Rare-earth Information Center INSIGHT

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Mass Production, Low Cost Lasers

IBM scientists from the Zürich Research Laboratory claim to have demonstrated that it is possible to fabricate over 20,000 diode lasers on a 5 cm diameter semiconductor wafer. According to IBM, it is the first time anyone has both mass-produced and tested semiconductor lasers on a complete wafer. The IBM team, headed by Peter Vettiger, deposited layers of (Al,Ga)As epitaxially onto GaAs wafers to form the direct gap junctions and optical resonators of lasers. Individual lasers are formed by reactive ion-beam etching to cut trenches ~600 μm long and ~5 μm deep through lithographic resists. These are then coated with a semitransparent reflective material which acts as a mirror. Application of a current produces a light, which is reflected back and forth between the mirrors, and then finally passes out of the device through the thin coating. Waveguides and photodiodes are fabricated next to each laser. This allows simultaneous testing for flaws in the lasers on the uncut wafers in an automated system.

This development could lead to mass produced, low cost lasers for CD (compact disc) players, laser printers, magneto-optic read-write storage discs, fiber-optic data transmission, absorption and fluorescence detectors, etc. The main disadvantage is that these lasers emit light in the 830-850 nm (near-infrared) range. But shifting the wavelength into the 415 to 450 nm (blue-green) range would make these diode lasers much more useful.

One may wonder what this development has to do with rare earths? By itself, nothing. But it portends for some significant uses for the rare earths, not only as noted above (magneto-optic storage discs and fiber optics), but also as the upconversion material. One such material would be a Nd-YAG laser to drive a nonlinear, frequency-doubling crystal to produce the green light. Another possibility is to use a Tm upconversion solid laser (see next item).

Blue-green Upconversion Solid State Laser

Scientists from Los Alamos National Laboratory have developed and patented (U.S. Patent 4,949,345, August 14, 1990) a Tm^{3+}:$YLiF_4$ laser to convert near infrared or red light from semiconductor laser diodes into blue light by a multiphonon excitation process. In this scheme the Tm^{3+} ion is excited

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in two steps by absorbing low energy infrared photons to a higher energy level from which it can emit a high energy blue or blue-green photon. The upconversion lasers are highly efficient and reliable compared to nonlinear frequency-doubling techniques because they operate at low light intensities. This blue-green upconversion laser is expected to be used in communications, semiconductor processing, laser radar, laser ranging, scar-free tissue welding, retina welding, and industrial applications such as laser welding and cutting. The details concerning this new laser can be found in two papers by Nguyen et al., Appl. Optics **28**, 3553 (1989) and **SPIE 1223** (Solid State Lasers) 54 (1990).

Superconducting Market Projects

Speakers at the Second World Congress on Superconductivity suggest that significant commercialization of the high temperature superconductors is 5 to 15 years away. In 1990 the sale of superconducting devices amounted to $350 million, and essentially all of it was for low temperature superconductors (<25 K). The initial market for the high T_c materials is expected to be in electronics for communication, but between the years 2000 and 2005 medical and industrial devices will be a significant market for the high T_c superconductors. Beyond 2005 high energy physics, transportation and power distribution might become major markets. The market size is expected to reach $5 billion in 2000. The main question is, which will be the major high T_c material, $YBa_2Cu_3O_{7-x}$ or one of the bismuth phases, or something new and unknown today? Right now the $YBa_2Cu_3O_{7-x}$ is the leading candidate and will be for the immediate near future. It is impossible to predict with any certainty beyond 3 to 5 years if it will still be number one.

Cast-Hot Rolled Permanent Magnets

Reports coming out of Japan indicate that Seiko-Epson Company, Ltd. has been the first to develop a casting/hot rolling method for mass producing praseodymium-iron-boron-copper permanent magnets. This process is simpler than current production techniques used for preparing the rare earth-iron-boron permanent magnets (sintered powder or rapid solidification), and eliminates the need for molds. The cost of producing the cast/hot rolled magnets is about the same as the sintered powder process for small magnets, but substantial savings can be realized for large magnets. The material prepared by this process is reported to have lower levels of impurities, such as carbon and oxygen, better corrosion resistance and higher mechanical strength than the conventionally produced magnets. The maximum energy product of these materials is 29 MGOe and the coercive force is 17 kOe. Seiko-Epson is presently producing two metric tons per month.

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