GaN Photonic-Crystal Surface-Emitting Laser at Blue-Violet Wavelengths.

Science 319, 445 (2008)

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Recommended with a commentary by Stephen Berry, University of Chicago.

While we have long had means to produce coherent radiation in the blue and ultraviolet, those means have all depended on having some other primary source whose radiation could be manipulated–frequency-doubled or mixed–in order to reach the short wavelength region. Finding and developing a laser source that produces violet or ultraviolet radiation has been a long-sought goal. Now a group from Kyoto has achieved this goal with an elegant, small, relatively simple device, essentially a two-dimensional crystal of gallium nitride. The photonic crystal's band edge locks the group velocity of the radiation to zero and radiation emerges just from the surface. To produce the desired radiation, the photonic crystal structure must be within 300 nanometers of the optically active layer. The researchers achieved a structure with the requisite large lattice constant by generating ”air holes over growth” or ”AROG” in an epitaxial layer of GaN/AlGaN over the basic GaN that generates the radiation. The air holes are separated by 186 nm and are 100 nm deep, Initially, they form a two-dimensional triangular lattice but SiO2 is deposited in the air holes, from which a sparser regular structure is produced. It is the regular array of holes with GaN at their bottoms that is the essential key to the lasing device. One must go to the supplementary material to see what the structure really is. Lasing action occurs when the in-plane vector of the radiation matches that of the photonic band structure.

The emission characteristics are striking. Below a critical current the light output rises smoothly, in a relatively broad frequency band. Above a critical current, the rate of light output intensity rises much more rapidly with current, and the radiation falls in a very narrow frequency band. Moreover the blue-violet radiation forms a rather diffuse spot for currents below the critical value, but the illuminated area becomes a very small spot for currents above the critical.

The authors look forward to improving the device by improving the crystal quality, by optimizing the distance between the active layer and the photonic crystal overlayer, and by using a transparent electrode that would allow much more radiation to escape.

All in all, it appears that an ingenious coherent light source for the violet and near ultraviolet is at last a reality.