Microlasing Demonstrated in Disordered Material

In a development that could prove to be significant for the future of integrated photonic circuits, researchers H. Cao, J.Y. Xu, E.W. Seelig, and R.P.H. Chang of Northwestern University have fabricated microlasers using micron-sized clusters of disordered ZnO nanoparticles. Whereas previously described methods of microlaser fabrication require expensive crystal-growth techniques, this one relies on inexpensive chemical-precipitation procedures.

For microlasing to occur, light must be confined to a volume whose dimensions approximate the optical wavelength. Research has been focused on highly ordered crystalline materials that could trap light between two distributed Bragg reflectors (vertical cavity surface emitting lasers), or utilize total internal reflection at the edge of high-index disks (microdisk lasers). In the study at Northwestern, however, the investigators took advantage of a phenomenon known as Anderson localization of light: In a highly disordered structure, the strong scattering and wave interference of light can result in a scattering mean free path of about half the optical wavelength, effectively trapping the photons.

As reported in the April 17 issue of *Applied Physics Letters,* ZnO nanocrystallites with an average size of 50 nm are synthesized by hydrolysis of a zinc salt in a polyol medium. Scanning electron microscope (SEM) images show that these nanocrystallites agglomerate in micron-sized clusters. When a single cluster is optically pumped at room temperature using a Nd:YAG laser, initially a single broad emission peak is observed. Increasing the pump energy above a threshold measured to be 0.2–0.3 nJ results in a sharp peak in the ultraviolet emission spectrum at about 380 nm. Simultaneous observation of the spatial distribution of the emitted light intensity in the sample cluster using an ultraviolet microscope shows the "localization cavity" to be a bright spot approximately 0.3 μm in diameter. Further increases in pumping power can produce additional emission peaks and bright spots as other cavities in the cluster begin lasing due to the Anderson localization phenomenon.

TMS Names Five Fellows for 2000

The Minerals, Metals & Materials Society (TMS) has honored **Reza Abbaschian**, professor and chair of the University of Florida Department of Materials Science and Engineering; **Robert W. Cahn**, Distinguished Research Fellow at Cambridge University; **Lionel C. Kimerling**, Thomas Lord professor of materials science and engineering and the director of the Materials Processing Center at the Massachusetts Institute of Technology (MIT); **Subra Suresh**, R.P. Simmons Professor of materials science and engineering at MIT; and **Jeffrey Wadsworth**, deputy director for science and technology at the Lawrence Livermore National Laboratory, as TMS Fellows.

Abbaschian is recognized as an outstanding scientist and educator and a leading researcher in solidification fundamentals and materials processing. He earned his BS degree (1965) in mining engineering at the University of Tehran, Iran; his MS degree (1968) in metallurgical engineering from Michigan Technological University, Houghton; and his PhD degree (1971) in materials science and

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engineering from the University of California—Berkeley. Abbaschian was a visiting scientist at MIT and a visiting associate professor at the University of Illinois—Urbana-Champaign. A former chair of the National Science Foundation panel for education in materials science and engineering, he has been active in numerous other national educational and professional organizations. Abbaschian is the author or co-author of over 200 scientific articles, four patents, and five books. He is the recipient of several honors and awards, including three NSF Research Creativity Awards.

Cahn is recognized for outstanding contributions to the understanding of atomic ordering, diffusion, recovery, rapid solidification, and twinning in metals and intermetallics. He received his BS degree (1945) in metallurgy, PhD degree (1950) in physics, and ScD degree (1963) in metallurgy from Cambridge University. He has taught at Sussex University and was the founding editor of the *Journal of Nuclear Materials.* He served *MRS Bulletin,* a publication of the Materials Research Society, as Visiting Scientist in 1997 and currently serves on its Editorial Board and Book Review Board. Cahn is a Fellow of six academies, including the Royal Society. He has received numerous other honors and awards.

Kimerling is recognized for his outstanding basic and applied research on defects in semiconductors and for his professional and academic leadership in the field of electronic materials. Kimerling earned both his BS degree in metallurgical engineering and his PhD degree in materials science from MIT in 1965 and 1969, respectively. He has served as an adjunct professor of physics at Lehigh University. Kimerling was the head of the Materials Physics Research Department at AT&T Bell Laboratories and served as a captain in the U.S. Air Force at the Solid State Sciences Laboratory of the Air Force Cambridge Research Laboratories. He has authored over 200 technical articles. Kimerling is a past TMS president and chair of the *Journal of Electronic Materials* editorial board. He is the recipient of numerous awards and honors.

Suresh is recognized for pioneering contributions to mechanical behavior and the mechanics of materials and leadership in materials education. He received his Btech (1977) and MS (1979) degrees in mechanical engineering from the Indian Institute of Technology and Iowa University, respectively, and his ScD degree in materials from MIT. He was a professor of engineering at Brown University and chair of the Materials Division of the American Society of Mechanical Engineers. Suresh is the program chair of the Singapore-MIT Alliance Advanced Materials Program. He is the recipient of many awards and honors, including the TMS Hardy Award and the Champion H. Mathewson Award.

Wadsworth is recognized for outstanding contributions in superplasticity, refractory metal alloys, and ultrahigh-carbon (Damascus) steels, and leadership in promoting materials science in major industrial and national programs. He earned his BS degree in 1972 and PhD degree in 1976, both from Sheffield University in metallurgy. He was awarded a DMet degree in 1990 from Sheffield for published research. Wadsworth has held research positions at Stanford University and Lockheed Martin Corporation. He is

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a consulting professor in materials science and engineering at Stanford and an adjunct professor of applied science at the University of California—Davis. Wadsworth is the co-author of over 230 scientific papers, one book, and four patents. He is the recipient of several awards and has served on numerous academic, industrial, professional, and government councils and committees.

X-Ray Images of Lanthanum Iron Oxide Reveal Alignment of Nanocrystalline Magnetic Domains

Researchers at the Advanced Light Source (ALS), an x-ray spectromicroscopy facility located at Lawrence Berkeley National Laboratory, have produced images that reveal that the alignment of tiny magnetic domains in lanthanum iron oxide, each only a few hundred nanometers in size, corresponds to a particular orientation of the material's crystals.

Andreas Scholl, a member of the Experimental Systems Group at ALS, led by Howard Padmore, said, "A modern read head uses layers of very thin films with different magnetic properties. As the head passes over the hard disk, these layers sense the orientation of the domains on the disk and cause the head's electrical resistance to change in response."

Scholl said that when the head's ferromagnetic layers share the same magnetic orientation, there is less electrical resistance than when they are magnetically opposed. In order for one layer to switch independently of another, however, one must be "pinned" by an underlying antiferromagnetic layer, which is insensitive to applied magnetic fields.

There are many different materials with ferromagnetic and antiferromagnetic properties, but read heads are constructed from these on a trial-and-error basis," said Joachim Stöhr of IBM Almaden Research Center in San Jose. "Nobody really knows the mechanism that couples the ferromagnet to the antiferromagnet."

As reported in the February 11 issue of *Science*, the researchers used molecular-beam epitaxy to deposit single layers of lanthanum oxide and iron oxide one after the other to build up the compound. They gradually heated the samples in the PEEM2 microscope to ensure that the images were due to magnetism and another feature of the thin film. The Néel temperature (like the Curie temperature of other magnetic materials) is the temperature at which antiferromagnetic materials lose magnetism. When the thin-film sample was heated, image contrast vanished and returned again as the sample cooled. However, whereas in bulk the Néel temperature of lanthanum iron oxide is 740 K, in the sample it was 670 K.

Jin Won Seo of the University of Neuchâtel said, "We think that what lowers the Néel temperature of our lanthanum iron oxide sample is structural deformation. It's a film only 40 nm thick, laid on a substrate of strontium titanium oxide. When an epitaxial thin film of one material is laid onto a substrate of a different material, it's almost impossible to get the two crystal lattices to match perfectly, and atoms get pushed out of place, which modifies magnetic properties."

Seo compared the images of magnetic domains with her transmission electron micrographs of the same sample. The

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