

PHOTONICS spectra®

WHITE PAPERS & APPLICATION NOTES



Nanopositioners: What Are They Good For?

NANOPositioner Applications, Utility, and Functionality Often Are Misunderstood – To the Detriment of Researchers Whose Experiments Might Benefit from Their Stability, Precision, and Repeatability These Instruments Offer.

By Damon Eberhart, Mad City Labs, Inc.

The word “nanopositioner” is a generic, wide-ranging term used to describe different types of motor technology capable of positioning a stage within ranges of tens of nanometers, to even picolitersly single-digit nanometers. Often, the perception is these instruments are highly specialized and only useful in certain scenarios, but that perception is inaccurate.

Users often believe that nanopositioners are primarily used when you need nanometer or better resolution. However, this approach overlooks some of the characteristics of nanopositioners and how they can be used as part of an integrated approach to motion control.

This article addresses the nuances of nanopositioners, how they function, and the extent of their capability. Specifically, it addresses piezo nanopositioners (PNA, piezo stages), so called because of the piezo electric actuator serving as their drive mechanism and differentiating them from positioning systems utilizing other forms of driving motor technology. We also examine how closed-loop feedback control can be applied to a piezo nanopositioner – significantly improving stability, resolution, and repeatability – to push the limits of user precision when controlling a platform at the nanometer scale.

How Does a Closed-Loop Piezo Nanopositioner Work?

Closed-loop piezo nanopositioners are composed of three core components: piezo actuators, flexure, and position sensors.

Piezo Actuators — Piezo actuators act as the driving mechanism for the nanopositioner. Ideally, piezo actuators change dimension in response to an applied voltage. For a multi-layer actuator, the length change of the actuator is dependent on the voltage applied. However, some piezo actuators also have other attributes such as cross-coupling, creep, and hysteresis, which are less desirable in a precision nanopositioner.

Compensating for the hysteresis motion of the bare piezo actuator is an inherent characteristic of piezo actuators, but this nanopositioner system can be corrected using flexure-guided stage designs. Creep is a property of bare piezo actuators resulting from the

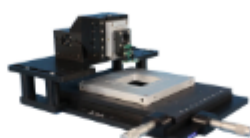


Fig. 1. Schematic of a nanopositioner system consisting of a piezo actuator, flexure, and position sensors. The piezo actuator can be used for AFM and other microscopy techniques, as it allows translation of light through the sample without the need for a coarse approach. The flexure is mounted across the sample surface.

application or withdrawal of applied voltage. The piezo actuator tends to continue moving forward or backward, depending on the direction of motion. For this case, creep leads like the positioner is continuing to move. Fortunately, this effect can be mitigated with position sensors and closed-loop feedback control.

Hysteresis can be defined in a number of ways, but in this context, it is used to describe the non-linear movement inherent to piezo actuators. Similar to piezo nanopositioners, the practical effect is that the actuator takes slightly different paths with each movement. For example, when a piezo nanopositioner's applied voltage is increased, it moves in a non-linear fashion to reach its destination point. When the applied voltage is released, the nanopositioner will return to its original point via a slightly different path, also non-linear. To generate precision motion, the positioner needs to have linear, predictable motion.

Nanopositioning! What is it good for?

This article explores the nuances of piezo nanopositioners, how they function, and the extent of their capability. We also examine how closed-loop feedback control can be applied to a piezo nanopositioner — significantly improving stability, resolution, and repeatability — to push the limits of user precision when controlling a platform at the nanometer scale. Examples of how nanopositioners can be deployed across various industries and environments are given.

DOWNLOAD WHITE PAPER



More White Papers from This Sponsor

- Resonant probe AFM: Uses and Advantages
- Near-Field Scanning Optical Microscopes: Capabilities and Applications
- Atomic Force Microscopy Enhances the Nanoscopy Toolkit

Visit [Photonics Media](#) to download other white papers and learn more about the latest developments in lasers, imaging, optics, biophotonics, machine vision, spectroscopy, microscopy, photovoltaics and more.

www.photonics.com/WhitePapers.aspx

We respect your time and privacy. You are receiving this email because you are a Photonics Spectra magazine subscriber. You may use the links below to manage your subscriptions or contact us.

Questions: info@photonics.com

[Unsubscribe](#) | [Subscribe](#) | [Subscriptions](#) | [Privacy Policy](#) | [Terms and Conditions of Use](#)

Photonics Media, 100 West St., PO Box 4949, Pittsfield, MA 01202-4949

© 1996 - 2021 Laurin Publishing. All rights reserved. Photonics.com is Registered with the U.S. Patent & Trademark Office.

Reproduction in whole or in part without permission is prohibited.



Laurin Publishing

PHOTONICS MEDIA