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Metal-boride interlayers for chemical vapor deposited nanostructured diamond films on 316 stainless steel

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Carbon is a phenomenal material that has garnered much attention from the scientific community given its many unique forms. Diamond is only one example that possesses some of the most attractive properties of any material including ultimate hardness and exceptional thermal conductivity. Use of chemical vapor deposition (CVD) allows for thin films of diamond to be deposited onto a variety of materials. This surface modification allows for the increased longevity of the bulk material by utilizing the thin film's properties. Diamond's extreme hardness makes it a natural coating choice for many applications such as cutting tools. In this work, thin films are deposited via plasma-assisted CVD onto 316 stainless steel. Prior to diamond deposition, the steel surface is borided using diborane in conjunction with the CVD process. This method of plasma boronization should have a reduced energy consumption advantage over more commonly used industrial boriding methods such as pack cementation given the lower temperatures and times utilized. Control of the CVD parameters during the boriding step allows one to tailor the resultant borided surface layer. X-ray diffraction of as-borided samples shows that for substrate temperatures from 500-600°C, the CrB structure (end-centered orthorhombic) dominates while for higher substrate temperatures near 700 °C the Fe2B phase (body-centered tetragonal) is the only boride observed. Furthermore, boriding time influences the layer thickness (in addition to the temperature) given that this is a diffusion-based process. The purpose of the borided surface is to allow for subsequent adherent diamond film deposition by preventing the catalytic effect of elemental iron on carbon that otherwise results in graphitic soot formation and poor coating adhesion. Additionally, intermediate physical properties of the metal-boride, such as hardness and coefficient of thermal expansion, relative to the stainless steel and diamond film will help to offset residual stresses that are detrimental to adhesion strength. Given the wide use of steel based materials, successful deposition of an adherent diamond film would be a huge achievement with far-reaching applications.

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