Rare-earth Information Center INSIGHT

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Scandium Saves Aluminum

As large scale integrated (LSI) circuits become smaller and smaller, the material requirements become more and more stringent. One of the severe problems is the failure of aluminum interconnections due to stress induced migration (SIM) and electromigration (EM). In the former case (SIM), voids are formed in the aluminum interconnection alloy (a typical composition is 1%Si, 0.5%Cu, balance Al) due to stresses which have developed in the aluminum alloy in the integrated circuit. In time, as these voids build up, electrical open circuits develop, rendering the integrated circuit useless. In the latter case (EM), electrical currents in the aluminum alloy cause the migration of some of the minor alloys constituents, and this too leads to voids and eventual electrical failure in the interconnect alloy of the LSI circuits.

Research carried out by S. Ogawa and H. Nishimura of Matsushita Electrical Industrial Co., Osaka indicated that the addition of 0.15% Sc was sufficient to prevent failure by either SIM or EM under the same test conditions as applied to the conventional 1.5Si-0.5Cu-Al alloy. Even at the 0.15% level, the solid solubility limit of scandium in aluminum is exceeded and small size precipitates (< 10 nm) were observed in the microstructure. These precipitates were thought to be Sc or $ScAl_3$ (the latter being more likely), and are believed to act as sinks for the vacancies. Heat treating studies showed that many voids (~ 1μm diameter) formed in the 1.5Si-O.5Cu-Al alloy after annealing at 480 and 530°C, while no voids were formed in the 0.15Sc-Al alloy. Furthermore, the scandium addition decreases the grain size of aluminum, and increases its hardness. EM tests showed that lifetime was ten times longer for the 0.15Sc-Al alloys than that observed in the 1.5Sc-0.5Cu-Al alloy. The actual mechanism for superior EM performance has not been established.

Although the amount of scandium used in this alloy is minute, and the small size of the aluminum interconnects, this potential application could result in a significant market for scandium, because of the large number of LSI circuits that will be manufactured.

New Fluorite Rare Earth Source

Dodgex, Ltd. of Whitehorse, Yukon, Canada, announced the discovery of a major resource of rare earth and other specialty metals (primarily niobium, zirconium and hafnium) in a fluorite-bearing vein, containing over 1.5 million tons with a gross value of $500 million. The ore contains 1.5% rare earth oxides, predominately Ce, La and Nd, but also 0.15% Y. The rare earths are present in the form of monazite and xenotime. Dodgex has planned a late 1994 production start-up date.

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Mt. Weld Update

News from Australia indicates that the Mt. Weld Rare Earth Project is more or less continuing on schedule. The pilot plant program was completed in November 1992 and the product samples are being evaluated. They have also received approval from the Western Australia Environmental Protection Agency for the project, but are now awaiting the Western Australia state and the Australian federal government approvals. These are expected either this month or in May. Ashton Mining will be making a decision on the project development in July/August 1993, with the hope to be operational in late 1994. The ultimate goal is to be able to produce 4000 tons of CeO_2 per year at full production.

Palladium Auto Catalytic Converter

Recently, Allied-Signal announced that they have developed a competitive automobile catalytic converter that only uses palladium, which is the least expensive metal of the platinum group of metals. Most catalytic converters use a mixture of platinum, rhodium and palladium. By eliminating the platinum and rhodium, the system costs can be reduced by 30 to 50%. The new catalytic converter will also meet the stringent California air emission standards which go into effect in 1997. The change over from a platinium-rhodium-palladium catalyst to a palladium one should have little, if any, effect on the utilization of rare earth oxides, primarily cerium, in catalytic converters (see **RIC Insight 5**, [3] and [4], March and April 1992), since the role of the rare earth oxides is essentially independent of which platinum metal group element is used.

Er-Si Optical Semiconductor -- A Step Closer to Reality

Erbium doped into silicon is being intensively studied because of its potential utilization in optoelectronic technology. Erbium is of special interest because its optical transitions emit light with a wavelength near 1.5 μm, which is of great importance in communications because of the absorption minimum in silica-based materials at 1.5 μm. In the December 1992 issue of **RIC Insight** we reported on the role of oxygen on improving the erbium luminescence of an erbium doped into silicon semiconductor. Now, Dutch scientists have reported that they have been successful in increasing the doping level of erbium in silicon by two orders of magnitude [A. Polman et al. **Appl. Phys. Lett. 62**, 507 (1 February 1993)]. They were able to incorporate up to 10^{20} Er/cm^3 into crystalline silicon (c-Si) by either implanting Er directly into c-Si or into amorphous silicon (a-Si). In either case, after implantation the surface layer is in the amorphous state. The a-Si material is then heated to crystallize the material by thermal solid phase epitaxy at 600°C, in which segregation and trapping of erbium occurs at the moving c-Si/a-Si interface, incorporating the erbium into c-Si. A rapid thermal anneal of 15 seconds at 1000°C, results in a sample with a sharply peaked photoluminescence spectra centered at 1.55 μm.

This work is another important step toward practical silicon-based optical devices, such as light emitting diodes and optical amplifiers.

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