tion technique based on post-growth thermal diffusion of Fe in polycrystalline ZnSe.

As reported in the January 1st issue of *Optics Letters* (DOI:10.1364/OL.36.000094; p. 94), the researchers investigated Er:Cr:YSGG laser-pumped Fe:ZnSe lasing in a Fabry–Perot cavity in the temperature range of 236–300 K. Thermal diffusion of Fe was carried out in sealed quartz ampoules at 10^{-5} Torr for 14 days at 1000°C, which resulted in a highly concentrated (Fe concentration 2×10^{19} cm^{-3}) gain element. High gain in the developed active medium ensured reduced oscillation build-up time, improved temporal overlap of the pump pulse (20 ns) and output oscillation (15 ns), and effective absorption of the pump pulse, leading to increased output energy. A fourfold increase in the output energy of the gain-switched Fe:ZnSe laser was obtained. The maximum laser output energy was 4.7 mJ at 4.3 μm and 236 K, and 3.6 mJ at 4.37 μm and 300 K (limited by available pump energy) with maximum obtained power of 0.3 MW at 4.3 μm. The researchers said that additional improvements can be achieved by further optimization of the laser cavity and also by using a pump with higher energy.

Mousumi Mani Biswas

Energy Focus

ZnO nanoforest delivers high-efficiency solar cell

Inspired by the network of branches that trees use to gather sunlight, an innovative team of researchers recently grew a "nanoforest" of light-absorbing nanowires to ramp up productivity in dye-sensitized solar cells (DSSC). As detailed in the January 5th online edition of *Nano Letters* (DOI: 10.1021/nl1037962), S.H. Ko and co-workers at the Korea Advanced Institute of Science and Technology and University of California, Berkeley developed a multi-stage seeded growth process to grow intricately branched structures of ZnO nanowires that resemble a tightly packed forest of pine trees. The team then fabricated the nanoforests into a DSSC and demonstrated a significant jump in the solar cell's efficiency.

In a DSSC, a wide-bandgap semiconductor works in conjunction with a sensitizing dye to absorb incident sunlight and convert it to electrical energy. ZnO is an effective semiconductor for this purpose and is appealing due to the ease with which it can be grown, but the resulting solar cells suffer from low efficiencies. However, this nanoforest approach could be the crucial step to making ZnO a viable DSSC component.

To achieve the forest-like structure, the researchers first grow nanowires by a hydrothermal growth process, depositing seed particles (ZnO quantum dots) on a substrate and immersing it in a solution containing zinc nitrate hydrate and the polymers hexamethylenetetramine (HMTA) and polyethylenimine (PEI). Then they wash off the polymer, bake the sample, and deposit a new layer of seed particles over the pillar-like nanowires. Next they repeat the hydrothermal growth step, which now causes nanowires to form along the length of the original wires, like branches on a tree. They perform additional cycles to create higher orders of branching, leading to a dense network of hierarchically branched nanowires.

The team demonstrated that both the "trunk" and the "branches" of ZnO are crystalline and grow along the wurtzite *c*-axis. The trunks are 40–50 μm long with an aspect ratio greater than 100, while the branches are 2–10 μm in length.

To test the usefulness of these novel structures, the researchers fabricated DSSCs by sandwiching a dye-sensitized ZnO nanoforest between electrodes. The measured current–voltage characteristics show a light-induced current that increases with trunk length and the degree of branching. Ko and the research team report efficiencies of 2.6% for their devices, which is an increase of 350–500% over devices made with regular, non-branched ZnO nanowires. The team cites the increased surface area as the primary cause for improvement, as it allows for greater dye-loading and photon absorption. They also said that the complex network of overlapping branches allows for better electron transport to the collection electrodes.

Alison Hatt

Nano Focus

Functionalization of graphene leads to enhanced hydrogen adsorption

The on-board, high-capacity, facile, and reversible storage of hydrogen fuel is one of several significant challenges for hydrogen-fueled vehicles. While gas-adsorbant metal-organic framework structures display high H_2 uptake, the volume of H_2 they can hold is insufficient due to the material's low density. The densities of carbon materials are sufficiently high but their capacity for H_2 adsorption is low. Strategies for increasing the H_2-uptake capacity of carbon materials include surface modification with heteroatoms or functional groups in order to polarize the H_2 molecules. Pillared graphene's potential for H_2 storage has been demonstrated with theoretical calculations. In addition, recent experiments show that H_2 uptake by thermally exfoliated graphene (TEG) increases linearly with surface area. Recently, C. Kittrell and J.M. Tour of Rice University, K.J. O'Neill of the National Renewable Energy Laboratory (NREL), and co-researchers hypothesized that H_2 uptake in TEG could be improved by engineering nanospaces; carbon scaffolds could be created by insertion of molecular spacers between graphene sheets.

As reported in the February 22nd issue of *Chemistry of Materials* (DOI: 10.1021/

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