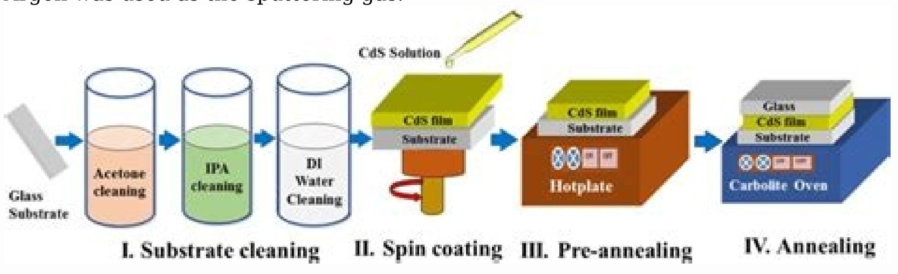
Substrate cleaning for thin film deposition pdf

Substrate cleaning for thin film deposition. Thin film production methods. Thin film deposition method. Substrate cleaning methods.

Access through your institutionScience, Applications and Technology2010, Pages 93-134Author links open overlay panel rights and contentView full textCopyright © 2010 Peter M. Martin. Published by Elsevier Inc. All rights reserved. Access through your institutionVolume 124, Issue 1, 1 February 1985, Pages 3-10 85)90021-5Get rights and contentP.E. LuscherR.G. Musket et al.D.M. MattoxS. Schiller et al.E. Dullni et al.D.M. MattoxD.M. MattoxJ.L. Vossen et al.E. ZinnerD.M. Mattox et al.Electrostatic spray pyrolysis (ESP) technique has been used for thin film deposition of fluorine-doped tin oxide, which is used for optoelectronic applications. The results show that films are polycrystalline, highly conductive (ρ=9.3×10−4 Ω cm), and have a high transmission (85%) in the visible range.The aim of this work was to study the adhesion of thin films to given substrates. Experiments were carried out on carbon, aluminum, chromium and tungsten films deposited on steel and polished TA6V titanium alloy substrates. Numerous parameters have an influence on the adhesion. These include stresses in the film, contamination, chemical bonding between the film and the substrate, the physical properties of the substrate and the roughness of the substrate. Sputter cleaning appeared to be one of the most effective methods approches in the PVD (physical vapor deposition) process to improve the adhesion of thin films.
Argon was used as the sputtering gas.



The sputtering time was varied from 0 to 70 min.
The adhesion of thin films was characterized by mechanical tests. The film cracking induced by these mechanical tests was observed by optical microscopy. We noticed that there was a clear correlation between sputter cleaning time and adhesion of films. The level of oxygen in the interface was studied with SIMS (secondary ion mass spectrometry) and NRA (nuclear reaction analysis); there was no linear reduction of the amount of oxygen as a function of sputter cleaning time. According to the SIMS results, there was no clear dependence between the amount of oxygen at the interface and adhesion. Measurement of oxygen content at the interface was quite a complicated problem and dynamic-SIMS was found to be a valuable method to perform assessment of this parameter when the thickness of the films exceeds 100 nm.Other phenomena connected to sputter cleaning were physical changes in the surface of the substrate, such as the removal of contaminated top layers, the decrease in substrate grain size and changes of texture. The major disadvantage of the sputter cleaning method was the surface contamination. The main contamination sources were residual water vapor and backscattered atoms introduced by the sputtering process.Physical vapor deposition (PVD) methods have found widespread application in the deposition of hard coatings. In order to compare potentials and limitations of the PVD methods, a good knowledge of the physical processes of film growth, formation of various film microstructures, and the resulting properties is necessary. Here the latest advances in understanding the effects of physical film growth parameters on the microstructure of growing films are reviewed. Examples of sputtered TiN film microstructures are given. A critical review of the structure zone models is presented. The importance of the homogeneity of both vapor and ion fluxes is also discussed and illustrated with examples. The problems of uniformity of both the film thickness and properties are also discussed. The requirements imposed on surface pretreatment are highlighted.The surface of low alloy steel (En40B) has been engineered in the plasma of a glow discharge via plasma nitriding and ion plating of titanium nitride (TiN) coatings on the nitrided substrates with the purpose of enhancing the surface properties and fatigue strength. The nitriding response of the steel has been accessed by the evaluation of phase composition, layer thickness, hardness profile, residual stresses and nitrogen and carbon distributions. The wear and fatigue characteristics of the plasma-nitrided steel have been investigated and simple models have been developed to describe the influence of such properties as depth and strength of the nitrided case on the fatigue limit and load-bearing capacity of the nitrided steel. In order to further improve the tribological properties and load-bearing capacity of the low alloy steel, a duplex plasma surface-engineering technique has been developed. This is achieved by plasma nitriding the steel first so as to produce a thick, strong subsurface and then depositing a thin, hard and wear-resistant TiN coating on the nitrided substrate by ion plating. Dry-sliding wear tests demonstrated that the duplex-treated steel, i.e. the TiN coating-nitrided steel composite, not only exhibited enhanced wear resistance over the as-nitrided steel (by a factor of 2–8) but also had much higher load-bearing capacity than the TiN coating on unnitrided steel. Optimization of the coating-substrate combination can be achieved by correct control of the plasma-nitriding, surface preparation and ion-plating processes.Sol-gel derived alumina was used to coat 316 stainless steel substrates. The coating showed crystallization starting at 1000°C. The crystalline particles were α-Al.After analyzing the interaction of some possible substrate elements with alumina sol, iron was determined to be the most important element in the crystallization of α-Al2O3. Our experiment shows, however, that coating crystallization originates from the substrate-coating interface. Substrate surface crystallography seems to play a more important role than additives in α phase nucleation.When oxide powders were used as additives, iron, manganese and chromium increased crystallization. Since the substrate surface includes iron, manganese and chromium, crystallization behavior may be a result of a combination of topography and some chemical effects.View all citing articles on ScopusIn this research, we synthesized a quaternary composite containing a graphene-based LaYAgO4-Graphene-TiO2 nanocomposite using a hydrothermal method. We examined all prepared samples by means of physical techniques, such as XRD, SEM-EDX, HRTEM, XPS, Raman, and DRS. We tested the photocatalytic activity of the ternary composite for CO2 reduction in a reactor using commercial carbonated water, and the target product was methanol (CH3OH), detected under UV and Vis light irradiation. The ternary nanocomposite, which contains three times a quaternary composite (LaYAgO4), exhibited high photocatalytic activity and improved a sum total of methanol of 12.27% after 48 h reaction time. In a heterogeneous system, the relevance between the Graphene-TiO2 and LaYAgO4 components showed an excellent photoreduction efficiency. This heterojunction presented herein offers a promising route for the rational design of a new class of photocatalysts for various applications in environmental protection and solar-energy conversion.Solar-driven chemical production of methanol from CO2 has become a hot topic of research due to high-value addition, with methanol as a product, as well as reduction of CO2 which is a greenhouse gas. Here we report gold nanoparticles deposited on mesoporous titania with isolated Si sites, which converted CO2 into methanol under visible light irradiation using LED light source. Si amount in titania lattice was optimized to obtain the best methanol yield. DFT calculation showed that Si sites incorporation was responsible for higher adsorption of CO2 onto the surface, which was further proved experimentally with CO2 uptake results. We achieved highest methanol production of 1835 μmolgcat−1 using Au/TixSi1−xO2 material with 28 mol% Si in titania lattice and 1.0 wt% Au nanoparticles deposition.
The Au/TixSi1−xO2 photocatalysts were thoroughly characterized by inductively coupled plasma atomic emission (ICP-AES) spectrometry, powder X-ray diffraction (PXRD), field emission scanning electron microscopy (FE-SEM), high angle annular dark field-scanning transmission electron microscopic (HAADF-STEM), transmission electron microscopy (TEM), energy dispersive X-ray spectrometry (EDX), 29Si MAS NMR, UV-vis diffuse reflection spectroscopy (DRS), N2 sorption studies, CO2 uptake experiments, cyclic voltammetry (CV) and DFT calculations. The products were analyzed by GC-FID, GC–MS, and HPLC. The photocatalytic reaction was monitored using in situ FT-IR which established the formation of formaldehyde as an intermediate product which further converted into methanol.The effects of transition-metal atoms doping and elastic strain on the magnetic properties of monolayer WS2 are investigated by the first-principles calculation. Firstly, we investigate the magnetic properties of a series of 3d transition-metal atoms (from Sc to Zn) doped monolayer WS2.
Our calculations show that doping of transition-metal atoms from Sc to Cr results in nonmagnetic states, while Mn, Fe, Co, Ni, Cu and Zn doping can induce magnetism in WS2 monolayer. The localized nonbonding 3d electrons of TM atoms lead to the formation of magnetic moments. Meanwhile, our calculations indicate that the elastic strain can be used to manipulate the spin polarization of TM-3d orbital. Specifically, the magnetic moment of Fe and Co-doped monolayer WS2 increase with the increase of tensile strain, while the magnetic moment of Mn, Ni, Cu and Zn-doped WS2 monolayer initially increase and then decrease with the increase of tensile strain. On the other hand, the magnetic moment of Fe, Co, Mn, Ni, Cu and Zn-doped WS2 monolayers decrease with the increase of compressive strain. While the magnetic moment of Sc, Ti, V and Cr-doped WS2 monolayers remain 0μB independent of tensile strain and compressive strain.We investigate the electronic and magnetic properties of X-doped (X=Ni, Pd, Pt) WS2 monolayer using the first-principles methods based on density functional theory. The results show that WS2 monolayer doped by Ni, Pd and Pt is ferromagnetic. The impurity states near the Fermi level depend highly on the atomic size and electronegativity. For different X-doped WS2, the formation energy is lower under S-rich conditions, which indicates that it is energy favorable and relatively easier to incorporate X atom into WS2 under S-rich experimental conditions. Moreover, Ni-doped system owns the lowest formation energy compared with other atoms under S-rich experimental condition. Our studies predict X-doped (X=Ni, Pd, Pt) WS2 monolayers to be candidates for thin dilute magnetic semiconductors. Ni-doped WS2 has relatively wide half-metallic gap. So Ni-doped WS2 is the most ideal for spin injection among Ni, Pd, and Pt, which is important for application in semiconductor spintronics.A series of monodisperse sub-micron spherical zirconia solid solutions were prepared by hydrolysis of zirconium, aluminum, nickel and copper salts in ethanol. The heat-treatment process of the as-prepared amorphous materials in air atmosphere at 500 °C leaded to the production of the zirconia solid solutions in tetragonal phase. Further heating from 800–1400 °C resulted in the formation of stabilized monoclinic zirconia solid solutions. X-ray diffraction, Fourier transform infrared spectroscopy and scanning electron microscopy confirmed the formation of pure phase nanocrystalline zirconia solid solutions with spherical shape even at 1000 °C. Optical studies of the nanostructured solid solutions showed the decreases in band gaps with increasing the heat-treatment temperature due to grain growth.This paper proposes a new method for tracking the whole trajectory of a ballistic missile (BM), in a low-observable environment with 'imperfect' sensor measurement incorporating both miss detection and false alarms. A hybrid system with state dependent transition probabilities is proposed where multiple state models represent the ballistic missile movement during different phases; and domain knowledge is exploited to model the transition probabilities between different flight phases in a state-dependent way. The random finite set (RFS) is adopted to model radar sensor measurements which include both miss detection and false alarms. Based on the proposed hybrid modeling system and the RFS represented sensor measurements, a state dependent interacting multiple model particle filtering method integrated with a generalized measurement likelihood function is developed for the BM tracking. Comprehensive simulation studies show that the proposed method outperforms the traditional ones for the BM tracking, with more accurate estimations of flight mode probabilities, positions and velocities.View full text A study of substrate cleaning methods for thin film evaporations was made. The study included investigation of ultrasonic cleaning, effects of water impurities, and tests for substrate cleanliness.

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Surface Roughness of Thin Gold Films and its Effects on the Proton Energy Loss Straggling

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We present a description of the effect of the surface roughness on the energy straggling associated to the energy loss distributions of protons transmitted through a self supported metallic thin foil. For this purpose we prepared a polycrystalline gold thin films using the standard sputtering method with different deposition rates. The statistics of the surface height distribution induced in these thin films were determined using Atomic Force Microscopy. The measured surface roughness allowed us to quantify the ion energy loss straggling in these samples for different deposition parameters and as a function of the incident ion energy.

Keywords: Ion Scattering; Atomic Force Microscopy; Self-supported thin films

I. INTRODUCTION

At the present time there is a great interest to carry out stopping power cross section measurements of light ions at low energies in metallic targets using a transmission geometry [1]. For this purpose it is necessary to provide self supported thin films with a precise thickness and a known surface roughness. It is well known that the ion energy loss distribution has a Gaussian shape and the standard deviations of these distributions are directly related with the collision statistics, target characteristics (density, surface roughness, grain size) and experimental conditions such as energy resolution and beam angular divergence. These two last conditions are not very important in the energy straggling as will be shown below.

For stopping cross section measurements it is necessary to know the parameters that characterize the homogeneity of the target, such as: average thickness, roughness and grains size distribution of the film. In order to include the thickness of the layer, an indirect method, based on the measurement of the stopping power of the ion beams has been developed [2]. However, in order to establish statistical models of the surface roughness, it is necessary to make systematic measurements of these parameters and to correlate them with measurements of the energy loss straggling in the ion energy loss distributions. In this sense we need to characterize the roughness of the thin film by a direct and non destructive method.

In this report we focus in the study of the surface roughness of gold polycrystalline thin films and its effect in the energy loss straggling.

II. EXPERIMENTAL DETAILS

The gold thin films were grown by techniques of sputtering deposition at room temperature (RT) on a silicon substrate with the native oxide on the top layer. Roughness was characterized by Atomic Force Microscopy.

The 10x5mm^2 Silicon substrates were cleaned in an ultrasonic bath with high purity methanol during 1 minute and the residual impurities cleaned with distilled water. The substrates were subsequently dried in an argon atmosphere before proceeding with the gold deposition.

The deposit of the gold thin films was carried out in a commercial sputtering system (SPI), with a quartz crystal balance (QCB). The sputtering system is evacuated using a small turbo molecular pump with an oil free rotary pump, reaching a pressure below 10 mTorr. Samples were prepared with three different deposition rates, 0.6 Å/s, 1.2 Å/s and 1.4 Å/s, for a total nominal thickness of 130Å. The purity of the films was monitored by Auger Electron Spectroscopy (AES) in the energy range between 0-1000eV. Measurements of the surface roughness were obtained from topographic images from an Atomic Force Microscope (AFM, Omicron VT-AFM) in contact mode. For each case the measured values of roughness were correlated with the different deposition rates.

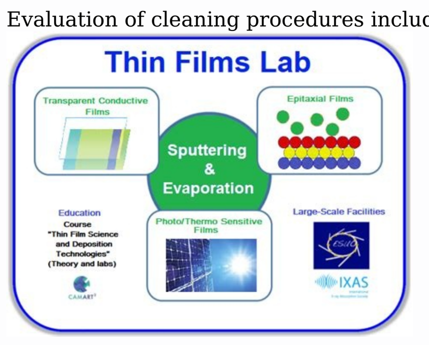
III. RESULTS

For each film we obtained a series of topographic images with different magnifications. Spatial representations of the surfaces are shown in Fig. 1. These images correspond to the SiO_2 substrate, and a set of 130Å thick thin films grown with different deposition rates (0.6 Å/s, 1.2 Å/s and 1.4 Å/s, samples 1, 2 and 3, respectively). Differences in the surface roughness are clearly observed between the clean substrate and the Au films. This particular substrate was chosen by its original low roughness. The RMS roughness of the SiO_2/Si(111) shown in Fig.1 is 0.51nm.

¿From the AES spectra of Fig. 2, we can appreciate the samples are pure gold thin films. The spectra of the different samples show the same number of peaks and each one of them is associated to a gold transition. We can also observe the films are free of oxygen and other surface contaminants. No signals associated to the substrate are detected; indicating the deposited film is uniformly grown over the substrate.

Topographic images were taken with the AFM in contact mode, set to take images, at different magnifications

Evaluation of cleaning procedures included the use of the electron microscope. The cleaning procedures developed during this study were tested on glass substrates only but they should be useful for a wide variety of other materials.



Metzger's method forms the basis for the procedures developed in this study. This method uses a detergent solution in an ultrasonic cleaner. The final rinse is made in conductivity water. Since production of conductivity water is tedious and the necessary equipment was not available during this study, triple distilled water was used with some degree of success. The impurities in commercial distilled water produced stains on the substrate during the oven drying process. A method of forced gas blowing was devised to prevent water from drying on the substrate, thus eliminating the stain. The combination of ultrasonic cleaning, distilled water rinse, and forced gas blowing, produced substrates with undetectable contamination. (Author).