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# THE MATERIALS SCIENCE OF FULLERENE-LIKE CARBON NITRIDE (CNX) THIN FILMS; - EFFECTS OF DOPING ON STRUCTURE AND MECHANICAL RESILIENCY

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This presentation reviews growth-structure-property relationships for fullerene-like (FL) carbon-based thin solid films deposited by magnetron sputtering and studied by ab initio (DFT) synthetic growth calculations, XPS, Raman spectroscopy, HREM [1], and nanoindentation. The alloying of N [2], P [3,4], F [5,6], and S [7] to C is used to control synthesis and tune mechanical properties and surface energy of films. Applications for fullerene-like compounds are highlighted, including wear-protective coatings on hard-drives, ball bearings, and orthopaedic implants. As the base model system we consider FL-CNx ($x \leq 0.3$) films produced by magnetron sputtering methods. For example, the flux and energy of the species – C, CN, C2N2, C2, N2, and N - are found to determine the film growth and the materials properties. C2N2 that form in the graphite target during sputtering serve as precursors or building blocks for the evolving fullerene-like film structure. Thus, the deposition process should be viewed as a hybrid between PVD and CVD. CNx compounds are resilient and has a more reactive surface compared to DLC. The prime role of N is to promote the curving of graphite planes by substituting for C and lowering the energy barrier to form pentagon that constitutes fullerene-like materials. N can also promote cross-linking between the curved planes at Csp2 and possibly hybridized Csp3 sites. Carbon nitride deforms elastically and can store energy by bending of such structural units. Thus, CNx shows promising rolling contact fatigue properties for coated bearing components [8]. Adhesion of CNx coatings to steel substrates was optimized using metal HiPIMS pretreatments [9].

## References

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**SHORT BIO**

**LARS HULTMAN** - Professor in Material's Physics and Head of the Thin Film Physics Division at IFM, Linköping University, Sweden - has built a multidisciplinary research environment encompassing national and international collaboration. He has been a visiting scientist to Northwestern University and University of Illinois at Urbana-Champaign. A leitmotif of his work is "application-inspired basic research".

He is an elected member of the Royal Swedish Academies of Science (KVA) and Engineering Sciences (IVA), as well as Fellow of the American Vacuum Society and the Forschungszentrum Dresden-Rossendorf. Recent recognitions include ERC Advanced Grant, Wallenberg Scholar, AkzoNobel Science, and American Ceramic Society Ross Coffin Purdy Awards.

Lars has directed centers of excellence in materials science, nanotechnology, advanced surface engineering, and electron microscopy. He presently also serves as CEO of the Swedish Foundation for Strategic Research.

He has authored 700+ papers (ISI most cited researcher) with h-index 65, and holds twenty patents.