NANO HIGHLIGHT
SCIENCE AND TECHNOLOGY OF ULTRANANOCRYSTALLINE DIAMOND FILMS FOR MULTIFUNCTIONAL MEMS/NEMS DEVICES

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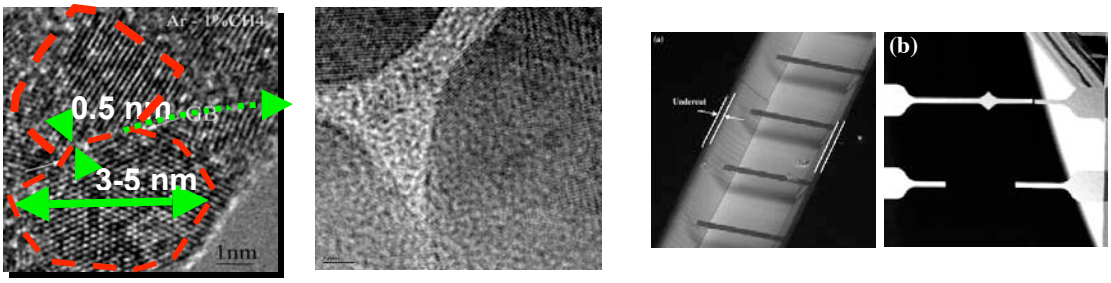
This project is focused on performing fundamental and applied research and education to understand the mechanical and surface properties of a novel ultrananocrystalline diamond (UNCD) material in thin film form developed at Argonne National Laboratory (ANL). Through interdisciplinary efforts of the team members in collaboration with national laboratories, an integrated experimental, analytical and computational program has evolved with the following preliminary results since the project was funded in September 2003.

The UNCD films are grown using innovative microwave plasma chemistries with or without nitrogen doping. The films grown by introducing nitrogen in the plasma result in nitrogen doped UNCD with the highest electrical conductivity demonstrated today [~ 260 $(\Omega.cm)^{-1}$]. The UNCD growth process produces undoped and nitrogen-doped films with unique microstructures [Figs. 1(a) and (b)] that are responsible for the outstanding mechanical and surface properties of this material as revealed by measurements done with the use of the UNCD-MEMS structures fabricated at Northwestern University (NU), as shown in Figs. 1 (c) and (d).



(a) (b) (c) (d)

Figure 1. Nanostructures of undoped (a) and nitrogen doped (b) UNCD films as revealed by high resolution TEM; UNCD-MEMS cantilevers (c) and membranes (d) fabricated at NU, using UNCD films produced at ANL.

With the use of combined ab initio, molecular dynamics and kinetic Monte Carlo methods, efforts have been made to study the film deposition and growth process, and the relationship between microstucture and electro-mechanical properties of UNCD films, in collaboration with Sandia National Laboratories (SNL). The integrated experimental, analytical and computational study of the unique properties of UNCD films, as being performed in this project, is the first of its kind. The identified mechanical, electrical and surface properties of these films will be essential for further studies of MEMS devices that are made from UNCD.

References

[1] For further information, link to http://clifton.mech.northwestern.edu/~me395 or email to chenzh@missouri.edu.
[2] O. Auciello, J. Birrell, J.A. Carlisle, J.E. Gerbi, X. Xiao, B. Peng and H.D. Espinosa, "Materials Science and Fabrication Processes for a New MEMS Technology Based on Ultrananocrystalline Diamond Thin Films," *Journal of Physics: Condensed Matter* Vol.16, pp.539-552, 2004.
[3] L. Shen and Z. Chen, "An Investigation of the Effect of Interfacial Atomic Potential on the Stress Transition in Thin Films," *Modeling and Simulation in Materials Science and Engineering*, Vol. 12, S347-S369, 2004.