**Automated design and global optimization of projection lenses**

**for lithography based on global search algorithms**

N. Zoric, I. Smirnova and A. Kuleshova

*National Research University ITMO: Information Technologies, Mechanics and Optics, St. Petersburg, Russia*

nenadz@itmo.ru

Global optimization strategies in lens design are radically enhanced by novel features and implemented algorithms over the last six decades. Available computer power boosted the interest in development of new tools for global optimization strategies that can overcome the barriers of merit function around the local minimum. Nevertheless, as the number of variables grows, even the local optimization begins to be extremely time-consuming process, and it becomes challenging task to apply such a tool in lens design.

We describe the method based on global search algorithm that can be successfully used in design of complex systems, such as lithographic objectives with more than 20 lenses. The well-known grouping method is splitting the complex optical system, into more subsystems with moderate complexity [1]. We explored a few approaches which allow that a smaller number of variables distributed on two subsystems simplify design of complex lithographic lens and increase the applicability of global search algorithm.

A shortcoming of developed method is that we first generate two starting points of photo-objectives in the UV spectrum with maximum of 15 lenses. More in detail, we build macros in Synopsys OSD lens design software and run global search of two separate modules [2].

The most challenging parameters of macro input to be adjusted and determined in macro are: the field of view, a number of lenses, length of objective and glass material. Developed method consist of few steps and stages which should formalize the writing of macro input.

In Step 1, we calculate the characteristics of both parts at object side, field of view and semi-aperture. This is the easier part of adjusting input parameters of macro by assuming a point where the two parts to be connected.

In Step 2, we run a series of simulations that sweep through the possibilities of starting designs adjusting the number of lenses and total length of optical module. Ideally, these simulations by Design Search should determine a set of input parameters where the transversal aberrations, over entire field, will be less than 0,005 mm. In Step 3. we combine the separate parts in one optical scheme obtaining the starting point of lithographic objective for further global optimization which tends to provide adequate quality, while maintaining moderate system length and size.

While the traditional design methods lead to designs with very complex theoretical analysis of separate modules which is not inevitable, our modified grouping design method relay on effectiveness of global search algorithm [3]. The final key advantage of proposed design approach is that we generate significantly more starting points of microlithographic objective, that can be analyzed with further optimization leading to the best solution, in less time-consuming process.

REFERENCES

[1] W. Ulrich, H.J. Rostalski, and R. Hudyma, Development of dioptric projection lenses for deep ultraviolet lithography at Carl Zeiss, J. Microlithogr. Microfabr. Microsyst. 3(1), 2004.

[2] N. Zoric, I. Livshits, D. Dilworth, S. Okishev, Design of an ultraviolet projection lens by using a global search algorithm and computer optimization , Adv. Opt. Techn. 2016.

[3] D. C. Dilworth, D. Shafer, Man versus Machine; a Lens Design Challenge, SPIE Vol. 8841. 2013.