incoherent and would require both a slit and a collimating mirror. In principle, the signal-
to-noise ratio obtainable would be similar
to that of a grating instrument at the same
resolution. Whether or not it will be possible
to exploit the potentially higher resolution
will depend on the luminance of the source,
but the high wavenumber accuracy will
nevertheless remain an important advantage.

We should expect many further results
from this exciting new instrument, both
in its present form at Synchrotron SOLEIL
and in new applications elsewhere with
different light sources.

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LIQUID CRYSTALS

Tiny tunable 3D lasers

Integrated photonics applications require
lasers that are cheap, highly tunable,
can emit light in all directions and have
low thresholds, narrow linewidths and
ultrasmall mode volumes. The recent
findings of Matjaž Humar and Igor
Muševič from the J. Stefan Institute and
University of Ljubljana in Slovenia may
fulfil these requirements (Opt. Express 18,
26995–27003; 2010).

Instead of building a solid-state 3D
microlaser, the researchers opted for
a soft-matter approach. “Soft matter
has an inherent natural ability to self-
assemble into a variety of structures that
are potentially interesting for photonic
applications,” explained Muševič.

Humar and Muševič created their
microlaser by placing a 15–50-μm-
diameter microdroplet of cholesteric
liquid crystals doped with a laser dye into
an isotropic carrier fluid. Dispersing the
microdroplet in an immiscible fluid such
as glycerol allowed it to spontaneously
self-assemble into an aspherical shape
because of surface tension. Strong
periodic modulation of the refractive
index induced by the chirality of the
cholesteric liquid crystals caused the
formation of a multilayered spherical
Bragg resonator. This microresonator can
be thought of as hundreds of concentric
shells of alternating refractive index.

Optically pumping the microdroplet
with external pulses caused the photonic
bandgap in the Bragg resonator to
concentrate the light emitted from the
dye molecules inside the microdroplet,
thereby emitting monochromatic light in
different directions. Specifically, lasing was
observed at ~600 nm with a linewidth
of ~0.1 nm at a threshold of ~1.8 mJ
~0.1 nm at a threshold of ~1.8 mJ
cm–2 when a 1 ns pumping pulse from a
Q-switched frequency-doubled Nd:YAG
laser was used to uniformly illuminate
a 40-μm-diameter microdroplet. The
average output power was reported to be
0.05 mW at a repetition rate of 200 Hz.

The dependence of the lasing
wavelength on the helical period of
the cholesteric liquid crystals allowed
it to be tuned simply by varying the
temperature of the system. The researchers
demonstrated a reversible temperature
tuning of ~35 nm at 3.5 nm K–1. They also
pointed out that the lasing threshold was
dependent on the number of layers in
the microdroplet, corresponding to the
Q-factor of the microcavity and hence
to the diameter of the microdroplet. The
smallest lasing-allowable diameter in the
work was 15 μm.

According to the researchers, millions
of identical microlasers can be produced
in a fraction of a second, simply by mixing
two different immiscible fluids. This is
almost impossible to produce in a solid-
state device — a clear advantage of the
soft-matter approach.

“I expect that the long-term impact
of these cheap, disposable and easy-
to-produce microlasers as coherent,
onidirectional light sources might be for
soft-matter integrated photonic circuits.
In the short term, they might be useful for
imaging and sensing,” said Muševič.

RACHEL WON