MICHAEL G. RUPPERT

Q. How did your education and early career lead to your initial and continuing interest in the control field?

Michael: When I went to the University Open Day at the University of Stuttgart, I wanted to decide whether I should study classical mechanical engineering, electrical engineering, or computer science. However, as I went to Prof. Frank Allgöwer's lecture on automation technology and engineering cybernetics, he produced an endless list of examples where control is found, not just in engineering but also in economics, nature, and human behavior. It then dawned on me quite quickly that I wouldn't have to decide on one subject or the other. Mechatronics combines it all, and the specialization into feedback control systems and control engineering seemed obvious. Throughout my undergraduate studies and while working on my student research projects, I always felt that control theory was the most challenging; this has continued to be a motivating factor and has encouraged me to want to learn more about the field.

Another coining moment was when Prof. Reza Moheimani visited the University of Stuttgart and gave the talk "Dynamics and Control of Nano Systems." Even though I studied microtechnology subjects, it was fascinating to see the level of precision for which control needs to perform when it comes to nanometrology systems. Following his inspiring talk, I joined Prof. Moheimani at the University of Newcastle for my master's thesis and naturally stayed when I received the offer for a Ph.D. fellowship. During my Ph.D. studies, yet another opportunity came when Prof. Moheimani relocated to the University of Texas at Dallas, where I joined him during two research visits before submitting my thesis. In Dallas, I had the opportunity to work on the first silicon-on-insulator single-chip atomic force microscope as well as on atomically

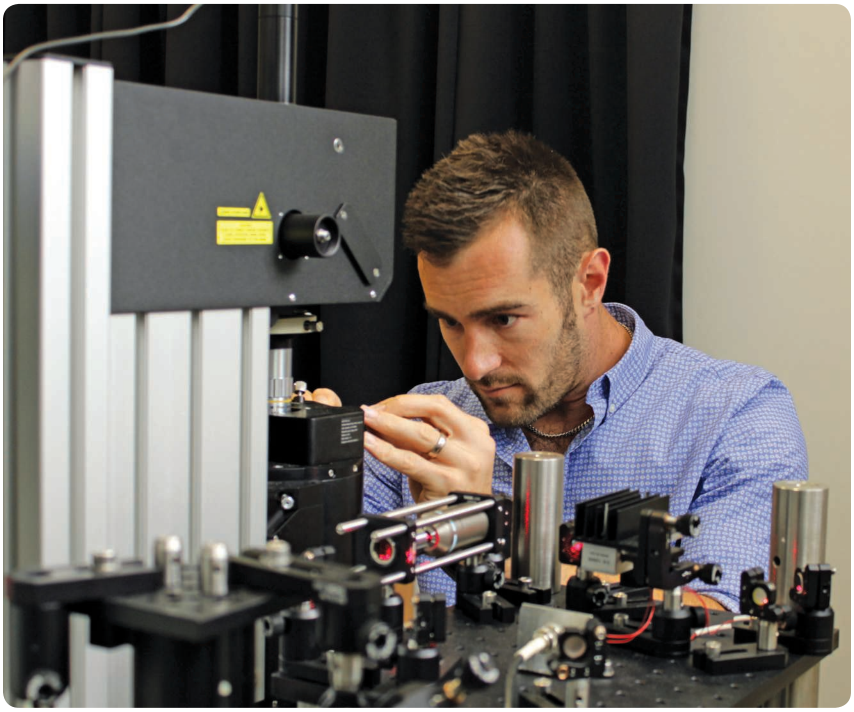
Michael Ruppert at the University of Newcastle, Australia.

precise manufacturing, both topics requiring a high level of mechatronics and control effort.

Q. What are some of your research interests?

Michael: My research topics are situated within the area of microprecision mechatronics and, as such, bridge the gap between classical electrical/control engineering and emerging applications in the field of microelectromechanical systems, high-performance microscopy, and nanotechnology. My recent work has focused on the development of estimation, control, and self-sensing approaches for piezoelectric microcantilevers for multifrequency and single-chip atomic force microscopy.

For instance, one of the crucial bandwidth-limiting components in the z-axis feedback loop of an atomic force microscope is the demodulator. In light of modern multifrequency techniques, we came up with a number of system-theoretic demodulators that outperform traditional methods in measurement bandwidth, multifrequency capability, and distortion. I also work a lot on the design, instrumentation, and control of active microcantilevers. Being able to design cantilevers of arbitrary shape and integrate active actuators and sensors on the chip level opens up a number of possibilities such as optimized deflection sensitivities or guaranteed robust



Michael Ruppert aligning a custom-made probe on a modified tip-enhanced Raman microscope.

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stability when controlling the quality factor of multiple modes. Bringing it all together, one of the most exciting (but also the most time consuming in terms of lab hours) projects I worked on so far was probably the single silicon chip atomic force microscope. It was the culmination of multiple years of research by Prof. Reza Moheimani, Dr. Mohammad Maroufi, Dr. Anthony Fowler, and myself to shrink an entire atomic force microscope onto a square-centimeter footprint.

Michael Ruppert and his wife kayaking through the Abel Tasman National Park in New Zealand.

Q. Congratulations on winning the 2018 IEEE Transactions on Control Systems Technology Outstanding Paper Award! What was this paper about?

Michael: Thank you very much. I am both honored and humbled to have received this award! In multifrequency atomic force microscopy, the microcantilever interacts with the sample at multiple eigenmodes simultaneously and thus enables extraction of topography as well as nanomechanical properties. The paper (coauthored by my former Ph.D. advisor Prof. Reza Moheimani at the University of Texas at Dallas) proposes a robust feedback controller that enables arbitrary control of the quality factor of these modes. This enabled us to improve imaging stability and achieve higher cantilever bandwidth while imaging nanometer features.

Profile of Michael G. Ruppert

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Q. What are some of the most promising opportunities you see in the control field?

Michael: I think there are a lot of opportunities for control engineers in the field of nanometrology and nanomanipulation, two areas that have been rapidly expanding over the past decades. For instance, the atomic force microscope has evolved from a large, expensive, and slow instrument to one that can fit in the palm of your hand or take images of self-assembling molecules in real time. A common theme with instruments that operate at the nanoscale is that their performance heavily relies on feedback loops, which provide a lot of potential for optimization.

Q. What are some of your interests and activities outside of your professional career?

Michael: Being fortunate enough to live in Australia, I enjoy the outdoors, especially the many beautiful beaches, and I take advantage of this as much as possible. My favorite outdoor activity is surfing, for which I don't mind getting up at dawn. I also enjoy (and play) beach volleyball, fishing, and traveling with my wife.

Q. Thank you for your comments.

Michael: You are most welcome. Thank you very much for this opportunity.