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研究论文

高功率脉冲磁控溅射ZrN纳米薄膜制备及性能研究

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摘要: 采用高功率复合脉冲磁控溅射的方法(HPPMS)在不锈钢基体上制备ZrN纳米薄膜, 并研究了不同的工作气压对薄膜形貌、相结构及各种性能的影响。采用SEM、XRD对其表面形貌和结构进行分析, 发现制备的薄膜表面光滑、致密, 无大颗粒, 主要以ZrN(111)和ZrN(220)晶面择优生长, 并呈现出多晶面竞相生长的现象。对薄膜硬度、弹性模量、耐磨性和耐腐蚀性的测试发现薄膜具有很高的硬度, 最高可达33.1 GPa, 同时摩擦系数均小于0.2, 耐腐蚀性也都有很大提高, 腐蚀电位比基体提高了0.28 V, 腐蚀电流下降到未处理工件的1/5。工作气压较低时, 薄膜耐磨耐蚀性能都较好, 但在较高气压时, 耐磨耐蚀性能出现一定的下降。

关键词: 材料表面与界面 高功率脉冲磁控溅射 氮化锆 微观结构 表面性能

Fabrication and Surface Properties of ZrN Films by High Power Pulsed Magnetron Sputtering

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Abstract: ZrN nano-films were prepared by high power pulsed magnetron sputtering technique (HPPMS) under the different work pressures. SEM and XRD were used to investigate the surface morphologies and the phase structure of the films. The results show that the surface of the prepared ZrN films was smooth and dense, and they have no any macroparticles. The grains of the films grow under the preferred orientations of ZrN (111) and ZrN (220), and show the combined texture with several preferred orientations. The films have very high hardness of 33.1GPa and lower friction coefficient of 0.2. Corrosion resistance has been improved with an increase of the corrosion potential by 0.28V and a decrease of corrosion current by a factor of 5. The samples fabricated at low work pressure possess a better surface properties, but the surface hardness, wear-resistance and corrosion resistance show a decrease at high gas pressure due to more frequent particle collisions.

Keywords: surface and interface in the materials high power pulsed magnetron sputtering ZrN micro-structure surface properties

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参考文献：

[1] S.Konstantinidis, J.P.Dauchot, M.Ganciu, A.Ricard, M.Hecq, Influence of pulse duration on the plasma characteristics in high-power pulsed magnetron discharges, Journal of Applied Physics, 99, 013307(2006)

[2] WU Dawei, ZHANG Zhihong, LUO Hailin, GUO Huaixi, FAN Xiangjun, Properties of the ZrN films prepared by reactive magnetron sputtering, Chinese Journal of Materials Research,11, 207-208(1997)

(吴大维, 张志宏, 罗海林, 郭怀喜, 范湘军, 直流反应磁控溅射法淀积ZrN薄膜, 材料研究学报, 11, 207-208(1997))

[3] V.Kouznetsov, K.Macak, J.M.Schneider, A novel pulsed magnetron sputter technique utilizing very high target power densities, Surface and Coatings Technology, 122, 290 (1999)

[4] K.Sarakinos, J.Alami, S.Konstantinidis, High power pulsed magnetron sputtering: A review on scientific and engineering state of the art, Surface& Coatings Technology, 204, 1661(2010)

[5] J.-H.In, S.-H.Seo, H.-Y.Chang, A novel pulsing method for the enhancement of the deposition rate in high power pulsed magnetron sputtering, Surface& Coatings Technology, 202, 5298(2008)

[6] P.Vasina, M.Mesko, M.Ganciu, Reduction of transient regime in fast preionized high-power pulsed-magnetron discharge, Europhysics Letters, 72, 390(2005)

[7] TIAN Xiubo, WU Zhongzhen, SHI Jingwei, GONG Chunzhi, YANG Shiqin, Development and discharge behavior of high power density pulse magnetron sputtering system, Vacuum, 47, 44--47(2010))

[8] (田修波, 吴忠振, 石经纬, 巩春志, 杨士勤, 高脉冲功率密度复合磁控溅射电源研制及放电特性研究, 真空, 47, 44--47(2010))

[9] P.Ehiasariana, W.-D.Munz, L.Hultman, High power pulsed magnetron sputtered CrNx films, Surface and Coatings Technology, 163-164, 267(2003)

[10] K.Bobzin, N.Bagcivan, P.Immich, Advantages of nanocomposite coatings deposited by high power pulse magnetron sputtering technology, J. Mater. Process. Tech, 209, 165 (2009)

[11] J.Alami, P.Eklund, J.Emmerlich, High-power impulse magnetron sputtering of Ti--Si--C thin films from a Ti3SiC2 compound target, Thin Solid Films, 515, 1731--1736(2006))

[12] W.D.Sproul, High--rate reactive DC magnetron sputtering of oxide and nitride superlattice coatings, Pergamon, 51, 641-646(1998))

[13] N.Vershinin, K.Filonov, B.Straumal, W.Gust, I.Wiener, E.Rabkin, A.Kazakevich, Corrosion behaviour of the protective and decorative coatings on large area steel strips, Surface and Coatings Technology, 125, 229(2000)

[14] CAO Meng, LI Qiang, DENG Xiangyun, LI Dejun, Effect of ion bombarding energy on the Properties of ZrN/TiAIN nanometer multilayered coatings, Chinese Journal of Materials Research, 21, 627--631(2007))

[15] (曹猛, 李强, 邓湘云, 李德军, 离子轰击能量对ZrN/TiAlN纳米多层膜性能的影响, 材料研究学报, 21, 627-631(2007))

[16] E.Budke, J.Krempel-Hesse, H.Maidhof, Decorative hard coatings with improved corrosion resistance, Surface and Coatings Technology, 112, 108--113(1999))

[17] G.Greczynski, J.Jensen, J.Bolmark, L.Hultman, Microstructure control of CrNx films during high power impulse magnetron sputtering, Surface & Coatings Technology,205, 118--130(2010))

[18] C.P.Liu, H.G.Yang, Deposition temperature and thickness effects on the characteristics of dc-sputtered ZrNx films, Materials Chemistry and Physics, 86, 370--374(2004))

[19] J.V.Ramanaa, S.Kumara, C.David, A.K.Ray, V.S.Raju, Characterisation of zirconium nitride coatings prepared by DC magnetron sputtering, Materials Letters, 43, 73--76(2000))

[20] D.R.McKenzie, Y.Yin, W.D.McFall, N.H.Hoang, The orientation dependence of elastic strain energy in cubic crystals and its application to the preferred orientation in titanium nitride thin films, J. Phys.: Condens. Matter., 8, 5883--5890(1996)

[21] ZHANG Yujuan, WU Zhiguo, ZHANG Weiwei, LI Xin, YAN Pengxun, LIU Weimin, XUE Qunji, Effect of deposition parameters on texture of TiN films deposited by filtered cathodc arc plasma, The Chinese Journal of Nonferrous Metal, 14, 1264--1268(2004))

(张玉娟, 吴志国, 张伟伟, 李鑫, 阎鹏勋, 刘维民, 薛群基, 磁过滤等离子体制备TiN薄膜中沉积条件对薄膜织构的影响, 中国有色金属学报, 14, 1264--1268(2004)))

[22] W.J.Chou, G.P.Yu, J.H.Huang, Bias effect of ion-plated zirconium nitride film on Si(100), Thin Solid Films, 405, 162--169(2002))

[23] Z.Wokulski, Mechanical Properties of Titanium Nitride Whiskers, Physica Status Solidi (a), 120, 175--184(1990))

[24] J.Schiotz, K.W.Jacobsen, A Maximum in the Strength of Nanocrystalline Copper, Science, 301, 1357--1359(2003))

[25] XU Chengjun, Study on Properties of TiN and ZrN Films Deposited by Magnetron Sputtering, Master Degree Dissertation of Chongqing University, 04(2005)

[26] (徐成俊，磁控溅射TiN及ZrN薄膜的特性研究, 重庆大学硕士论文, 04(2005))

[27] J.Alami, K.Sarakinos, F.Uslu, M.Wuttig, On the relationship between the peak target current and the morphology of chromium nitride thin films deposited by reactive high power pulsed magnetron sputtering, J. Phys. D: Appl. Phys, 42, 015304(2009)

[28] A.Hecimovic, K.Burcalova, A.P.Ehiasarian, Origins of ion energy distribution function (IEDF) in high power impulse magnetron sputtering (HIPIMS) plasma discharge, J. Phys. D: Appl. Phys, 41, 095203(2008)

[29] ZHANG Hongtao, WANG Tianming, WANG Cong, Progress in Research on Corrosion Resistance of PVD Hard Coating, Materials Review, 16, 15--16(2002))

[30] (张洪涛, 王天明, 王聪, 物理气相沉积技术制备的硬质涂层耐腐蚀的研究进展, 材料导报, 16, 15--16 (2002))

[31] R.Constantin, B.Miremad, Performance of hard coatings made by balanced and unbalanced magnetron sputtering for decorative applications, Surface and Coatings Technology, 120-121, 728(1999)

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