

# Surface Damage Correction, and Atomic Level Smoothing of Optics by Accelerated Neutral Atom Beam (ANAB) Processing

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## ABSTRACT

Surface damage and surface contamination of optics has long been a source of problems for laser, lithography and other industries. Nano-sized surface defects may present significant performance issues in optical materials for deep UV and EUV applications. The effects of nanometer sized surface damage (scratches, pits, and organics) on the surface of optics made of traditional materials and new more exotic materials is a limiting factor to high end performance. Angstrom level smoothing of materials such as calcium fluoride, spinel, zinc sulfide, BK7 and others presents a unique set of challenges. Exogenesis Corporation, using its proprietary Accelerated Neutral Atom Beam (ANAB) technology, is able to remove nano-scale surface damage and contamination and leaves many material surfaces with roughness typically around one angstrom. This process technology has been demonstrated on nonlinear crystals, and various other high-end optical materials. This paper describes the ANAB technology and summarizes smoothing results for various materials that have been processed with ANAB. All surface measurement data for the paper was produced via AFM analysis.

Exogenesis Corporation's ANAB processing technology is a new and unique surface modification technique that has demonstrated to be highly effective at correcting nano-scale surface defects. ANAB is a non-contact vacuum process comprised of an intense beam of accelerated, electrically neutral gas atoms with average energies of a few tens of electron volts. The ANAB process does not apply normal forces associated with traditional polishing techniques. ANAB efficiently removes surface contaminants, nano-scale scratches, bumps and other asperities under low energy physical sputtering conditions as the removal action proceeds. ANAB may be used to remove a precisely controlled, uniform thickness of material without any increase of surface roughness, regardless of the total amount of material removed. The ANAB process does not involve the use of slurries or other polishing compounds and therefore does not require any post process cleaning. ANAB can be integrated as an in-situ surface preparation method for other process steps in the uninterrupted fabrication of optical devices.

**Key Words:** super-polish technique, accelerated neutral atom beam, ANAB, lateral sputtering, angstrom smoothing