



US007309870B2

(12) **United States Patent**
Omura

(10) **Patent No.:** **US 7,309,870 B2**
(45) **Date of Patent:** **Dec. 18, 2007**

(54) **PROJECTION OPTICAL SYSTEM,
EXPOSURE APPARATUS, AND EXPOSURE
METHOD**

(75) Inventor: **Yasuhiro Omura**, Kumagaya (JP)
(73) Assignee: **Nikon Corporation**, Tokyo (JP)
(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **11/583,934**
(22) Filed: **Oct. 20, 2006**

(65) **Prior Publication Data**
US 2007/0037080 A1 Feb. 15, 2007

Related U.S. Application Data
(63) Continuation of application No. 11/266,288, filed on Nov. 4, 2005, which is a continuation-in-part of application No. PCT/JP2004/006417, filed on May 6, 2004.
(60) Provisional application No. 60/721,582, filed on Sep. 29, 2005.

(30) **Foreign Application Priority Data**
May 6, 2003 (JP) 2003-128154
Oct. 9, 2003 (JP) 2003-350647
Oct. 24, 2003 (JP) 2003-364596

(51) **Int. Cl.**
G02B 17/00 (2006.01)
G02B 3/00 (2006.01)
(52) **U.S. Cl.** **250/492.2**; 250/492.3;
359/730; 359/364; 359/365; 359/726; 359/649;
359/350; 355/53

(58) **Field of Classification Search** None
See application file for complete search history.

(56) **References Cited**

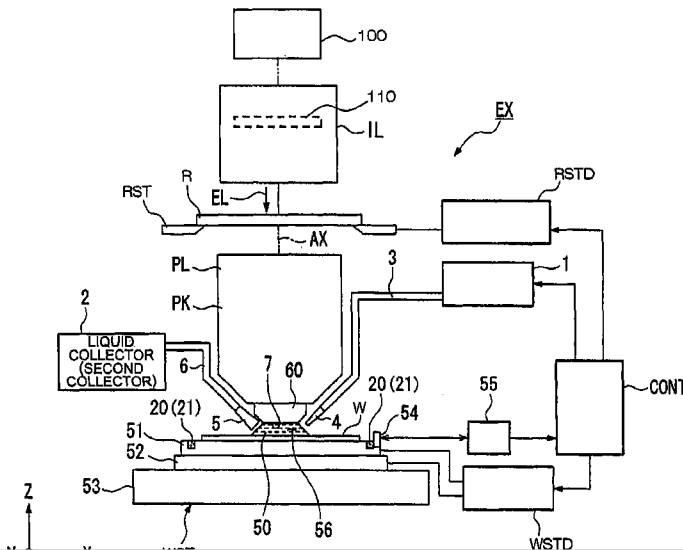
U.S. PATENT DOCUMENTS
4,346,164 A 8/1982 Tabarelli et al.
(Continued)
FOREIGN PATENT DOCUMENTS
EP 1 069 448 A1 1/2001
(Continued)

OTHER PUBLICATIONS
Switkes et al; "Resolution Enhancement of 157-nm Lithography by Liquid Immersion"; Massachusetts Institute of Technology; 7 pages.
Primary Examiner—Jack I. Berman
Assistant Examiner—Zia R. Hashmi
(74) *Attorney, Agent, or Firm*—Oliff & Berridge, PLC

(57) **ABSTRACT**

A catadioptric projection optical system for forming a reduced image of a first surface (R) on a second surface (W) is a relatively compact projection optical system having excellent imaging performance as well corrected for various aberrations, such as chromatic aberration and curvature of field, and being capable of securing a large effective image-side numerical aperture while suitably suppressing reflection loss on optical surfaces. The projection optical system comprises at least two reflecting mirrors (CM1, CM2), and a boundary lens (Lb) whose surface on the first surface side has a positive refracting power, and an optical path between the boundary lens and the second surface is filled with a medium (Lm) having a refractive index larger than 1.1. Every transmitting member and every reflecting member with a refracting power forming the projection optical system are arranged along a single optical axis (AX) and the projection optical system has an effective imaging area of a predetermined shape not including the optical axis.

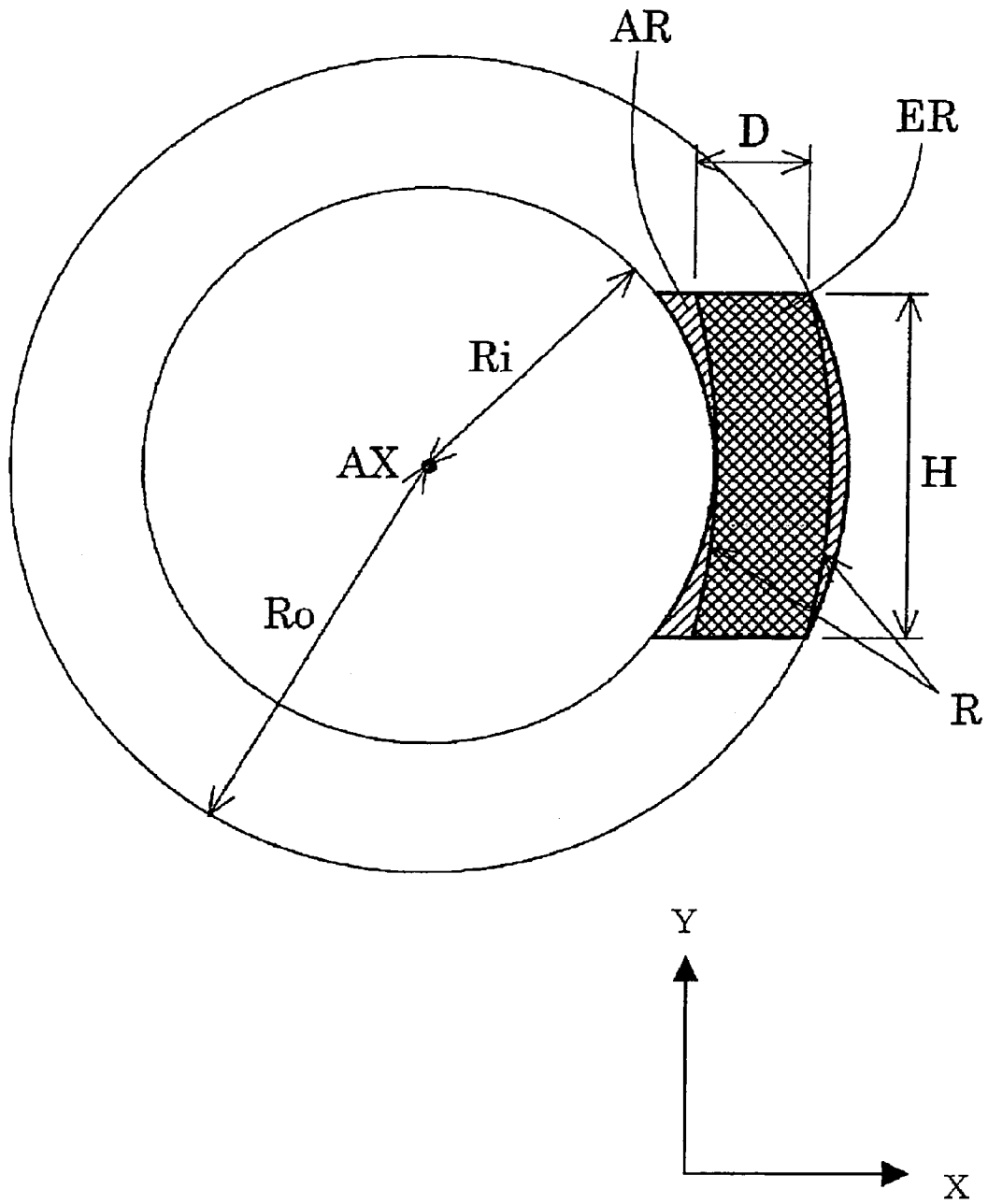
49 Claims, 21 Drawing Sheets

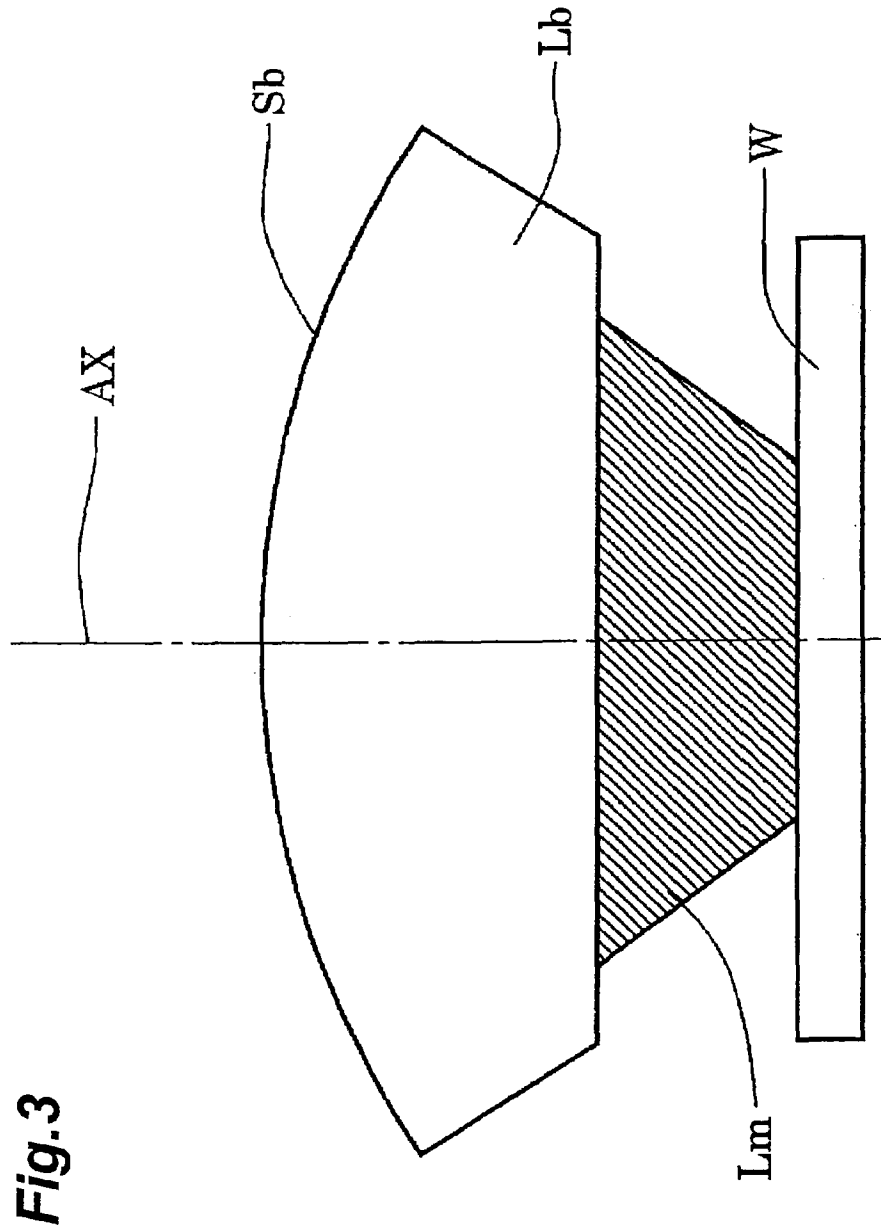


U.S. PATENT DOCUMENTS						
				JP	A 10-163099	6/1998
				JP	A 10-214783	8/1998
				JP	A 10-303114	11/1998
6,473,243	B1	10/2002	Omura	JP	A 2000-505958	5/2000
6,600,608	B1	7/2003	Shafer et al.	JP	A 2001-228401	8/2001
6,631,036	B2	10/2003	Schuster	JP	B2 3246615	11/2001
6,636,350	B2	10/2003	Shafer et al.	JP	A 2002-208551	7/2002
6,829,099	B2	12/2004	Kato et al.	JP	A 2003-114387	4/2003
6,873,476	B2	3/2005	Shafer	WO	WO 98/28665	7/1998
2002/0024741	A1	2/2002	Terasawa et al.	WO	WO 2004/019128 A2	3/2004
2003/0197922	A1	10/2003	Hudyma	WO	WO 2005/015316 A2	2/2005
2004/0130806	A1	7/2004	Takahashi	WO	WO 2005/015316 A3	2/2005
2004/0240047	A1	12/2004	Shafer et al.	WO	WO 2005/098505 A1	10/2005
2005/0036213	A1	2/2005	Mann et al.	WO	WO 2006/005547 A1	1/2006
2005/0190435	A1*	9/2005	Shafer et al. 359/365			
FOREIGN PATENT DOCUMENTS						
JP	A 6-188169	7/1994				

* cited by examiner

Fig.2





Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts



Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research



With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips



Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.