Model based Diagnostic and Monitoring of Mechatronic Tilting Devices in a highly complex modular system

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Abstract

A modern high precision semiconductor lithography optics must ensure the possible highest imaging resolution. This challenge requires to develop an optical illumination system with highly complex modular components. A concept of such a system can be based on a facet mirror with an array of tiltable elements, which provides to set optimized illumination shapes. In addition, the monitoring and diagnostic of several hundreds of mechatronic tilting devices becomes a not trivial task and requires advanced mathematical methods. This work introduces a mathematical force model of a mechatronic tilting device, which can be used to effectively check the condition of the device during integration and in the field as well.

The force model presents a linear decomposition of two-dimensional forces into position and current dependencies. Due to observed geometrical and symmetrical properties of the actuator, the Fringe Zernike polynomials can be chosen as a set of basis functions to describe the position dependent parts. The current dependent parts are resolved into a third order polynomial, which is sufficient to consider magnetic saturation behaviour. The Zernike and current terms of the model are parametrized with a set of coefficients, that gets identified from measured force characteristics. This model is a linear clear-cut approach to describe the force characteristics of the mechatronic tilting device in a very compact form.

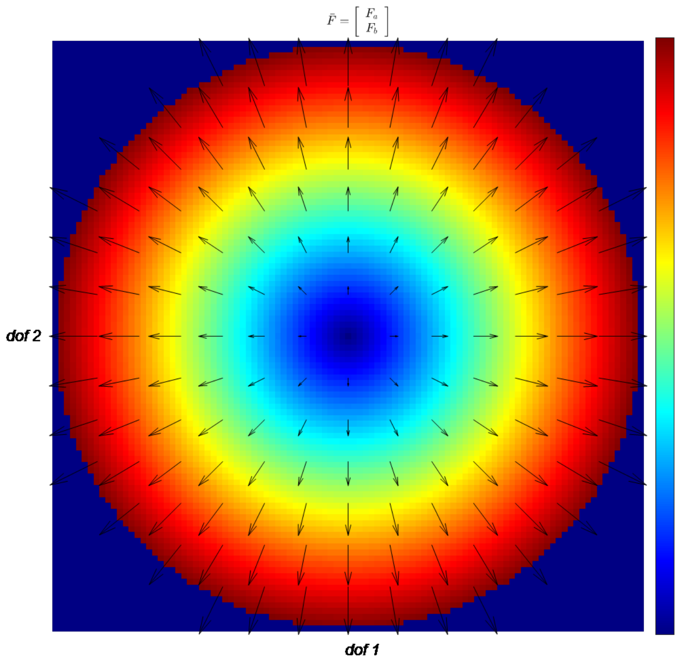

Figure 1: A nominal passive force model of a tilt actuator (color scale shows magnitude of the force vectors)

The nominal parameters of the force model were defined using generalised linear regression from precision measurements of forces, positions, and currents of several serial tilt actuators. The nominal force model was successfully verified. The model is used to define the most important properties like force reserve, power consumption, stiffness, and actuator gain. The model based diagnostic and monitoring approach requires a set of simple position-current measurements. From these data, the residual force contributions (excess force) are extracted by comparison of individual actuators with the nominal model. A repetitive comparison between the nominal model and the actual state of the system is a simple and meaningful monitoring method. Deviations from the nominal model will be systematically analysed, categorised, and assigned to their causes.