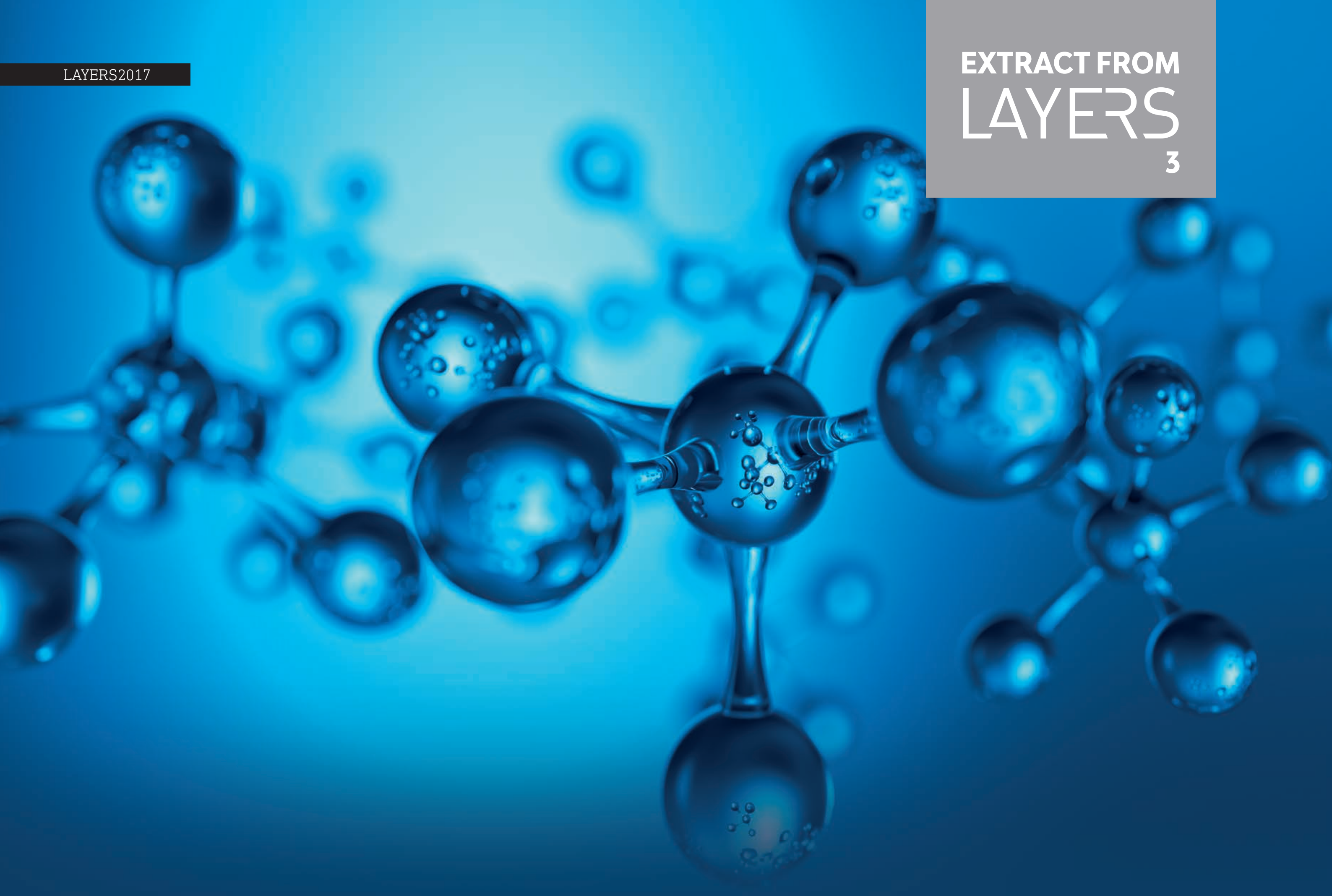


Reducing Cost of Ownership for DLC

Head of Process Development **Rico Benz**, and **Dr. Heiko Plagwitz**, Product Marketing Manager, from BU Photonics show how new approaches in the deposition of DLC coatings can save time and money for both custom infrared and mass market consumer applications.

It's already used in a whole range of applications such as in tool coatings but also for corrosion and impact protection in hard disk data storage applications and now increasingly in optical applications. On one hand DLC is the perfect coating for the surface protection of high end hand held devices, and on the other, its index of refraction in the infrared is in the range 1.7 to 1.9 making it a good optical match and a good choice of protection for high index substrates like Si, Ge and ZnS used in infrared optics which have limited durability and get damaged easily.

Typical requirements for the DLC layers required in all these applications vary widely. e.g they could be employed as a thin layer on top of the substrate or AR stack, or in thicker layers as part of the AR stack itself. However, a common request from device manufacturers is for more cost effective production methods than are currently available where the DLC process is usually isolated in a separate step requiring extra equipment, floor space and human handling.

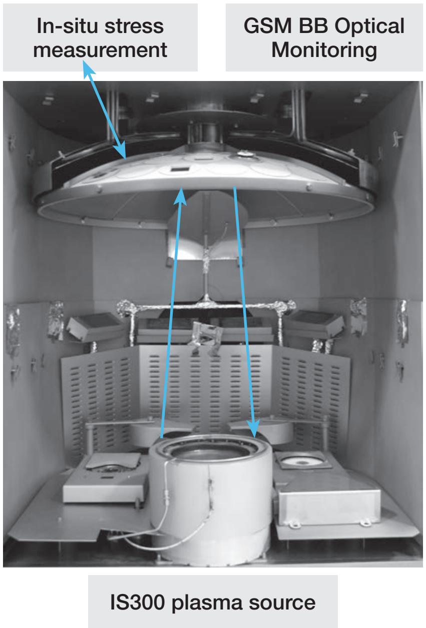
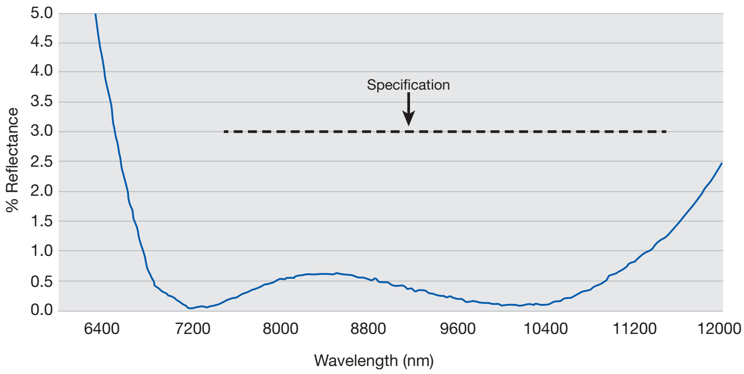


Fig 1. Set up in BAK1101

Fig 2. Optical spectrum for combined AR+DLC prepared in BAK1101



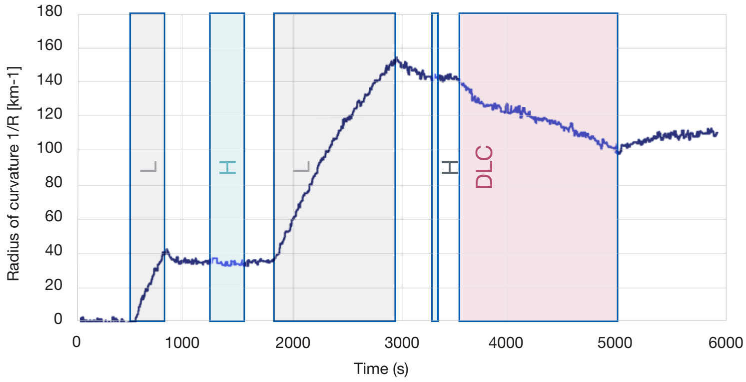


Fig 3. Stress monitoring during the deposition cycle

SOLVING CHALLENGES FOR INFRARED OPTICS

Coatings on optics for IR applications at 3-5 or 8-12 microns for applications like thermal detection and night vision are typically made in a two stage process. In a first step the spectral AR coating is prepared by evaporation in a box coater, while in a second independent step a thin DLC protective coating is prepared in a separate system by techniques such as PECVD or magnetron sputter.

In a new approach we have been able to combine PVD of the multispectral coating and PECVD deposition of the DLC coating in the same BAK 1101 box coater deposition system to bring superior film quality without the intermediate vacuum break, reduced handling and ultimately bringing lower production costs. Broadband AR films for IR in the 8-12 micron regions could be prepared using e gun sources in the normal way. An inductively couple plasma source combined with combinations of Methane, Butane and Acetylene process gases could then be used to deposit high quality DLC coatings.

The equipment set up is shown in Figure 1. Optical spectra measurement results for combined AR+DLC are shown in Figure 2. In situ stress measurement during deposition itself (Figure 3) show a compressive stress of around 750 MPa in the DLC. The coatings show good adhesion, spectral performance and satisfy tough tests required for military applications including “wiper tests” (Figure 4).

THE WIPER TEST

Fig 4.

Different hardness and wear tests such as “Nanoindentation” or the “Bayer” are carried out depending on the application of the DLC layer. In the “Windshield Wiper Blade Test” a container is filled with a sand and water mixture. A wiper blade rotates with defined force on a test sample according to standards defined by RSRE (Royal Signals and Radar Establishment) test results are judged by eye and classified.

Fig 5: SOLARIS S380 high throughput inline sputter system

COATINGS FOR PROTECTION OF CONSUMER DEVICES

For mass market consumer applications like smart tablets the focus is very different. Speed is of the essence for throughputs of many thousands of substrates per hour at typical processing times of just a few seconds per substrate. Effective protection of the glass surface must be achieved with DLC coatings of just a few nanometres without detrimental influence on the image colour rendering or surface roughness. This requires careful balancing of process powers and gas flows to produce films that achieve the inherent film densities and low surface roughness for good abrasion resistance but which avoid absorption with its consequence of bad cosmetics.

Combining our experience of sputtered DLC coatings for the hard disk industry, and our know-how for high speed handling on SOLARIS (Figure 5) means we can achieve excellent abrasion resistance for films in the thickness range 10 to 25 nm and at low surface roughness below 0.9 nm. Figures 6 and 7 show the results for absorption and scratch resistance as a function of film thickness.

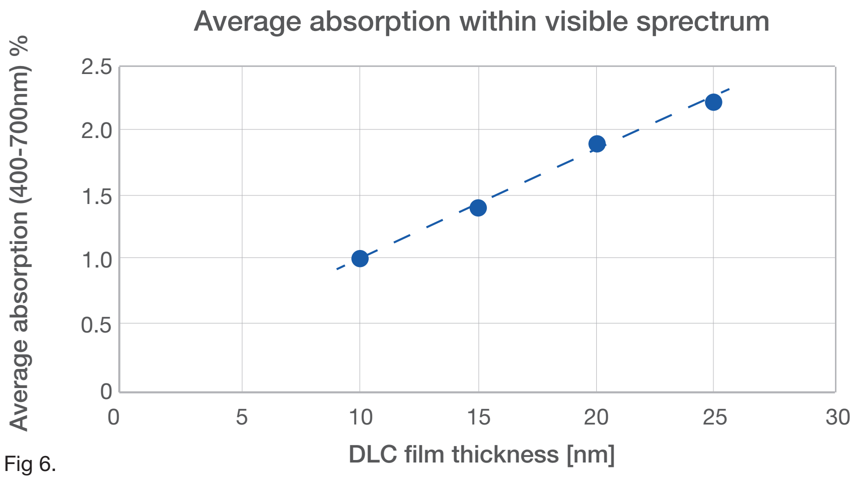


Fig 6.

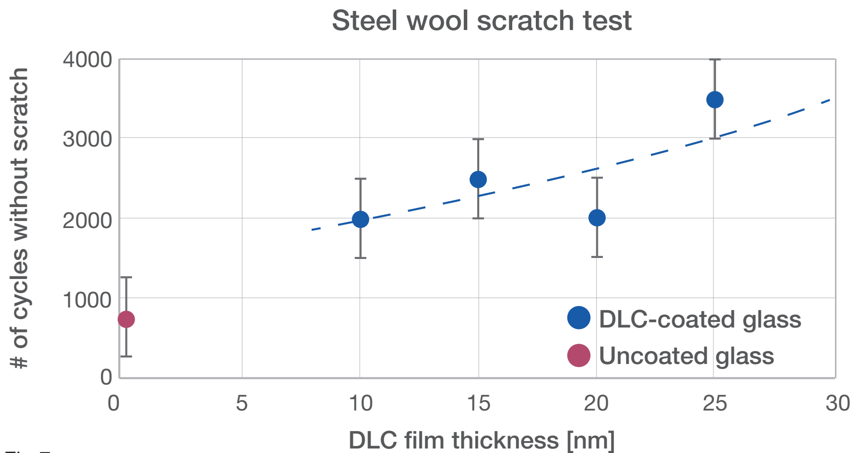


Fig 7.

TYPICAL FILM CHARACTERISTICS FOR SPUTTERED DLC FILMS

Refractive index $1.66 \leq n \leq 2.06$

Extinction coefficient: $0.014 \leq k \leq 0.410$

Film density: 2.35 ± 0.05 g/cm^3

Surface roughness:
0.7 nm ≤ Ra ≤ 0.9 nm for 10 nm thin films

DLC PROCESSES ARE READY

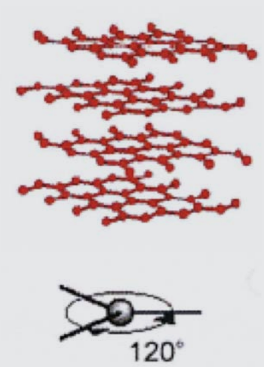
Whether its combined Evaporation / PECVD in the BAK or sputter processes on SOLARIS we are ready with process know-how for tailored DLC coatings according to our customer requirements. Our platforms are production ready too with handling and safety system needed for any special gases required.

THE ROAD AHEAD

For some applications, its not only a question of combining optical performance with spectral, adhesion and abrasion testing but also of satisfying additional specific tests like the Salt Fog Test- typically demanding coating resistance to an 85% salt solution at 35ºC for durations up to 90 days. It's a challenge we are already well on the way to solving!

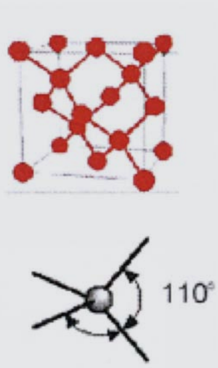
Background Reading

Graphite



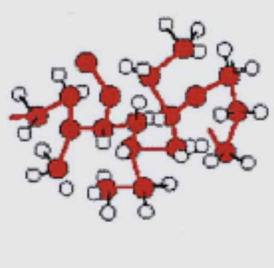
sp²
X-tal / black /soft

Diamond



sp^3
X-tal / transparent / hard

a-C(:H)
tetrahedral hydrogenated amorphous carbon «DLC»



sp^2 + sp^3
Amorphous / polymeric / black – transparent / soft - hard

Diamond Like Carbon is not a material, but a class of materials

Requirements for films with desired properties for IR optical applications:
- Hybridization sp^3 / sp^2: > 60%
- Hydrogen content: < 40%

DLC is not a single material but a whole class of materials made of amorphous hydrogenous carbon (a-CH) having an optimal mixture of extremely hard sp3 (diamond) and soft sp2 (graphite) bonds. The combination of these results in an extremely durable and hard layer.