government has provided financial support through the ERDF projects iSMAT and Multi-Immerse, and ME Saar (the Association of Metalworking and Electrical Industries in Saarland) has funded a doctoral research scheme. In addition to developing valves and pumps, the research team is using this technology for a wide range of other applications, from robotic grippers and loudspeakers to smart textiles and haptic feedback systems.

To facilitate the transfer of their applications-driven research to commercial and industrial applications, the team established the company 'mateligent GmbH', which will also be exhibiting at the Saarland Innovation Stand at this year's Hannover Messe.

wissenschaftliche Ansprechpartner:
Prof. Dr.-Ing. Paul Motzki: Tel.: +49 681 85787-13; Email: paul.motzki@uni-saarland.de

URL zur Pressemitteilung: https://imsl.de – Intelligent Material Systems Lab

URL zur Pressemitteilung: https://smip.science – Chair of Smart Material Systems for Innovative Production
URL zur Pressemitteilung: https://imsl.de/projekte – Information and videos on research projects
URL zur Pressemitteilung: https://zema.de – Center for Mechatronics and Automation Technology (ZeMA)



The research team is showcasing its latest vacuum pump prototype at this year's Hannover Messe. PhD student Carmen Perri is carrying out research into smart pumps and valves made from ultrathin silicone film.
Credit: Oliver Dietze
Saarland University

Paul Motzki, Professor of Smart Material Systems for Innovative Production at Saarland University and Managing Director at the Center for Mechatronics and Automation Technology (ZeMA).
Credit: Oliver Dietze
Saarland University