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Organic lasers sniff for TNT

Organic materials are entering the world of lasers and electronics, says S.Ananthanarayanan.

It is silicon that has held sway during the strides of electronics in the last half century. And laser technology, for communications and industrial use, has worked with hardy, crystalline materials or simple gases.

Organic materials

Organic materials derive from the ‘chain and ring’ chemical structures that arise when elements like hydrogen, oxygen, nitrogen, phosphorus combine around the ‘4-way crossroads’ of the carbon atom. These materials, like plastics and aromatics, were usually unstable or volatile and stayed far from copper and silver metals, of the world of electronics.

On the other hand, organic chemicals are assemblies of atoms that can be manipulated and adjusted, so that the final structure can be almost ‘made to order’ – a facility that is not available with the silicon, ruby, copper and silver of the inorganic world.

The laser

The laser is an arrangement where an atom which is raised to a higher energy state by external stimulation pauses for a bit before giving up the extra energy and returning to the base state. This ‘pause’ helps push the material into a state where more of it is in the higher energy state than in the lower state. Now, in this ‘inverted’ condition, the quantum of radiation emitted by an atom returning to the base state can be arranged to ‘stimulate’ another atom to do likewise. While the external stimulus keeps ‘parking’ atoms in the higher, ‘paused’ state, arrangements can be made that a portion of the light emitted by de-exciting of atoms is reused to ‘stimulate emission’ continuously – and the result is the laser beam.

These conditions, that a convenient ‘parking energy state’ should exist, the material should be transparent, etc., have been elusive and useful laser materials have been difficult to come by.

Organic laser

Organic materials, while they may not be hardy and are away from the ideal in some ways, are amenable to manipulation. Organic molecules that do emit stimulated radiation, like lasers, can then be modified so that the laser action works at a slightly different frequency of light or even gets switched off by the slightest trace of a contaminant.

The first property is getting used as a ‘tunable’ laser. Absorption of light passing through a sample is a very sensitive way of detecting the absorbents. This becomes even more sensitive with laser light. But the use of lasers is good only at the fixed frequency of the laser. Now with the possibility of a range of frequencies for the laser, the doors are opened for advances in chemical analyses.

Detecting explosives

The second property, that the laser action could get switched off by traces of some materials, has found a use in detecting explosives at airports and other public places. The standard way to detect hidden of buried TNT, so far, has been with the help of trained ‘sniffer’ dogs. But dogs cannot be used for long periods and are also expensive to maintain.

Scientists at Massachusetts Institute of Technology have developed a semi-conducting organic polymer which is sensitive to TNT. In pure air, the material emits laser-like radiation when bathed in ultra violet light. But any trace of TNT attaches to the molecules of the material and jams the laser action. The material is stable and can be used continuously for long periods. It is 30 times as sensitive as other devises used so far.