In contrast to these largely phonon-mediated energy-transfer mechanisms, Achermann *et al.* find a qualitatively different sort of heating mechanism altogether[2], involving a process known as Auger recombination. This is the process by which two excitons (bound electron–hole pairs) interact, and one is annihilated, immediately and directly generating a single exciton of much higher energy (see Fig. 1a). In a bulk semiconductor, such a process is quite inefficient, owing to the need for it to satisfy energy conservation and the fact that any two excitons must come into close proximity to each other before they can interact. In nanoscopic structures, such as the CdSe quantum rods investigated by the authors, confinement effects relax both these limitations, and can thereby greatly improve the efficiency with which Auger recombination takes place[6].

Achermann and colleagues report that the efficient Auger-like annihilation observed in quantum rods can actually be used to slow down hot-carrier relaxation rates. At high excitation intensities, where on average there is more than one electron–hole pair per quantum rod, Auger recombination processes begin to occur, which creates a significant population of energetically excited excitons with an effective temperature greater than the lattice temperature. Coupling to optical phonons cools these 'hot excitons' (Fig. 1). It is this balance between heating through Auger processes, and cooling via interaction with optical phonons, that slows the overall cooling rate by over an order of magnitude compared with that at lower excitation intensities.

The technological implications of these findings are potentially significant, in both good and bad ways. In quantum dot lasers, for example, longer carrier-relaxation times imply an increased chance for non-radiative decay before the carriers reach the lasing transition[7]. Thus, a higher effective temperature for electrons and holes could suppress optical gain and reduce the efficiency of lasers that use quantum rods as the gain medium[8]. On the other hand, the drastic reduction in carrier cooling rates should also allow for easier hot-carrier extraction in solar cells, increasing the photovoltages attainable[9]. Slower cooling rates might also increase the probability of multiple electron–hole pair generation through a process of 'impact ionization' and improve the conversion efficiency of these devices still further[9].

Another potentially useful observation Achermann *et al.* make is that the heating process is not simply a matter of confining enough excitons to a small space, but that it depends on the length of the rods too. They find that the carrier heating rate in shorter rods, which are more zero-dimensional in character, increases more steeply with laser intensity than longer rods, which have a more one-dimensional character. This opens up the exciting possibility that the performance characteristics of future devices that are affected by hot-carrier cooling processes could be tailored by simply changing the lengths of the quantum rods used.

It remains to be seen precisely how these findings will affect the development and operational characteristics of nanoscale devices in practice. Materials synthesis and environmental stability problems still limit the performance of current devices to far below that which should, in principle, be achievable. But at the very least, this latest report provides a noteworthy hint of the sort of fundamental insight into the behaviour of these intriguing materials that we may expect in the future.

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ERRATA

EDITORIAL

Nature Physics **2,** 425 (2006)

In the Editorial *To him who waits*, Ray Davis's affiliation after his retirement from Brookhaven National Laboratory was given as Penn State University. In fact, it was the University of Pennsylvania.

THIS ISSUE

Nature Physics **2**, July 2006

In the pdf and print versions of the This Issue page, the page number information for the Cover Story was incorrect. It should have appeared as [Article p484].