Photonic capsules for injectable laser resonators

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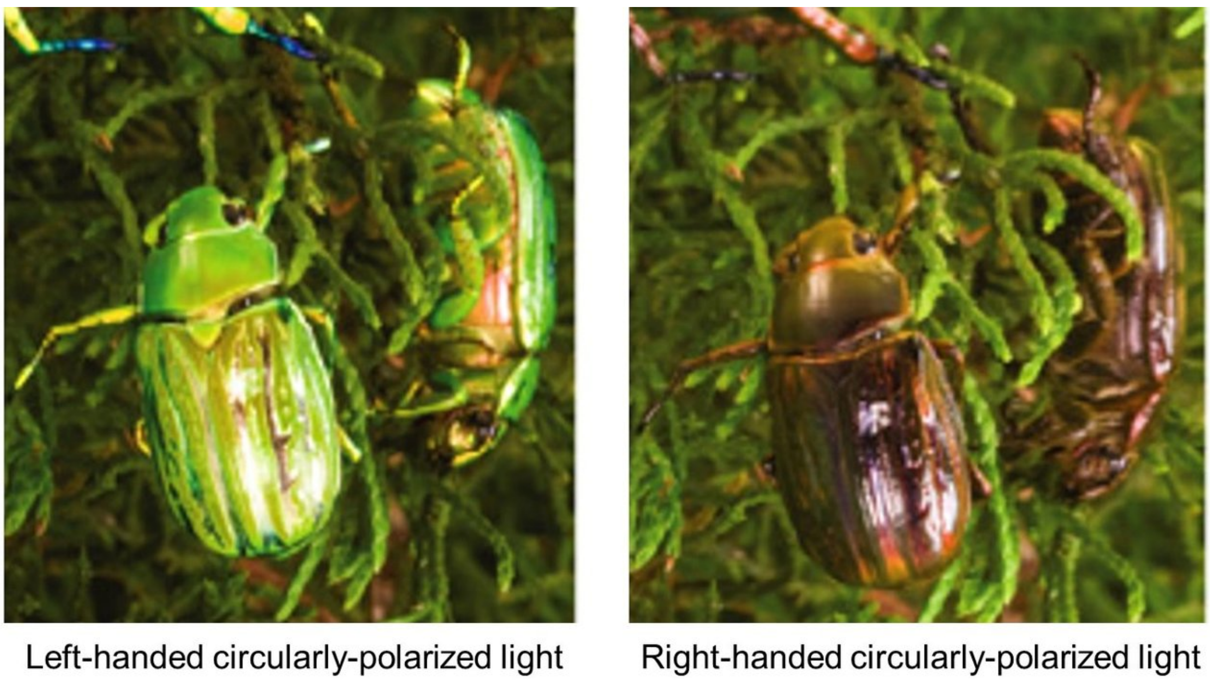


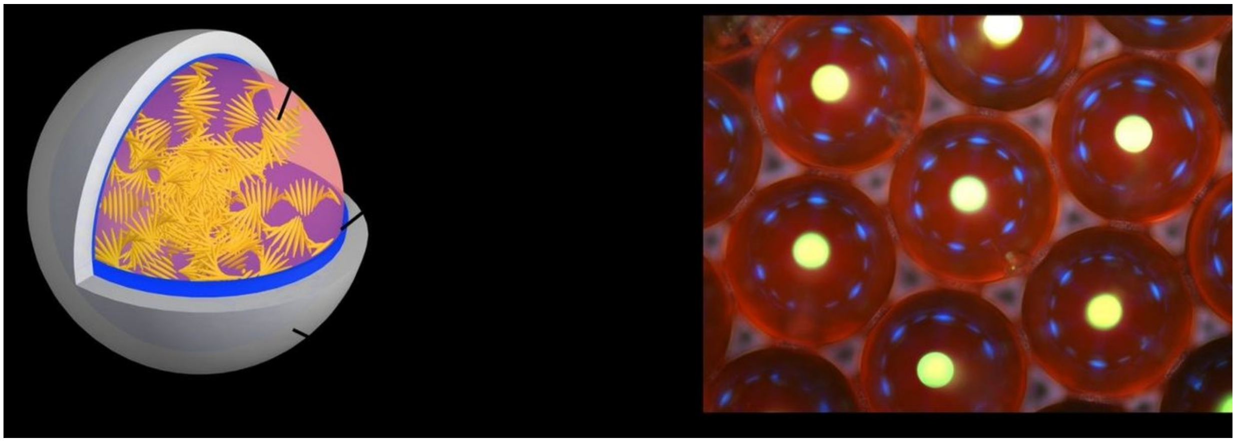
Chrysina gloriosa illuminated by left-handed (left panel) and right-handed (right panel) circularly-polarized lights. (Image source: https://doi.org/10.1016/j.cub.2010.05.036, permitted for reuse in news media) Credit: KAIST

A KAIST research group presented photonic capsules for injectable laser resonators using microfluidic technology. The capsule's diameter is comparable to a human hair and stable in gas and liquid media, so it is injectable into any target volume. The research group, headed by Professor Shin-Hyun Kim in the Department of Chemical and Biomolecular Engineering, applied an interesting optical property from nature.

Chrysina gloriosa, commonly known as the glorious beetle, shows a green color similar to leaves when illuminated by left-handed, circularly-polarized light showing no color with right-handed, circularly-polarized light. This unique optical feature helps the beetles communicate with each other and protects them from predators.

The principle behind this interesting optical property relies on helical nanostructures with left-handedness that are present on the shell of the beetles. The helical structures reflect a circularly-polarized light with the same handedness of the helix at the wavelength selected by the helical pitch through optical interference. Such helical nanostructures can be artificially created using liquid crystals (LCs). LCs with a helical arrangement are referred to as cholesteric LCs (CLCs). The CLCs exhibit the polarization-dependent reflection of light in the same manner as the beetles and have been used for various photonic applications.

In particular, CLCs have been cast to a film format that serves as mirrorless laser resonators, unlike conventional lasing systems. However, the film-type CLCs are large in size and show unidirectional emission, which restricts the use of CLC resonators in microenvironments.



Composition (left panel) and optical microscopy image (right panel) of the capsule-type laser resonator. Credit: KAIST

To overcome these limitations, Professor Kim's group has encapsulated the CLCs with dual shells using microfluidic technology. The inner shell is a water layer that promotes the alignment of LC molecules and the outer shell is an elastic polymer layer that secures capsule stability and enables reversible mechanical deformation. The spherical symmetry of the capsules enables omnidirectional laser emissions. Moreover, laser intensity and lasing direction can be further controlled by deforming the capsules, while its wavelength remains tunable. This new type of CLC laser resonator is promising for laser treatments in various biomedical applications.

Professor Kim said, "The helical nanostructure used in the laser resonator resembles that of the shell of chrysina gloriosa. Humans learn from nature and engineer materials to create something unprecedented."

More information: Sang Seok Lee et al, Wavelength-tunable and shape-reconfigurable photonic capsule resonators containing cholesteric liquid crystals, *Science Advances* (2018). DOI: 10.1126/sciadv.aat8276

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