Rare-Earth Information Center INSIGHT

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Volume 2 June 1, 1989 No. 6

Rare Earth Markets Continue to Show Strong Growth

The eagerly awaited U.S. Bureau of Mines **Mineral Commodity Summaries 1989** is now available, and so is the 1988 Rothskill rare earth study. The growth of the total rare earth market was fairly flat with perhaps as high as a 6% growth over the last two years. The major reason for this slow down was the decrease in the consumption in the petroleum cracking catalysts and in iron and steel, where mixed rare earths are used. That is the bad news. The good news is that the individual rare earth markets grew by about 33%. The major increases were for cerium oxide in automotive exhaust catalysts, neodymium metal in permanent magnets, and yttrium oxide in ceramics, primarily stabilized zirconia and silicon nitride.

The supply for most rare earth products was in excess of demand, except for samarium which was tight. The availability of rare earth products should continue to be good because of the completed plant expansions, the current expansions in progress, and announced processing plant expansions.

According to the preliminary figures released by the U.S. Bureau of Mines the mine production of rare earths in the People's Republic of China and the United States is virtually the same, about 17,000 metric tons of rare earth oxide equivalent each. These were followed by Australia (6,600), Malaysia (3,300), India (2,200), USSR (1,500) and Brazil (1,100).

Rare Earths in Osteosynthesis

In surgery for fixing bone fragments, stainless steel or titanium metal plates and pins are commonly used. After the bone has healed a second operation is necessary to remove the plates and pins from the patient. A second approach is to use a metal which can be used as plates and pins, but in time it is introduced into the organism and has no deleterious effect on its vital functions. Magnesium is one such promising element, but it dissolves too rapidly and releases gases during the dissolution process. Furthermore, pure magnesium is structurally too weak. Enter the rare earths.

Russian scientists A. A. Bylablin, et al. [**Metallov. Term. Obrab. Met. 1988**, [2], 29; Engl. transl. **Metal Sci. Heat Treat. 30**, 122 (1988)] have found that the addition of rare earths to magnesium helps to overcome these drawbacks. The authors studied three different rare earth metals - yttrium, cerium and neodymium - at two concentration levels - 1.5 and 2.5 wt.% (?). They found that the 2.5 Nd gave the best tensile strength and ductility, and

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that it increased the corrosion resistance of the alloy to a level which was satisfactory for use in osteosynthesis.

Multilayer Heat Mirrors

M. A. Angadi and K. Nallamshetty from the University of the West Indies, St. Augustine, Trinidad have shown that $CeO_2/Cu/CeO_2$ multilayer films can be used as heat mirrors in tropical countries [J. **Mater. Sci. Lett. 8**, 391 (1989)]. Heat mirrors are used in energy conserving architectural windows. These mirrors must transmit the visible radiation and have a high reflectivity of the infrared radiation. There are many multilayered dielectric/metal/dielectric films available, e.g. $SiO_2/Al/SiO_2$, which are suitable for cold and temperate climates, but are unusable in tropical areas because they transmit too much of the visible radiation (~80%). The authors found that a $CeO_2/Cu/CeO_2$ film in which the layers were 22, 30 and 22 nm thick, respectively, exhibited a high reflectance in the near-infrared region (>90%) and transmitted less than 50% of the visible light. The films were exposed to temperatures of 35°C and humidities of 90% for one month, with essentially no change in the transmission characteristics, and a slight decrease in the reflectance (less than 10%). Exposure to sunlight did not show any observable decoloration, and the mechanical stability appeared to be satisfactory. These initial tests indicate that the $CeO_2/Cu/CeO_2$ coatings have considerable promise as a heat mirror for tropical climates.

Ceramics in Aircraft Engines

The prospect of ceramic parts in aircraft engines is looking good, but not in the immediate future. Initial uses are expected to occur in the late 1990's and by the turn of the century perhaps as much as 10% of the weight of the engine will be made of ceramic composite materials. The rare earths are expected to see some action in these materials.

Initial uses are expected to involve NiCrAlY (or CoCrAlY) and yttria-stabilized zirconia (YSZ) as thermal barrier coatings (TBC). TBC systems consist of a dense oxide-free metal coating (NiCrAlY) and a porous, finely microcracked oxide coating (YSZ), which are used to protect aircraft gas turbine engine components from deteriorating at high operating temperature. The metal coating prevents the oxidation of the engine components and the top ceramic oxide coating serves as thermal insulation. The leading metal coating alloys capable of operating at 1200°C are Ni-35Cr-6Al-0.95Y and Ni-25Cr-6Al-0.75Y (wt.%). The role of yttrium is said to enhance scale (primarily Al_2O_3) adherence by diffusing toward the surface of the bond coating to form a complex Al_2O_3-Y_2O_3 scale. The leading state-of-the-art thermal barrier oxide coating is a 7 to 8 wt.% Y_2O_3-ZrO_2 ceramic, which has a low thermal conductivity. Furthermore, YSZ is more compatible with the metal substrate by virtue of its high thermal expansion, which helps to reduce strains at the metal-ceramic boundary. A newly developed $24CeO_2$-$2Y_2O_3$-ZrO_3 (wt.%) ceramic is reported to be better than YSZ in that its: (1) cyclic thermal fatigue resistance is better, (2) thermal conductivity is lower at high temperatures, and (3) the hot corrosion resistance is superior.

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