very large spin polarization." In their related work published in *Advanced Materials* (**15**, 2003), the researchers showed that proton microbeam makes it possible to create magnetic spots on the graphite with diameters of only a few micrometers.

ANDREI A. ELISEEV

CdS Nanoparticles on Si Self-Organize into Luminescent Nanorings

Realization of nanometer-sized devices is dependent on the physical properties of nanostructures. A group of researchers from NTT, the Royal Institution of Great Britain, the University of Wales, and Yokohama National University has achieved a self-organization process of cadmium sulfide nanoparticles that results in the formation of luminescent nanometer-sized ring structures on a silicon wafer.

As reported in the September 16, 2003, issue of *Advanced Materials*, nanoparticles of CdS, 10 nm in size, were synthesized by the reaction between cadmium acetate and thioacetamide. This method enables control of the size and shape of the CdS nanoparticles. Planar silicon wafers of (111) orientation with a thin oxide layer (<1 nm) were used as the substrate. Nanoparticles were introduced onto the silicon wafer by dip coating from ethanol suspension, aided by an ultrasonic bath, at room temperature. On annealing of these Si substrates, in an ultrahigh-vacuum chamber at 800–850°C, the CdS nanoparticles formed circular structures on the silicon surface. The nanorings, consisting of particles from 20 nm to 100 nm, ranged in size from 100 nm to 1000 nm. Information about particle size was obtained by atomic force microscopy. Mapping of tunneling electron luminescence from these nanoring structures showed a one-to-one correspondence between the topography and light emission. The resolution of this mapping technique enabled the observation of luminescence from individual nanoparticles (about 10–20 nm in size). The researchers said that the decomposition of the silicon oxide layer, followed by a drying phenomenon, leads to the formation of these luminescent nanorings.

The researchers said that "this material could be a potential candidate for developing optical components on silicon, if ultimate control of these structures can be achieved."

MAXIM NIKIFOROV

InGaP/GaAs HBTs Operate as Light-Emitting Transistor

The concept of wide-bandgap semiconductor emitters for minority carrier injection efficiency has been known since the work of Shockley in 1948 and Kroemer in 1953. This concept has been used to achieve high minority carrier injection efficiency in bipolar transistors, of which InP heterojunction bipolar transistors (HBTs) are the fastest, with operating speeds exceeding 450 GHz. In this approach, base-current recombination has been regarded as a source of undesired waste heat. However, as reported in the January 5 issue of *Applied Physics Letters*, M. Feng, N. Holonyak Jr., and W. Hafez of the Department of Electrical and Computer Engineering at the University of Illinois at Urbana-Champaign have directly observed radiative recombination in the graded base layer of an InGaP/GaAs HBT. The researchers were able to change the spontaneous light-emission intensity by varying the base current from 0 mA to 5 mA. They demonstrated that the modulation of the light emission was in phase with the base current modulated in transistor operation at 1 MHz.

The scientists used metalorganic chemical vapor deposition to grow the InGaP/GaAs HBT test structure consisting of a 3500 Å *n*-type GaAs collector, a 600 Å carbon-doped and compositionally graded *p*-type InGaAs base with 1.4% In, an 800 Å *n*-type InGaP emitter, and a 1000 Å *n*-type InGaAs emitter contact cap. The tested HBT device consists of electron-beam-defined Ti/Pt/Au emitter contacts fabricated by using self-aligned emitter etch and base metal deposition. The researchers employed a bisbenzocyclobutene (BCB) based etch-back process for back-end fabrication to render the electrode and contact formation on the top of the transistor.

The researchers observed no light emission for zero base current, while at 1 mA, they observed the first weak light emission that increased in strength when the base current was increased to 5 mA. The output emission wavelength of 885 nm is consistent with the energy bandgap of the compositionally graded InGaAs base of the HBT. The researchers also performed tests of output light modulation at 1 MHz

https://doi.org/10.1557/mrs2004.28 Published online by Cambridge University Press