



# RARE-EARTH INFORMATION CENTER INSIGHT

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## Large Pore Size Molecular Sieves

The use of mixed rare earths in gasoline cracking catalysts has been, and still is, a major rare earth market. The rare earth cracking catalysts have been around for over 25 years, which is extremely unusual for a catalyst, since the half-life for an industrial catalyst is about five years.

Recently a new family of molecular sieves have been developed in a collaborative project between scientists at Virginia Polytechnic Institute and State University (Prof. M. E. Davis and co-workers) and Dow Chemical (C. Crowder). Davis' group has synthesized aluminophosphate-based sieves with pore sizes larger than 10Å in diameter, approximately 50% larger than those of standard catalytic materials. These new molecular sieves consist of rings containing 18 tetrahedrally coordinated atoms, called T-atoms. These T-atoms are generally silicon, aluminum and phosphorus. This compares to rings formed by 12 T-atoms for the materials currently used in catalytic applications.

These large pore size molecular sieves are of interest to the petroleum refining industry for cracking the large molecules which cannot be cracked by the molecular sieves currently in use, thus increasing the motor fuel yields from the crude oils. Do these new molecular sieves represent a threat to the rare earth cracking catalyst market? Hardly! It is unlikely that the large pore size molecular sieves will replace the current normal pore size catalysts because the former are too expensive. More than likely, the new molecular sieves will complement the standard zeolites. Furthermore, it is possible that rare earth additions will improve the catalytic efficiency of the large pore sieves (this remains to be shown), and thus expand this rare earth market.

## New Laser Host

Russian scientists have synthesized single crystals of  $KY_3F_{10}$  doped with several lanthanide species and studied their optical properties. Abdulsabirov et al. [Kristallografiya 32, 951 (1987); Engl. transl. Sov. Phys.-Crystallogr. 32, 559 (1987)] claim they were the first to obtain laser action in  $KY_3F_{10}:\text{Nd}$  single crystals. From their studies they concluded that the  $KY_3F_{10}$  shows promise as a laser matrix since it has a

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smaller concentration quenching of the luminescence than most Nd laser host materials. Furthermore, they suggest that  $\text{KY}_3\text{F}_{10}:\text{Ce}$  is a promising tunable laser based on the d-f transition in  $\text{Ce}^{3+}$ .

### Multilayer Magnetic Structures

Over the last few years scientists have been "tailor-making" magnetic materials on an atomic scale and have gained important insight into the nature of magnetic interactions and coupling in rare earth materials, which portends of new rare earth applications in the magnetic arena. By using "epitaxial" methods scientists have been able to deposit materials, atomic layer by atomic layer, on an appropriate substrate. Studies of various magnetic lanthanide-yttrium (which is nonmagnetic) combinations have led to some exciting developments. For example, Y/Gd multilayers can be either ferromagnetic or antiferromagnetic depending on the Y thickness: for an yttrium layer of five atoms thickness the material was ferromagnetic, but when the layer thickness was doubled to ten yttrium atoms the coupling between Gd layers was antiferromagnetic.

When Dy was substituted for Gd, a spiral structure, which is the same as in pure Dy, resulted in the Y/Dy multilayer material. Furthermore, the spiral retains its coherence over many multilayer periods, which implies that the spiral is propagated through the Y layers. The ferromagnetism which occurs in bulk Dy at low temperatures does not occur in the multilayer material. As one may have guessed when two magnetic lanthanides form a multilayer material, the resulting magnetic structure is extremely complicated. So far only one combination has been studied to date, namely Gd/Dy.

These multilayer magnetic structures are prepared by molecular beam epitaxy (MBE) technique, and if done properly have a well defined crystalline superlattice structure. Studies have shown that interdiffusion between layers is small or nonexistent.

The ability to make tailored magnetic structures holds promise for (1) the integration of magnetic structures with semiconductors, (2) new thin-film recording devices, (3) magnetostrictive devices, and (4) interesting permanent magnet materials, in addition to increasing our fundamental knowledge of magnetic coupling, the role of magnetoelastic energy in determining magnetic phases, etc.

Some minor practical applications might be reasonably expected by 1995, and extensive utilization of magnetic multilayers will appear at the turn of the century. Because these are tailor made materials they will be expensive and will not replace many conventional magnetic materials but they should find their own particular niches. Furthermore, the rare earth multilayer materials will be competing with transition metal multilayered substances.

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