

Not All Photovoltaic Materials are Created Equal

To the Editor:

I am a little dissatisfied with the October 1993 issue of the *MRS Bulletin*, dealing with materials for photovoltaics. Ten different technologies were treated side by side, without any discrimination among them about their short- or middle-term commercial usefulness, evoking the impression that one is as good as the other. I agree with your guest editor Wim C. Sinke's editorial evaluation, but you have to be a scientist working in the field and able to read between the lines to see that iron sulfide (pyrite) and dye-sensitized photoelectrochemical cells are in their deepest research stage and not close to any industrial application (for stability reasons), while long-term stability problems also affect the thin film technologies (CuInSe₂, CdTe, and to a lesser extent, a-Si). Sufficient stability has been reached so far only with crystalline materials, manufactured and doped at high temperatures.

As photovoltaics should finally be a rentable energy option, one has to count with energetic amortization times and energy yield (or substitution) factors, and not only with module prices. Amortization, however, includes lifetime! A photoelectrochemical solar cell is easily made, but also goes rapidly out of order! Thin film solar cells are inherently fragile; wrong bending of the module or temperature shock, even the normal thermal cycling between night and day over an extended period, may destroy them. A reasonable solar cell option should have mechanical as well as electrical stability for at least 10 to 20 years. In this perspective, today we only find single- and polycrystalline silicon (including the promising field of thin film, CVD, or cast polycrystalline Si) and gallium arsenide. The latter contains expensive and toxic materials (which is also true for CuInSe₂ and CdTe, by the way!), and is therefore out of the question for large-scale terrestrial applications (due to the waste problem with the disposal of used modules). In this respect for the immediate future, we have to rely mainly on silicon technology, and the principal goal there is to lower the energy requirement, and thus the manufacturing cost, per module. Silicon is a very stable material and presents no environmental hazards in any sense, which enables its successful large-scale terrestrial application.

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Response:

I fully agree with Dr. Müller that the PV technologies discussed in the *Bulletin's* October issue differ widely as far as their maturity and state of development are concerned. In fact, this is a key remark in my guest editorial (see page 20). Almost by definition it will take a long time before photovoltaics contributes significantly to our global energy consumption. Therefore PV R&D programs generally involve the whole range, from improvement of existing technologies to fundamental research aimed at (possible) future application of new thin film materials and structures. The aim of this special issue was to give an overview of this spectrum of approaches, not to suggest that all of them will be successful or that they should be compared.

Dr. Müller also correctly states that there are many, and even more important, factors to the success and applicability of a PV technology than just the record laboratory efficiencies or great expectations. Indeed, system lifetime and environmental aspects of production, use, and disposal are key issues for large-scale application of PV. This point is dealt with on page 20.

I do not, however, agree with some of Dr. Müller's other remarks:

■ Although stability of (polycrystalline) thin film cells and modules has been and is a matter of concern, there is now substantial evidence that some of them are stable on a timescale of years. In addition, there is substantial progress in the

reduction of intrinsic degradation of amorphous silicon modules. To my knowledge, "fragility" of thin film cells is *not* a problem (rather the opposite!)

■ Dr. Müller suggests that the use of toxic elements in PV modules will inhibit their use. Although this may follow from Swiss regulations, I think that it is too early to make such a general statement. Several studies point out that problems arising from modules containing toxic elements may well be controlled. My personal interpretation is that nontoxic materials are certainly preferred, but if toxic materials would have substantial advantages over, for instance, thin film silicon, the use of such materials should not be excluded beforehand. In the meantime there are efforts to eliminate the most hazardous elements from PV cells and modules, like cadmium from CuInSe₂ cells.

■ There seems to be a misconception that lowering the energy requirement of silicon technology will automatically reduce the manufacturing cost. Lowering the energy requirement is a very important item (although there is consensus that silicon-based PV systems are net energy producers) but it is rather more a spin-off from an overall process simplification and optimization than vice versa, at least in the present stage of development.

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