International Workshop on Advanced Patterning Solutions

Aberration Control Method of Parasitic Force for Ultra-Low Aberration Lithography Lens

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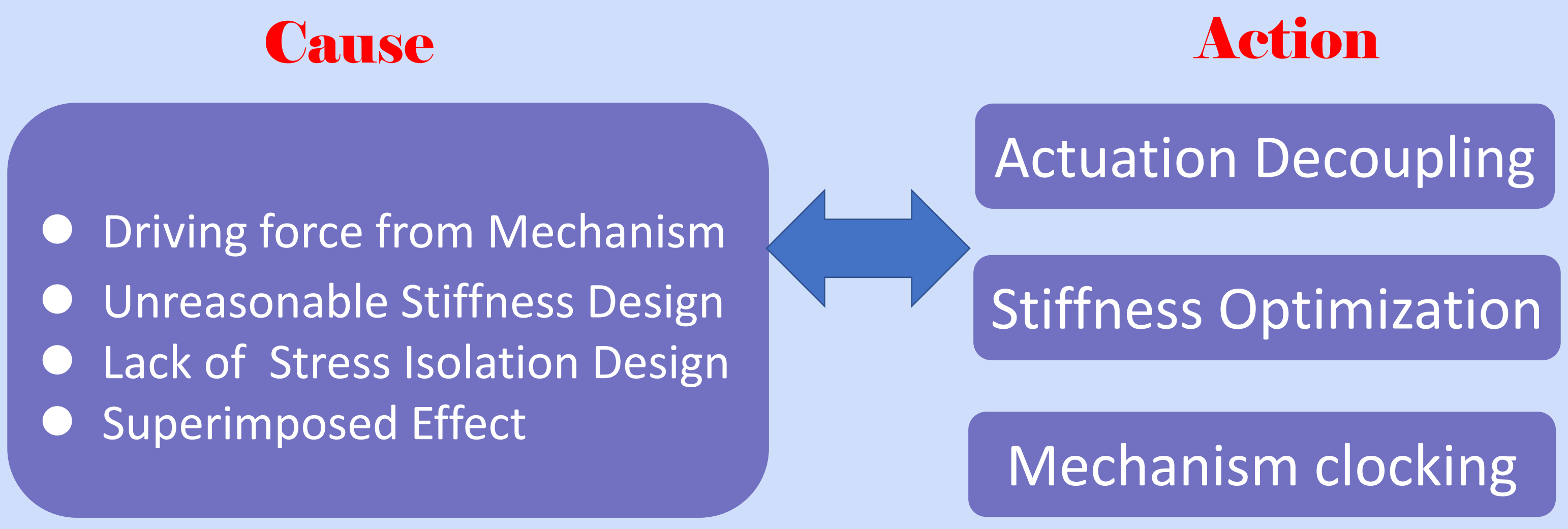
Introduction

- ☼ Projection lithography objective lens has to use more adjusting mechanism units for image quality compensation facing higher lithography nodes.
- ☼ The mechanism will induce aberration and distortion during working due to the parasitic force.
- ☼ The generation mechanism and suppression method of the parasitic force in the adjusting mechanism are studied and optimized to meet the requirements of ultra-low aberration of leading-edge microlithography.



Cause

- Driving force from Mechanism
- Unreasonable Stiffness Design
- Lack of Stress Isolation Design
- Superimposed Effect

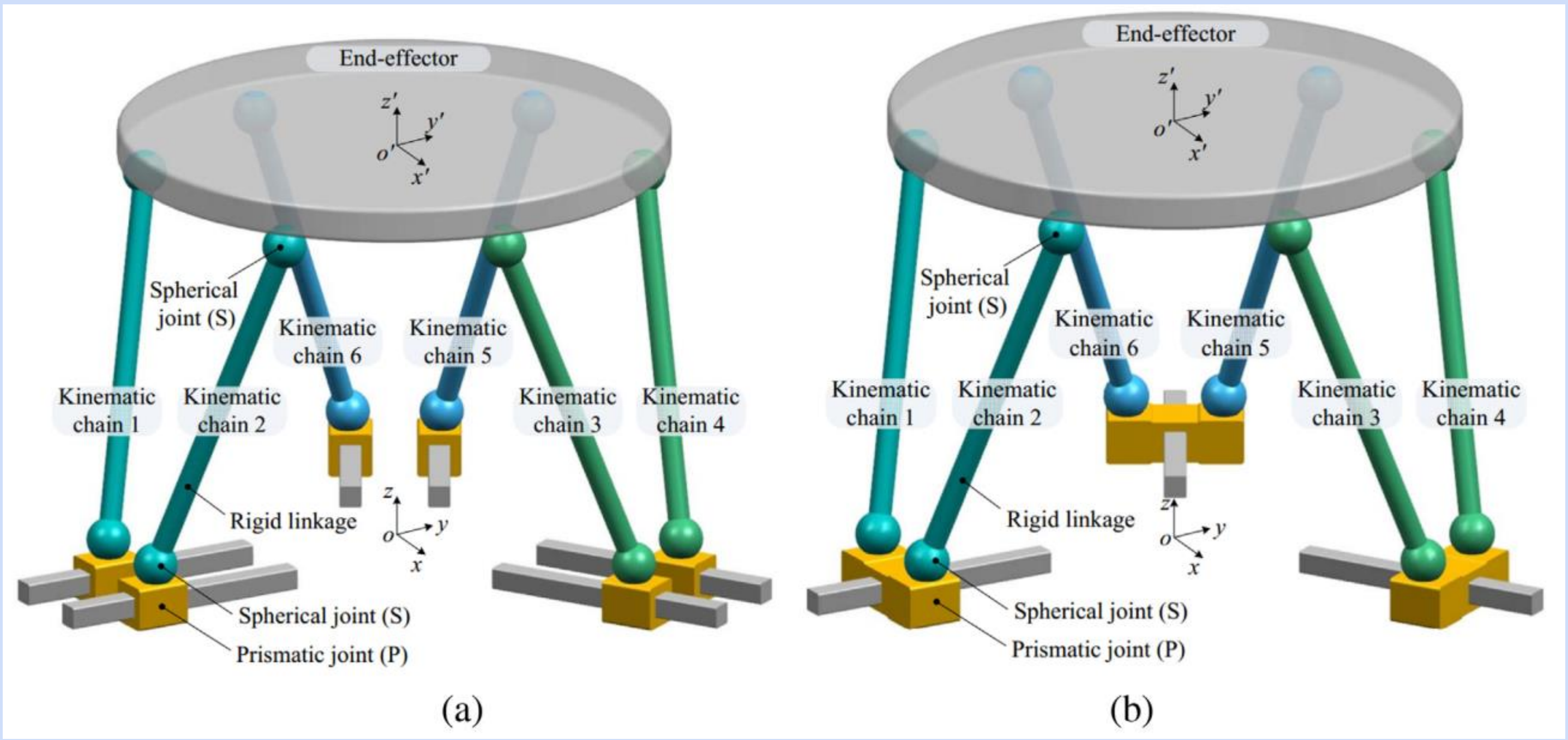
Action

- Actuation Decoupling
- Stiffness Optimization
- Mechanism clocking

Methods used to control aberration from parastitic force

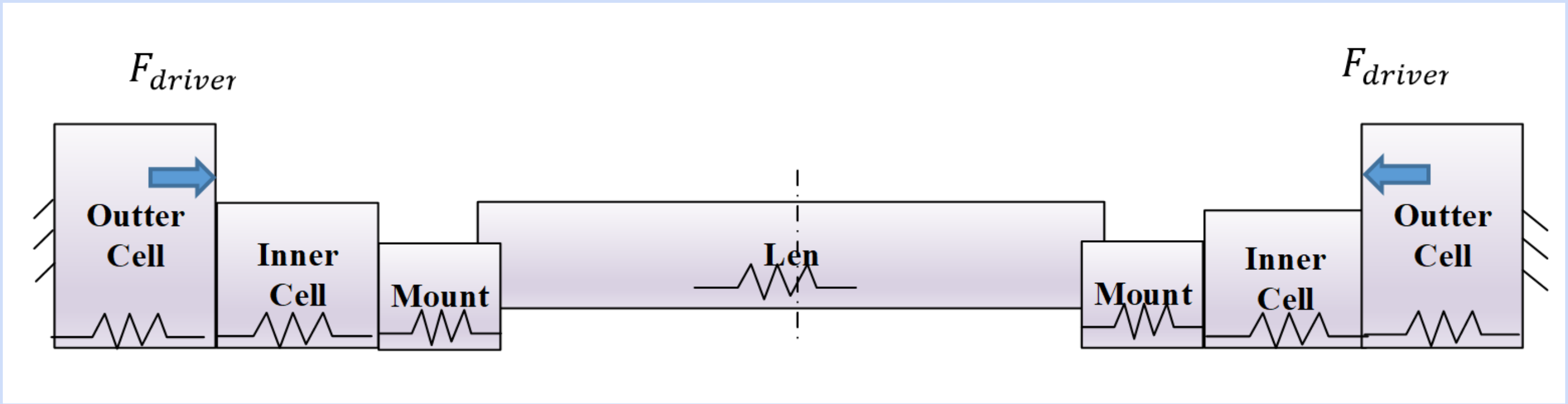
Kinematic Constraint Coupling Design

- ☼ A ultimate way to prevent deforming the lens from the parasitic force is kinematic coupling connection design.
- ☼ We use this design between outer cell and inner cell connection in the mechanism to avoid deformation during working.
- ☼ The mechanism coupling force can also be canceled through reasonable kinematic constraint .

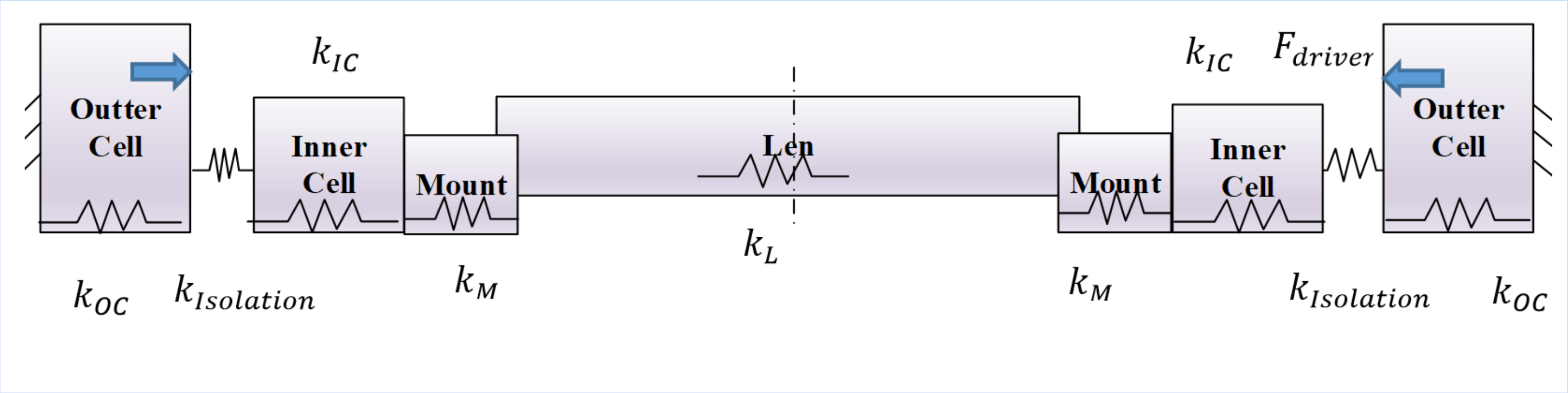


Two kinematic constraint configurations

Sturcture of mechanism Optimization

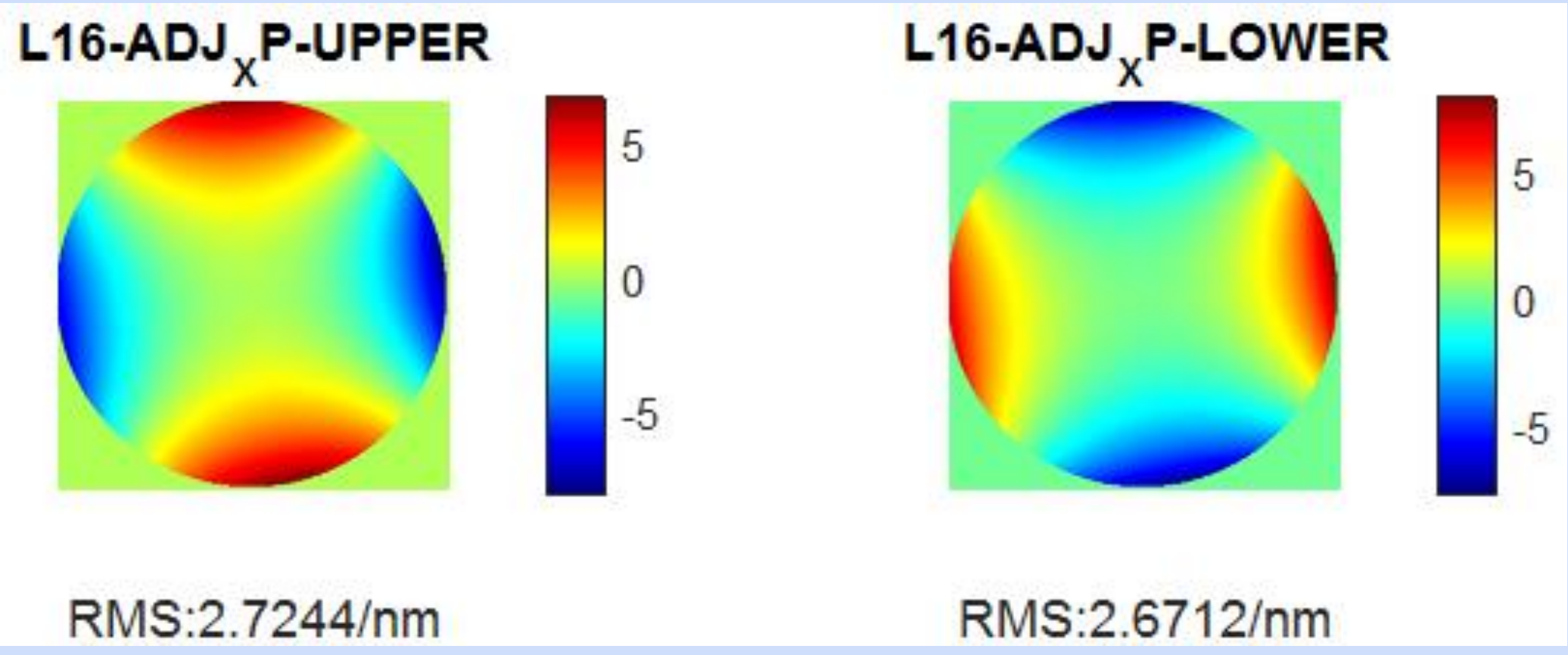


- ☼ Adjusting mechanism units in lithography objective lens can driver the lens in multi DOF direction .
- ☼ In the previous design, driver force will deform the lens directly due the stiffness during the adjusting process .



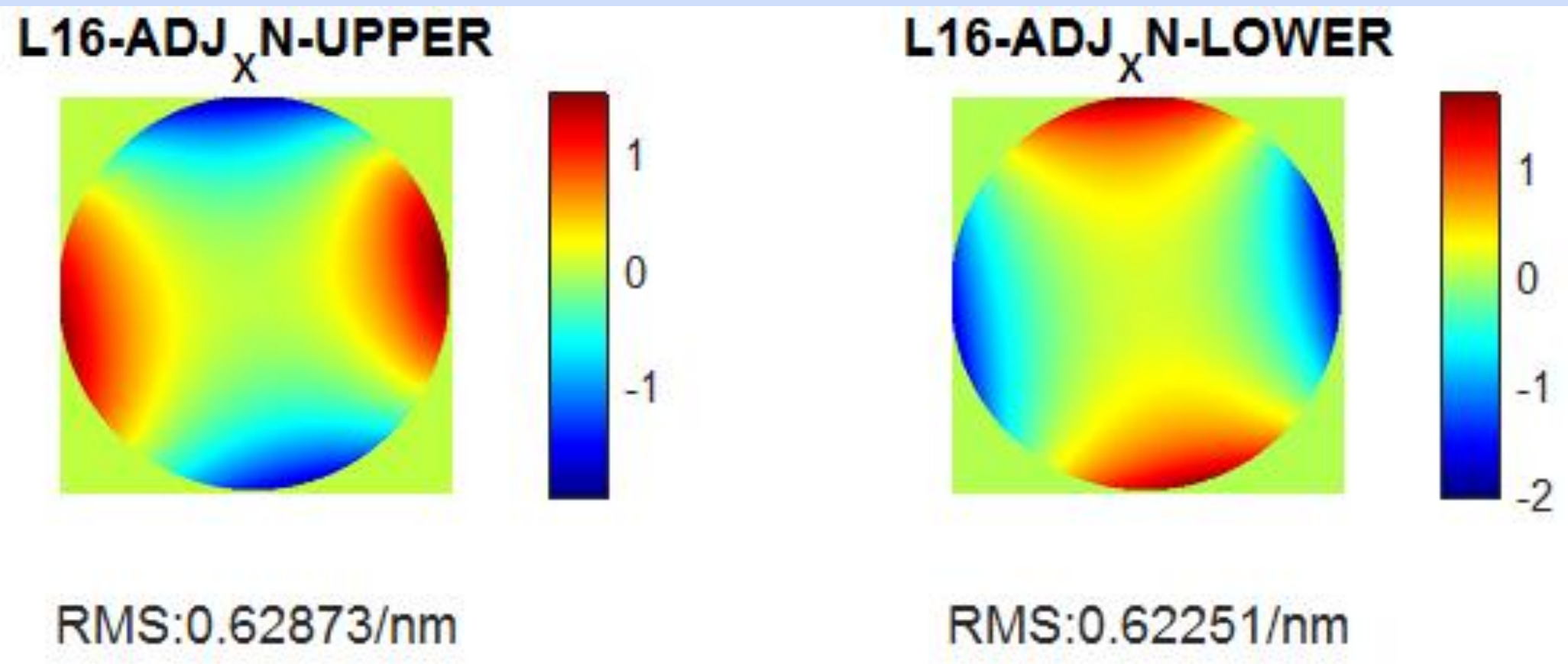
- ☼ After optimization design, there is a Stress Isolation Design（$k_{Isolation}$ is added).
- ☼ Driver force will not deform the lens directly because the force is decreased through the SID.
- ☼ Stress Isolation Design is achieved through stiffness design of the cell, mount and mechanism flexure.

Results



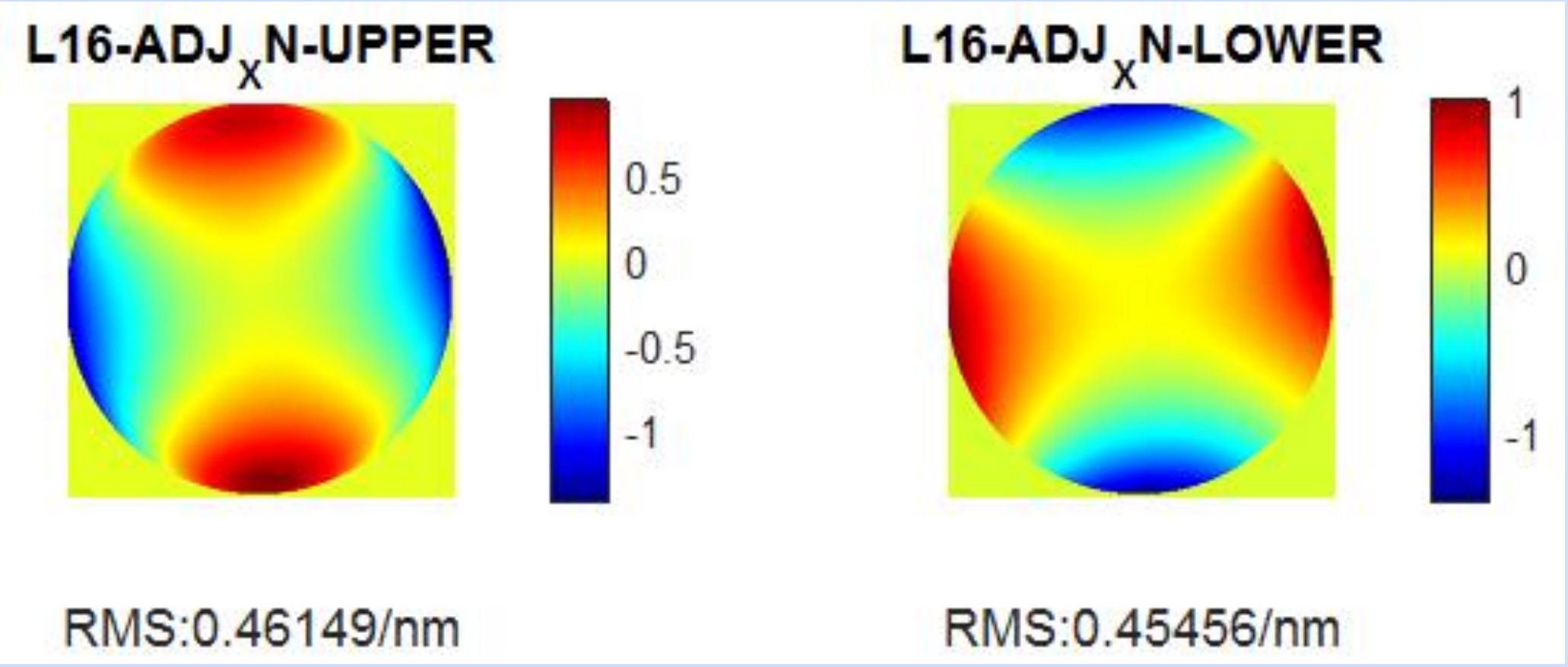
RMS:2.7244/nm RMS:2.6712/nm

Origin rigid design caused figure of 6 DOF mechanism



RMS:0.62873/nm RMS:0.62251/nm

Stiffness and isolation design caused figure of 6 DOF mechanism



RMS:0.46149/nm RMS:0.45456/nm

Kinematic Coupling design caused figure 6 DOF mechanism

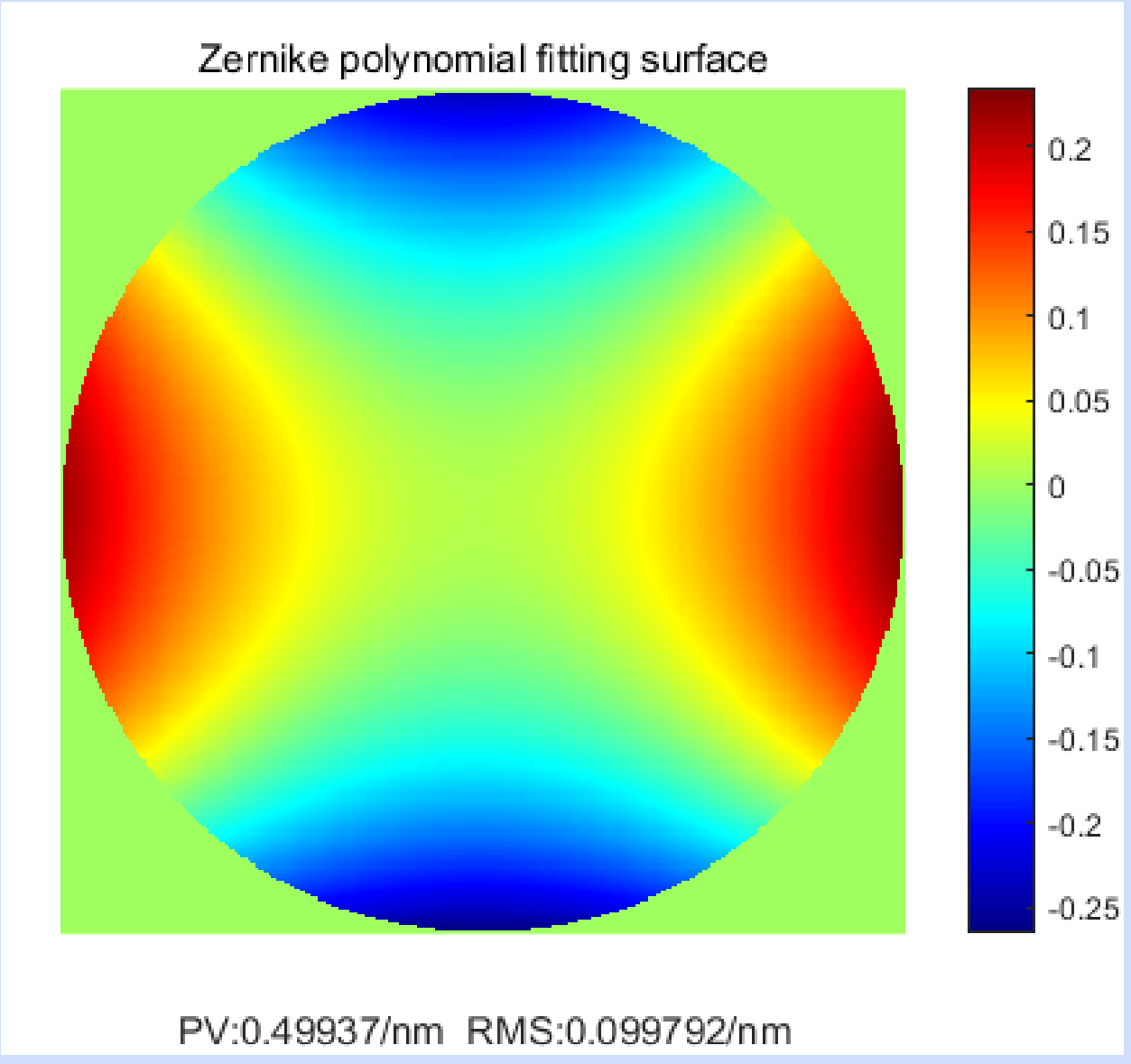
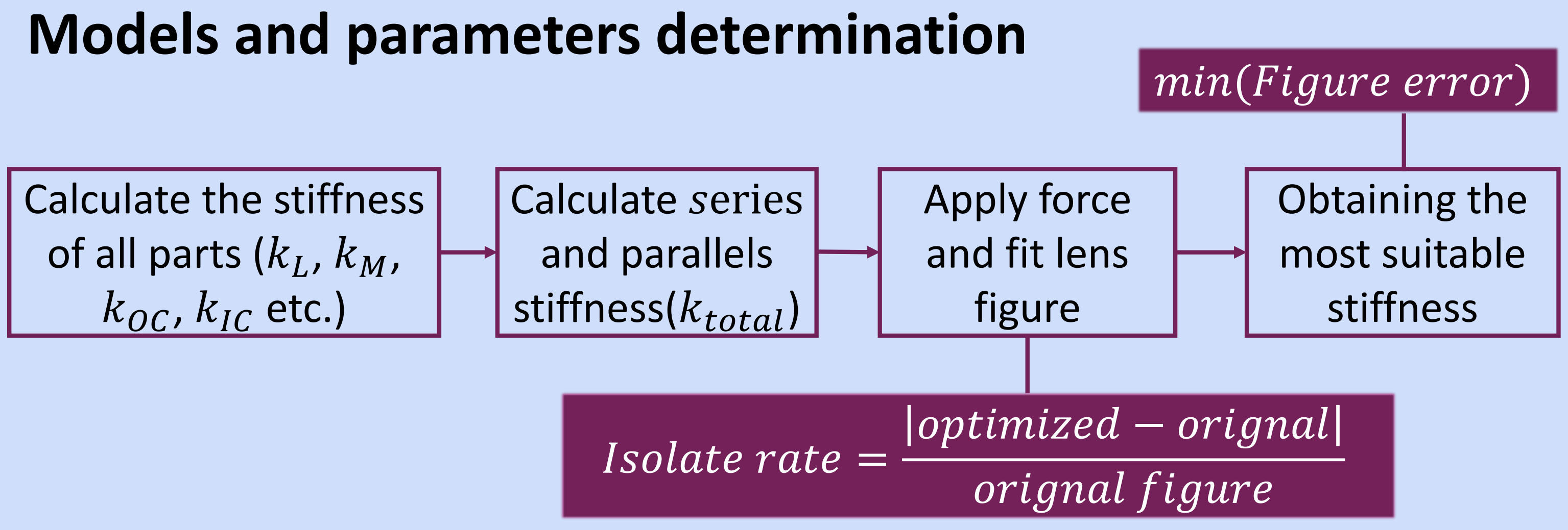


Figure introduced by Z-manipulation aberration controller

Models and parameters determination



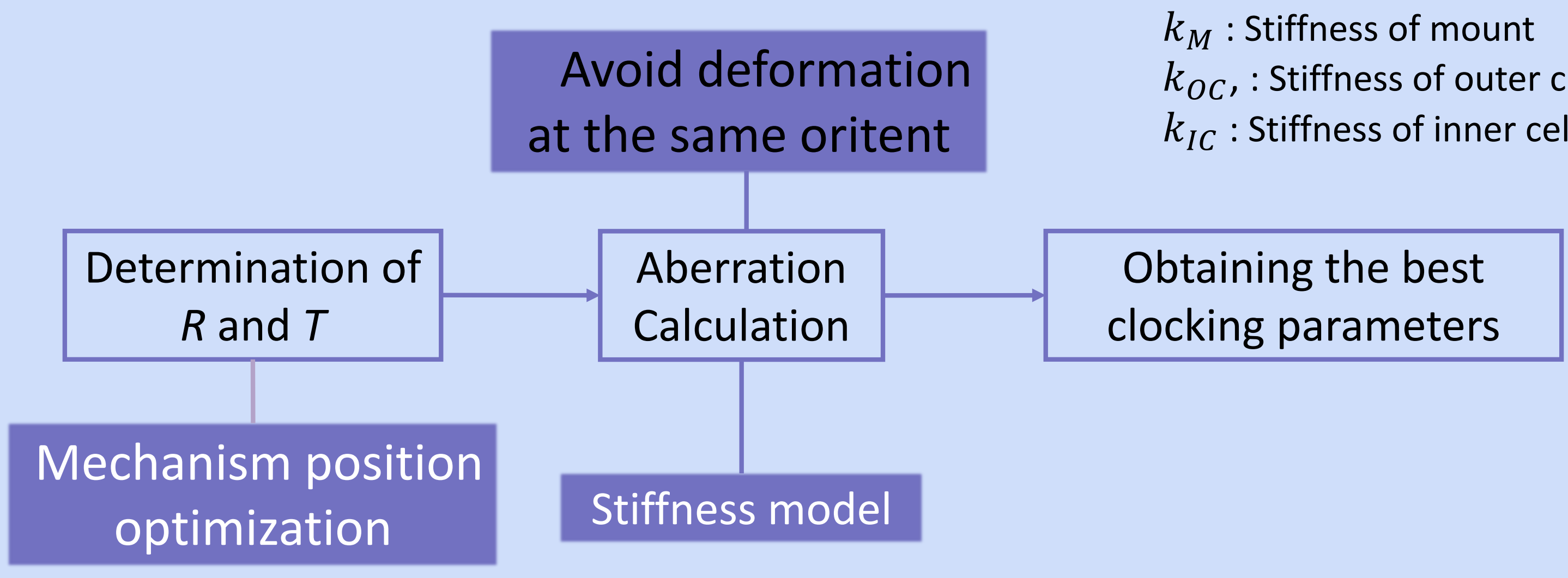
$min(Figure\ error)$

Calculate the stiffness of all parts (k_L, k_M, k_{OC}, k_{IC} etc.) → Calculate *series* and parallels stiffness(k_{total}) → Apply force and fit lens figure → Obtaining the most suitable stiffness

$$Isolate\ rate = \frac{|optimized - orignal|}{orignal\ figure}$$

Determination process of the mechanism Stiffness models

k_L : Stiffness of lens
k_M : Stiffness of mount
k_{OC}, : Stiffness of outer cell
k_{IC} : Stiffness of inner cell



Avoid deformation at the same oritent

Determination of *R* and *T* → Aberration Calculation → Obtaining the best clocking parameters

Mechanism position optimization

Stiffness model

Estimation of the mechanism assembly angle

Conclusions

- ☼ The biggest source of the parasitic force is unreasonable stiffness design.
- ☼ Mechanism stiffness optimization can be used to reduce the deformation induced by the parasitic force.
- ☼ Kinematic constraint design is also a good choice to avoid deforming lens.
- ☼ Through the reasonable clocking between the mechanisms, the wavefront aberration caused by parasitic force will not overlying.
- ☼ The figure of lens induced by the parasitic force in the Z-manipulation aberration controller is less than 0.1nm RMS and the ultra-low aberration is achieved for the leading-edge lithographic projection objective

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2. Wavefront aberration compensation of projection lens using clocking lens elements [J] . ChunLai Liu, Wei Huang, Zhenguang Shi, Applied optics .

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