Figure 5 shows refractive index data for silicon oxynitride as a function of oxygen/ nitrogen ratio region.

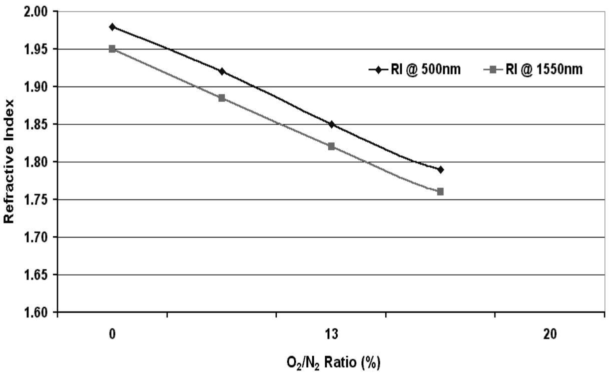


**Figure 5** Refractive Index for silicon oxynitride as a function of oxygen/ nitrogen ratio

## Germanium Carbide

Germanium carbide is formed by sputtering of germanium in a hydrocarbon reactive gas.

Figure 6 shows the germanium carbide refractive index (@ 10um) as a function of hydrocarbon to argon gas ratio.

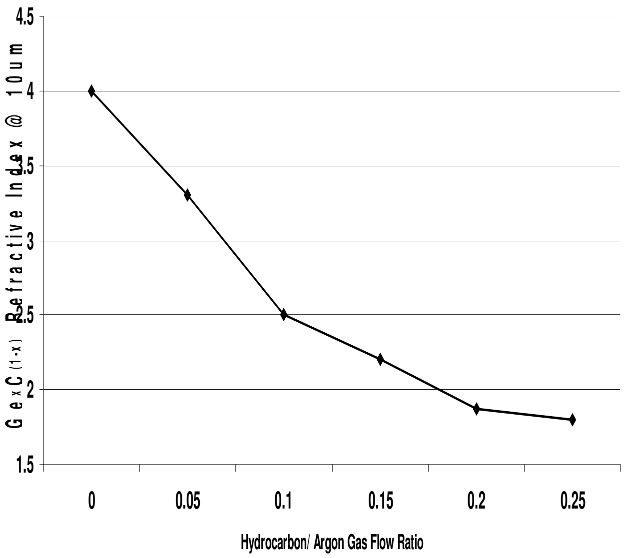


**Figure 6** Refractive Index of germanium carbide as a function of hydrocarbon/ argon ratio

## Diamond Like Carbon

Optical constants for diamond like carbon (DLC) are shown in Figure 7.

DLC is deposited by CFM sputtering graphite in a hydrocarbon reactive plasma.

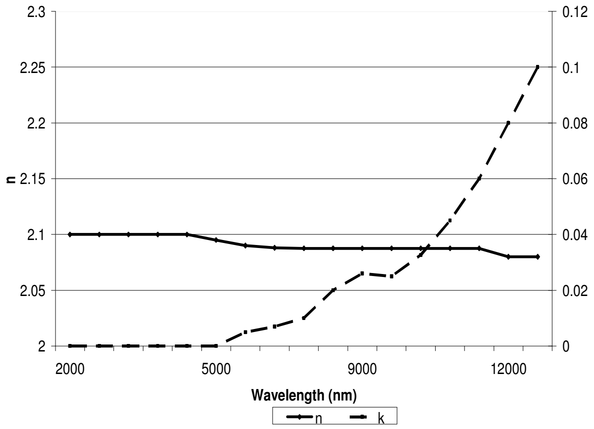


**Figure 7** Optical constants for CFM sputtered diamond like carbon

## STRESS

Film stress was evaluated from measured substrate curvature before and after film deposition. Stress was calculated from the Stoney formula[10]. Curvature was measured along two perpendicular axes across the wafer. Typical values are indicated in Table 1.

| | CFM Sputtered | RF Sputtering | PECVD |
|---|---|---|---|
| **GexC** (1-x) | - 150MPa | - 800MPa | - 0.5 to - 1GPa |
| **DLC** | - 120MPa | N/A | -0.7 to -1.1GPa |
| **Si3N4** | - 100MPa | - 300MPa | - 300 to -500Mpa |

Table 1 Measured stress for a range of oxide films (negative value indicates compressive stress)

Method – Deflection of thin coated substrate. Error ±5%

## ENVIRONMENTAL & MECHANICAL PERFORMANCE

Environmental performance[11] for GeC and DLC on germanium substrates are indicated in Table 2.

© 2008 Society of Vacuum Coaters 505/856-7188

| Test | Method | Specification |
|---|---|---|
| **Adhesion** | **Scotch Tape Test** | **Mil_C_48497A para 4.5.3.1** |
| **Humidity** | **24hrs , 50ºC, 95 % RH** | **Mil_C_48497A para 4.5.3.2** |
| **Severe Abrasion** | **50 strokes** | **Mil_C_48497A para 4.5.35.1** |
| **Salt Spray** | **24hrs** | **Mil_C_675C para4.5.9** |

**Table 2** Environmental performance of GeC coating on germanium substrate

Hardness levels have been assessed[11] between 12 to 20GPa, for film thicknesses ranging from 1 to 10um.

## DISCUSSION

Closed field reactive magnetron (CFM) sputtering has been used for many years to produce highest quality tribological coatings. The same basic process produces transparent nitride and carbide coatings with outstanding optical, durability and environmental properties. Also the process is capable of producing low stress, dense, super-smooth coatings with low optical scatter. These properties are all derived from the fundamental advantage of the closed field strategy inherent in the combination of high ion current density combined with low ion energy.

The CFM process can be exploited in batch format or in-line format. The process does not require an auxiliary ion or plasma source and without this overhead, the batch systems are scaleable to meet the demands for a small development system through to high throughput production systems. The in-line format is particularly appropriate to the high volume production demands for displays and photovoltaics.

## REFERENCES


1. D.G. TEER, SURF COAT TECHNOL 1989; 39/40:565

2. P J Kelly, R D Arnell, Vacuum 56 (2000), 159-172

3. J.M. Walls, D.R. Gibson, I. Brinkley, D.G. Teer, P. Teer and J. Hampshire, *SVC 46th Annual Technical Conference Proceedings*, 2003, 387

4. D.R. Gibson, J.M. Walls, I. Brinkley, D.G. Teer, P. Teer and J. Hampshire, *SVC 47th Annual Technical Conference Proceedings*, 2004, 377

5. Photon International, May 2005

6. Daniel Harris, Materials for Infrared Windows and Domes: Properties and Performance (SPIE Press Monograph Vol. PM70)

7. Shinar, Joseph (Ed.), *Organic Light-Emitting Devices: A Survey*. NY: Springer-Verlag (2004). ISBN 0-387-95343-4

8. D G Teer Wear 251 (2001) 1068

9. D R Gibson and J M Walls Europhotonics 9 (2004), 32

10. . Ohring, *Materials Science of Thin Films* (Academic, New York 1992)

11. Private communication, Teer Coatings Ltd, United Kingdom