

ADVANCES OF NANOCRYSTALLINE DIAMOND FILMS AND ITS APPLICATIONS

Ashok Kumar

Department of Mechanical Engineering
Nanomaterials & Nanomanufacturing Research Center
University of South Florida
Tampa, FL 33620; USA
E-mail: akumar@eng.usf.edu
Tel: (813)974-3942

Many current Si-based MEMS components and devices exhibit performance limitations due to the relatively poor physical, mechanical, chemical and tribological properties of Si. Diamond and diamond-like carbon offer several advantages over conventional materials currently being explored for such applications, particularly, over Si and even SiC being explored as alternative MEMS materials. Fabrication of MEMS components and devices based on diamond or diamond-like films can be achieved using microfabrication techniques developed for the fabrication of Si-MEMS. However, fabrication of diamond-MEMS components using conventional CVD processes results in diamond coatings with coarse grains ($\geq 1 \mu\text{m}$) and rough surfaces ($\text{rms} \sim 0.5\text{-}1\mu\text{m}$), while vapor-deposited diamond-like coatings are not suitable for covering high aspect ratio MEMS features conformally, require high temperature post-deposition processing to relieve stresses, and exhibit lower hardness than natural diamond. A new type of nanocrystalline diamond (NCD) coatings with 5-15 nm grains and smooth surface (15-30 nm rms) can provide a unique combination of excellent mechanical, tribological, chemical, electrical and biocompatible properties. The NCD films were grown on Si substrates by microwave plasma enhanced chemical vapor deposition (MPECVD) method. Parameters such as gas composition, temperature, and pressure had been optimized to prepare the best quality thin films. Scanning electron microscopy (SEM), Raman spectroscopy, Near Edge X-ray Absorption Fine Structure (NEXAFS), Transmission Electron Microscope (TEM), and other analytical techniques were used to characterize the NCD films. A discussion will be presented on the fundamental and applied science done on NCD and microfabrication processes and characterization of mechanical, tribological, electronic transport, and bio-compatible properties.