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Mechanical properties of plasma polymer films controlled by RF power

Erik Palesch[1], Sona Kontarova[1], Vladimir Cech[1]

[1]Brno University of Technology, Brno, Czech Republic

xcpalesch@fch.vutbr.cz

Plasma polymers are important materials in many areas nowadays, including electronics, surface protection and fiber-reinforced composites. Mechanical properties are the key factors for many of film applications. They can be effectively controlled by varying process parameters during deposition. In the study here presented, we characterized selected mechanical properties of organosilicon thin films. The films were prepared from tetravinylsilane gas (TVS, monomer) and were deposited onto silicon wafers of 1 cm^2 size. The deposition technique was plasma-enhanced chemical vapour deposition (PECVD) using RF plasma (13.56 MHz) in continual regime. After deposition, mechanical properties of plasma-polymerized films with a thickness of 1 µm were measured using nanoindentation head Hysitron TriboScope TS-70 attached to NTEGRA Prima (NT-MDT) scanning probe microscope. Pyramidal Berkovich indenter with a curvature radius of 150 nm was used. The Young's modulus and hardness were evaluated for the films prepared at a power of 10 – 70 W. We observed an increasing trend for both the modulus and hardness at enhanced power due to the increased polymer cross-linking. The modulus was in range 12 – 70 GPa, while the range for hardness was 0.6 – 8 GPa. Nanoscratch tests were employed for the thin films with a thickness of 100 nm to observe influence of RF power on film adhesion. We looked for the critical normal force that caused film delamination as a parameter to describe adhesive properties of thin films. The critical normal force showed an increasing trend when enhancing RF power. Similarly, we studied the thickness dependence of the critical normal force for films deposited at 10 W and a thickness in range of 25 nm – 0.5 µm. The results proved that a higher delamination force was necessary to delaminate a thicker film. Finally, AFM images of scratches were carried out to correlate measured data with nature and shape of scratches.

Keywords
thin films
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nanoindentation
scratch test