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process. The rate constants include an Arrhenius type temperature parameter (apparent activation energy). The effect of set-modifying admixtures on the rate constants is now under investigation based on continuous measurements of heat of hydration. Preliminary analysis of the hydration kinetics of the Portland cement and blast furnace slag system for different accelerator (CaCl2) concentrations (0-2.5%) suggest that the accelerator is primarily affecting the nucleation-growth stage while the later stage diffusion process is only slightly altered. An optimum rate accelerating admixture concentration was found. Further test results are needed in order to predict compatibility of a given admixture and blended cement.

11:40 AM

Alkali Activated Pastes of Pulverized Fuel Ash and Blast Furnace Slag, Effect of Blending Proportions and Sodium Silicate Modulus on Strength and Microstructure: *J. Ivan Escalante*[1]; Karla Campos-Venegas[1]; Gabriela García-Martinez[1]; Alexander Gorokhovsky[1]; [1]Cinvestav Unidad Saltillo

Composite pastes of fly ash (PFA) and blastfurnace slag (BFS) were chemically activated with waterglass of various moduli (M). The strength and microstructures were investigated for PFA-BFS composites of 100-0, 75-25, 50-50, 25-75 and 0-100; the waterglass moduli were 0, 0.75, 1, 1.5 and 2, for %Na_2O of 4-8% relative to the total binder weight. The pastes were cured 24h at 75°C and then at 20°C. For pure PFA composites 4% Na_2O was ineffective and higher %Na_2O improved the compressive strength, reaching up to 25MPa for M=1. For the 100%BFS composites the highest strengths were for 4% Na_2O regardless of the modulus (80-85MPa). For the composites, the strengths reduced as the PFA content increased, for 50%PFA the best modulus was 1-1.5 (45-48 MPa). Strength was reduced due to the porous nature of the PFA, as shown by the microstructures, and the increased water demand as the %PFA increased.

Advanced Processing of Biomaterials: Metallic Biomaterials

Program Organizers: Roger Jagdish Narayan, University of North Carolina and North Carolina State University; Carl Boehlert, Michigan State University; James Holbery, Pacific Northwest National Laboratory

Monday AM — Room: 201N
October 16, 2006 — Location: Duke Energy Center

Session Chair: Carl J. Boehlert, Michigan State University

8:30 AM Introductory Comments

8:40 AM

Recent Advances in Biomedical Titanium Alloys: *Henry J. Rack*[1]; [1]Clemson University

This presentation will examine the current status of several efforts being undertaken to provide new advanced titanium alloys for biomedical applications. Included will be the development of ultra-fine grain structures, thermal processes and modified chemistries for enhanced combinations of modulus, super-elasticity, tensile strength and tensile ductility. The impact that these developments have on the biocompatibility and osteointegration will also be considered. Finally the remaining limitations to their full implementation in the biomedical device community will be discussed.

9:00 AM

Wear-Resistant Boride Reinforced Titanium Alloy Composites for Orthopedic Implants: *Soumya Nag*[1]; Rajarshi Banerjee[2]; Sonia Samuel[2]; Hamish L. Fraser[1]; [1]Ohio State University; [2]University of North Texas

Wear resistance is one of the most important requirements for the femoral head in orthopedic implants. While titanium-base alloys are the materials of choice for implants, offering superior biocompatibility and balance of mechanical properties as compared with more traditional biomaterials, their poor wear-resistance and strong tendency for debris formation severely restricts their applicability in femoral heads. By employing novel near-net shape processing technologies, such as laser engineered net shaping (LENS™), it is possible to deposit functionally-graded metal-matrix composites consisting of stiff and strong titanium boride reinforcements in a tough titanium alloy matrix. This paper will focus on the microstructural evolution and resulting wear resistance of these laser-deposited composites. Specifically, the refinement in scale and homogeneity of the micro- and nano- structure resulting from the laser processing will be highlighted. In addition to mechanical properties, the electrochemical response, and, biocompatibility of these materials will be discussed in this presentation.

9:20 AM

Potential Use of Nanostructured Titanium for Biomedical Applications in the Urinary Tract: Darren R. Tyson[1]; Ken Knapp[1]; Ralph Clayman[1]; *James C. Earthman*[1]; [1]University of California, Irvine

The use of biomaterials for medical use in the urinary tract is hampered by the formation of calcium-based crystal deposits in vivo, generally referred to as encrustation. These deposits serve as the precursor to stone formation. Anecdotal evidence suggests that titanium possesses encrustation-resistant properties in vivo and may be useful in urologic applications. Of particular interest is the possibility of coating surfaces with nanostructured titanium. Several samples were submersed in artificial urine with saturating concentrations of calcium for a period of 14 days. These specimens were removed, rinsed briefly in deionized water and analyzed by scanning electron microscopy and energy dispersion spectroscopy to determine calcium content of crystals on the surface of the various samples. Our initial observations indicate that nanostructured titanium offers superior resistance to encrustation when compared to polyurethane or conventional coarser grained titanium. Further studies investigating the use of nanostructured titanium in urologic applications are warranted.

9:40 AM

In-Situ X-Ray Analysis of Mechanism of Non-Liner Super Elastic Behavior of Ti-Nb-Ta-Zr System Beta Type Titanium Alloy for Biomedical Applications: *Mitsuo Niinomi*[1]; Toshikazu Akahori[1]; Nobuhito Sakaguchi[1]; [1]Tohoku University

The in-situ X-ray analysis during the deformation of Ti-25Nb-10Ta-5Zr that exhibits the shape memory effect based on the deformation induce a" martensite, Ti-30Nb-10Ta-5Zr that exhibits no-liner super elastic behavior followed by slip deformation, and Ti-35Nb-10Ta-5Zr that exhibits a general liner elastic deformation behavior followed by slip deformation were carried out in order to verify the mechanism of non-liner super elastic behavior of Ti-Nb-Ta-Zr system alloys for biomedical applications.During the deformation of Ti-25Nb-13Ta-4.6Zr, the peaks of a" marten site phase were observed, but not observed in Ti-30Nb-13Ta-5Zr and Ti-35Nb-13Ta-5Zr. The anisotropy of lattice strain is very large in Ti-30Nb-13Ta-5Zr. The one lattice reaches to the elastic limit, and then another lattice can reaches to the elastic strain without slip deformation in Ti-30Nb-10Ta-5Zr, but the one lattice reaches to the elastic limit, and then the slip deformation occurs before another lattice reaches to the elastic limit.

10:00 AM

New Plasma Surface Treated Memory Alloys: Towards a New Generation of "Smart" Orthopaedic Materials: *Kelvin Yeung*[1]; Roy Y. L. Chan[1]; Kin On Wong[1]; Xuangyong Liu[2]; C. Y. Chung[2]; Paul K. Chu[2]; William W. Lu[1]; Keith D.K. Luk[1]; Danny Chan[1]; Kenneth M. C. Cheung[1]; [1]University of Hong Kong; [2]City University of Hong Kong

Nickel-titanium shape memory alloys (NiTi) are promising in orthopaedics due to their super-elasticity and shape-memory-effect. However, release of toxic nickel ion remains a major concern. We have developed a novel method to reduce nickel release by using plasma immersion ion implantation (PIII) surface treatment. This study compares the surface mechanical and biological properties of PIII treated samples with untreated NiTi. NiTi discs containing 50.8% Ni were implanted with nitrogen and carbon. Their elemental depth profile, chemical composition, surface hardness, corrosion resistance, in-vitro and in-vivo biocompatibility were compared with untreated NiTi. After PIII treatment, all the mechanical properties were improved. The Ni concentration in the simulated body fluid was undetectable. In animal study, the bone grew better on treated surfaces. PIII results in enhanced mechanical and biological properties. This technique will allow NiTi alloys to be safely implanted in humans. A new generation of "smart" orthopaedic implants will likely result.