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PUBLISHER

Randolph A. Nanna
Tel: 301-209-3102
rnanna@aip.org

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Tel: 301-209-3051
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LETTERS

Electronics

In the feature “Time-Resolved Spectroscopy Comes of Age” (February/March, pp. 16–19), it is asserted that “applications in the semiconductor industry constitute a largely unexplored potential market.” Reading on, it becomes clear that the comment is intended to refer to the semiconductor electronics industry. You also should have mentioned the semiconductor optoelectronics industry (e.g., semiconductor lasers, detectors, and modulators), where time-resolved spectroscopy is a well-established and important characterization tool.

Michael E. Flatté

Optical Science and Technology Center
Department of Physics and Astronomy
University of Iowa
Iowa City, Iowa
michael_flatte@mailaps.org

Hydrogen

I enjoyed reading the article “Bottling the Hydrogen Genie,” by Frederick E. Pinkerton and Brian G. Wicke (February/March, pp. 20–23). But I wonder why the authors did not mention the pros and cons of methanol fuel coupled to a methanol fuel cell.

S. Fred Singer

The Science & Environmental Policy
Project
Arlington, Virginia
singer@sepp.org

In “Bottling the Hydrogen Genie,” I take issue with the list of three elements critical to “another transportation revolution: the transformation from petroleum to clean hydrogen power”—develop a hydrogen-

fueled power source, build the infrastructure to deliver hydrogen to the vehicle, and store hydrogen on-board vehicles.

Unless the authors have buried it inside “infrastructure,” they have not addressed a major element that I rate as the number 1 challenge: finding a way to reasonably and practically make hydrogen fuel.

Many people do not seem to recognize the nature of this issue. Typical citizens and politicians might figure that because there is ample H₂O available on the surface of the earth, hydrogen is also plentiful. There is plenty of “burned” hydrogen available. However, “hydrogen fuel” is very difficult to come by in quantities that would allow a transportation revolution. It is inherently reactive and unstable, and it wants to quickly change to a lower-energy, stable state, and it typically will, by any number of possible reactions.

I am not confident that we will have a revolution to a hydrogen-fueled transportation economy until we first get a major revolution in energy generation. Whether we use fossil fuels, wind, solar, hydro, biomass, nuclear fission, or whatever energy to “unburn” our hydrogen, we face obstacles with the first two laws of thermodynamics. The first, conservation of energy, says we will have to put as much energy into unburning the water as we will get back out of it when we use the fuel. The second, the principle of entropy, says we will have some losses or inefficiencies with each transformation of energy.

I think our best hope will be to get practical nuclear-fusion energy generation technology in place before we will have the noted transportation revolution. I also hope that



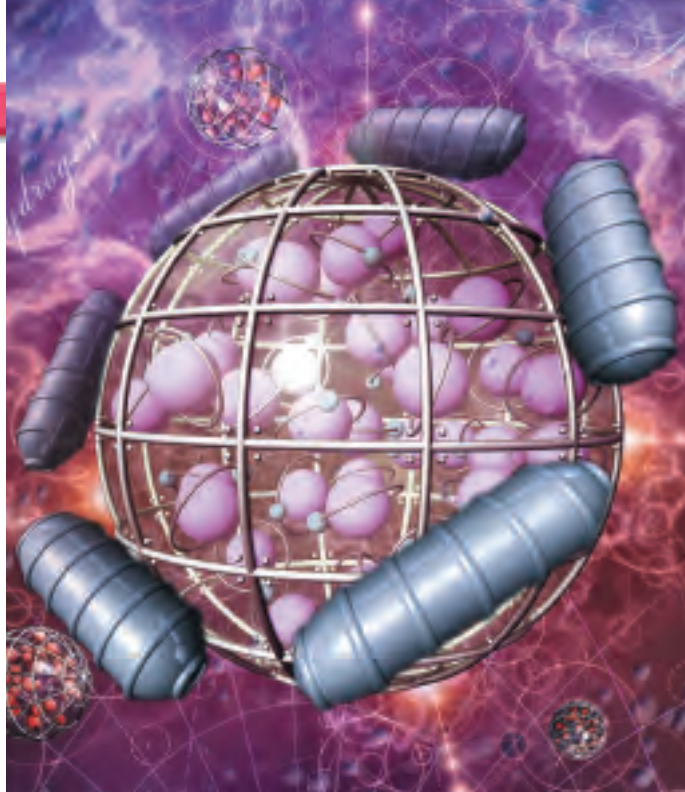
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physicists and others will help the general public better understand the challenges and benefits of seeking these energy and transportation revolutions.

Doug Bringhurst
Shape Corp.
Grand Haven, Michigan
bringhurstd@shape-corp.com

In the article “Bottling the Hydrogen Genie,” the opening is poetic, storage and fuel cells are thoroughly discussed, and distribution is briefly mentioned. But the main omission is a discussion about producing hydrogen. This requires both a raw material and energy. The possible raw materials are those containing carbon (fossil fuels, cellulose, etc.) and water. Use of carbon-containing materials will inevitably produce carbon dioxide. Water is an obvious choice, but the present plan to photoelectrolyze water is so



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terribly inefficient that the volume of hydrogen needed cannot be produced. The alternative is to decompose water thermally using nuclear energy. That alone will produce the hydrogen needed, but there is a flaw—the U.S. resource of fissionable urani-

um is about the same as that of oil and gas (approximately 200 quads), so a nuclear breeder system has to be used, and that is against the law. Perhaps “we stand on the threshold of another transportation revolution,” but it is going to be a long threshold indeed.

E. G. Meyer
University of Wyoming
Laramie, Wyoming
egmeyer@uwyo.edu

[*Authors respond:* Each of the topics raised by readers in these letters deserves an article to do it justice, and the topics are beyond the scope of our article. We focused on the problem of hydrogen storage, which, by itself, represents a considerable technical challenge, particularly for mobile applications in the transportation industry.

The issues surrounding methanol fuel


cells for automotive applications are much too complex to treat in this response. For now, the hydrogen-fueled proton-exchange-membrane fuel cell is a leading candidate for the long-range future of the light-vehicle fleet.

Bringhurst's point is *absolutely key* in the overall discussion of a hydrogen economy—unlike petroleum, hydrogen is not an energy source but only an energy *carrier*. In contrast to hydrogen storage, however, hydrogen generation for vehicular use is not technology-limited. Today, very large quantities of hydrogen gas are produced by steam reformation of natural gas (methane). Smaller quantities are produced on-site by electrolysis of water. As Bringhurst emphasizes, in both cases we must supply the energy needed to liberate hydrogen chemically bound in methane or water. On a large scale, initially that energy will be obtained conventionally by burning fossil fuels, either to produce the heat for reformation or to generate the electricity for electrolysis. In the near term, greenhouse gases such as CO₂ will be produced in these processes, as Meyer observes. However, as shown in recent “well-to-wheel” analyses (1, 2), producing hydrogen from reformed natural gas and using it in a fuel-

cell vehicle would generate significantly less total greenhouse gas than a conventional gasoline internal-combustion engine. This benefit derives from the substantially greater efficiency of the fuel-cell engine and the lower carbon content of natural gas compared with gasoline. Additionally, the total well-to-wheel energy used by a fuel-cell vehicle with compressed-gas hydrogen storage has been estimated to be less than that for a conventional gasoline-powered vehicle. Moving the transportation sector toward hydrogen-fueled fuel-cell vehicles will reduce the contribution that vehicles make to urban pollution and help decrease our reliance on foreign petroleum.

Hydrogen production does not represent a technical barrier to adoption of fuel-cell vehicles. Ultimately, however, building a full hydrogen economy requires sustainable hydrogen sources. We must develop the technology to efficiently manufacture hydrogen using clean renewable energy (wind, solar, direct photolysis, etc.) or at least sustainable energy sources such as nuclear power. Over the next few generations we, as a global community, must make some difficult decisions that will shape the fabric of our society for the next century and beyond.

References

1. Well-to-Wheel Energy Use and Greenhouse Gas Emissions of Advanced Fuel/Vehicle Systems—North American Analysis, June 2001; <http://www.transportation.anl.gov/ttrdc/publications/gapc.html>.
2. Comparative Assessment of Fuel Cell Cars; MIT LFEE 2003-001RP; Massachusetts Institute of Technology, February 2003.] 

Corrections

In the February article “Time-Resolved Spectroscopy Comes of Age” (p. 18, last paragraph), there were some errors in editing. The MetaPULSE can measure very thin opaque films from 4 nm (not 40 nm) to 3 μm and is capable of measuring single or multiple layers at a rate of 40 to 60 wafers per hour. Greg Wolf is the director of technology development.

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