New method of producing optical materials reduces cost, improves performance

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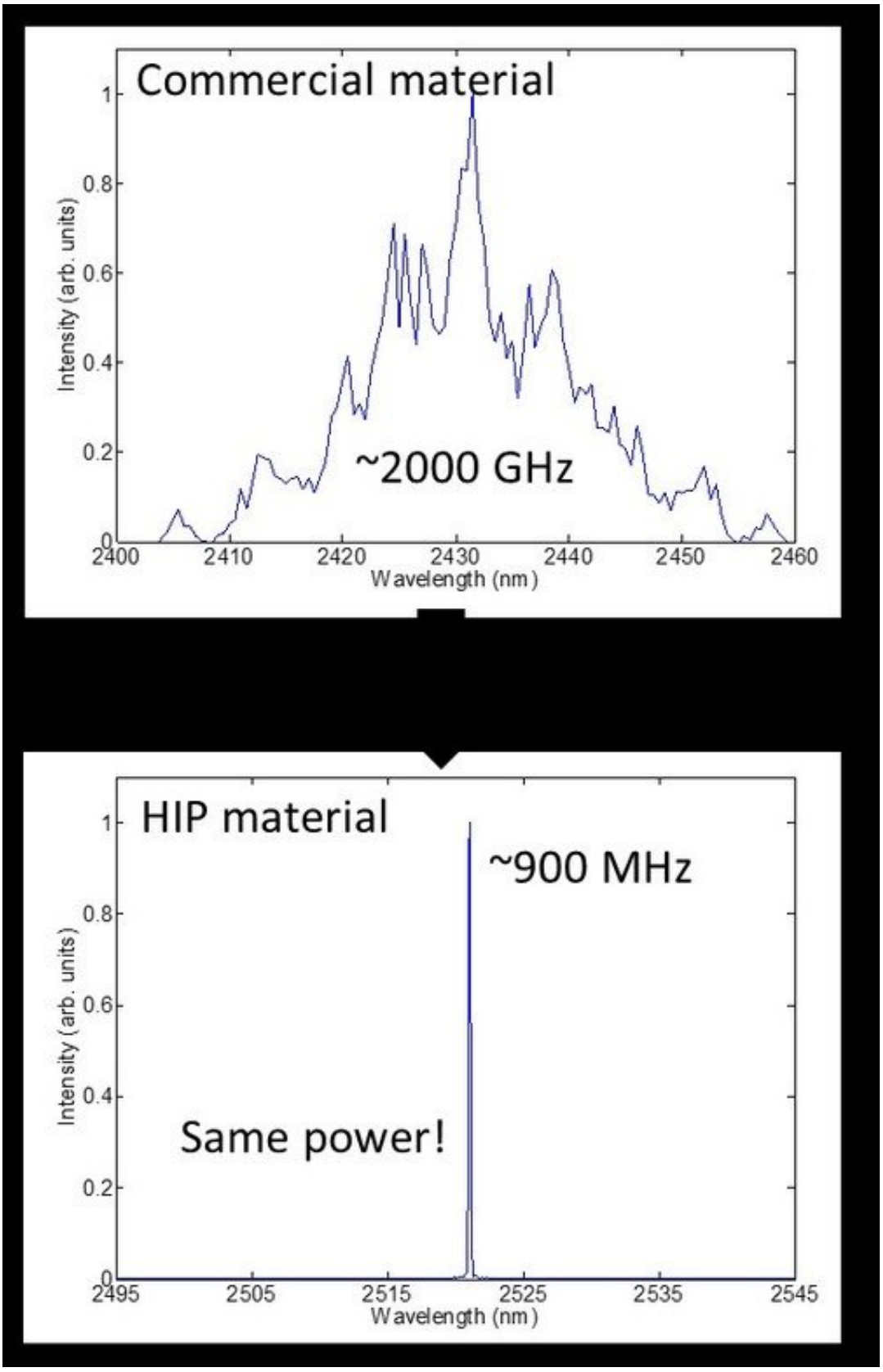

A comparison of the laser emission spectrum between standard commercial

material (top) and the HIP material (bottom).The two graphs have the same laser power (area under the curves) and the HIP material is spectrally much, much brighter. Credit: Air Force Technology Transfer Program Office

Optical material manufacturers now have the opportunity to license a game-changing production method for doped solid optical materials.

Developed by Drs. Gary Cook and Ronald Stites of the Sensors Directorate at the Air Force Research Laboratory, the new method uses hot isostatic pressing (HIP) to drive the diffusion of transition metal ions into chalcogenide laser host crystals such as Chromium (Cr), Iron (Fe), Cobalt (Co) or Nickel (Ni) into Zinc Selenide (ZnSe).

"This new method does two things," said Cook. "First, it converts the quality of laser material to a new state that allows users to get all of the power out of the laser without worrying about how narrow the line width has become. Second, it allows manufacturers to make higher-quality laser materials very quickly and cheaply."

The resulting doped crystals provide an unparalleled increase in performance over the current methods and significantly reduced manufacturing cost and increased output. For the case of Cr:ZnSe, crystals produced using the technique have resulted in diffusion rates of 5.48E-8 cm2/s and sub 140 picometer (pm) linewidth resolution, equating to 100x faster diffusion and 350x narrower linewidth than commercially available Cr:ZnSe. Early results with iron doped zinc selenide (Fe:ZnSe) have produced similarly promising results, with a measured linewidth of less than 300 pm as compared to 50 nanometers in the untreated crystal.

"With existing methods, when a narrow line-width is required, you

sacrifice a good deal of power," said Cook, "The new method allows for a very narrow linewidth but no loss of power."

The method provides a controlled and efficient, post crystal growth diffusion via a two-step process of sputter deposition and hot isostatic pressing. Undoped polycrystalline chemical vapor deposition grown crystals are polished to optical quality, then sputter coated with Cr, Fe, or other transition metal before being placed directly in a HIP chamber for subsequent HIP treatment to facilitate diffusion.

This straightforward process is easily scalable for batch operations and considerably faster than current manufacturing methods which involve vacuum heat treatment for up to weeks at a time. The same method may be extended to other alloyed optical materials and potentially to alloys with graded doping requirements which may be difficult or not possible to produce by other means. The HIP process has also been applied to currently available Cr:ZnSe materials (without additional Cr sputtering) with equivalent performance increases demonstrated.

Benefits

- Unparalleled Performance: Cr:ZnSe laser materials produced via HIP diffusion offer 100x faster diffusion and over 350x narrower linewidth than commercially available options
- Increased Manufacturing Throughput: HIP based diffusion of dopants is complete within hours and may be applied to large batches whereas conventional vacuum heat treatment diffusion requires several weeks under highly controlled conditions for limited numbers of crystals per batch
- Wide Range of Material Systems: The HIP method has been successfully demonstrated on multiple material systems including Cr:ZnSe and Fe:ZnSe and is expected to provide benefit for numerous other doped optical material systems

Provided by Air Force Office of Scientific Research

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