'Ubiquitous element strategy' for overcoming potential deficiencies of rare elements

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Japanese scientists report on a unique ‘ubiquitous element strategy’ to overcome the ‘rare-element crisis’ that was triggered by increasing demand for such elements as lithium, used in batteries, and dysprosium for Ne-Fe-B permanent magnets.

‘Ubiquitous element strategy’ for overcoming potential deficiencies of rare elements in the synthesis of industrially important electronic, thermionic, and structural materials.

Japanese scientists report on a unique ‘ubiquitous element strategy’ for synthesizing industrially important electronic, thermionic, and structural materials using naturally abundant elements. This strategy aims to overcome the ‘rare-element crisis’ that was triggered by increasing demand for such elements as lithium, used in batteries, and dysprosium for Ne-Fe-B permanent magnets.

In the review article published in the journal *Science and Technology of Advanced Materials*, scientists from Tokyo Institute of Technology describe their research on the synthesis and applications of oxide materials based on the 20–30 most abundant elements including Si, Al, Ca, Na, and Mg. The key to this strategy is an in-depth knowledge of the role of elements in the physical properties of materials—knowledge available from research on the science and technology of nanometer-sized materials.

Research covered in this paper includes:

The conversion of ceramic 12CaO•7Al2O3 (C12A7)—interconnected, positively charged nano-cages—into a chemically and thermally stable transparent conductor which undergoes a metal-superconductor transition at 0.2 K. C12A7 has a wide bandgap of >7 eV and a low work function of 2.4 eV. The authors describe the synthesis, properties, and applications—light-emitting, electron field emitters, and nonvolatile memories—of C12A7 based on their own research.

The generation of ionized oxygen is important in the electronics industry for applications including the production of silicon diode layers on semiconductors. Conventional methods rely on the catalytic action of Pt—a metal in scarce supply. Here, the researchers describe the production of large quantities of atomic oxygen by incandescent heating of 2-mm-diameter tube of yttria-doped zirconia—a solid oxide electrolyte that conducts oxygen ions. This method of generating atomic oxygen is more efficient, highly selective in the types of ions generated, and enables lower temperature oxidation of silicon compared with thermal oxidation.

In another example of the ‘ubiquitous element strategy’ the authors describe the effect of phase transitions on the controlled fracture in mullite ceramics (3Al2O3•2SiO2), which is crucial for impact-resistant armor and bumper shields for spacecraft. The researchers found that mullite exhibited superior protection as Whipple bumper shields compared to conventional aluminum alloys “tested for the impact by an aluminum alloy flyer at 5.5 km/s”.

Other materials discussed include SrTiO3/TiO2, exhibiting a fivefold higher Seebeck effect compared with bulk material; the pulsed laser deposition of flat MgO(111) films on Al2O3(0001) substrates and of atomically flat MgO(111) films on YSZ(111) substrates with NiO(111) buffer layers.

More information: Hideo Hosono et al., "New functionalities in abundant element oxides: ubiquitous element strategy", *Science and Technology of Advanced Materials* 12 (2011) p. 034303. dx.doi.org/10.1088/1468-6996/12/3/034303

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