George Z. Voyiadjis[1]

"Crystal Plasticity Modeling for the strengthening Effect of multilayered Copper-Graphene Nanocomposites"

The paper investigates plastic deformation mechanisms in metal-graphene nanocomposite to demonstrate the strengthening effect of materials through a crystal plasticity finite element (CPFE) model comparing published experimental results. The existing experimental research identified that the two-dimensional shape of graphene, which can effectively control dislocation motion, can significantly strengthen metals. Considering the nature of dislocation motions in hundreds of nano-meter length scales, nanopillar compression tests were simulated by using the physics-based CP model that incorporated surface nucleation and single-arm source dislocation mechanisms. The crystal plasticity models have the configuration of a nanolayered composite with layers of copper grains and monolayer graphene sandwiched between them, with repeat layer spacings of 200 nm, 125 nm, and 70 nm, respectively. The present study quantified the accumulation of dislocations at the graphene interfaces, leading to the ultra-high strength of the copper-graphene composite. Furthermore, a Hall-Petch-like correlation was established between yield strength and the number of embedded graphene layers.

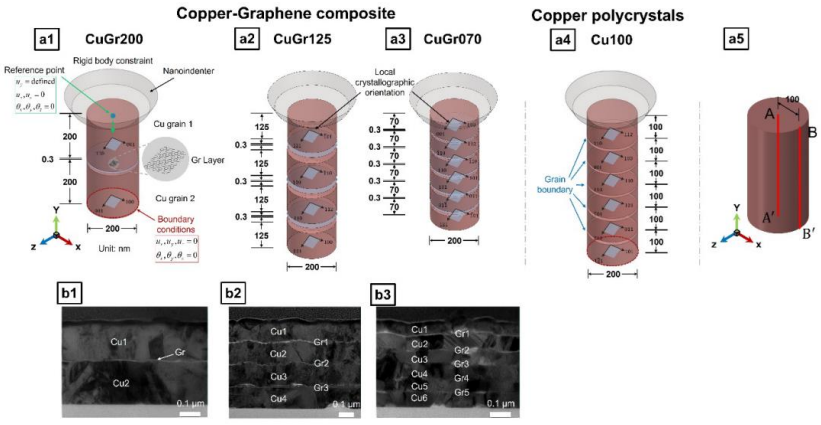

Figure: (a1-a4) Configurations with different repeated layer spacing of copper-graphene composite and copper polycrystal. From left to right, 200-nm, 125-nm, and 70-nm repeated copper layers with the insertion of graphene layers are named CuGr200, CuGr125, and CuGr070. (a5) Two paths AA' and BB' for all computational models. (b1-b3) TEM images of experimental specimen [Kim et al., 2013].

George Z. Voyiadjis is the Boyd Professor and Chair of the Department of Civil and Environmental Engineering at the Louisiana State University. He also holds the Freeport-MacMoRan Endowed Chair in Engineering and serves as the Director of the Louisiana State University Center for GeoInformatics (LSU C4G). Voyiadjis received a M-Sc. in Civil Engineering from California Institute of Technology (1970) and D.Eng.Sc. in Engineering Mechanics from Columbia University (1973). His primary research interest concerns plasticity and damage mechanics with emphasis on the theoretical modeling, numerical simulation of material behavior, and experimental correlation. He authors two patents, over 385 refereed journal articles and 23 books (13 as editor). Voyiadjis is a Foreign Member of the Academia Europaea (Physics & Engineering Sciences), the European Academy of Sciences, and the European Academy of Sciences and Arts (Technical and Environmental Sciences). He received numerous awards, such as the Blaise Pascal Medal for Engineering from the European Academy of Sciences.

[1] Juyoung Jeong contributed to this seminar