Study of Densification and Plastic Deformation Behaviour of Ultra-tough a-C/a-C:Cr Multilayer Coatings Under Indentation and Scratch Tests

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Abstract

Hard coatings is one of the most widely used methods to improve wear resistance of materials. In principle,
hard coatings with a high modulus and hardness provide an opportunity to assure contact in the elastic state
under conditions of low compressive loading. Unfortunately, the coatings with extremely high elastic modulus
and hardness become more sensitive to cracks which release elastic energy. Normally the energy dissipated by
elastic deformation or brittle fracture are negligible compared with the energy losses associated with plastic
deformation.
Alternated a-C/a-C:Cr coatings were made by DC magnetron sputtering from graphite and Cr target in an
argon discharge. Mechanical properties were measured by indentation and scratch tests. The columnar
alternated a-C/a-C:Cr multilayers accommodate shear and normal forces by viscoelastic, plastic deformation
and densification. The energy dissipated by a-C/a-C:Cr multilayer coatings may significantly disperse the

radial tensile stress developed at the sides of the indenter and hence avoid tensile cracks along the edge of the
scratch tracks. Energy dissipation by the coatings also delays plastic deformation and pile up of the substrate
materials and avoids premature partial ring crack development ahead of the indenter. The greater compliance

and fracture toughness of the a-C/a-C:Cr multilayer coatings allows greater strains or strain energy to be stored
before coating failure, and hence significantly enhance the scratch critical load under scratch tests.

Keyword：a-C/a-C:Cr coatings, scratch, indentation, densification, plastic deformation