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bond strengths. Treating a plastic produces a highly hydrophilic surface. Beyond surface modification, the industry is using plasma for cleaning, microroughening, increasing the surface molecular weight, initiating grafting reactions, and for depositing thin, highly crosslinked polyhydrocarbon coatings. Advantages of gas plasma technology for surface treatment are: superior effectiveness over most materials; surface oriented; low operator sensitivity; no disposal, permitting, or hazardous materials issues; low operating costs; excellent reproducibility; and the capability to tailor specific surface chemistries for the application.

225 Pretreatment of Polymer with Low Pressure Plasma: *G. Liebel*, Technics Plasma, D8011 Kirchheim Bei Munchen, Germany

Low pressure plasma treatment is a simple, sure and at the same time versatile method for cleaning, modifying, and conditioning the surfaces of a very wide range of materials. Microwave excitation can be used to very effectively treat plastics without causing visible changes at the surface. Owing to the short processing times and the small amount of materials needed for running the equipment, the method is economical; the freedom from problems with respect to waste disposal and the safety of the workplace play a significant role.

226 Characterization of Surface Modifications during Metallization of Polyetherimide: *M. C. Burrell*,* *B. R. Karas, D. F. Foust, W. V. Dumas, E. J. Lamby*, and *J. J. Chera*, GE Corporate Research and Development, Schenectady, NY 12301

The chemical and compositional modifications of a polyetherimide surface during metallization processes have been monitored using x-ray photoelectron spectroscopy (XPS). The following aspects will be discussed: (*i*) detection of contaminants on the polymer surface and the effectiveness of various cleaning agents; (*ii*) determining the degree of imide hydrolysis; (*iii*) quantifying the coverages of metallization catalysts using Rutherford backscattering spectrometry (RBS) as a calibration method; (*iv*) measuring the changes in catalyst composition (colloidal Pd/Sn) during sensitization and acceleration steps; and (*v*) verification of the cause of incomplete plating and leakage current between runs.

227 Ion Bombardment of Polyimide Films: An XPS Study: *B. J. Bachman* and *M. J. Vasile*,* AT&T Bell Laboratories, Murray Hill, NJ 07974

Surface modification techniques such as wet chemical etching, oxidizing flames, and plasma treatments (inert ion sputtering and reactive ion etching) have been used to change the surface chemistry of polymers and improve adhesion. With an increase in the use of polyimides for microelectronic applications, the technique of ion sputtering to enhance polymer to metal adhesion is receiving increased attention. For this study, the argon ion bombarded surfaces of PMDA-ODA and BPDA-PDA polyimide films were characterized with x-ray photoelectron spectroscopy (XPS) as a function of ion dose, Graphite and high density polyethylene were also examined by XPS for comparison of Cls peak width and binding energy assignments. Results indicate that at low ion doses the surfaces of the polyimide does not change chemically, however, adsorbed species are eliminated. At higher doses the chemical composition is altered and is dramatically reflected in the Cls spectra where graphitic-like structures become evident and the prominent carbonyl peak is reduced significantly. Both polyimides demonstrate similar chemical changes after heavy ion bombardment. Atomic composition of PMDA-ODA and BPDA-PDA polymers are almost identical after heavy ion bombardment.

228 Radiation-Enhanced Adhesion of Metal Films on Polymers: *J. E. E. Baglin*, IBM Almaden Research Center, San Jose, CA 95120-6099

The use of ion beam techniques to enhance adhesion of metal films at interfaces with polymer substrates is discussed. In particular, success achieved with copper vapor-deposited directly on presputtered Teflon is cited, together with an outline of the intrinsic processes which could be responsible for adhesion enhancement in this case. Some possibilities for other metal-polymer systems are reviewed.

229 Effect of the Plasma Pretreatment or the Ion-Plating on the Adhesivity of the Metallized Plastics: *K. Nakamae*,* *S. Tanigawa*, and *T. Matsumoto*, Dept. of Industrial Chemistry, Faculty of Engineering, Kobe University, Rokko, Nada, Kobe, Japan

Recently, it was found that adhesion for metallized plastics prepared by vacuum deposition, etc., is improved. We have investigated the availability of the pretreatment of polymer substrates or the ion-plating technique for metallized deposition on adhesion. In this study, the adhesiveness of the metal(Co) thin film was deposited onto the engineering plastics was pretreated by the plasma was investigated from the viewpoint of interfacial chemistry. Consequently, the adhesivity of metallized plastics was greatly dependent upon the density of the active group on the polymer surface.

230 Thin Film Adhesion—A Review of the Mechanical Methods for Adhesion Assessment: *P. A. Steinmann** (Present address: Lewis Research Center, National Aeronautics and Space

technique. In this particular test, the critical load (normal force applied on a moving stylus responsible for debonding of the film) is a characteristic value of adhesion. Several methods of determining the critical load and its interpretation as it relates to adhesion, as well as the concepts and theory of the test, are discussed. A few examples of scratch tests performed on metallized plastics are given to demonstrate the potential of this technique.

231 Adhesion and Deformation Behavior of Thin Metal Films on Polyimide: *F. Faupel, Y. H Jeng*,* *S. T. Chen*, and *P. S. Ho*, IBM, T. J. Watson Research Center, Yorktown Heights, NY 10598

A stretch-deformation method has been developed to measure the adhesion energy of metal/polymer structure. This method is based on measuring the difference in the stress *vs.* strain behaviors between metal/polymer and polymer structures. When combined with *in situ* microscopic observations, it can be used to investigate the deformation behavior of multilayered thin film structures. This method has been applied to study a number of metal/polymer structures, including Cu and Cu/Cr. Results are discussed.

232 Proposed Methods for Identification and Normalization of Strain Dynamic Effects in Adherence Testing of Metallized Plastics: *R. P. Riegert*, Quad Group, Santa Barbara, CA 93101

Adhesion testing of metallized plastics is more complex than with rigid substrates, as indicated by the extreme sensitivity of rate-of-load application. The low elastic modulus and plastic-flow induced stress distribution anomalies produce strain-dynamic effects in the surface, which are further complicated by the anisotropic of strain and surface anomalies intrinsic to some plastics. These manifest uncertainty as to the validity of any single adherence test method, especially in sheet plastics. Cross-correlation between multiple tests utilizing various forms of force application may identify the dynamics involved. Eleven different tests employing five diverse adherence test methods, z-axis tension, tear, bend spallation, shear, and peel, are discussed.

233 Surface, Interface, and Adhesion Properties of Metallized Plastics: *P-g. Cao*, Central Laboratory, Peking Electron Tube Factory, Peking, China

The paper explains the properties of metallized plastics film adhesion. We used surface analysis EDX/SEM, AES/SEM, ESCA, and SIMS during studies. Experimental results show that for metal evaporation film, the adsorption mechanism is dominant, but sometimes mechanical and diffusion mechanisms will also be important; for ion plated film, the diffusion is dominant, but sometimes the other two will also be important. The conclusion is that metal film adhesion is mainly determined by substrate surface and interface properties, which is dependent on surface pretreatment.

DIELECTRICS AND INSULATION/ELECTRONICS

Isolation and Trench Technology

234 Planarized Deep-Trench Process for Bipolar Device Isolations: *Y.-C. S. Yu, C. Hacherl*,* *E. Patton, E. Lane, S. Dottarar*, and *T. Yamaguchi*, Tektronix, Inc., Beaverton, OR 97077

A planarized device isolation process has been developed by using a deep-trench isolation technology combined with a local oxidation of silicon (LOCOS) process. Deep-trench etch and polysilicon etch-back processes have been optimized in terms of gas ratio, pressure, and power density. As a result of a deep-trench isolation, the collector-substrate capacitance was minimized at 9.0 fF. While maintaining a transistor-to-transistor isolation voltage of 25V. A cutoff frequency of 15.5 GHz and a 4-bit A/D converter with a sampling rate of 1.5 GS/s were demonstrated.

235 CMOS Device Isolation Using Silicon Selective Epitaxial Growth: *C. H. Ting*,* *A. Stivers*, and *J. D. Borland*, Intel Corp., Component Research, Santa Clara, CA 95052-8125

The silicon selective epitaxial growth (SEG) process has been studied intensively for device isolation applications. We have found that the SEG surface planarity depends not only on the pattern orientation but also on the deposition conditions. In general, compromise has to be made between facet formation and SEG material quality. A planarization process after SEG growth will be needed to give a truly planar surface. CMOS devices fabricated in SEG material are compared with standard LOCOS-isolated devices. Good device characteristics have been obtained with SEG and any difference with the LOCOS control will be explained. Relative merits between SEG and other device isolation techniques will also be discussed.

236 Process and Device Simulation of Trench Isolation Corner Parasitic Device: *T. Furukawa* and *J. A. Mandelman*, IBM General Technology Div., Essex Junction, VT 05452

2-D process and 3-D device modeling were used for studying the electrical characteristics of n-channel oxide filled trench isolated devices. The modeling focused on the influence that the corner parasitic device had on the transfer characteristic of the total device. Modeling showed that the short channel effects of the parasitic device were less severe than for the main part of the device, and the results were confirmed experimentally.