US005225926A

United States Patent [19]

Cuomo et al.

[11] Patent Number: 5,225,926

[45] Date of Patent: Jul. 6, 1993

[54] **DURABLE OPTICAL ELEMENTS FABRICATED FROM FREE STANDING POLYCRYSTALLINE DIAMOND AND NON-HYDROGENATED AMORPHOUS DIAMOND LIKE CARBON (DLC) THIN FILMS**

[75] Inventors: **Jerome J. Cuomo**, Lincolndale; **Charles R. Guarnieri**, Somers, both of N.Y.; **Bruce A. Hoenig; Hajime Seki**, both of San Jose, Calif.; **James L. Speidell**, Poughquag; **Stanley J. Whitehair**, Peekskill, both of N.Y.

[73] Assignee: **International Business Machines Corporation**, Armonk, N.Y.

[21] Appl. No.: **754,861**

[22] Filed: **Sep. 4, 1991**

[51] **Int. Cl.**[5] **G02B 1/10**; G02B 5/30; G02B 27/10; G32B 9/00

[52] **U.S. Cl.** **359/350**; 359/486; 359/507; 359/629; 359/896; 428/408; 427/577

[58] **Field of Search** 359/350, 355, 642, 352, 359/356, 483, 486, 507, 629, 896; 428/408; 427/160, 577

[56] **References Cited**

U.S. PATENT DOCUMENTS

3,895,313	7/1975	Seitz	331/94.5 D
3,977,787	8/1976	Fletcher et al.	356/106 S
4,009,962	3/1977	Lauer	356/82
4,320,973	3/1982	Fortunato et al.	356/346
4,698,256	10/1987	Giglia et al.	427/34
4,744,658	5/1988	Holly	356/351
4,809,876	3/1989	Tomaswick et al.	428/36.6
4,844,785	7/1989	Kitabatske et al.	204/192.11
4,935,303	6/1990	Ikoma et al.	428/408
4,940,015	7/1990	Kobashi et al.	118/723
4,948,629	8/1990	Hacker et al.	427/53.1
4,954,365	9/1990	Neifeld	427/53.1
5,006,203	4/1991	Purdes	156/646
5,082,359	1/1992	Kirkpatrick	359/642

FOREIGN PATENT DOCUMENTS

0467043	4/1992	European Pat. Off. .
61-155703	7/1986	Japan .
2-45704	2/1990	Japan .
2165265	4/1986	United Kingdom .

OTHER PUBLICATIONS

Bubenzer, et al "Role of Hard Carbon in the Field of Infrared Coating Materials", *Optical Engineering*, vol. 23, No. 2 Mar. 1984 pp. 153–156.

Windishmann et al "Properties of Diamond Membranes for X-ray Lithography" *Journal of Applied Physics*, vol. 68, No. 11 1 Dec. 1990 pp. 5665–5673.

Southworth et al. *ECO3: Hard Materials in Optics* 14–15 Mar. 1990 The Hague, Netherlands "Optical and other properties of mpacvd diamond" pp. 36–43.

(List continued on next page.)

Primary Examiner—Rodney B. Bovernick
Assistant Examiner—David R. Parsons
Attorney, Agent, or Firm—Robert B. Martin

[57] **ABSTRACT**

Optical elements, and methods for fabricating them, are described wherein each element includes a free standing (self supporting) polycrystalline continuous thin film of diamond combined with a non-hydrogenated amorphous diamond like carbon (DLC) film having a high percentage of sp^3 bonding. These elements may be designed to have optically smooth surfaces, have wide optical transmission ranges (for example, be transparent across the infrared portion of the spectrum), and exhibit exceptional durability characteristics. Optical instruments that include such elements are also described, along with the derivative benefits, such as improved operating performance and lower maintenance requirements, realized using the novel optical elements. In particular, a polarization Michaelson interferometer (PMI) is taught which is operative over the entire range from far infrared into the visible portion of the spectrum without requiring the exchange of beam splitters or beam polarizers. These performance benefits are achieved as a result of the transmission characteristics of the novel optical elements associated with the PMI.

16 Claims, 2 Drawing Sheets