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Large range nanopositioning stage design: A three-layer and two-stage platform

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ABSTRACT

In this article, a novel two-dimensional nanopositioning platform (NanoPla) design is described. Its requirements are not only sub-micrometer accuracy for nanotechnology applications, but also long working range (*XY*-motion 50 mm × 50 mm). These features increase the common range operation of devices for nanotechnology issues (e.g. an atomic force microscope), and the number of potential metrological applications: positioning for manufacturing, manipulation or sample characterization. This novel design is characterized by a three-layer architecture and a two-stage motion strategy, which minimizes the measurement error. The manufactured prototype is here justified considering precision engineering principles and a wide state-of-art study of the literature, regarding long range nanopositioning stages. The simulations, the experimental results and the error budget also allowed, first, the optimization and, secondly, the validation of the design at nanometer scale.

Contents

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1. Introduction

Positioning stages act as supplementary units for measuring and manipulating samples at different working ranges. New systems and technologies have been developed to overtake the metrological challenges of accuracy, repeatability and stability when positioning is required at submicrometer or nanometer scale [1,2]. Nonetheless, a wide variety of applications demand not only these hard requirements, but also longer travel working ranges to increase the number of potential manufacturing and measuring tasks [3,4]. To obtain effective positioning, different options of metrological systems are currently available. Some of these systems are adequate for many demanding and accurate operations, but their measuring and positioning range is often very limited [5,6]. This is a drawback for tasks that require working with larger areas in a planar part (solar cells, foils, silicon wafers...), where cutting of specific samples may be necessary.

In order to perform precise and accurate movements along a wide working range, a two-dimensional nanopositioning platform stage (NanoPla) is presented in this paper. Its first application integrates an AFM as a suitable technique for micro- and nanometrology [7], due to the high vertical as well as lateral resolution in the topographic characterization task of specimens. The stage will increase the measuring range of that sort of instruments up to 50 mm × 50 mm, accomplishing nanometer resolution and submicrometer accuracy. A novel concept has been developed in a first prototype, which is characterized by its simpler design and compactness. The long motion range and the three-layer architecture are the main novelties of the design, which, together with a two-stage motion strategy, minimize the measurement error.

This article presents the main features and results after design, manufacturing and assembly of the platform. That includes an extensive review of state-of-art systems described in the literature, and used for similar applications, together with the application of

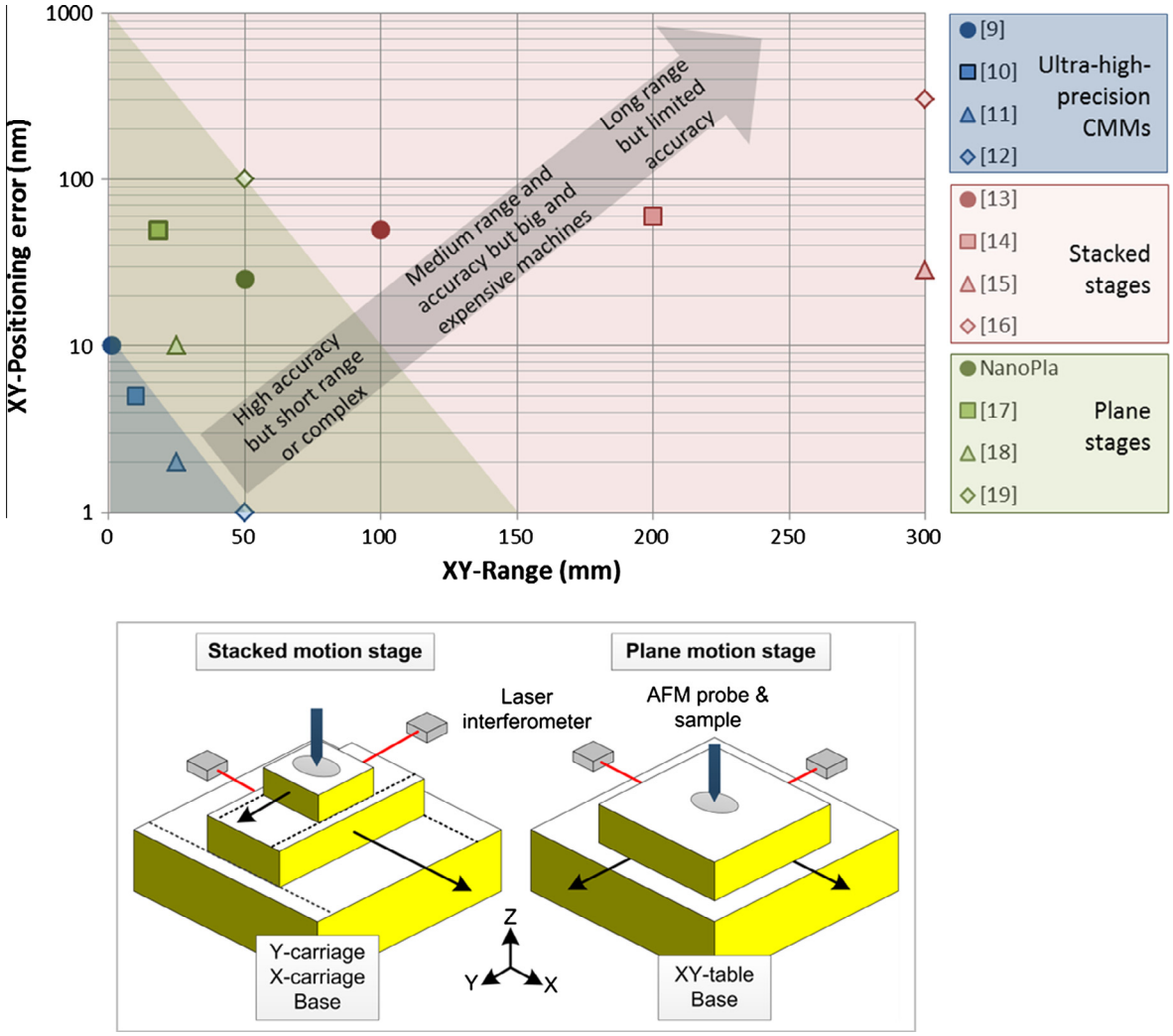

Fig. 1. Nanopositioning stages classification scheme: *XY*-range vs. *XY*-positioning error (up) and stacked and plane motion stages: structural differences (down).