Rare-earth Information Center Insight

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Ta – microcystalline CeO_2 Diffusion Barrier

Al is currently used as the metallization material for large-scale integrated circuits (LSIC) due to its compatibility with the processing of silicon. Cu with its lower bulk resistivity and superior resistance to electromigration would seem preferable, but Cu oxidizes easily and at temperatures as low as 200°C can diffuse into Si and form Cu silicide. In order to avoid degradation of the Si devices in the LSIC, a diffusion barrier is required between the Si and the Cu. Ta is an interesting material for a barrier layer given its high melting temperature, the high temperature required to form silicides and the lack of compound formation and low solubility of Cu. However, Cu can diffuse through microstructural defects in the Ta barrier. A recent study by D.-G. Yoon et al. {*J. Appl. Phys.*, **83**, 1333-6 (1998)} studied the use of CeO_2 as a microstrucutral control agent. The CeO_2, which is co-sputtered with the Ta, is believed to be "stuffed" along the grain boundaries of the Ta layer. The authors state that this impedes diffusion of Cu along those boundaries. The diffusion barrier is effective to about 800°C. I speculate that the CeO_2 acts as a grain-refining agent reducing the size of the Ta grains; hence, decreasing strain at the grain boundary while increasing path length through the layer. An article in a recent Wall Street Journal states that IBM is starting to produce a high-speed microprocessor with Cu metallization.

Optical Refrigerator

In the October 1997 *Insight*, I reported on the observation of a net cooling using an optical system. B. C. Edwards et al. {*Rev. Sci. Instrum.*, **69**, 2050-5 (1998)} discussed a design for a refrigerator based on this effect, using a cooling element of Yb^{3+} doped ZBLANP (a heavy metal fluoride glass containing Zr, Ba, La, Al, Na and Pb). The design based on currently available solid state technology would produce 5 W of cooling at 77 K with efficiency claimed to be comparable to that of small commercial mechanical cryocoolers. Unlike mechanical cryocoolers, the optical refrigerator would produce no vibrations or electromagnetic signature. The enabling technology is the recently developed high-power diode laser, which operate around the required wavelength of 1.02 μm and produce the required 50 W input power. At the current time, it is the lifetime of the diode laser which limits the operating time of the refrigerator.

Batteries

Nickel-metal hydride batteries represent a major market for rare earth materials. A recent article {*C&EN*, **76**, [31], 37-43 (1998)} provides a brief description of the Ni-metal hydride technology as part of an overall description of the state-of-the-art in rechargeable batteries. In addition to Ni-metal hydride batteries, Ni-Cad, Lithium-ion, and Zinc-air batteries are discussed. The article reports that 500 million Ni-metal hydride batteries were produced in 1997.

LaB_6 Photoinjector

High-brightness electron accelerators, such as linear accelerators or synchrotrons, require a source of a considerable number of electrons. A filament, such as the one in the CRT of your computer display, will simply not supply the required current. One method of producing these electrons is to produce photoelectrons by illuminating a suitable material with a laser. These sources are typically expensive and difficult to operate. The expense comes from the requirement of a frequency doubled or tripled Nd:YAG or Nd:YLF laser. Recently, P. G. O'Shea et al. {*Appl. Phys. Lett.*, 73, 411-3 (1998)} have demonstrated that if LaB_6 is used as the cathode material, an efficient photoinjector can be made using a relatively inexpensive TEA nitrogen laser. Furthermore, heating the cathode to just below the threshold for thermionic emission allows the operation of the photocathode in a relatively low vacuum.

Magnequench and Sumitomo Take Patent Action

Magnequench International Inc. and Sumitomo Special Metals Company Limited have filed a complaint with the United States International Trade Commission charging that a number of companies are importing rare-earth magnets, magnetic materials, or articles, which contain these magnets into the United States. The magnets are claimed to infringe on a number of U.S. Patents held by Magnequench and Sumitomo for neodymium-iron-boron magnets. The companies named in the complaint are Houghes International, Inc., International Magnaproducts Inc., Multi-Trend International Corp., American Union Group, Inc., Harvard Industrial America, Inc., High End Metals Corp, H.T.I.E., Inc. and CYNNY Magnets. The complaint follows a letter sent out by Magnequench in April of this year, which specifically mentions that evidence for the USITC complaint was being gathered. More information about the complaint may be obtained from the USITC web site (http://www.usitc.gov/docket.htm). The docket number is 2013.

YBM

A story by Karen Howlett in the Saturday, August 22, 1998 edition of the *Toronto Globe and Mail* reports that YBM Magnex International Inc.'s (YBM) biggest shareholder is taking steps to replace the company's entire board of directors. The unidentified Canadian institutional investor, represented by VC & Co. Inc., a Toronto advisory firm, has asked YBM to call a shareholders meeting so that a new slate of directors can be voted in. Wesley Voorheis, managing director of VC & Co., is quoted in the article as saying he and his client have been negotiating with YBM management and the board over the past two weeks in a bid to persuade the directors to voluntarily step down, but his client decided to take action after discussions between the two sides broke down. On August 24, 1998, YBM issued a statement confirming the request for a shareholders meeting and stating that it is currently being reviewed with the companies legal advisors. Of interest to magnet users is that Douglas A. Koop has been appointed Chief Operating Officer. Mr. Koop has been President of the Magnetics Division of Crucible Materials Corporation and General Manager of the Magnetics Products Division of Philips Electronics North America Corporation.

Notes:

Last month, a decimal got shifted and I reported that each Toyota Prius uses 1.5 kg of rare earth magnets. That number should be 15 kg. In addition to the usual input from K. A. Gschneidner, Jr, I would like to acknowledge F. G. Jones and P. M. Wheeler for bringing articles (and errors) to my attention.

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Director CREM/RIC