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Spatially localized structures in a self-imaging semiconductor laser cavity: diffraction and complex non-linearity management.

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In recent years, degenerate laser cavities have gathered attention for their versatility in the transverse structuration of laser emission [1, 2]. In non-linear optics, they are also used to generate patterns of temporally localized structures [3]. Degenerated laser system with high Fresnel number and saturable absorption are also suited for spatial localized structure (SLS). They appear as individually addressable peaks of lights in the transverse plane of the laser system [4]. In this work, we design a spatially degenerated self-imaging laser cavity integrating a slow saturable absorber semiconductor mirror (SESAM) and a high gain ($\sim 15\%$) semiconductor mirror for SLS generation. The optical cavity is composed of two high numerical aperture (0.2 NA) and low aberrations lenses in a 4-f configuration. It improves the degenerated system response while allowing for normal and anomalous diffraction tuning. A thin ($< \lambda$) chromium layer was deposited on the gain surface to define an area with strong absorptive boundary condition for light particle observation.

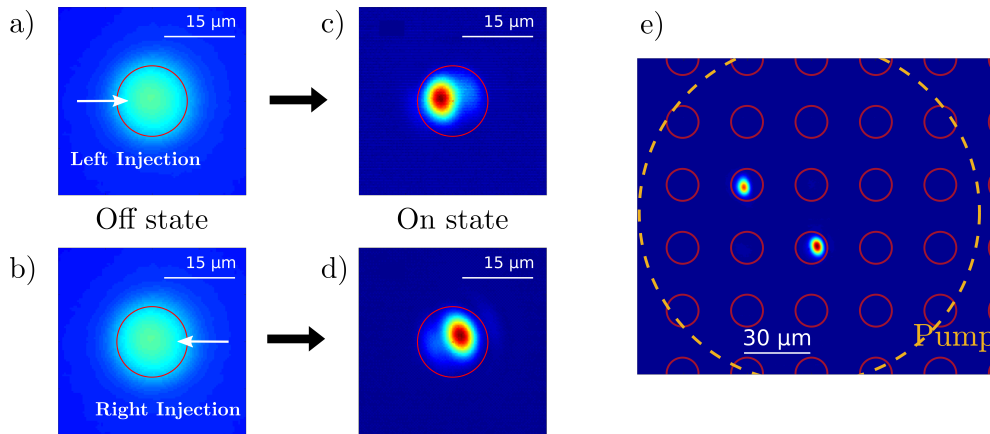


Fig. 1 (a)-(d) 2D Near field intensity profiles of the transition from the off state to the On state with local SESAM saturation. (a) and (c) Injection on the left side of the chromium mask. (b) and (d) Injection on the right side of the chromium mask. e) Multiplex emission of light particles controlled by a 2D array of chromium holes.

In Fig. 1 we show the observation of SLS in the transverse plane of the laser (panels (a) to (d)) as well as multiplexed emission of those states (panel (e)). The SLS can be address from the Off state of the laser by non-resonant injection locally saturating the saturable losses. The spatial position and transverse shape is not imposed by the cavity boundaries but only by the non-linear forces (SAM and SPM) allowing for multiplex emission over hundred of micrometers. We show that those light states exhibit transverse dynamics coherent with the behavior of slow light in the transverse plane of the resonator [5]. A strong absorptive boundary condition limiting an area of two to three time the size of the SLS is then needed in order to observe a single stable state.

This work demonstrates the existence of spatially localized structure in a self-imaging semiconductor laser cavity. Those results combined with the results of [3] provide a basis for possible spatio-temporal localization. The multiplexing capabilities of such system also open the way for intra-cavity generation of exotic transverse modes array (vortex beam, HG/LG beams), or multiple-frequency combs generation.

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