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Nikon's 157 nm Technology — Status and Plans

28 January 2004, Lithography Forum

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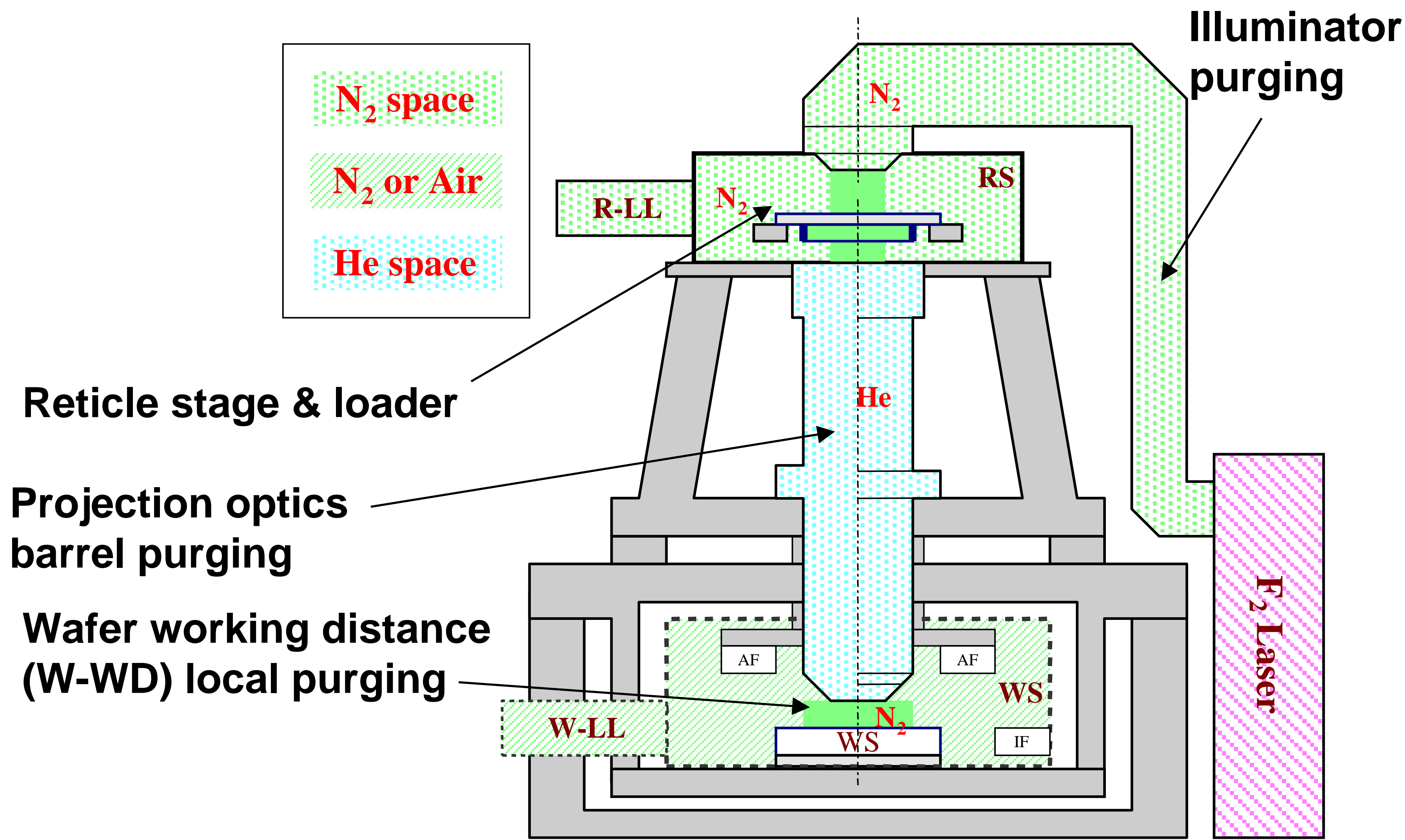
Overview

- Introduction
- Nikon's 157 nm (F_2) development history and status
- Relationship with 193 nm immersion lithography and EUVL programs
- Going forward: Nikon's future 157 nm work

Introduction

- **Nikon's F_2 (157 nm) program has reached the commercialization stage. But …**
- **Successful work with ArF (193 nm) immersion means no immediate need for F_2.**
- **So: what next for F_2 and why?**

Schematic — Nikon's F_2 Optics and Body



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Some F_2 Background, Nikon's Perspective

- Early recognition of practicality of an F_2 excimer laser in 1998
- Nikon began exploratory work on F_2 in 1998
  - with hi-NA all-CaF_2 optics, AR coatings, rigorous purging
- Further, the industry recognized that F_2's wavelength brings almost the same intrinsic resolution progression that ArF brings over KrF.
  - However, with the need now for CaF_2, no other practical transparent material.
  - And the need developed for catadioptric designs to achieve very high NAs. (No practical, high-NA, all-mirror design.)
  - And difficulties in finding soft pellicles, with the "band-aid" of relatively thick hard pellicles (acting as optical elements)
  - And practical F_2 resists with practical thicknesses difficult to develop.

Some F_2 Background (cont.)

- **Then, spring/summer 2001, NIST informed the industry that stress birefringence in CaF_2 isn't the main problem: need to deal with *intrinsic* birefringence.**
  - **Causing some major development delays in CaF_2 production with new crystal orientations and new projection lens designs.**
- **Hard pellicles, 0.8 mm thick, require attention paid to thickness and tilt variations from mask to mask.**
  - **Pellicles are now optical elements.**
- **Stringent requirements also placed on "complete" purging of the illumination and projection lens areas to remove unwanted residual gases and leave relatively inert gas; without setting up side effects.**

Some F_2 Background (cont.)

- **Further, high-quality CaF_2 material yields remain only barely acceptable, with cost consequences.**
- **Adding it up:**
  - Cost of F_2 litho tool manufacturing (complexity, CaF_2 costs, etc.)
  - Immaturity of mask industry infrastructure, including pellicles and related metrology
  - Immaturity of resist supply
  - Availability of an extension to ArF: Immersion
- **Nevertheless, Nikon would be ready to manufacture an F_2 lithography tool, with IB compensated.**
- **However, the F_2 program's date of full commercial introduction with a commercial infrastructure slips, while ArF immersion appears to be lower risk.**

F_2's relationship to ArF Immersion

- **Nikon has been developing an ArF immersion proof of concept since early 1997, as a plausible extension to conventional ArF technology.**
- **Benefits are obvious**
  - **Lasers, optical design technology, most of the body technology, extensions to existing ArF resists, preservation of the mask industry infrastructure and the IC fab engineering activities**
  - **Schedules appear to be much more reasonable, with lower risks as compared to F_2 technology.**
- **Nikon has decided to prioritize commercial development of ArF immersion over F_2.**
- **What, then, for F_2?**

Nikon's plans for further F_2 work

- **The F_2 tool development is relatively mature**
  - **Much of the effort, particularly the catadioptric lens design technology and advancements in body designs are applicable to ArF immersion.**
  - **Thus, there's rationale to preserve a low-level effort on F_2 as an ArF immersion backup and possibly for special IC fab applications requiring dry lithography.**
  - **This level of effort is cost-effective and affordable.**
- **With a successful ArF immersion technology, F_2 becomes a possible backup for EUVL.**
  - **But will need F_2 immersion designs.**

Nikon's plans for further F_2 work (cont.)

- **Thus, Nikon's main work on F_2 will be to investigate possible fluids for 157 nm immersion lithography**
  - **Needs compatibility with an immersion design, 157 nm wavelength, CaF_2, resists, and with a sufficiently high index of refraction .**
  - **Look at optical properties: transparency, index (n), dn/dT, homogeneity (also lot to lot), etc.**
  - **Look at physical, chemical properties: viscosity, surface tension, vapor pressure, contact angle on resist, compatibility with resist chemistry and with lens element AR coatings, etc.**
  - **Cost: needs to be acceptable.**

Relationship with EUVL

- **Nikon expects to complete development of our initial EUVL tools in 2006.**
  - **A successful industry acceptance of cost-effective EUVL with a commercial infrastructure (masks, resists, EUV source, metrology, etc.) will replace any F_2 potential.**
- **However, with the current F_2 technology successes, F_2 immersion can serve as a backup for EUVL**
  - **Needs an immersion fluid, of course.**
  - **It is cost-effective to maintain the needed low level of effort to preserve this backup option.**

Summary

- **Nikon's relatively mature F_2 tool development is not matched yet with sufficiently mature infrastructure.**
  - **Hence, ArF immersion is a more attractive current lithography option.**
- **F_2 dry and immersion can serve as backups first to ArF immersion and then to EUVL.**
  - **At relatively low, affordable cost.**
- **Nikon plans to keep our mainstream lithography programs as industry's preferred IC fabrication solutions.**
  - **Plus cost-effective backups, wherever practical.**

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