MASER power comes out of the cold: Researchers demo solid-state MASER capable of operating at room temperatures

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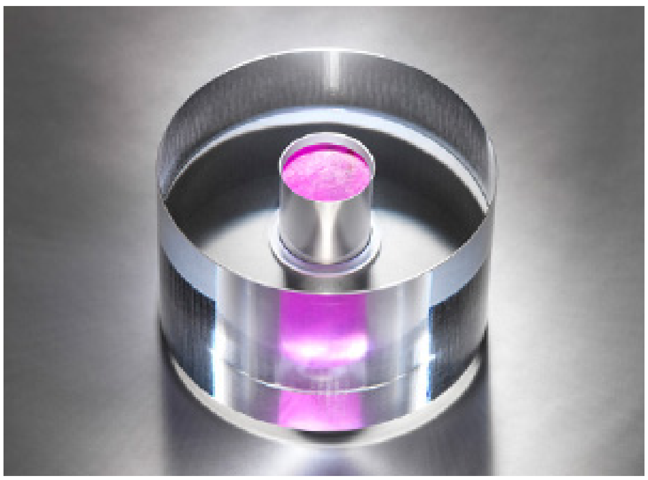

The MASER core - a sapphire ring containing a reddish pink crystal that amplifies microwaves to create a concentrated beam.

Scientists from the National Physical Laboratory (NPL) and Imperial College London demonstrate, for the first time, a solid-state 'MASER' capable of operating at room temperature, paving the way for its widespread adoption - as reported in the journal *Nature*.

MASER stands for Microwave Amplification by Stimulated Emission of Radiation. Devices based on this process and known by the same acronym were developed by scientists more than 50 years ago, before the first LASERs were invented. Instead of creating intense beams of light, as in the case of LASERs, MASERs deliver a concentrated beam of microwaves.

Conventional MASER technology works by amplifying microwaves using crystals such as ruby - this process is known as 'masing'. However, the MASER has had little technological impact compared to the LASER because getting it to work has always required extreme conditions that are difficult to produce; either extremely low pressures, supplied by special vacuum chambers and pumps, or freezing conditions at temperatures close to absolute zero (-273.15 °C), supplied by special refrigerators. To make matters worse, the application of strong magnetic fields has often also been necessary, requiring large magnets.

Now, the team from NPL and Imperial have demonstrated masing in a solid-state device working in air at room temperature with no applied magnetic field. This breakthrough means that the cost to manufacture and operate MASERs could be dramatically reduced, which could lead to them becoming as widely used as LASER technology.

The researchers suggest that room-temperature MASERs could be used to make more sensitive medical instruments for scanning patients, improved chemical sensors for remotely detecting explosives; lower-noise read-out mechanisms for quantum computers and better radio telescopes for potentially detecting life on other planets.

Dr Mark Oxborrow, co-author of the study at NPL, says:

"For half a century the MASER has been the forgotten, inconvenient cousin of the LASER. Our design breakthrough will enable MASERs to be used by industry and consumers."

Professor Neil Alford, co-author and Head of the Department of

Materials at Imperial College London, adds:

"When LASERs were invented no one quite knew exactly how they would be used and yet, the technology flourished to the point that LASERs have now become ubiquitous in our everyday lives. We've still got a long way to go before the MASER reaches that level, but our breakthrough does mean that this technology can literally come out of the cold and start becoming more useful."

Conventional MASER technology works by amplifying microwaves using hard inorganic crystals such as ruby. However, masing only works when the ruby is kept at a very low temperature. The team in this new study have discovered that a completely different type of crystal, namely p-terphenyl doped with pentacene, can replace ruby and replicate the same masing process at room temperature. As a curious twist, the pentacene dopant turns the otherwise colourless p-terphenyl crystal an intense reddish pink - making it look just like ruby!

The twin challenges the team currently face are getting the MASER to work continuously, as their first device only works in pulsed mode for fractions of a second at a time. They also aim to get it to operate over a range of microwave frequencies, instead of its current narrow bandwidth, which would make the technology more useful.

In the long term, the team have a range of other goals including the identification of different materials that can mase at room temperature while consuming less power than pentacene-doped p-terphenyl. They will also focus on creating new designs that could make the MASER smaller and more portable.

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The full paper, 'Room-temperature solid-state maser', was published in *Nature* on 16 August 2012.

More information: "Room-temperature solid-state maser", published in *Nature* 16 August 2012. www.nature.com/nature/journal/ … ull/nature11339.html

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